ISBN 999466799-8

Rice Science and Technology in Nepal

2017

Rice Science and Technology in Nepal

(A historical, socio-cultural and technical compendium)




Government of Nepal
Ministry of Agricultural Development
Department of Agriculture
Crop Development Directorate
Hariharbhawan, Lalitpur, Nepal

Agronomy Society of Nepal
Khumaltar, Lalitpur
Nepal

2017 (2073 BS)

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Publishers: **Crop Development Directorate (CDD)**
Hariharbhawan, Lalitpur, Nepal
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cddnepal2013@gmail.com, www.cddnepal.gov.np

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Suggested citation: CDD and ASoN. 2017. Rice Science and Technology in Nepal (MN Paudel, DR Bhandari, MP Khanal, BK Joshi, P Acharya and KH Ghimire, eds). Crop Development Directorate (CDD), Hariharbhawan and Agronomy Society of Nepal (ASoN), Khumaltar, 976p.

Cover photo: Top - Rice harvesting in mid hill of Nepal
Bottom (clockwise) - *Oryza granulata, O. rufipogon, O. nivara* and *O. sativa*

Published: April 2017

Available at: www.cddnepal.gov.np

ISBN: 978-9937-0-2622-2

Copies: 180

Cover & Layout: Pranaya Sindurakar
9841324249
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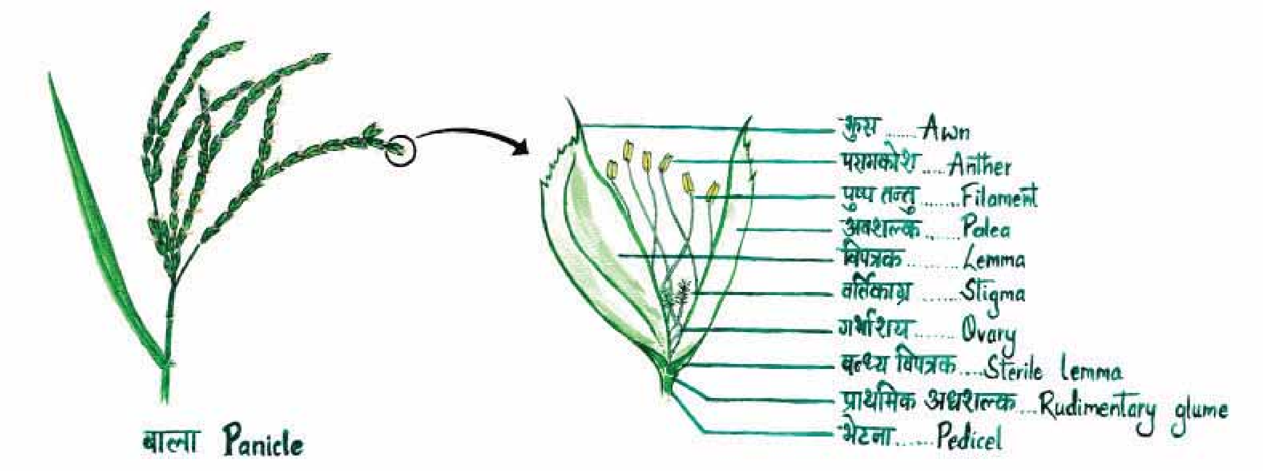
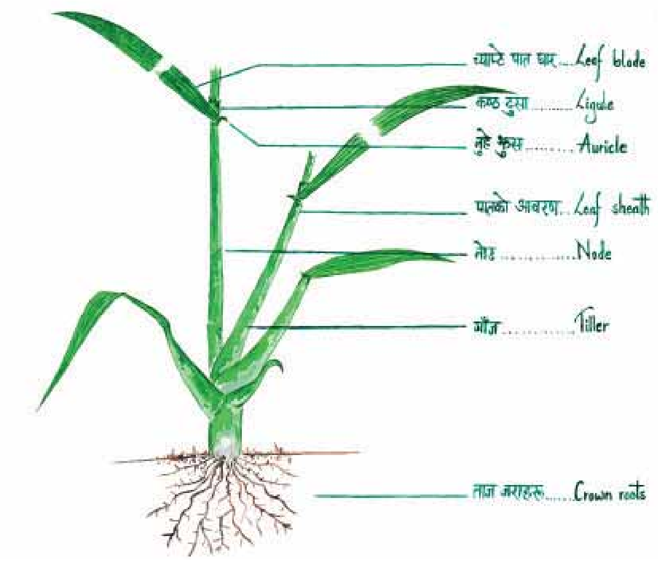
Print: Global Print Connection Pvt. Ltd.
Dillibazar, Kathmandu, Nepal
01 4435932
globalprintgpc@gmail.com

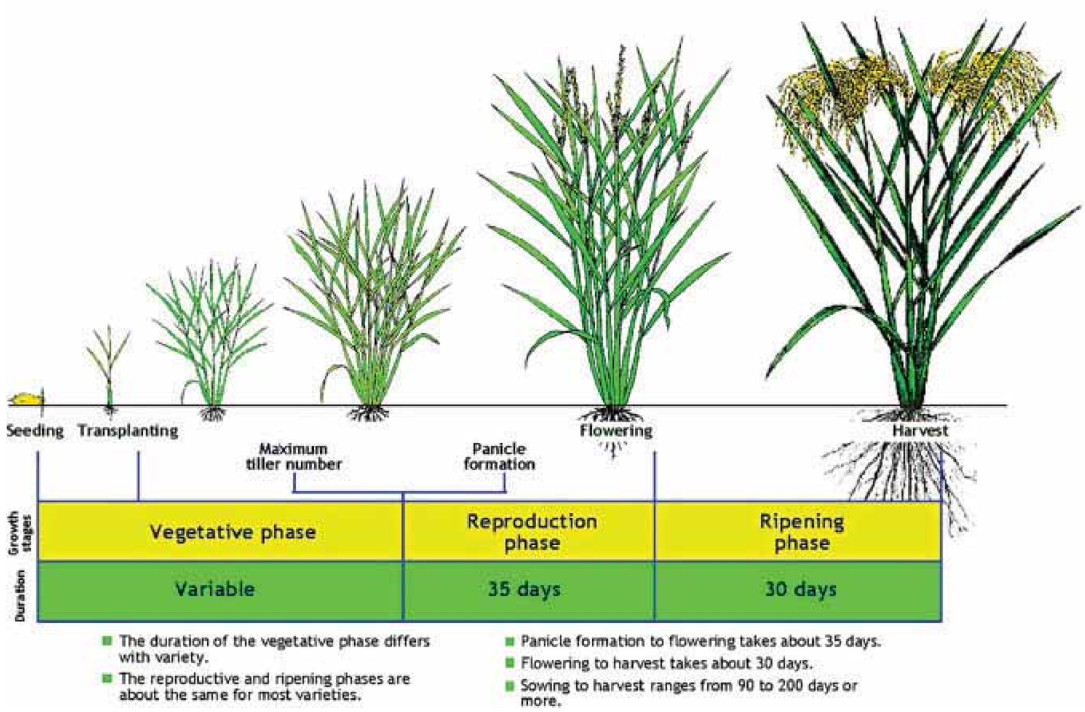


Rice panicle and spikelets



Rice plant

(Art by: Chandra Budha, DoA)



Growth stages of rice plant (Source: IRRI)

The Prime Minister

KATHMANDU
NEPAL

Message

Nepalese agriculture remains a major source of livelihoods and employment for several decades. There is significant contribution of agriculture sector in the national economy. Realizing the importance of agriculture in overall economic development, Government of Nepal has given top priority to this sector in its policy provisions. As a result, agriculture was recognized as a major pillar of economic development from the first to the ongoing fourteenth national periodic plan.

Nepal is the country where food security is kept under the fundamental rights of citizens in the constitution. The current constitution is in the process of implementation. Restructuring the organizations related to agriculture sector in the federal structure has become an urgent need of the nation. In this process, we have to develop federal, provincial, and local level organizations keeping the farming system and faces of farmers at the center. To increase the land and labor productivity from agriculture sector, we need to put our extra efforts on policy support, enhancing the knowledge level of farm families, increasing inputs use, farm mechanization, advancement in science and technology and its use, upgrading equipment and facilities, and developing agriculture as a respected business endeavour. It is expected that all these efforts will help towards modernizing the agriculture for brilliant achievements and its great contribution in food safety and peaceful development of the nation.

With the aim of making country self-reliant in agriculture production, improving livelihoods, and food security situation of Nepalese people, the Government has recently implemented Agricultural Development Strategy. Being the principal staple crop, this strategic document emphasizes on rice, which plays an important role in maintaining food security situation. Therefore, recently implemented "Prime Minister Agriculture Modernization Project", which is a supportive project of the ADS, focuses primarily on rice to make the country self-reliant in rice production in next three years. I hope this book "Rice Science and Technology in Nepal" will serve as a reference material to implement policy provisions for achieving advancement in rice production.

I would like to congratulate the officials working in the Ministry of Agricultural Development and Department of Agriculture for their initiatives to publish such a valuable book. Appreciation goes to the Crop Development Directorate and Agronomy Society of Nepal for their efforts to incorporate all aspects of rice in a single book by receiving papers from the most appropriate authors. I fairly regard this book as a national document which could be used by development planners to formulate appropriate plans and programs for the promotion of rice in Nepal.

Prachanda

April, 2017 **Puspa Kamal Dahal 'Prachanda'**

नेपाल सरकार

मा. गौरी शंकर चौधरी
कृषि विकास मन्त्री

Message

Majority of people in Nepal depend on agriculture for their livelihood. Rice ranks the first among cereal crops in Nepal in terms of area, production and employment generation. As the most important staple food of Nepalese people, rice has significant contribution in meeting the calorie requirement of Nepalese people. Rice has maximum share in AGDP among all crops grown in Nepal. Rice has special cultural, religious and traditional values in the Nepalese society. Ministry of Agricultural Development (MoAD) is a leading ministry of GoN working for promotion of rice and rice related R&D in the country.

In an attempt to increase production and productivity of paddy, the government of Nepal has made concerted efforts to address challenges associated with paddy crop promotion and development. Since the beginning of the planned development in Nepal, emphasis was given for the promotion of rice production. The projects like Fine and Aromatic Rice Promotion Program and Mega Rice Promotion program are implemented to increase production and their productivity, aimed at decreasing import substitution and enhancing food security.

Thirteen Plan had mainly focused on increment of production and productivity of crops (including rice and other food crops) with subsidy provisions on improved seeds, organic fertilizer, irrigation, machineries and equipment, chemical fertilizers as well as with subsidy in the premium for insurance of various crops. Current fourteenth plan aspires to produce 5.561 million metric tons of rice towards its completion. Similarly, programs such as crop insurance, barren land use policy and mechanization have been given due importance to promote rice production in Nepal.

In this regards, it gives me an immense pleasure to know that Crop Development Directorate of Department of Agriculture and Agronomy Society of Nepal (ASoN) have taken initiative to painstakingly document various aspects of rice. I feel this work will stand as the living manuscript in the history of agriculture in Nepal.

I extend my sincere gratitude to Crop Development Directorate/DoA, Agronomy Society of Nepal for their efforts to prepare this document entitled **"Rice Science and Technology in Nepal"** and all other helping hands for their technical support and editorial assistance in shaping this document to this form. I hope that this information will be used for wider purpose from planning to implementation of rice R&D in Nepal.

April 2017.

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Gauri Shankar Chaudhary
Honorable Minister
Ministry of Agricultural Development

नेपाल सरकार

राधिका तामाङ
कृषि विकास राज्यमन्त्री

Message

Rice is the number one crop among major food grains in Nepal and majority of Nepalese depend on rice for food and calorie. Nepal's economy hinges on rice and when economic growth increases rice production increases and the vice versa. It has been accorded the topmost priority in every periodic plan, national agricultural policies and programmes. The ADS has also included rice as a potential value chain commodity focused on development programmes to ensure food and nutrition security of the country.

Rice is also intricately linked with our culture and tradition. From birth to the funeral ceremony, it is considered as the essential element and has its unique importance in different forms. It is cultivated in all eco-zones of our country from Tarai to mountains. Various projects and programs have been implemented by government bodies for the promotion and development of rice in Nepal.

It gives me a real joy to enact the leading role as the State Minister for Agriculture towards the establishment of strong agricultural sector for ensuring food security and national prosperity of the country. I have a strong belief that the main responsibility of the Ministry of Agricultural Development is to provide every kind of support to farmers because this nation can thrive in their prosperity alone. Every need of the farmers, who dedicate their lives to feed the entire populace of the country must be addressed and taken care of. The Ministry of Agricultural Development along with institutions operating under its purview are always ready to guide the farming community towards receiving higher yield at low cost, utilizing both traditional and modern agricultural practices and technology. The ministry has also taken measures to extend helping hands to youth agro-entrepreneurs by providing them with technological and financial support. I would like to assure the farming community that the ministry is always committed towards fulfilling their needs and it stands with their effort to feed nation by grappling with numerous challenges of the nature.

In this scenario, the initiative taken by Crop Development Directorate of Department of Agriculture and Agronomy Society of Nepal (ASoN) for gathering information on various aspects of rice technology is highly appreciated.

Rice Science and Technology in Nepal is a fresh treasure of collection of rich information on rice and will have great practical and historical value. The book is concise yet comprehensively illustrated and offers a coherent account of rice science. It is written for wide scale of readers and should be of interest to agricultural planners, trainers and those who are involved in rice R&D. The book has also a rich insight into the cultural historical, ancient mythological and the life cycle of this extraordinary grain. This work is indeed an honor to the people who grow rice contributing to the overall national economy. This gem is a real delight to all lovers of knowledge on the rice crop.

April 2017.

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Radhika Tamang
Honorable State Minister
Ministry of Agricultural Development

निजी सचिवालय सिंहदरबार, काठमाडौं, फोन नं.: ४२११६३९, फ्याक्स: ४२११६३९

Government of Nepal
Ministry of Agricultural Development

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Singha Durbar
Kathmandu, Nepal

Message

Nepalese economy remains to be dominated by agriculture for decades which still contributes to around one third to the Gross Domestic Product. Within the agriculture sector, cereal crops have the highest contribution and the share of rice/paddy alone stands at around 20 percent in the Agricultural Gross Domestic Product. Similarly, rice contributes major share of the dietary needs of the people in Nepal. Rice fulfills the major nutritional requirement, especially carbohydrates.

Amidst this backdrop, Crop Development Directorate and Agronomy Society of Nepal has taken a noble initiative of meticulously collecting and compiling scattered information on rice from its origin to the present situation in diverse aspects as: religious, cultural, social, economic, and technical and publishing the book entitled **"Rice Science and Technology in Nepal".** The book also covers the information on agronomic practices: post production management, nutritional analysis, breeding and varietal development, statistics, economics and marketing, product diversification, and the use of rice by-products. Analytical discussions on policy support, coordination, and challenges for rice production are interesting features of this book. The incorporation of folk songs that form living culture in rice cultivation process prevalent among different communities in different languages in different parts of the country make this document lively. Articles and review papers included in this book contains wealth of information for researchers, academicians, scientists, policy makers, extension officials, and other personnel working in the field of rice.

I would like to express my sincere thanks to the editorial board, officials of Crop Development Directorate of the Department of Agriculture, and Agronomy Society of Nepal for their relentless efforts to publish this book. I hope the book will carve a distinct position in the agriculture history of Nepal.

April 2017.

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Suroj Pokhrel, PhD
Secretary
Ministry of Agricultural Development

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Foreword

Agriculture is not only intricately related to human life but has a significant role in furthering the culture and human civilization itself. From its inception to this stage, the government of Nepal has been actively engaged in the development of agriculture in the country through investment on overall aspects of agriculture such as: formulating plans and policies, enacting required acts and laws and also on the development of physical infrastructure, service sectors as well as human resources. The country has also been investing on agricultural research works in participation of local farmers besides promoting agricultural education and disseminating information related to agriculture among the public. There is no contestation that rice is the major crop among several crops, to ensure: rights to food, food security and food sovereignty as enshrined in the constitution.

With local breed as the matrix, the technology of rice cultivation has scientifically evolved inbred improved varieties, hybrid and super hybrid varieties. Adhering to this spirit of the rice crop development, attempts are made in this book to incorporate diverse aspects related to rice in Nepal such as religious, cultural, social, economic and technical issues. However, the prime objective of this initiative is to document the attempts and initiatives made so far on rice crop in Nepal and their resulting achievements. I hope this publication becomes useful and valuable for those who seek the knowledge and information on various aspects of rice. Since this book provides an overall picture on the value of rice crop, it may establish Nepal as the place of origin of this multi-featured crop rice in the world thereby helping to enhance the pride of the nation.

Even an eon undergoes changes so do the established values and thoughts. Tomorrow is ahead of today. As such, new thoughts, changes and inventions are inevitable. Yet, on the retrospect several changes that we witness today are founded on the base of the past or are inspired by the past. Therefore, it is unjust to completely ignore the past and say that nothing existed in the past or that there were no hands behind the present day achievements. Therefore, **Rice Science and Technology in Nepal** is published as the recognition of the endeavors of our ancestor farmers who had preserved the diverse breeds of rice for ages and our seniors who made an invaluable contribution to the development of rice crop. This compendium is the result of tireless efforts of the writers who are experts on rice crop and I express my gratitude to them all. I would also like to thank the editorial committee of this book. In the similar vein, I would like to express my heartfelt gratitude to National Planning Commission, Ministry of Finance, Ministry of Agricultural Development, Department of Agriculture, Crop Development Directorate (CDD) and IRRI Nepal for providing enabling environment in getting this book published.

April 2017.

Dila Ram Bhandari
Director General
Department of Agriculture, Hariharbhawan

Preface

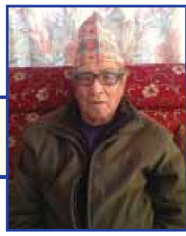
"कृषि मुलश्चः जीवनम्"-Agriculture is the basic of life, thus does the eastern civilization sum up the bond between agriculture and human life. This assertion is even emboldened in Nepalese perspective. "वुभुम्क्षमाण रौद्ररूपेन अभितिष्ठती"-शयनाचार्य, meaning a hungry person is like the fierce *Shiba* who can exterminate everything. These statements signify how much important is agriculture in the human civilization. In other words, the dawn of agriculture enabled human beings to think aside from the basic need of food. As such they excelled in the present status of the highest life form ever ascending the ladder of civilization. In Nepalese society also agriculture was regarded in the highest esteem, "उत्तम खेती मध्यम व्यापार अधम नोकरी" thereby emphasizing agriculture amongst all professions. Unfortunately, these days in Nepal reverse has been true where millions of Nepalese youths are wandering in search of jobs in gulf countries, toiling in scorching heat mostly in agriculture and construction related menial jobs. Major chunk of earnings of these migrant workers in Nepal is spent for agricultural commodities and consumable which could be produced abundantly in Nepal itself. However, this hard earned remittance has been poured in buying consumable agro-products imported mostly from India and China. While on the other hand most of the country's fertile lands are left untended in lack of labor force. This remains plight of agriculture based country Nepal.

The fact remains that many developing countries which were on a par with or lower than Nepal in development index during 1960s now are far ahead of Nepal mainly because of according high priority in agriculture among infrastructural and other forms of development. Example is our big neighbors, China and India. Immediately after the independence of India in one of the meetings of the Indian Congress, Gandhiji displaying a lanky *Ageratum* plant asked party members, "Why are plants so unhappy in their place of origin?" Understanding the importance of agriculture, Nehru took bold decision saying that everything can wait but not the agriculture. As a result, now, India is food self-sufficient and there are more than 50 agriculture universities in India. So is the case of China where statesmen like Mao and Teng gave high priority to agriculture. Now, these two Asian giants are food self-sufficient and are even exporting their produce in countries like Nepal where agriculture is suffering in absence of due priority in policy and practice. After the food crisis of 2008 many countries in the world are giving high priority to agriculture and making very good progress in this regard. Most of the civil unrests in the developing world are mainly due to food and nutritional insecurity.

Nepal *per se* cannot be developed until and unless agriculture is given due priority both by public and private entities. To add a brick in making Nepalese agriculture robust and to fulfill the need of the day, Crop Development Directorate (CDD)/DoA solicited the Agronomy Society of Nepal (ASoN) to help publish **"Rice Science and Technology in Nepal".** ASoN happily accepted the proposition and concentrated its effort to make the mission a success. In Nepal, of the many sectors of agriculture, rice science is one of the most important single sectors it should get high on agenda of public and private agencies as to graduate Nepal from LDC to DC as envisaged by the Government of Nepal. In this regard, ASoN is immensely gratified to extend its helping hands in the auspicious work initiated by the CDD/DoA to bring the publication in the present form.

April 2017.

Mina Nath Paudel, PhD
President
Agronomy Society of Nepal (ASoN)



शुभेच्छा

नेपालको के हिमाल, के पहाड के तराइ सबै ठाउँमा चामलको उत्तिकै महत्व र वैभव रहेको छ । संस्कृतिको हिसाबले नेपालमा रहेका विभिन्न जातजातिहरूको आफ्नै मौलिक विशिष्ट पहिचान भएतापनि कुनै एउटा चाड पर्व र संस्कृति छैन होला जहाँ धान चामलको नाता नहोस् । धान हाम्रो खाद्यान्न मात्र नभएर संस्कृतिको धरोहर पनि हो । नेपालीहरूको जन्मदेखि मरणसम्म धानको संलग्नता रहनुले पनि धानको नेपाली समाजमा महत्व स्वतः स्पष्ट हुन्छ । ढिडो, रोटी जे खाए पनि "भात खाइयो/भान्सा भयो" भन्ने नेपाली थेगो बिहान बेलुकाको कुरा सुरु गर्दा प्रयोग गर्ने शब्द भातबाटै हुन्छ । पहिलो भेटमा भलाकुसारी गर्ने सुरूवात भात नै हो । यसले जनाउँछ धान कति गहिरोसँग नेपाली समाजमा बसेको छ । धान बालीको यो ग्रन्थ कृषक र कृषि प्राविधिकलाई मात्र नभएर सम्पूर्ण नेपाली जगतका लागि कोशेली भएको मैले अनुभव गरेको छु । धान बाली सम्बन्धी लेख संग्रह प्रकाशन गर्न लाग्नु भएकोमा बाली विकास निर्देशनालय र एग्रोनोमी सोसाइटी, नेपाललाई धन्यवाद दिन चाहन्छु । साथै, आगामी दिनहरूमा यस्तै महत्वपूर्ण नीधिहरू नेपालको कृषि क्षेत्रमा निरन्तर प्राप्त हुँदै जाने प्रेरणा सम्बन्धित सबैलाई मिल्दै रहोस् भन्ने कामना गर्दछु ।

२०७३ मार्ग ३० गते, काठमाण्डौ ।

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माधव प्रसाद घिमिरे

राष्ट्रकवि

शुभेच्छा

वैदिक साहित्य एवम् पुरातात्विक उत्खननमा धान सबैभन्दा पुरानो बालीमध्ये एक रहेको छ । कृषि प्रधान देश नेपाल र नेपाली समाजमा धान एउटा अभिन्न पक्षको रूपमा स्थापित छ, धान । यो नेपाली समाजको संस्कृति र इज्जतको प्रतिबिम्बको रूपमा रहेको छ । नेपाली समाजको प्रमुख खाद्यान्न बाली धानको उपयोग जन्मदेखि मृत्युसम्म गरिने विविध सांस्कृतिक एवम् सामाजिक कार्यहरूमा गरिन्छ । नेपाली समाजमा बहुआयामिक महत्व भए पनि सोबारे यथेष्ठ रूपमा सुसूचित हुने अपेक्षा पुरा नभएका सबैलाई धान सम्बन्धी ऐतिहासिक, आर्थिक, प्राविधिक, सांस्कृतिक, ऐतिहासिक पक्षहरू समेटी यो रूपमा भएको प्रकाशन कार्य अत्यन्तै सह्रानीय एवम् प्रशंसनीय रहेको छ । यो ग्रन्थ धान सम्बन्धित सरोकारवालाहरूको लागि मात्र उपयोगी नभई नेपाली संस्कृति, रहन-सहन, रितिरिवाज आदिसँग संलग्न हुने सबैलाई धानसँग हाम्रो संस्कृतिको सम्बन्धको बारेमा प्रष्ट हुन निकै उपयोगी सावित हुने छ भन्नेमा म विश्वस्त रहेको छु । यस किसिमको ग्रन्थ प्रकाशन गरी पाठक वर्गमा धान सम्बन्धी सम्पूर्ण विषयवस्तुहरू पस्कने जमर्को गर्नुभएकोमा बाली विकास निर्देशनालय र एग्रोनोमी सोसाइटी, नेपाललाई विशेष धन्यवाद दिन चाहन्छु । साथै मेरो सन्देश समेत समावेश गर्ने मौका दिनुभएकोमा प्रकाशक प्रति हार्दिक आभार व्यक्त गर्न चाहन्छु ।

२०७३ मार्ग २८ गते धान्य पूर्णिमा, काठमाण्डौ ।

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सत्यमोहन जोशी

इतिहासविद् एवम् संस्कृतविद्

शुभेच्छा

दैनिक जीवनमा हामी धानलाई विविध रूपमा प्रयोग गर्दछौं । धानबाटै चामल बन्छ, धानबाटै लावा बन्छ, धानबाटै अरू अनेक परिकार बन्छ । धानको इतिहास खोज्दै जाँदा वेद एवम् हरप्पा, मोहनजोद्डो जस्ता सभ्यताहरूमा पनि तिनको प्रयोग पाइन्छ । वैदिक यज्ञ–यागादि धानबिना हुँदैन भनिदिए हुन्छ । कृषिमूखी जीवनपद्धति र कृषिपेशा नै मुख्य पेशा रहेको पाउँछौं । वास्तवमा भन्ने हो भने धान हाम्रो पहिचान र प्रतिबिम्ब पनि हो । वैज्ञानिकहरू अध्ययन गर्दैछन् कि नेपालमा यति धेरै धानका जंगली जातहरू कसरी जोगिन सक्यो । हिमाल, पहाड, उपत्यकामा हुने विभिन्न जातका धानहरूको आ आफ्नै वैशिष्ट्य रहेको छ ।

नेपालको धर्म सस्कृतिकै अभिन्न अंग रहेको धानको बारेमा अफैसम्म गहन अध्ययन नभइरहेको परिप्रेक्षमा प्रस्तुत कृतिले यसको इतिहास, उपयोगिता, खेतीका प्रकार, धानका किसिमहरू, यसका विविधताको बारेमा भलिभाँति प्रकाश पारेको छ । धानको बारेमा अध्ययन गर्न चाहने विद्यार्थी, पारखी तथा अनुसन्धानदाताहरूलाई यो ग्रन्थ एकदमै उपयोगी हुन पाएको छु । साँच्चै भन्ने हो भने यो कृति धानसम्बन्धी ज्ञानको भण्डार नै हुन पुगेको अनुभव भयो । यति बृहत् र बिस्तृत रूपमा यो ग्रन्थ तयार पार्न लाग्नु हुने सम्पादक मण्डलका सदस्य, लेख दिएर सहयोग पुऱ्याउनु हुने विद्वानहरूका साथै बाली विकास निर्देशनालय र एग्रोनोमी सोसाइटी, नेपाललाई विशेष धन्यवाद दिन चाहन्छु । मलाई पनि आफ्ना केही भनाई राख्ने अवसर दिनुभएकोमा आभार एवम् यस्तो महत्वपूर्ण ग्रन्थ प्रकाशन भएकोमा हार्दिक शुभेच्छा व्यक्त गर्दछु ।

२०७३ मार्ग २८ गते धान्य पूर्णिमा, काठमाण्डौ ।

डा. गोविन्द टण्डन
अध्यक्ष, पशुपति क्षेत्र विकास कोष

शुभेच्छा

बहुजाति, बहुधर्म, बहुसंस्कृतिले सिंगारिएको सुन्दर शान्त हाम्रो देश नेपालमा धानको आर्थिक, सामाजिक एवम् सांस्कृतिक महत्व रहिआएको छ । नेपाली समाजमा धान संस्कृतिको प्राणको रूपमा रहेको र हरेक सामाजिक एवम् सांस्कृतिक कार्यहरूमा धानकै प्राधान्यता रहको हुन्छ । नेपालमा प्रधान बालीकै रूपमा रहेको धानले नेपालीको खाद्य तथा पोषण सुरक्षाको सुनिश्चिता कायमका साथै राष्ट्रिय अर्थतन्त्रलाई चलायमान बनाउनमा समेत महत्वपूर्ण भूमिका निर्वाह गरेको छ । बहुआयामिक महत्व रहेको धानका ऐतिहासिक, सामाजिक, सांस्कृतिक, प्राविधिक पक्षहरूलाई समेटी धान सम्बन्धी बृहत् प्रकाशन गर्न लागेकोमा ज्यादै खुशी लागेको छ । प्रस्तुत पुस्तकमा समावेश गरिएका विषयवस्तुहरू जुन सुकै विधामा रूचि राख्ने पाठकहरूको लागि उपयोगी सिद्ध हुने अपेक्षा लिएको छु साथै यसमा समावेश गरिएका विषयवस्तुले आगामी दिनमा नेपालको प्रमुख बाली धानसँग सम्बन्धित नीति निर्माण तथा कार्यान्वयन गर्नमा थप सहयोगी हुने विश्वास समेत लिएको छु । अन्त्यमा अथक् मेहनत र खोजपूर्ण विषयवस्तुहरू समावेश गरी धान सम्बन्धी ग्रन्थलाई यस रूपमा ल्याउनुहुने बाली विकास निर्देशनालय परिवार र एग्रोनोमी सोसाइटी, नेपाललाई हार्दिक धन्यवाद एवम् बधाई दिन चाहन्छु ।

२०७३ मार्ग २८ गते धान्य पूर्णिमा, काठमाण्डौ ।

डा. माधव प्रसाद भट्टराई
अध्यक्ष, राष्ट्रिय धर्मसभा, नेपाल

शुभेच्छा

ऐतिहासिक कालदेखि धान र नेपाली समाजको अन्योन्याश्रित सम्बन्ध रहेको तथ्यमा कसैको दुइमत रहेन । नेपालमा रहेका विभिन्न जातजाति, संस्कृति, रिति-थिति, धर्म-कर्म आदिमा धान नै त्यस्तो अन्न हो जसले नेपाली समाजलाई परापूर्व कालदेखि एक सुत्रमा बाँधेको छ । धान सम्बन्धी विविध पक्षहरू समेटी यस किसिमको महत्वपूर्ण ग्रन्थ तयार गर्नु हुने सम्पूर्ण कृषि विज्ञ/वैज्ञानिकहरूलाई साधुवाद छ । यो ग्रन्थमा समावेश भएका लेखहरू अत्यन्तै सारपूर्ण र सन्दर्भ योग्य भएको हुँदा नेपाली समाज आगामी दिनमा अरू लाभान्वित हुने अपेक्षा गरेको छु । यस्ता उपयोगी सामाग्रीहरू सम्बन्धित विज्ञहरूबाट संकलन गरी धान ग्रन्थको रूपमा प्रकाशन गर्नु अति समय सापेक्षित कार्य हो । यसको लागि बाली विकास निर्देशनालय र एग्रोनोमी सोसाइटी, नेपाल धन्यवादका पात्र हुनुहुन्छ । यो ग्रन्थको प्रकाशनले अरू यस्तै ग्रन्थ प्रकाशनमा सम्बन्धित सबैलाई प्रेरणा मिलोस् भन्ने शुभकामना दिदै मलाई यो सन्देश दिने मौका दिनुभएकोमा सम्पादक मण्डललाई पुनः धन्यवाद दिन चाहन्छु ।

२०७३ मार्ग २८ गते धान्य पूर्णिमा, काठमाण्डौ ।

प्राज्ञ डा. जगमान गुरूङ
वरिष्ठ संस्कृतिविद्

शुभेच्छा

धान बाली सम्बन्धी ग्रन्थ प्रकाशन भएकोमा मलाई ज्यादै हर्ष लागेको छ । धान नेपालको खाद्यान्न बाली मात्र नभई संस्कृतिको धरोहर समेत रहेको तथ्य सबैमा अवगत भएकै हो । नेपाली समाजका सबै समुदायहरूमा धानको सामाजिक, सांकृतिक तथा आर्थिक महत्व रहेको छ । यस ग्रन्थमा समावेश भएका लेखहरू मुर्धन्य विज्ञबाट लेखिएका हुनाले यो ग्रन्थ धान सम्बन्धी चासो राख्ने वैज्ञानिक, योजना विद्, प्राध्यापक, कृषक तथा आम नागरिकलाई समयपयोगी हुने सन्दर्भमा दुइमत रहने छैन । यसको अलावा यो ग्रन्थ कृषिसँग सरोकार राख्ने सबैको लागि ज्यादै बहुमूल्य स्रोत हुनेछ भन्नेमा मेरो पुरा विश्वास छ । यस ग्रन्थमा मलाई छोटो सन्देश दिने अवसर प्रदान गर्नुहुने सम्पादक मण्डललाई मुरीमुरी धन्यवाद दिदै आगामी दिनहरूमा यस्तै महत्वपूर्ण नीधिहरू नेपालको कृषि क्षेत्रमा निरन्तर प्राप्त हुँदै जाने प्रेरणा सम्बन्धित सबैलाई मिल्दै रहोस् भन्ने सदिक्षा सहित मेरो छोटो सन्देशको बिट मार्दछु ।

२०७३ मार्ग २८ गते धान्य पूर्णिमा, काठमाण्डौ ।

जगबहादुर बुढाथोकी
पूर्व महानिर्देशक
बजार सेवा विभाग

शुभेच्छा

"कृषि मुलश्चः जीवनम्" भनिएभै कृषि हामी सम्पूर्ण नेपाली जातजातिहरूको प्रमुख आधार हो । साथै कृषि नेपाली संस्कृतिको जग हो र धान कृषि क्षेत्र मध्येमा प्रमुख अन्न बाली हो । धान र यससँगको पहिचान बिना नेपाल र नेपाली संस्कृति अधुरो रहन्छ । धान सम्बन्धी तयार पारिएको यो ग्रन्थ कृषिकर्मीहरूको लागि मात्र नभएर यससँग सरोकार राख्ने सम्पूर्ण नेपालीका लागि एक अमूल्य नीधि भएको मैले महसुस गरेको छु । कृषि बिज्ञ एवम् वैज्ञानिकहरूको लामो खोज तथा अनुभवको आधारमा प्रस्तुत ग्रन्थमा समावेश भएका धान सम्बन्धी ऐतिहासिक, प्राविधिक, सामाजिक लेखहरू आउने पिढीहरूको लागि समेत बहुउपयोगी हुने अपेक्षा गरेको छु । अन्त्यमा, नेपालको कृषि विकासकै इतिहासमा पहिलो पटक धान सम्बन्धी यस किसिमको ग्रन्थ प्रकाशन गर्नुभएकोमा कृषि बिज्ञहरूमा मुरीमुरी धन्यवाद एवम् बधाई ज्ञापन गर्न चाहन्छु र मलाई यो सन्देश दिने मौका दिनुभएकोमा सम्पादक मण्डल समेत धन्यवादका पात्र हुनुहुन्छ ।

२०७३ मार्ग २८ गते धान्य पूर्णिमा, काठमाण्डौ ।

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प्रा.डा. नोवल किशोर राई
पूर्व विभागीय प्रमुख
भाषा विज्ञान, केन्द्रीय विभाग
त्रिभुवन विश्वविद्यालय, काठमाण्डौ

शुभेच्छा

कृषि नेपाली संस्कृतिको धरोहर हो भने धान त्यसको जग हो । धान र यससँगको पहिचान बिना नेपाल र नेपाली संस्कृति अधुरो मात्रै रहदैन लंगडो, पहिचान रहित र खोक्रो समेत हुने हुन्छ । तसर्थ नेपालमा हाल चलन चल्तीमा रहेका संस्कृति, धार्मिक अनुष्ठान, चाड पर्व, रिति-रिवाज र सम्पूर्ण नेपाली सभ्यता कृषि र धानसँग अन्योन्याश्रित रहेको तथ्य सबै सामु छर्लङ्ग छ । नेपालीहरू चाहे स्वदेशको जुनसुकै भागमा वा विदेशमा रहुन्, कृषि र धान महिमाले एक सुत्रमा गाँसिएका छन् । यो महत्वपूर्ण ग्रन्थ तयार गर्नु हुने सम्पूर्ण सहभागीहरू विशेषत कृषि विज्ञ/वैज्ञानिकहरूको जति प्रशंसा गरेपनि कम हुने मेरो ठम्याई छ । यो ग्रन्थमा समावेश भएका सबै लेखहरू समयपयोगी छन् र आउँदो पुस्ताको लागि अमूल्य नीधि हुन् । कृषि विज्ञ एवम् वैज्ञानिकहरूको यस प्रयासले अगामी दिनहरूमा यस्ता कृषि र संस्कृतिसँग साइनो राख्ने कोशेलीहरू अरू पनि प्राप्त हुने अपेक्षा राख्दै मलाई यो सन्देश दिने मौका दिनुभएकोमा आभार व्यक्त गर्दछु ।

२०७३ मार्ग २८ गते धान्य पूर्णिमा, काठमाण्डौ ।

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प्रा. डा. वीणा पौड्याल
पूर्व विभागीय प्रमुख
नेपाली इतिहास, संस्कृति तथा पुरातत्व केन्द्रीय विभाग
त्रिभुवन विश्वविद्यालय, काठमाण्डौ

शुभेच्छा

नेपाली पुस्तकालय संग्रहालयमा धान सम्बन्धी एउटा नव ग्रन्थ थपिएकोमा ज्यादै हर्षित भएको छु । यो ग्रन्थ कृषिमा समर्पित मुर्धन्य विज्ञहरूको ज्ञान भण्डार हुँदा अब आउने नव पुस्ताहरूलाई धान र सो सम्बन्धी ज्ञानको कमि नहुने गरी लेखिएको मैले महसुस गरको छु । यस ग्रन्थमा समावेश गरिएका विषयहरू धान सम्बन्धी काम गर्ने अनुसन्धानकर्ता, प्राध्यापक, विद्यार्थी, कृषक, योजनाविद् सबैलाई सन्दर्भ सामग्रीको रूपमा प्रयोग हुने सामग्रीहरूको संकलन भएकोले प्रकाशनलाई यो रूपमा ल्याउनुहुने सम्पूर्ण कृषि विज्ञ/वैज्ञानिकहरू धन्यवादका पात्र हुनुहुन्छ । धान लगायत अन्य मुख्य खाद्यान्न बाली सम्बन्धी जानकारीमूलक सन्दर्भ समाग्री तयार गर्ने प्रेरणा अरू क्षेत्रमा कार्यरत वैज्ञानिकहरूलाई मिल्ने छ भन्ने विश्वास लिएको छु । साथै, विगतमा धान/चामल निर्यात गर्ने देश भनि बनाएको पहिचान पुनः कायम गर्न सकोस् भन्ने शुभकामना समेत दिन चाहन्छु । यो महत्वपूर्ण ग्रन्थमा मलाई छोटो सन्देश दिने अवसर प्रदान गर्नुहुने सम्पादक मण्डललाई मुरीमुरी धन्यवाद दिन चाहन्छु ।

२०७३ मार्ग २८ गते धान्य पूर्णिमा, काठमाण्डौ ।

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लालबाबु यादव
सह प्राध्यापक, त्रिभुवन विश्वविद्यालय एवम्
सांसद, व्यवस्थापिका संसद

शुभेच्छा

कृषि विद्हरूको पहलमा सायद नेपालमा धान बाली सम्बन्धी यति बिस्तृत ग्रन्थ प्रकाशन भएको पहिलो पटक हुनु पर्छ । यसले "कृषि मुलश्चः जीवनम्" भन्ने नेपाली संस्कारलाई पुनः प्रतिबिम्बित गर्नमा अर्को इँटा थपेको छ । यस कार्यमा संलग्न हुनु भएका सम्पूर्ण विज्ञहरू धन्यवादका पात्र हुनुहुन्छ । धानको महिमा नेपाली समाजमा धेरै गहिरोसम्म छ भन्न कसैलाई पनि हिचकिचावट हुँदैन । नेपालका सबै जात, जाति, वर्ग, क्षेत्रका समुदाय तथा सबै नेपाली संस्कृतिमा धानको महत्व विशेष किसिमको रहेको छ । आ-आफ्नै मौलिक पहिचान भएका समुदायहरूले मनाउने सबै चाड/पर्वहरूमा धान/चामलको प्रयोग अनिवार्य जस्तै रहेको छ । यस ग्रन्थमा समेटिएका लेखहरू उत्तिकै महत्वपूर्ण छन् । धान र नेपाली संस्कृतिको हिसाबले लेखिएका लेखहरू अझै अति महत्पूर्ण र जानकारी मूलक छन् । धान सम्बन्धी लेखहरू समावेश गरी यस किसिमको पुस्तक प्रकाशन गर्नुहुने प्रकाशक धन्यवादका पात्र हुनुहुन्छ । यो ग्रन्थ नेपाली समाजको महत्वपूर्ण नीधिको रूपमा आएको अर्को कोसे ढुंगा भएको महसुस भएको छ । यस महत्वपूर्ण ग्रन्थमा केही सन्देश व्यक्त गर्ने मौका दिनु भएकोमा सम्पादक मण्डललाई धन्यवाद दिन चाहन्छु ।

२०७३ मार्ग २८ गते धान्य पूर्णिमा, काठमाण्डौ ।

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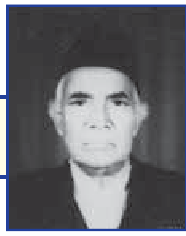
मीन बहादुर विश्वकर्मा
सांसद, व्यवस्थापिका संसद

Greetings



I got chance to lead the Department of Agriculture (DoA) from 2038/9/14 to 2044/10/20 BS in the capacity of Director General (DG). During that period, crop commodity programs of major crops: rice, maize, wheat, potato and sugarcane were in the initial stages. A full thrust was given for those commodity programs to develop technology and disseminate them under different agro ecological regions of the country with a combined help of research and development under the sole umbrella of DoA. Farm irrigation was given priority to increase production and productivity of these crops. One door program to provide agriculture inputs (seeds, fertilizer, loan, technology and market), a production program was launched in 17000 ha of irrigated areas of Tarai under command areas of the different irrigation projects in Tarai. Due emphasis was placed for adopting improved technology under irrigated regions of the country to boost agriculture production and productivity. Research and extension were in full swing in arrears implemented production program during these periods. This has helped increase rice production and as a result Nepal could maintain its status of rice exporting country.

Howver, now Nepal is one of the top most rice importing countries despite her potentiality of rice export as in the past. Under today's science driven age research, extension and teachings are working differently in Nepal which is hindering agriculture development of the country. In fact, reverse is the demand of the day for having joint approaches of three pillars research, extension and teaching under one umbrella to develop and disseminate agriculture technology as a whole.

I am pleased to see the work done by the Crop Development Directorate (CDD) of Department of Agriculture and Agronomy Society of Nepal (ASoN) to document works related to R&D of rice in Nepal. This will be valuable assets for future generation to work for the development of rice in Nepal. I congratulate all involved in bringing out this publication.

January 2017.

P.P. Gorkhaly
2073/9/17
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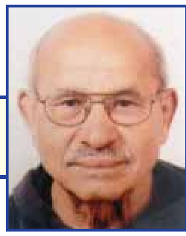
Purushottam Prasad Gorkhaly

Former Director General, DoA

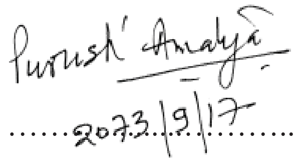
Greetings



Nepal Agriculture Research Council (NARC) was incepted in 2048 BS and I was the first Executive Director (ED) of the NARC from 2048/11/28-2051/7/23. During my tenure as ED, I had given high priority for rice research in Nepal. It is evident that rice is not only the main staple crop but also the number one industry of Nepal. Bulk of the AGDP comes from the rice production and GDP hovers around on the basis of rice production in the country; meaning if rice production increases GDP surges and if it decreases it plumages as well. Hence, overall development of Nepal is entirely based on agriculture in general and rice R&D in particular. I am feeling that neither research nor extension have given adequate priority for rice compared to its contribution in the national economy of the country. However, I am very pleased to see the joint works done by the Crop Development Directorate (CDD) and Agronomy Society of Nepal (ASoN) to document works related to rice R&D in the form of **Rice Science and Technology in Nepal**.

This initiative taken by Mr. Dila Ram Bhandari, Program Director of CDD/DoA and Dr. Mina Nath Paudel, President of ASoN deserve very commendable appreciation and I appreciate this work from the core of my heart. I urge other professional societies of agriculture to engage in such constructive works with respect to agriculture development of Nepal. This publication will be very precious material for those who are concerned to the development of agriculture in Nepal in general and rice in particular. I congratulate CDD and ASON for giving me a chance to put forth my message for the unique publication of rice, the mainstay of Nepal.

January 2017.



Purushottam Amatya

First Executive Director, NARC

Greetings

In 1962, Seed Testing Lab was inside the Agronomy Farm, Singh Durbar where I started my career in agriculture. I was posted from Singh Durbar to Parwanipur Agriculture station, Bara at the end of 1970, as the First Rice Coordinator for the National Rice Research Improvement Program in Parwawanipur Agriculture Centre, the oldest center where work on rice research and development were initiated aside from the work on other disciplinarians of agriculture in Parwanipur. Nepal jointed IRRI in 1968 and established strong relation with other CGIARs in general and rice in special. In 1973, USAID supported WINROCK system and works on minikit distribution for major cereals of rice, maize, wheat and other crops including research worked on varietal development, agronomy, plant protection, post harvest and extension as well, under the unified command of DoA.

Upto 1980's many rice varieties such as Parwanipur-1, Mansuli, Chandina, Janaki, Shabitri, Bhindeswari, Himali, Kanchan, Chianan-242, Makwanpuur-1, Taichung Native-1, and Khumal-1 were released for different agro-ecological domains of Nepal. Some of these varieties are still popular in farmers' field. Many rice researchers during this time got chance to receive their higher education from the USA, India and other advanced nations. Nepal had a functional relation with IRRI thereby collection of more than 2000 rice accessions across the country were preserved in IRRI gene pool and these are used for developing insect pest resistance and stress tolerant varieties by the IRRI up to these days. This is the great contribution of Nepal towards sustaining food and nutritional security across the world.

In Nepal, rice and agriculture were so honored even in the ancient time that Ranjit Malla, king of Bhakatpur used to display his collection of more than 300 varieties of various kinds of crops and flowers seeds instead of Jewelries which was symbol of dignity to his subjects. This was reported by Percival in 1710. This gave the impression that King Ranjit Malla was the pioneer of germplasm collection even in ancient period when modern agriculture was in dormant stage. This is how we Nepalese love agriculture since ancient time. After my resignation from the government service in 1982, I joint IRRI and served for rice science for many countries of Asia and Africa. During 1980's Nepal was rice exporter but now reverse is true and Nepal has become a net rice importer country despite all good works by rice workers. This situation should not prevail at least in agriculture based country like Nepal. Now after my retirement I am able to see such an insurmountable work initiated by the CDD, DoA and the ASoN. This has made me immensely happy and I want to congratulate all involved for such a noble work on the main staple crop not only of Nepal but also the world as well. Nevertheless, I am very pleased to see the commendable job undertaken by Mr. Dila Ram Bhandari, Program Director of the CDD, DoA and Dr. Mina Nath Paudel, president of the ASoN to get published rice and rice related works up to the day. This document will be a valuable asset to those who are involved in agriculture progress of Nepal in general and rice in special. My congratulation to all hard working members of this team which is documenting rice and rice related works in Nepal for future generation as well.

December 2016.

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Bal Bahadur Shahi, PhD

First Rice Coordinator, DoA

Greetings

Rice serves as the mainstay of Nepal because it is the staple food for all sections of people. The straw forms an important animal fodder; husk is used as fuel, insulation material, and fertilizer and building material. The rice bran is utilized in animal and poultry feed. We have not been able to extract bran oil which is popular in India, Bangladesh, China and Japan. It also offers employment to millions of Nepali farmers providing income especially for the weaker sections of the society. In order to meet the demands of increasing population, we have to focus on its productivity and production enhancement all the time. The record production of over 5.2 million tonnes of rice this year (2015/016) could have been possible because the extension, research personnel and farmers in addition to input supplying agencies must have excellent coordination and cooperation.

Is it not something to ponder as to why Nepal, once a rice exporting country became a rice importing country? There seems to be mismatch between population increase and rice production. The instability in the government is largely responsible for these reverses along with open border with southern neighbor. The calculation of our requirement often goes wrong because of the porous border. Our planning has completely gone awry. Food production chain is further compounded by climate change where we have to deal with long drought or frequent floods. Temperature rise, global phenomenon is likely to hit wheat production adversely which in turn will increase rice consumption.

Rice research in NARC should be strengthened without any delay. There is a need of establishing the Rice Research Institute on a priority basis. The retention of scientists is one of the biggest challenges facing the institution today and some bold initiatives in this regard must be taken promptly.

There was an urgent need to have rice history and technologies in a book so that it will be easier for everybody to know about rice. This **Rice Science and Technology in Nepal** compiled by my friends Dr. Mina Nath Paudel and Mr. Dila Ram Bhandari will be a milestone for rice science. I sincerely thank them for their hard work in compiling and publishing it.

January 2017.

Thaneswor P. Pokharel
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Thaneswor Prasad Pokharel
Former Rice Coordinator, NARC

Greetings

International Rice Research Institute (IRRI) and Nepal have been working together on rice research and development since 1966. This relationship got further strengthened after establishment of IRRI-Nepal Office in Kathmandu in 2005. IRRI and Nepal collaboration have been primarily focused to develop better rice production technologies including varietal improvement and improved management practices for both rainfed and irrigated ecosystems. In addition to this, IRRI has been collaborating with Nepal Agricultural Research Council (NARC) for strengthening capacity of scientists/technicians in stress tolerant rice, hybrid rice, post-harvest technologies, socioeconomic and policy research. Recently IRRI has been working with Nepal for the development and out scaling of high yielding, good grain quality flood and/or drought tolerant rice varieties to enhance and stabilize rice production in rainfed areas.

Under Stress Tolerant Rice for Africa and South Asia (STRASA) project, funded by Bill & Melinda Gates Foundation (BMGF), Government of Nepal released few drought tolerant and submergence tolerant rice varieties as well as both drought and submergence tolerant rice variety. More than 50% rice varieties released by the Government of Nepal were introduced from IRRI through INGER and other projects. Under Accelerating the adoption of stress-tolerant varieties by smallhoder farmers in Nepal and Cambodia (ASTV) project both IRRI and national partners (NARC, DoA, public and private sector seed companies, NGOs, cooperatives, Agrovets etc) in Nepal are working for the rapid seed multiplication and out scaling of new stress tolerant rice varieties and suitable management technologies to the farmers. This involves strengthening of entire seed chain including policy issues and capacity building. The technical capacity of Scientists of NARC and Extension Officers as well as technicians are developed by providing trainings in Nepal and abroad.

I take this opportunity to congratulate Crop Development Directorate of Department of Agriculture and Agronomy Society of Nepal for bringing a comprehensive information on rice in single book entitled **Rice Science and Technology in Nepal**. The commendable efforts of officials particularly Dila Ram Bhandari, to document various aspects of rice in Nepal is highly appreciated. I hope this monumental publication will serve as reference book on all aspects of rice in Nepal for years to come. I consider it huge achievement in the field of rice research and development in Nepal

January 2017.

U.S. Singh

Uma Shankar Singh
Senior Scientist-II & South Asia Regional Coordinator
Stress Tolerant Rice Program
International Rice Research Institute

Editors' Note

Rice Science and Technology in Nepal is a compendium of documentations of rice research and development in Nepal. Rice, being the main staple crop with about 20% share in national AGDP, is the largest diligence of the country. It has its share of over 50% of dietary supplement of Nepalese. Nepal's culture is largely shaped by agriculture and rice is almost everything in this country in the sense that almost every festival and ritual is based on agriculture in general and rice in particular. The bond of rice with Nepalese society is strong since people are associated with this crop from cradle to grave. Hence, Nepalese society and its culture without rice cannot be imagined.

Mr. Dila Ram Bhandari, Director General of DoA (then Program Director of the Crop Development Directorate) has put his heart and soul in bringing out this collection. Mr. Bhandari, couple of years back while attending a budget discussion workshop in Janakpur, shared his idea with Dr. Mina Nath Paudel, President of the Agronomy Society of Nepal (ASoN) to do something about rice crop's situation in Nepal. These two agriculturists discussed a number of time as to what should be documented on this crop which is not only a prime sector but also the backbone, life line and socio-culture artery of Nepal. They agreed that on a work on rice that shall be a memorable collection as a reference materials for planner, researchers, and all concerned who are eager to foster this crop. As a result, it was decided to ask ASoN to shoulder the task of editing the articles to be collected from different experts covering holistic sphere of rice and related fields encompassing from origin, technical, industrial and many more without ignoring any fields whatever possible. In this way, articles related to rice were requested from experts concerned. Mr. Bhandari personally contacted many persons to write papers in their field of expertise if possible and if not provide at least good wishes from the seniors and dignitaries of Nepalese society. In this way, articles and good wishes for this collection were assembled and edited by the editorial board and submitted to Mr. Bhandari for compilation to bring them in this form. Our concerns for this publication were to make it as the ***Gita*** of rice. Readers are left to evaluate this publication on their own. We hope, in coming days, agriculturists engaged in other important commodities will follow this model and bring available findings of respective commodities in up to date form in a single collection.

In this collection, there are Vedic, socio-economic, technical, economic and cultural aspects of rice with respect to rice research and development. Once articles started to come in, editors were asked to edit to the best of their capacity sometimes asking authors to provide information as demanded by editors and in other cases editors made some correction without distorting the theme of the articles. The editorial team is very much grateful to edit this historical document despite their usual professional responsibilities. We are confident that benefit of this document will be harnessed by all the concerned to advance this crop for enhancing livelihood of Nepalese in the days ahead.

April 2017. Editors

Acknowledgements

Rice Science and Technology in Nepal is the first official document of its kind seeks to cover all the information related to rice in Nepal. The main goal of publishing this book is to recognize the valuable contribution of farmers for maintaining the genetic diversity of rice for centuries and its use by our predecessors for improving rice production. The expectation is to reassert Nepal in the global forum as one of the place of origins of rice by explaining its historical, cultural, social, and economic importance. In this connection, Crop Development Directorate (CDD) would like to express sincere thanks to the entire agronomist community for motivating me to publish this book. The publication of such a precious volume would not possible without their support. Continuous encouragement and inspirations of Honorable Minister for Agricultural Development Mr. Gauri Shankar Chaudhary, Honorable State Minister for Agricultural Development Mrs. Radhika Tamang, Secretary of the Ministry of Agricultural Development Dr. Suroj Pokhrel and Director General of the Department of Agriculture Mr. Dila Ram Bhandari during the entire duration of document preparation are highly appreciated. At this moment, CDD sincerely acknowledge the continuous inspiration from former Agriculture Secretaries, Mr. Govinda Prasad Pandey and Dr. Ganesh Raj Joshi.

The work was conceived at a daylong workshop participated in by the members of Agronomy Society of Nepal, academia, officials from the Ministry of Agricultural Development, Department of Agriculture, and Nepal Agricultural Research Council, retired agriculturists and representatives of other relevant organizations. The interactive sessions, group exercises, discussions, valuable comments, and suggestions of this workshop helped to develop the outline of this document. Articles were received from eminent paper writers and reviewed by a panel of intellectuals. This document is the product of a joint effort of Crop Development Directorate and Agronomy Society of Nepal and published from the approved annual program of Crop Development Directorate of FY 2016/17.

CDD would like to express sincere thanks to all the writers for providing with their research papers, articles and information on various aspects of rice. Special thanks go to the panel of reviewers for thoroughly reviewing the articles and providing constructive suggestions and feedback.

With due respect, CDD acknowledge National Poet Madhav Prasad Ghimire, historian and culturist Satya Mohan Joshi, Dr. Madhab Bhattarai, Dr. Govind Tandan, Prof. Dr. Nobal Kishor Rai, Ass. Prof. Lal Babu Yadav, Min Bahadur Bishwakarma, Prof. Dr. Bina Paudel, Thaneswar Prasad Pokharel, Dr. Bal Bahadur Shahi, Puruswottam Gorkhali, Puruswottam Amataya and Jag Bahadur Budhathoki for their greetings and best wishes, which become an important component of this document.

CDD is grateful to the cooperation and contribution of Dr. Uma Shankar Singh, Senior Scientist-II, coordinator of STRASSA project and representative of IRRI to India and Nepal as well as Dr. Bhaba Prasad Tripathi, Senior Associate Scientist, IRRI-Nepal office.

CDD is very much thankful to all the officials working at District Agriculture Development Offices and at the field level for participating in the survey and providing required data and information as and when required. Deep sense of gratitude and sincere thanks go to officials working at the Crop Development Directorate for their relentless efforts, generous assistance and cooperation to bring this document in final shape. Deep appreciation goes to Senior Crop Development Officer Mr. Prakash Acharya, who served tirelessly and efficiently for managing all the articles at different stages and for Mr. Guneshwor Ojha for language editing.

CDD will feel amply rewarded if the document proves helpful for readers in fulfilling their information needs on rice in Nepal from its history to present status. CDD believes that the document will be helpful for scholars in developing genuine rice research programs and conducting academic research works. Conservationists, teachers, scientists, specialists, planners, policy makers, and all those interested in farmers' welfare will also be benefitted from the wealth of information available in this book. The book is comprehensive and offers a coherent account of rice science and will have a great practical and historical value.

Finally, CDD would like to appreciate all rice growing farmers and express gratitude to them for joining hands to ensure food and nutrition security through rice production in Nepal.

April 2017.

Crop Development Directorate
Hariharbhawan, Lalitpur

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ABBREVIATIONS AND ACRONYMS

4-H	Head, Heart, Hands, Health (*Charpate)*
AAEO	Assistant Agriculture Extension Officer
ABD	Agriculture Botany Division
ABPSD	Agribusiness Promotion and Statistics Division
ABSC	Agriculture Buying and Selling Cooperation
ACIAR	Australian Center for International Agricultural Research
ADBN	Agricultural Development Bank Nepal
ADO	Agriculture Development Officer
ADS	Agriculture Development Strategy
AED	Agricultural Engineering Division
AERP	Agriculture Extension and Research Project
AESA	Agro-Ecosystem Analysis
AETIP	Agriculture Training and Extension Improvement Project
AFACI	Asian Food and Agriculture Cooperation Institute
AFSP	Agriculture and Food Security Project
AFU	Agriculture and Forestry University
AGDP	Agricultural Gross Domestic Product
Agron JN	Agronomy Journal of Nepal
AICC	Agriculture Information and Communication Centre
AICL	Agriculture Inputs Corporation Limited
AICRIP	All India Coordinated Rice Improvement Project
AIRC	Agricultural Implement Research Centre
AMC	Agriculture Marketing Cooperation
AMIS	Agency Managed Irrigation System
AMP	Agricultural Mechanization Policy
AoA	Agreement on Agriculture
APCAEM	Asia and Pacific Centre for Agricultural Engineering and Machineries
APGR	Agricultural Plant Genetic Resources
APMDD	Agribusiness Promotion and Market Development Directorate
APP	Agriculture Perspective Plan
APPSP	Agriculture Perspective Plan Support Program
APROSC	Agriculture Project Service Centre
AREP	Agriculture Research and Extension Project
ARPP	Agriculture Research and Production Project
ARS	Agriculture Research Station
ASC	Agricultural Supply Corporation
ASoN	Agronomy Society of Nepal
ATF	Agricultural Tool Factory
ATIM	Agricultural Tools, Implements and Machineries
ATSP	Agro-enterprise and Technology System Project

AUDPC	Area Under Disease Progress Curve
AVT	Advanced Varietal Trail
B.Sc.Ag.	Bachelor of Science in Agriculture
B.V.Sc.& A.H	Bachelor of Veterinary Science and Animal Husbandry
BC	Benefit Cost
BCM	Billion Cubic Meters
BLB	Bacterial Leaf Blight
BLGWP	Bhairhawa Lumbini Ground Water Project
BS	Breeder Seed
BSA	Bulk Segregant Analysis
CAD	Command Area Development
CADP	Commercial Agriculture Development Project
CAT	Climate Analysis Tool
CBD	Convention on Biological Diversity
CBS	Centre Bureau of Statistics
CBSP	Community Based Seed Production
CDD	Crop Development Directorate
CDO	Chief District Officer
CDP	Crop Diversification Project
CEAPRED	Center for Environment and Agricultural Policy Research, Extension and Development
CEDAW	Convention on Elimination of all Forms of Discrimination
CEU	Cultural Evaluation and Utilization
CFTRI	Central Food Technology Research Institute
CGIAR	Consultative Group for International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Center
CMIASP	Community Managed Irrigated Agriculture System Project
CRC	Convention on Child Rights
CSB	Community Seed Banks
CSISA	Cereal System Initiatives in South Asia
CTEVT	Council for Technical Education and Vocational Training
CURE	Consortium of Unfavorable Rice Environment
CV	Coefficient of Variation
CVT	Coordinated Varietal Trial
DADO	District Agriculture Development Office
DAS	Days After Sowing
DAT	Days After Transplanting
DB	Duty Bearer
DDC	District Development Committee
DFTQC	Department of Food Technology and Quality Control
DISSPRO	District Level Seed Self Sufficiency Program
DoA	Department of Agriculture
DoAE	Directorate of Agriculture Engineering

DOFD	Directorate of Fisheries Development
DoI	Department of Irrigation
DSCC	District Seed Coordination Committee
DSR	Direct Seeded Rice
DTW	Deep Tube Well
DUS	Distinctness Uniformity and Stability
ED	Entomology Division
FAN	Floriculture Association Nepal
FAO	Food and Agriculture Organization
FAT	Farmers Acceptance Test
FFS	Farmers Field School
FFT	Farmers Field Trial
FIWUD	Farm Irrigation and Water Utilization Division
FMC	Food Management Cooperation
FMIS	Farmers Managed Irrigation System
FOI	Foreign Direct Investment
FORWARD	Forum for Rural Welfare and Agricultural Reform and Development
FPT	Field Plot Technique
FS	Foundation Seed
FT	Field Technique
FTE	Full Time Equivalent
FYM	Farm Yard Manure
GAADP	Gandaki Anchal Agriculture Development Project
GAFSP	Global Agriculture and Food Security Program
GARDP	Gulmi Arghakhanchi Rural Development Project
GDP	Gross Domestic Product
GEO	Genetically Engineered Organism
GEU	Genetic Evaluation and Utilization
GHG	Green House Gases
GIS	Geographical Information System
GMO	Genetically Modified Organism
GoN	Government of Nepal
GOs	Government Organizations
GRiSP	Global Rice Science Partnership
GT	Gelatinization Temperature
GxE	Genotype X Environment
Ha	Hectare
HARP	Hill Agriculture and Research Project
HFPP	Hill Food Production Project
HMRP	Hill Maize Research Project.
HNG	Home Nutrition Garden
HVAP	High Value Agriculture Project

HYV	High Yield Varieties
IAAS	Institute of Agriculture and Animal Sciences
IBPGR	International Board for Plant Genetic Resources
ICIMOD	International Centre for Integrated Mountain Development
ICM	Integrated Crop Management
ICP	Integrated Cereal Project
IDE	International Development Enterprises
IDRC	International Development Research Center
IET	Initial Evaluation Trial
IFAD	International Fund for Agriculture Development
IFPRI	International Food Policy Research Institute
IHDP	Integrated Hill Development Project
IIMI	International Irrigation Management Institute
ILO	International Labor Organization
INGO	International Non-Government Organization
INS	Indigenous Nutrient Supply
IPCC	Intergovernmental Panel on Climate Change
IPGRI	International Plant Genetic Resources Institute
IPM	Integrated Pest Management
IPNI	International Plant Nutrient Institute
IPNS	Integrated Plant Nutrient System
IPR	Intellectual Property Rights
IRCTN	International Rice Cold Tolerant Nursery
IRDP	Integrated Rural Development Project
IRRC	Integrated Rice Research Consortium
IRRI	International Rice Research Institute
IRTP	International Rice Testing Program
ISP	Irrigation Sector Project
ISTA	International Seed Testing Association
ITC	International Trade Centre
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
IUCN	International Union for Conservation of Nature
IWM	Integrated Weed Management
IWRMP	Irrigation and Water Resource Management Project
IYR	International Year of Rice
JADP	Janakpur Agriculture Development Project
JICA	Japan International Cooperation Agency
JT	Junior Technician
K-BIRD	Karnali Bheri Integrated Rural Development Project
KCl	Muriate of Potash (MoP)
Kg	Kilogram
KHADP	Koshi Hill Agriculture Development Project

KHARDP	Koshi Hill Area Rural Development Project
KU	Kathmandu University
KUBK	Kisan Ka Lagi Unnat Biu Bijan Karyakram
LAC	Lumle Agriculture Centre
LCC	Leaf Color Chart
LCEDS	Low Carbon Economic Development Strategy
LEC	Landrace Enhancement and Conservation
LIBIRD	Local Initiative for Biodiversity Research and Development
LPHT	Long Ping High Tech
M.Sc.	Master of Science
MAPS	Medicinal and Aromatic Plants
MARD	Market Access Rural Development Project
MAS	Marker Associated Section
MAS	Marker Assisted Selection
MCM	Million Cubic Meters
MHIRDP	Mechi Hills Irrigation & Related Development Project
MIRDP	Mahakali Hill Integrated Rural Development Project
MoAC	Ministry of Agriculture & Cooperative
MoAD	Ministry of Agriculture Development
MoF	Ministry of Finance
MoFALD	Ministry of Federal Affairs and Local Development
MoFSC	Ministry of Forest and Soil Conservation
MoU	Memorandum of Understanding
MREs	Mega Rice Environments
MRSMP	Market Research and Statistics Management Program
MS	Micro Soft
MSP	Minimum Support Price
MT	Metric Tons
MVs	Modern Varieties
NAGRC	National Agriculture Genetic Resource Centre
NARC	Nepal Agricultural Research Council
NARI	National Agricultural Research Institute
NARSC	National Agricultural Research and Services Centre
NASC	National Agriculture Sciences Centre
NAST	National Academy of Science and Technology
NE	Nutrient Expert
NeKSAP	Nepal Kadhya Surakshya Anugaman Pranali.
NFC	Nepal Food Corporation
NGLRP	National Grain Legume Research Program
NGO	Non-Government Organization
NIAS	National Institute of Aerobiological Sciences
NISP	Narayani Irrigation Support Project

NLSS	Nepal Living Standard Survey
NMEP	Nepal Malaria Eradication Program
NPC	National Planning Commission
NPRP	National Potato Research Program.
NRD	National Rice Day
NRIP	National Rice Improvement Program
NRRP	National Rice Research Program
NSB	National Seed Board
NSCL	National Seed Company Limited
NTL	National Trading Limited
NWRP	National Wheat Research Program.
ODOP	One District One Product
OECD	Organization for Economic Co-operation and Development
OM	Organic Manure
OPM	Oxford Policy Management
OPV	Open Pollinated Varieties
OR	Outreach Research
OVOP	One Village One Product
PAC	Pakhribas Agriculture Centre
PACT	Project for Agriculture Commercialization and Trade
PCNB	Pentachloronitrobenzene
PCR	Polymerase Chain Reaction
PFL	Prevention of Food Loss
PGMS	Photo Genetic Male Sterile
PGR	Plant Genetic Regulator/Resources
PGRFA	Plant Genetic Resource for Food and Agriculture
PhD	Doctor of Philosophy
PHLM	Post Harvest Loss Management
PHMD	Post Harvest Management Directorate
PIC	Prior Informed Consent
PMAMP	Prime Minister Agriculture Modernization Project
PP	Procurement Price
PPB	Participatory Plant Breeding
PPD	Plant Protection Directorate
PPP	Public Private Partnership
PPVT	Pre-Production Verification Trial
PU	Purbanchal University
PVS	Participatory Varietal Selection
PYT	Preliminary Yield Trail
QTL	Qualitative Trail Loci
QVEFTs	Quantitative Evaluation of the Fertility of Tropical Soils
R&D	Research and Development

RAD	Regional Agriculture Directorate
RARS	Regional Agricultural Research Station
RBPR	Rapid Bioassay Pesticide Residues
RCBD	Randomized Complete Block Design
RHs	Right Holders
RISMFP	Raising Income for Small and Medium Farmers Project
RIV	Research into Use Program
RNAM	Regional Network of Agricultural Machineries
RPEs	Rice Production Environments
RSGP	Rural Save Grain Program
RSTL	Regional Seed Testing Laboratory
RSTV	Rice Tungro Spherical Virus
RTBV	Rice Tungro Bacilliform Virus
SAARC	South Asian Association for Regional Cooperation
SAIC	SAARC Agriculture Information Centre
SANDEE	South Asian Network for Development and Environmental Economics
SAN-N	Society of Agriculture Scientists Nepal
SAP	Structural Adjustment Programme
SARO	South Asian Regional office
SAS	Social Analysis System
SD	Standard Deviation
SDC/N	Swiss Agency for Development and Cooperation/Nepal
SEAN	Seed Entrepreneurs' Association of Nepal
SINKALAM	Sindhupalchouk, Kavre, Lalitpur and Makwanpur
SIRDP	Sagarmatha Integrated Rural Development Project
SISP	Second Irrigation Sector Project
SMIP	Sunsari Morang Irrigation Project
SMS	Subject Matter Specialist
SNV	Netherlands Development Organization
SOC	Soil Organic Carbon
SoHAM	Society of Hydrologists and Meteorologists-Nepal
SPAD	Soil Plant Analysis Development
SPISP	Seed Production and Input Storage Project
SPMP	Seed Production and Marketing Project
SPSS	Statistical Package for Social Sciences
SQCC	Seed Quality Control Centre
SRI	System of Rice Intensification
SRR	Seed Replacement Rate
SSA	Sub-Saharan Africa
SSD	Soil Science Division
SSMP	Sustainable Soil Management Project
SSNM	Site Specific Nutrient Management

SSNP	Social Safety Net Project
SSR	Self Sufficiency Rate
SSSP	Seed Sector Support Project
SSTP	Seed Science and Technology Division
STCL	Salt Trading Corporation Limited
STIP	Seed Testing and Improvement Program
STS	Sequenced Tagged Sites
STW	Shallow Tube Well
SZRDP	Seti Zone Rural Development Project
T & V	Training & Visit
TBT	Technical Barriers to Trade
TCP	Technical Cooperation Program
TL	Truthful Labelled
TPR	Trans plated Rice
TRIVSA	Tracking Rice Variety for South Asia
TU	Tribhuvan University.
UDHR	Universal Declaration on Human Rights
UK	United Kingdom
UNCDF	United Nation Capital Development Fund
UNDP	United Nation Development Program
UNGA	General Assembly of the United Nation
USA	United State of America
USAID	United State Association for International Development
USD	United State Dollar
USDA	United State Development of Agriculture
VARRS	Variety Approval, Release and Registration Sub-Committee
VDC	Village Development Committee
VMF	Village Model Farm
VRR	Varietal Replacement Rate
WB	World Bank
WFP	World Food Program
WTO	World Trade Organization
WUA	Water Users Association
WUC	Water Users Committee
WWF	World Wild Life Fund

Nepal: At a Glance

Geography and Location

Federal Democratic Republic of Nepal is a landlocked country in South Asia situated at the southern lap of Hindu-Kush Himalaya. The country is located between China in the north and India in other directions with an area of 147,181 square kilometers. According to land mass, Nepal is the 93rd largest country in the world. The country is expanded at the north latitude between 26^{0} 22' and 30^{0} 27' and the east longitude between 80^{0} 04' and 88^{0} 12'. Along with the Himalayan nation, it is also known as the land of Mt. Everest, which is the highest peak in the world, and the birth place of lord Budhha. Though Nepal occupies 0.03% total land area of the world and 0.3% of Asia, the country has diverse climate from hot tropical in the South to cool arctic in the North. The country is endowed with topographical and biological diversity due to altitudinal variations ranging from 60 m to 8848 m above the sea level. The country stretches from the East to West with mean length of 885 kilometers and widens from the North to South with the mean breadth of 193 kilometers. There are three ecological belts running parallel from east to west with north to south elevation gradient.

According to the present constitution, Nepal is politically divided into seven provinces. However, the previous administrative divisions of 5 development regions, 14 zones and 75 districts are still in existence till the constitution is fully implemented. Currently, there are 217 municipalities (including one metropolitan city and 12 sub-metropolitan cities) and 3157 village development committees (VDCs). These municipalities and VDCs are further divided into wards, which are the lowest political units in Nepal.

Figure 1. Political map of Nepal before the promulgation of the constitution of Nepal in 2015

Physiography

The country has five distinct physiographic regions divided along South- North direction; the Tarai, Siwaliks, middle mountain, high mountain and high himalayas. Each of these regions has typical bio-cultural and agro-ecological set up and livelihood patterns. The Tarai region has suitable climate for crop and fruit cultivation and good accessibility to market whereas high mountain region has cold climate and limited accessibility to produce the crops **(Figure 1)**.

Though small in size, due to vast topographical variations even within a short physical distance, Nepal has remarkable climatic differences. Hot monsoon or sub-tropical climate is found in the regions below 1000 meter in the southern parts whereas warm temperate monsoon climate is common in the lower middle mountains (up to 2000 meter); cool temperate monsoon climate in the higher middle mountains (up to 3000 meter); alpine climate in the high mountains (up to 4500 meter) and tundra-type arctic climate in the high himalayas (above 5000 meter) are found.

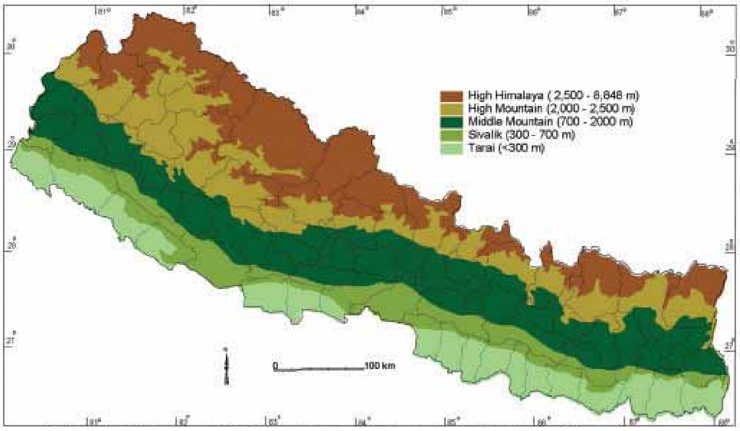

Figure 2. Map showing the physiographic regions of Nepal

Summer is hot and dry followed by rainfall and winter is generally dry and cold with occasional rain. Seventy five percent of the rain occurs during June-September through summer monsoon and about twenty percent of the precipitation occurs in winter through winter monsoon. About five percent of the rain is received as pre or post-monsoon periods. Generally, an increasing amount of rainfall occurs from West to East in summer and vice versa in the winter. Most of the eastern and central hilly areas lie within the isohyets of 1500 to 2500 mm whereas those in the western regions lie between 1000 to 1500 mm. Valleys with high mountain ranges to the South have considerably lower precipitations because of the rain shadow effect. The precipitation in the form of snow is common in high mountain regions mostly above 4200 meters. Temperature rises steadily from its minimum value in winter (December- January) to the peak value during summer (May-July) with gradual fall during monsoon (June-September), and sharp decline to minimum then after. Some areas have frost and snow during winter, especially in North facing slopes. In the high mountains and high himalayas the temperature is low throughout the year. The total land area available for agriculture is 4.121 million hectares (28% of total area), out of which, the cultivated land area is 3.091 million hectares (21% of total area). Out of total cultivated land, irrigated area is 13,31,521 ha.

Demographic and socioeconomic setting

Population of Nepal as of the census day (June 22, 2011) stands at 26,494,504 showing a decadal increase of 14.4% from 2001. Similarly, total number of households in the country is 5,427,302 with 5,423,297 individual households and 4,005 institutional households (Barracks, Hostels, and Monasteries etc). The average annual growth rate of the population from 2001 to 2011 was 1.35%, a sharp decline from the 2.25% of the previous decade 1991-2001. The growth rate varies in urban and rural areas with 3.38 and 0.98% per year, respectively. The highest growth rate (4.78%) is observed in Kathmandu. Sex ratio (number of males per 100 females) at the national level has decreased from 99.8 in 2001 to 94.2 in 2011. Sex ratio is highest (127) in Manang district and lowest (76) in Gulmi district. Population density (average number of population per square kilometer) at the national level is 180 compared to 157 in 2001. The highest population density is found in Kathmandu district (4,416 person per square km) and lowest (3 person per square km) in Manang district. Overall literacy rate (for population aged 5 years and above) has increased from 54.1% in 2001 to 65.9% in 2011. Male literacy rate is 75.1% compared to female literacy rate of 57.4%. The highest literacy rate is reported in Kathmandu district (86.3%) and lowest in Rautahat (41.7%). Estimates of life expectancy at birth for urban and rural areas stand at 70.5 and 66.6 years respectively in 2011.The major religion of Nepal is Hindu. Hinduism is reported to be the religion of 81.34% of the population followed by Buddhism (9.04%), Islam (4.38%), Kirat (3.04%), and Christianity (1.41%). One hundred and twenty three (123) local dialects were identified in the census of 2011, an increment from 92 reported in 2001. Nineteen mother tongues are spoken by 96% of the population, while 104 dialects are spoken by 4% of the total population. Nepali which is the linguafranca of Nepal, is spoken by 44.64% of the population. The majority of the population (59%) is monolinguals and 41% of the population speaks at least one second language. Nepal is a developing country with a low income economy and ranked 145th out of 187 countries on the Human Development Index (HDI) in 2014. The population below the poverty line was 25.2% in 2011, while it was 23.8% in the year 2014. On an average, households own 0.68 hectares of land, but the majority (45%) own less than 0.5 hectare. Agriculture is still the largest contributing sector of economy in Nepal which contributes around one third to the Gross Domestic Product (GDP) and employs two-thirds of the total population.

Overview of agriculture sector of Nepal

Agriculture is the mainstay of Nepalese economy. Agriculture contributed 31.6% of the total GDP in the country in 2014/15. It is a source of food security, income generation, employment and a way of livelihood for more than 60% of the Nepalese population. Agriculture shares significantly in Nepal's total exports to India and third countries. Realizing the importance of agriculture sector in overall development of the country, it has been a priority sector of government in its long term and periodic plans. However, the ultimate result achieved till date is not satisfactory. The growth rate of agriculture has been limited to 1.3% in the fiscal year 2014/015 with the decade average growth of

2.9% only. The labor force has been characterized by very low productivity. More than 1500 youths have taken off daily to the overseas to sustain livelihood of their families. The increasing trend of import of agricultural produces from India, China and other countries has resulted in huge trade deficit. Recognition of food grains exporting country of past times has changed to net food grains importer. The adoption of improved technology is still at very low level and there is huge gap between current and the potential productivity of agricultural produces across the various geographical domains. The farmers are still engaged in subsistence nature of farming and commercialization has rested only in imagination. More than 40 districts of the country are suffering from the food insecurity situations and issue of poverty has always been stood as matter of serious concern of the day. Despite the various commitments of state, the agricultural sector is still at low development stage. The major reasons for current level of low agricultural development are insufficient investment in infrastructure and agricultural research, low level of input use, insufficient adoption of modern technology, paper based commitments rather than functional implementation, non-regulated land complex, lack of agriculture act, fragmented land, monsoon dependence, under and disguised employment, inadequate availability of improved seeds and quality fertilizers, lack of basic infrastructures and transportation, warehouses and assured markets and so on and so forth.

In spite of the low development stage, there are some positive dynamics in the agricultural sector. The per capita income and productivity of labor have increased, poverty has reduced and malnutrition has declined gradually. The irrigation cover has increased and several villages have been connected through agricultural road networks. Production of vegetables, vegetable seeds, fruits, honey and other consumable has been accelerating and significant achievement has been received in the sector of agribusiness and commercialization. Realizing the central role of agriculture sector in the economy, Government of Nepal has promulgated several policies like National Agricultural Policy 2004, Agri-Business Promotion Policy 2006, National Seed Vision (2013-2025) Agricultural Development Strategy (2015-2035) to institutionalize the effort of commercialization and agribusiness development. In addition, specific policies for seeds, fertilizer, land use, irrigation, trade and other key areas have been revised and harmonized with agriculture sector priorities.

Farming system in Nepal

Nepal is endowed with the diversified climate suitable for production of various crops across the various geographical domains. Most of the Nepalese farmers are subsistent cultivators and majority of them manage their farming amid adversities and scarcities; both biophysical and socioeconomic, particularly in the hilly regions where peasants derive their living from fragmented parcels of land cultivated. Crop production, livestock and forestry have been closely integrated and interlinked in the farming system, one supporting other. The crops and trees supply feed, fodder and bedding materials (litter) to livestock. Animals contribute to the system by providing crops and trees with nutrients via manure. Livestock also provides the draft power. Cultivation of land by using draft power and enhancing the soil fertility through the use of farm yard manure are traditional practices in the Nepalese agriculture. The system is sustained through the recycling of organic materials within the farm as well as through the utilization of forest products. The sketch of typical Nepalese farming system is shown in figure below.

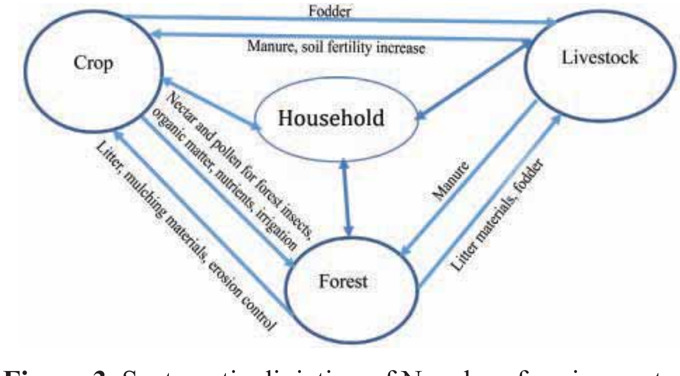

Figure 3. Systematic dipiction of Nepalese farming system

The cropping pattern of Nepalese agriculture varies according to the agro ecological zones. As long as we move toward North wards, the farming system seems to be dominated by agro-forestry and the farming system is dominated by cereal crops in the South. Among cereals, rice is number one food crop in Nepal in terms of area, production, value, contribution to GDP and AGDP as well as in Nepali people's food basket. Of the 75 districts, rice is grown in 73 districts in the country contributing more than 50% of cereal crops requirement and about 20% in all the crop and livestock products grown and produced in Nepal. The food basket of the Nepali people is dominated by rice average calorie contribution of about 30% which is the main product of rice besides others. Thus, rice as a major source of dietary energy for the Nepali people has a huge contribution to enhance the food and nutrition security in Nepal.

In Nepal we see the three types of farming system (FS) ie mountain FS, hill FS and Tarai FS, as discussed in brief below.

Farming system of mountain

High mountains that remain covered with snow year round is considered as the mountain farming system where human settlements is up to 3500 masl and the climate is very cold. Himalaya is the source of perennial rivers and aspiration of the people across the world. The main crops grown in high hills are barley (hulled and hull-less), buckwheat, potato, finger millet, amaranths, prosomillet *(chino)*, maize, apples, walnut and herbs. People keep *Chouri* cow for milk and sheep for wool production.

Farming system of hill

The hill region (*Pahad*) comprises of hills ranging from 800 to 4,000 masl. The climate of hill is pleasant and subtropical in river valleys to temperate in upper hills. Hill slopes are extensively terraced. In mid-hills crops like maize, millet, wheat, rice, soybean, fruits like citrus, walnut, animals like cows, buffaloes, goats and other items like honey and mushrooms are produced abundantly provided due attention is given for off-season supply in Tarai and valley markets of Nepal. Agriculture produce from hills and mountains are offseason produce even in bordering areas of India and China a where there is high demand of off-season produce of hills and mountains as well. Generally, maize based farming system is popular in the hills. Agroforestry plays a vital role in achieving sustainability in the hills farming system via increasing agricultural productivity by nutrient recycling, reducing soil erosion and improving soil fertility and enhancing farm income compared with conventional crop production. Furthermore, agroforestry also has promising potentials for reducing deforestation while increasing food, fodder and fuel wood production in hill farming system in Nepal

Farming system of Tarai

Tarai, the southern plain area with subtropical climate, is the granary of Nepal. Inner Tarai and river basins also have the same type of climate. Inner Tarai is the broad low valleys in the North of Siwalik foot hills (700-1000 m). The rice-wheat cropping pattern is predominant in the Tarai belt. In addition to rice and wheat, sugarcane, maize, jute, potatoes and tropical fruits like mango, banana, guava, litchi, and animals like cattle, buffalo, goat and milk and milk products are mainly produced in Tarai, inner Tarai and river basins. Tarai dominates national agricultural production.

Chapter I

(अध्याय १)

१. नेपालमा धान बालीका ऐतिहासिक, सामाजिक र सांस्कृतिक पक्षहरू (Historical, Social and Cultural Aspects of Rice in Nepal)

वेद, प्राचीन कालमा कृषि एवम् धान खेती

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महेश्वर शर्मा

उपक्रम

वेद, विश्वज्ञान कोशको रूपमा प्रतिष्ठित छ। वेदमा सूत्ररूपमा वर्णित कुरालाई अरू ग्रन्थले विस्तृत व्याख्या र उदाहरण साथ प्रस्तुत गरेका छन्। विश्वको साझा ज्ञानभण्डार भए पनि हामी वैदिक सनातन धर्मका अनुयायीहरूले वेदलाई सर्वोपरि प्रमाणग्रन्थ र सबै धर्मकर्म संस्कार–संस्कृति र सभ्यताको मूलस्रोत मान्दछौ एवम् वेदकै आधारमा सम्पूर्ण सृष्टिको संरचना भएको हो भन्ने धारणा राख्दै आएका छौं। महाभारतमा व्यास भन्दछन्-

अनादि - निधना नित्या वागुत्सष्टा स्वयम्भुवा ।
आदौ वेदमयी वाणी यतः सर्वाः प्रवृत्तयः ।। शान्ति पर्व २३२।३४

अर्थात् सृष्टिकर्ताले सर्वप्रथम आदि, मध्य र अन्त नभएको वेदवाणी अनायास नै प्रश्वासका रूपमा प्रकट गर्नु भयो र सोही आधारमा सबै सृष्टि (रचना) गर्नुभयो। व्यास भन्दछन् :

यानी-हागम शास्त्राणि याश्च काश्चित् प्रवृत्तयः ।
तानि वेदं पुरस्कृत्य प्रवृत्तानि यथाक्रमम् ।। अनुशासन पर्व १२२।४

अर्थात् यस विश्वमा जो जति शास्त्र वा पन्थ सृष्टिमा देखिन्छन् ती सबै वेदले देखाएको मार्ग (निर्देशन) अनुसार प्रवृत्तिमा (प्रचलनमा) आएका हुन्।

प्रस्तुत आलेखमा वेदले धान नाम दिएको अन्नको महत्व के छ र वैदिक समाजमा प्रचलित कृषिकार्यमा के कति प्रकारमा अन्न बाली लगाइन्थे भन्ने बारेमा संक्षिप्त चर्चा गरिदैछ। यो चर्चाको आधारनै वेद भएको हुनाले यहाँ मैले यो चर्चा गर्नु पूर्व वेद के हो कहिले र कहाँ बन्यो आदि बारे संक्षिप्त चिनारी समेत प्रस्तुत गर्ने सामयिक (प्रासङ्गिक) सम्झेको छु।

वेद

'वेद' शब्द ज्ञान, सत्ता, चेतना, विचार र लाभ अर्थ वाला विद धातुबाट 'अच्' अथवा 'घञ्' प्रत्यय भएर वनेको छ। साधारणतया वेद शब्द स्वरका आधारमा दुई अर्थमा प्रयोग भएको देखिन्छ। एउटा वेद शब्द कुशको मुठोलाई र दोश्रोले ज्ञान विज्ञानको बोधक शब्दलाई वुझाउँछ। वेद शब्द समूह (ज्ञानराशि) वुझाउने चाहिँ आद्युदात्त हुन्छ। कुशमुष्टिलाई वुझाउने वेद शब्द अन्त्योदात्त हुन्छ। वेद परमेश्वरका श्वास प्रश्वास हुन् भन्ने मान्यता छ –

अस्य महतो भूतस्य निःश्वसितमेतत्......शतपथ ब्राह्मण १४।२।४।१०

वेदबाटै सबै ज्ञान विज्ञानको विकास भएको हो भन्ने कुरामा सनातन हिन्दुहरू विश्वस्त छन्। वेदकर्ता (रचनाकार) कोही छैन, किन्तु **"वेदस्मर्ता चतुर्मुखः"** अर्थात् वेदको साक्षात्कार गर्ने प्रथम द्रष्टा स्वयम्भूः (प्रजापति, व्रह्मा) हुन् भन्ने विश्वास गरिन्छ। मन्त्रहरू समाधिद्वारा साक्षात्कार गर्ने साधक ऋषि, ऋषिकाहरूलाई द्रष्टा मात्रै मानिन्छ। वेदलाई प्रमाण मान्ने भएर वैदिक भनिएका सनातनी (वर्तमानमा हिन्दु) हरू वेद पढेपछि मात्रै सबै कुराको मर्म जान्न बुझ्न सकिन्छ भन्ने कुरामा विश्वस्त छन्। तर दुःखको कुरा वेद बुझेर पढ्नुभन्दा पूजा गर्नुमा नै सीमित भएर अहिले दुर्बोध भएको छ। दैनिक पठन पाठनबाट टाढिदैछ र हामी सत्य तथ्य ज्ञानबाट ठगिदैछौं।

'वेद' शब्द सुन्दा यसमा पूजापाठ, दान-दक्षिणा र कर्मकाण्ड मात्र छ भन्ने धारणा समाजमा अझ पनि धेरै नै छ। वेद कुनै तिथिमिति तोकिएको विषय र लेखकको नाम भएको ग्रन्थ होइन, यो त अनादि कालदेखि ज्ञानको भण्डार हो। वेदको भाषा पनि ज्यादै पुरानो

संस्कृत हुनाले सहजै बुझ्न सकिंदैन, तापनि वेदविद्हरूकै मिहेनतले गर्दा अब वेदमा भएका राम्रा कुरा सर्वसाधारणले बुझ्ने गरी प्रकाशमा आउन थालेका छन्।

वेदको रचना काल

यद्यपि वेदहरूलाई सनातनीहरू अनादि, अपौरुषेय मान्दछन् तापनि विश्वका पश्चिमी विद्वानहरू वेदलाई इ.पू. ८००० वर्षभन्दा अघि बनेको मान्दछन् भने कतिपयले वेदको रचना सृष्टिको प्रारम्भमा नै भएको मान्दछन्। वैदिक सनातनीहरूको समाजमा प्रचलित पञ्चाङ्ग गणना अनुसार यो सृष्टि रचना भएको करिब २ अरब वर्ष भएको मानिन्छ। नेपाल-भारत लगायत कतिपय देशहरूमा प्रचलित पञ्चाङ्ग गणकहरूले प्रत्येक वर्षको पात्रोमा मुखपृष्ठमानै सृष्टिवर्ष, कलिवर्ष, विक्रमवर्ष, इश्वीयवर्ष, शकवर्ष, नेपाल संवत् लगायत हरेक वर्षको उल्लेख गर्ने गरेको देखिन्छ। ती पञ्चाङ्ग गणित अनुसार सृष्टिवर्ष १९५५८८५११७ वर्ष कलिवर्ष ५११७, विक्रम सम्वत् २०७३, ईश्वी सम्वत् २०१६, शक सम्वत् १९३८, बुद्ध सम्वत् २५५२ नेपाल सम्वत् ११३७ वर्ष भएको मानिन्छ। वेदका रचनाकालबारे जर्मन प्रोफेसर म्याक्स मूलर, डा. अल्वर्ट बेबर, ए.बी. कीथ, श्लेगल, पं.भगवद्दत्त, अविनाश चन्द्र, लाटु सिं, चूटेल, अर्जुन चौव, प्रो.मैकोडेनेल आदिले लेखेका इतिहास ग्रन्थहरूले विस्तृत चर्चा गरेको देखिन्छ तर कसैले पनि यही वर्ष यतिनै वर्ष भयो भनेर ठोकुवा गर्न सकेका छैनन्। वेदको रचना काल र रचनाकार दुवैको टुङ्गो लाउने कुरामा आँखा नदेख्नेले हात्तीलाई यस्तै छ भन्न नसकेझैं आजसम्म पनि सर्वसम्मत निर्णय भएको छैन।

विश्वका अति विकसित, अर्ध विकसित र विकासोन्मुख कतिपय देशहरूले अरबौं डलर रकम संस्कृतको अध्ययन अनुसन्धानमा खर्चेर धेरै परिश्रम गरी रहेका छन् र पनि वेद कसले कहिले रचेको हो भन्ने टुंगो लाग्न सकेको छैन। जर्मनी, अमेरिका, बेलायत, फ्रान्स, जापान, रुस लगायत धेरै विकसित मुलुकले समेत उक्त कतिपय कुरा अझै स्पष्ट पार्न सकिरहेका छैनन्। यसबारे विशेष जानकारीका निम्ति इन्टरनेटमा संस्कृत र वेद शीर्षकमा हेरी जो सुकै जिज्ञासुले लाभ लिन सक्छन्। वेदको उत्पत्ती करिव २ अरब वर्षदेखि इ.पू. ८६ हजार वर्ष पूर्व भएको मानिन्छ। ती वेदहरू ऋक्, यजः, साम र अथर्व गरी ४ वटा छन्। प्रवचन पठन पाठन परम्परावट ११३१ वटा वेद शाखा बनेर अहिले करिव १५/१६ मात्र जेन तेन पठन पाठनमा रहेका छन्। वेदै पिच्छे मन्त्र, ब्राह्मण, आरण्यक र उपनिषद् गरी ४ खण्ड छन्। प्रत्येक वेदका ४ उपवेद ४ उपाङ्ग र ६ अंग शास्त्र (शिक्षा शास्त्र, कल्पशास्त्र, व्याकरणशस्त्र, निरुक्तशास्त्र, ज्योतिषशास्त्र र छन्दः शास्त्र) छन्। कल्पशास्त्र अन्तर्गत श्रौतसूत्र, शुल्वसूत्र, गृह्यसूत्र र धर्मसूत्र छन्। धर्मसूत्र अन्तर्गत ५० वटा स्मृति ग्रन्थ छन्। जसमा मनुस्मृति, याज्ञवल्क्यस्मृति, व्यास, पराशर, शुक्र, बृहस्पति आदि पर्दछन्। यस बाहेक अनुवाक्सूत्र, सर्वानुक्रमसूत्र र प्रत्येक ४ वटै वेदका परिशिष्टसूत्र समेत मिलाएर अपार ग्रन्थ सागरले र भाषागत कठिनता दुर्बोधताले समेत गर्दा वेदको पठनपाठन गुरु परम्परा बिना चल्नै नसक्ने मानिन्छ। तर अब त्यो प्राचीन गुरुकुले परम्परालाई आधुनिक बोर्डिङ्गे प्रचलनले करिब विस्थापित नै गरिसकेको हुँदा वेद पढ्न र बुझ्न धेरैनै मुस्किल पर्दैछ र हाम्रा पुर्खाका महत्वपूर्ण देन र पहिचानबारे हामीलाई प्रायः अत्तोपत्तो नहुने अवस्था आइरहेको छ।

वेदको उदगम स्थल

वेदको रचना प्राचीन भारतवर्षमा नै भएको थियो र त्यो प्राचीन भारतवर्ष भनेको वर्तमान एसिया महाद्वीपका साथै केही भाग युरोप समेत मिलेर बनेको विशाल भूभाग थियो। त्यो विशाल भारतवर्षको सीमाका बारेमा मनुस्मृति भन्दछ :

आ समुद्रात्तु वै पूर्वादासमुद्रात्तु पश्चिमात् ।
तयोरेवान्तरं गिर्योरार्यावर्तं विदुर्बुधाः ।।२।२२।।

अर्थात् हिमालय र विन्ध्याचल नाम भएका दुई पर्वतहरूको बीचमा पूर्वसागर अर्थात् चाइना सागर र पश्चिम सागर अर्थात् लाल सागरको बीचको भागनै आर्यावर्त वा भारतवर्ष हो। त्यो विशाल भारतवर्ष भित्र नौ वटा उपद्वीप पर्दथे। ती उपद्वीपहरूलाई पुराण साहित्यले (१) इन्द्रद्वीप, (२) नागद्वीप, (३) सौम्यद्वीप, (४) गान्धर्वद्वीप, (५) वारुणद्वीप, (६) कशेरुमानद्वीप, (७) गभस्तिमानद्वीप, (८) ताम्रपर्णद्वीप (सिंहल), (९) कुमारीकाद्वीप नामाकरण गरेको छ। वर्तमान जगतले ती नौ द्वीपलाई क्रमशः अण्डमान, निकोबार, यवद्वीप, फिलिपाइन्स द्वीपसंघ, बार्नियो, कशेरु, मलूका, सिलोन (लङ्का) र कुमारीद्वीप भन्ने गरेको देखिन्छ। वैदिक विज्ञान र भारतीय संस्कृति पृष्ठ १८५, १८८ मा महामहोपाध्याय गिरिधर शर्मा चतुर्वेदीले उल्लेख गरे अनुसार उत्तरमा हिमालयदेखि दक्षिणमा तराईसम्म, पूर्वमा चीन सागर र पश्चिममा लाल सागरसम्म फैलिएको यही भूभागलाई वेदको उद्गम स्थल मान्नुपर्ने देखिन्छ।

धेरै कालपछि राजनैतिक भौगोलिक एवम् प्राकृतिक परिवर्तन भएर अहिले नेपाल, भारत, पाकिस्तान, बङ्गलादेश, श्रीलङ्का, इन्डोनेसिया, सिङ्गापुर, थाइल्याण्ड इत्यादि अनेक छुट्टाछुट्टै मुलुक बनेका छन् । वर्तमानमा पनि कतिपय देश एकीकृत र पृथक् भैरहेका उदाहरण हाम्रा अगाडि प्रत्यक्षै छन् ।

वेदको साक्षात्कार वर्तमान नेपाल र भारतका हिमाल, पहाड र तराई क्षेत्रका कतिपय भागमा भएका थिए । वेदका मन्त्र द्रष्टा वशिष्ठको आश्रम रामायण अनुसार सेतीको फाँट र तराईमा देवघाटमा थियो, जहाँ अझै वसिष्ठ गुफा, दिलीपेश्वर आदि छन् । यसै गरी ऋग्वेदका मन्त्र द्रष्टा महर्षिहरू च्यवन, अगस्ति र दधीचिको आश्रम स्कन्द पुराण हिमवद् खण्ड अनुसार काठमाण्डौं जिल्लाको उत्तरपूर्व क्षेत्र सुन्दरीजलको शिवगङ्गा, बागमती र नागमतीको संगममा थियो भन्ने देखिन्छ । विश्व चर्चित महर्षि वाल्मीकिको आश्रम नेपालकै भैसालोटनमा अझै छदैछ । सुप्रसिद्ध राजर्षि जनकको राजधानी जनकपुरको ज्ञानकुपमा वसेर महर्षि यज्ञवल्क्यले सूर्यबाट शुक्ल यजुर्वेद आत्मसात् गरेका थिए भने सप्तकोशीको संगम वराह क्षेत्रमा बसेर महर्षि विश्वामित्रले कतिपय ऋगवेदीय मन्त्रको साक्षात्कार गरेको कुरा ऋगवेदबाटै स्पष्ट हुन्छ । ऋषि पुलहले म्याग्दीको उपल्लो थुम्कोमा बसी वेद मन्त्र साक्षात्कार गरेको कुरा वर्तमानमा समेत पाइने म्याग्दी लेकको पुलस्त्य र पुलह आश्रमले साक्ष दिदै छन् । वशिष्ठका छोरा शक्ति, शक्तिको छोरा पराशर, पराशरको छोरा व्यासका आश्रमहरू देवघाटदेखि व्यास नगर दमौलीसम्म रहेको कुरा अझै प्रत्यक्ष नै देखिदै छ ।

यजुर्वेदका मन्त्रहरूमा हिमालयको महत्वलाई अत्यन्त उच्च स्थान दिइएको छ । नेपालका सप्त नदीहरूको चर्चा वेदमा धेरैपटक आएको छ । नेपालका सुदूरपश्चिम, मध्यपश्चिम, पश्चिम र पूर्वाञ्चलका कतिपय स्थानहरूमा विद्यमान ऋषिहरूका आश्रम र तिनका सन्तति वंशधरहरूको थातथलो अनुसन्धान गर्दा व्यासले दमौलीको व्यास गुफामा बसेर वेद विभाजन गर्नु पूर्व मान्ममा आदिमानव मनुको राजधानी रहेको दैलेख, कास्की क्षेत्रका कतिपय आत्रेय अर्चनानस श्यावास्व आदि आत्रेय वंशका ऋषिहरूले साक्षात्कृत (दृष्ट सृष्ट) मन्त्रहरू ऋग्वेदको तृतीय मण्डलमा प्रशस्त हुनु महर्षि याज्ञवल्क्य, अत्री, ब्रह्मर्षि विश्वामित्र र शुनशेप, मधुच्छन्द आदि पुत्रहरूद्वारा दृष्टसृष्ट मन्त्रहरू ऋगवेदका तृतीय मण्डलमा प्रशस्त पाइनु वशिष्ठ स्पष्ट मन्त्र सातौं मण्डलमा पाइनु आदि प्रमाणका आधारमा भन्न सकिन्छ कि ऋगवेदको साक्षात्कार पनि नेपालमा नै भएको थियो । यसका साथै गुल्मी, अर्घाखाँची, दाँङ्ग तथा काठमाण्डौंको वालाजु र जितपुरफेदी ललितपुरको धिमिरे थोक र गोरखाका देवकोटा र अर्याल, दैलेखका पोखेल लगायतका आत्रेय काश्यप र भारद्वाज गोत्रका साथै बार्हस्पत्य भारद्वाज शम्यु ऋजिष्वा आदि ऋषिहरूले पनि ऋग्वेदका छैठौं र सातौं मण्डलका सयौं मन्त्रहरूको प्रणयन गरेको पाइएबाट पनि नेपालका हिमाल पहाड र तराई क्षेत्रका कतिपय गाउँ ठाउँमा बसेर वेदको साक्षात्कार गरेको कुरामा अझ बढी प्रमाण भेटिने देखिन्छ तर यी सबै कुराहरूमा अझ धेरै पुष्टि दिनको लागि अरू बढी गहन अनुसन्धान हुनपर्ने कुरा निर्विवाद छ । वेदबारे यति चर्चा गरेर अब प्रस्तुत धान बाली र कृषि कार्य बारे विचार गरौं ।

वेदमा के छ ?

'वेदमा के छ ?' भनेर कसैले प्रश्न गर्छ भने 'वेदमा के छैन ?' भनेर उल्टै प्रश्नले जवाफ दिन सकिन्छ । वेदको शाब्दिक अर्थ ज्ञान हो । समाजको आर्थिक, धार्मिक, सामाजिक नियमहरूको आधार वेद हो र सम्पूर्ण सामाजिक स्थिति व्यवस्थाको ज्ञानका लागि वेद प्रयोजनीय छन् । वेदमा यस्ता अनेकानेक ऋचा (श्लोक) छन् जसमा व्यक्ति, समाज र राष्ट्रको कल्याणको भावना पाइन्छ । मिहिनेत गर्ने, खेती र पशुपालन गर्ने, मिलेर बस्ने, बाँडेर खाने र जुआ आदि व्यसनबाट अलग रहने शिक्षा वेदमा छ । अर्थात्, एक सुखी र समृद्ध समाज निर्माण गर्ने वेदको भावना आजको सन्दर्भमा पनि उपयोगी छ ।

कैयौं कुरा सामाजिक परिवर्तनका साथ साथ बदलिंदै जान्छन् । एक समयका उपयुक्त कुरा अर्को समयमा अनुपयुक्त पनि हुन्छन् भने कति यस्ता साश्वत सन्देश हुन्छन् जो कहिल्यै पुराना हुँदैनन् । उदाहरणको लागि ऋग्वेदको यस ऋचालाई लिन सकिन्छ :

माता भूमिः
अज्येष्ठास अकनिष्ठास एते ।
संभ्रातरः वाबृधुः सौभगाय ।।

अर्थात्: हाम्री आमा पृथ्वी हुन् । समाजमा विभिन्न वर्ग, सम्प्रदाय पेशा र जातहरू भए पनि सबै मानिस बराबर हुन् । यहाँ कुनै जेठो (ठूलो) र कुनै कान्छो (सानो) छैन । त्यसकारण मान्छेहरू हो ! तिमीहरू मिलेर समाज कल्याणका लागि अघि बढ ।

वेदमा यस्तै असल कुराहरू छन् । खासगरी अन्नवृद्धि, आयुवृद्धि र अशोवृद्धि गरेर राष्ट्रको कल्याण गर्ने अनि यी भावनालाई क्रियात्मक रूप दिने उपायहरू पनि बताइएको छ ।

वेदमा धान

धान्यमसि धिनुहि देवान् प्राणायत्वोदानाय त्वा व्यानाय त्वा दीर्घामनु प्रसितिमायुषे धांन्देवो वः सविता हिरण्यपाणिः प्रतिगृभ्णात्वच्छिद्रेण पाणिना चक्षुषे त्वा महीनां पयोडसि।। (यजु १।२०)

अर्थात् हे हविष्यान्न धान ! तिमीहरू तृप्ति र पुष्टि दिन्छौ अतः यस यज्ञमा आएका देवता (अतिथि) हरूलाई पुष्ट र सन्तुष्ट गराइदेऊ । तिमी (धान्य, यव, गोधूम, तिल आदि) अन्नहरूले हाम्रा पाँचै वटा प्राणहरूलाई सम्वर्धन गर्ने, उर्जा प्रदान गर्ने हुनाले हामी ग्रहण गर्दछौं । यस निम्ति सूर्यका प्रकाशले बाली तयार भयो भन्ने आज्ञा लिएर जीवन प्राप्त गर्न (बाँच्न) का निम्ति ग्रहण गर्दछु । तिमीहरूलाई सुनौला किरण रूपि हात भएका रोग रहित प्रकाशमय सौर्य ऊर्जाका माध्यमले धर्तीका दूधका रूपमा ग्रहण गर्दछौं ।

व्याकरण अनुसार धान शब्द संस्कृतको धान्य शब्दबाट उत्पन्न भएको हो । 'धिञ् तर्पणे' धातुबाट धिनोति तर्पयति अर्थात् तृप्ति, आनन्द दिन्छ भन्ने अर्थमा 'यत्' प्रत्यय लागेर बनेका धान्य शब्दको तद्भव धान शब्द हो । अहिलेसम्मको अध्ययन अनुसार विश्वको सबैभन्दा जेठो धर्मग्रन्थ ऋग्वेदमा धान्य शब्दको पहिलो प्रयोग धान्यकृत (धान बताउने) प्रसंगमा गरिएको देखिन्छ ।

तदिद्वदन्त्यद्रयो विमोचने यामन्नञ्जस्पा इव घेदुपब्दिभिः । वपन्तो बीजमिव धान्याकृतः प्रिन्चन्ति सोमम्न मिनन्ति बप्सतः (द्रष्टव्य ऋग्वेद १०।९४।१३)

अर्थात् धान खेती गर्ने कृषकहरूले बीउ छानेर रोपे झैं सोमलताका पातहरू छानी छानी कन सोम यागका लागि टिप्ने गर्दछन् । त्यसै गरी धान कुटेर चामल र सोमलता कुटेर रस निकाल्ने काम जान्नेहरूले अन्न र सोमलाई हानी नपुऱ्याउने गरी गोडमेल मलजल गर्दछन् ।

शुक्ल, यजुर्वेद वाजसनेय संहिताको अठारौं अध्यायको १२ औं मन्त्रले अन्न बालीहरूको एउटा लामो सूचीनै उल्लेख गरेको छ जसमा व्रीहि (धान), यव (जौ), उपवाक (कागुनो), मुद्ग (मुगी), मास, तिल, अणु (तोरी, रायो, कोदो), खल्व (जौ), गोधुम (गहुँ), सीवार (नामो धान, जंगली धान), प्रियङग (कागुनु, पिप्ला), मसुर, श्यामाक (कोदो अथवा कालो मार्सी धान) आदिका साथै राती वयर, रानी वयर तथा सतीवयर समेत दर्जनौं अन्न बालीको उल्लेख गरेको देखिन्छ ।

"व्रीहयश्च मे यवाश्च मे माषाश्च मे तिलाश्चमे मुद्गाश्च मे खल्वाश्च मे
प्रियङ्गवश्च मेणवश्च मे श्यामाकाश्च मे नीवाराश्च मे गोधूमाश्च मे
मसूराश्च मे यज्ञेन कल्पन्तामद्र१८/१२/ शु.य.वेद

वैदिक कालमा जग्गा जमिन मापन गर्न व्याममात्री (पाँच हाते) लठ्ठी तथा जुवा (गोरु नार्ने ५ हाते काठ) को प्रयोग गरिने चलन थियो । सर सामान ढुवानी गर्न रथ, गाडा, गोरु, खच्चर, भैंडा आदिको प्रयोग हुन्थ्यो भने नदी सागर आदि तर्ने नौका (डुंगा), दशारित्र (दशजनाले ख्याउने) शतारित्र (सय जनाले ख्याउने), ठूला-ठूला ढुंगाको प्रयोग हुने प्रमाण पाइन्छन् । वैदिक कालमा कृषि पशुपालन, व्यापार जस्ता पेशा नभएको भए त्यसका साधनको चर्चा हुने थिएन । यस कुराले वैदिक आर्य घर खेत नभएका घुमन्ते थिएनन् भन्ने स्वतः स्पष्ट हुन्छ ।

वेदमा कृषि

अक्षैर्मा दिव्यः कृषि मित् कृषस्व (ऋग्वेद८।१७।२१)

अर्थात् धन दौलत जम्मा गर्ने द्युत (जुवा) क्रीडा झैं अनिश्चित व्यापार आदि पेशाभन्दा कृषि कार्य नै उत्तम छ, यसै कार्यबाट धन सम्पत्ति र परिवार समेत जोडिन्छ । यही कृषि कार्य नै यहाँका जनताहरूको मुख्य पेशा हो । यस बारेमा अथर्ववेद भन्दछ :

ते कृषिं च सस्यं च मनुष्या उपजीवन्ति (अथर्ववेद८।१०।१२)

अर्थात् मर्त्य लोकका मानवहरू कृषि (धान, गहुँ जौ मकै आदि अन्न खेती) कार्यबाटै पालिएका छन् ।

यवं न चर्कृषद् वृषा (ऋग्वेद १।१७६२)

अर्थात् गहुँ, जौ खेतीलाई मर्यादा (मलजल आदि दिनेकाम) विकास गर अनि मात्र अरू अन्न पनि प्रशस्त फल्दछन् ।

अथर्ववेदको यो मन्त्र भन्दछ :

यदश्नासि यत् पिवसि धान्यं कृस्याः पयः ।
यदाद्य. यदनाद्यं सर्वंते अन्नं अविषं कृणोमि (अथर्ववेद १८।२।१९)

अर्थात् हे मानव जुन कृषि कार्य गरेर अन्न खेती र दूधको सेवन गरी बाँच्दछौ त्यो पहिलो बाली र दोश्रो बाली अथवा खाद्य र अखाद्य (इन्धन, साधन) बालीलाई विषादि रहित बनाऊ । किनभने तिमीले खाने, पिउने कुरा विषाक्त बनायौ भने तिम्रै आयु कम हुन्छ। खाद्यान्नलाई कीटाणुरहित, स्वस्थ्यकर र पर्याप्त बनाइदिने विशिष्ट देवता सोम हुन् र सोमलाई प्राप्त गरेर नै आदित्य बलवान् भएका हुन् ।

सोमेनादित्या बलिनः ऋग्वेद । १०/८५/२

यसैगरी अन्नलाई कीटाणु रहित एवम् प्रशस्त पैदा गर्न पनि सोमसँग प्रार्थना गरिएको देखिन्छ :

इषं तोकाय नो दधत् अस्मभ्यं सोम विश्वतः । आ पवस्व सहस्रिणम् ऋग्वेद९।६५।२१।।

अर्थात् अमृतमय रस वर्षा गर्ने हे सोमदेव ! तपाईं हाम्रा जनसमुदायको हरतरहले पालनपोषण गर्न पर्याप्त अन्न दिनुहोस् र त्यो अन्नलाई हानिकारक कीटाणुरहित पार्नुहोस् ।

यस क्रममा अन्न बाली लगाउनका निम्ति जमिन खनजोत गर्ने हलो, फाली, कोदालो, कोदाली र पाता साँध लगाएर धारिला पर्ने कुरा पनि ऋग्वेदमा चर्चा भएको देखिन्छ :

कृषन्नित फालमाशितं कृणोति । ऋग्वेद १०।११७।७

अर्थात् खनजोत गर्न फाली पाताहरूलाई साँध लगाएर धारिलो पार्ने गर्दछन् ।

मा वो रिषत् खनिता यस्मै चत्वा खनामि वः ।
द्वीपच्चतुष्पद् अस्माकं सर्वमस्तु अनातुरम् । ऋग्वेद१०।३०।२

अर्थात् अन्न खेती गर्दा अन्न र जमिनको उर्जाशक्ति ननासिने गरी खनजोत गर्नुपर्दछ। अन्न फलेर हाम्रा द्वोपाया, चौपाया प्राणीलाई जिउन सजिलो होस् तर विषाक्त अन्नले जनता रोगी नबनुन् ।

यी हाम्रा भोजन कृषि पैदावारलाई अश्विनी कुमारहरू जडिबुटी झारपातले ओखति गरे झैं, मनचिन्ते मणिले झैं असुरोले उपचार गरी विषमुक्त बनाओस् भनेर **तेनेमा कृषिं अश्विनौ अभिरक्षत** (अथर्ववेद १०।६।१२) मन्त्रद्वारा विशेष आग्रह (प्रार्थना) गरिएको छ।

शतहस्त समाहर सहस्रहस्त संकिरद्र– अथर्ववेद ।

अर्थात् सय हातले कमाऊ र हजार हातले बाँड । अर्थात् जति ओइरो लगाइन्छ त्यत्तिनै पैरो चलाउन सकिने हुनाले खुब मेहनत गरेर परिश्रमको कमाई खानु पर्छ। जस्तैः–

कुर्वन्नेवेह कमाणि जिजीविषेच्छतं समाः– यजुर्वेद ।

अर्थात् अल्छी भएर होइन, यहाँ कामै गरेर सय वर्ष बाँच्ने इच्छा राख । यसैले हामी मेहनतको महत्व बुझेर पाखुरा बजार्ने हुनाले बिहानै उठेर प्रार्थना गर्छौं ।

कराग्रे बसते लक्ष्मीः करमध्ये सरस्वती ।
करमूले स्थितो ब्रह्मा प्रभाते कर दर्शनम् ।।

अर्थात् देवताका तिनै मान्छे प्यारा छन् जसले मेहनत गर्छन् । यसरी परिश्रम र पसिनाको महिमालाई वेदले सर्वोपरि मानेको छ । खेती गर, जुवा नखेल ।

घर्मन्तते पुरिषं तेन बर्धस्व चाच प्यायस्व
बर्धिषीमहि च वयमा च प्यासिषीमहौ । – ऋग्वेद ।

अर्थात् खेती गर्नु तिम्रो धर्म हो। पुष्टिकारक अक्षले आफूलाई बढाऊ (पोष) र त्यो अन्नले हामी पनि पुष्ट बनौं र बढौं ।

"कृषित्फाल आशितं कृणोतिद्र" – ऋग्वेद ।

अर्थात् कृषिको हलो र फालीको संकेत पाइन्छ। अनि बाह्रै मास ऋतु अनुसारको सहकाल होस् भनेर किसानहरूका लागि वैदिक

ऋषिहरू यस्ता गीत गाउँथेः–

गृमस्ते भूमे वर्षाणि सरद्वेमन्तः शिशिरो बसन्तः ।
ऋतवस्ते विहिता हायानी रहोरात्रे पृथवी नो दुहाताम् । अथर्ववेद।

अर्थात् हे पृथिवी ! गृष्म र वर्षा, शरद र हेमन्त, शिशिर र बसन्त यी छ ओटै ऋतु अनि दिन, रात र वर्ष सबै हामीलाई फलदिने बनून् ।

संहिता, ब्राह्मण, आरण्यक र उपनिषद् गरेर वेदका चार भाग छन् । यीमध्ये एउटा उपनिसद्मा **"आहार शुद्धौ सत्वशुद्धिः"** अर्थात् असल खुराक खान पाए भने आन्तरिक र बाह्य दुवै कोश शुद्ध हुन्छ र मानिस कर्मशील हुन्छ भनिएको छ । त्यस्तै "**अन्नं ब्रंह्मति व्याजनासद्र**" अर्थात् अन्ननै ब्रह्मा हो भन्ने कुरा पनि उपनिसद् मै उल्लेख गरिएको छ ।

"**अन्नादेव खल्विमानि भूतानि जायन्ते ।**
अन्नेन जातानि जीवन्ति ।
अन्नं प्रयन्त्यभिसंविशन्तीतिद्र" – उपनिषद् ।

अर्थात् अन्नबाटै सबै प्राणी उत्पन्न हुन्छन् । अन्नले नै सबै प्राणी बाँच्छन् र अन्नमै विलय हुन्छन् । तसर्थः अन्नव्रतको पालन गर ।

अन्नं न निन्द्यान्त् – तद् व्रतम्,
अन्नं नपरिचक्षीत – तद् व्रतम्,
अन्नं बहुकुर्वीत – तद् व्रतम्,
तस्माद्यथा कया च विघया बह्म
वन्नं प्राप्नुयात् – उपनिषद् ।

अर्थात् अन्नको निन्दा नगर्ने, अन्नलाई हेला नगर्ने र धेरै अन्न फलाउने व्रत लेऊ, कुनै न कुनै उपायद्वारा धेरै अन्न प्राप्त गर ।

कृषि र अन्न सम्बन्धी यो व्रतलाई आजको भाषामा 'नारा' भन्न सकिन्छ । अझ विशेष रूपले यी व्रतहरू पालन गर्नु पर्ने आवश्यकता छ । ज्ञान, विज्ञान र आध्यात्मिक बलमा वेदले जति जोड दिइएको छ, नागरिकहरूको शारीरिक बल र पुष्टिका लागि अन्न वृद्धिमा पनि त्यत्तितै जोड दिइएको पाइन्छ । कृषिकर्म यौटा 'यज्ञ' हो र यज्ञको अन्न भनेको पर्याप्त परिश्रम गरेर उब्जाएको अन्न हो । वेद यही भन्छ, गीता यही भन्छ ।

शतपथ ब्राह्मण (वेद) ले अन्न खेती (कृषि) लाई तीन भागमा बाँडेको छ ।

- खनजोत राम्ररी गर्नुपर्ने,
- बीउ बिजन राम्रो (शुद्ध, किरा नलागेको) हुनुपर्ने,
- वर्षा राम्रो हुनुपर्ने अर्थात् सिँचाइ व्यवस्था राम्रो हुनुपर्ने यी तीनै कुरा (खनजोत, बीउ र वर्षा) सन्तुलित र व्यवस्थित भए भने कृषि उत्पादन प्रशस्त फलदायी बन्दछ ।

अथैनं विकृषति, अन्नं वै कृषिः (७।२।२।७ शतपथव्राह्मण)

ऋग्वेदकालदेखि नै कृषि कृषक जस्ता शब्दहरूको प्रयोग भएको पाइन्छ । त्यसताका ६ वटा गोरुले दाइँ गर्थे भन्ने कुरा पनि ऋग्वेदमा आएको छ । **षड्युक्तान् नुसेषिधत् । गोभिर्यवं न चर्कृषत् ।।** ऋग्वेद १।२३।१५ जस्तै ऋग्वेदको प्रथम मण्डलको वाउन्नौ सूक्तको एघारौं मन्त्रमा पनि दिनभरि कृषकहरूले खेतको काम गरे **– अहानि विश्वा ततनन्त कृष्टयः** भनिएको छ । ऋग्वेदकै प्रथमपण्डलको १०९ औं सूक्तको दशौ मन्त्र भन्दछः **सं ग्रामेमिः सनिता सं रथोविलं विश्वामीः कृषि भिर्न' अद्य ।**

अर्थात् ती कृषकले स्वच्छन्दले गाउँमा रथमा चढेर सबै कृषि कार्यको जानकारी लिने गर्दछन् । यसैगरी ऋग्वेदको १।१६०।५मा भनिएको छ कि यी आकाश (पानी दिने) र धर्ती (उव्जाउ दिने) मिलेर हाम्रा सारा कृषि कार्यको विस्तार तथा सुरक्षा दिएर समृद्ध पारी हामी जनताहरूलाई उर्जा (जीवनशक्ति, वल) बढाइदिने गर्दछन्**– एनामि कृषिस्ततनाम विश्वाः पनाप्यमोजो अस्मे समिन्वतम्**

धर्तीमा जीवनदाता सूर्यले धान बाली गरिसकेका जनतालाई चाहेको जति अनाज फलाइदिउन्–

मित्रो देवेस्वायुषु जनाय वृक्त वर्हिय इष इस्टवता अकः ऋग्वेद ३।५९।९

कृषिका देवता इन्द्रको त्यो महान् सोमयागमा इच्छा अनुसार प्रशस्त अन्न खर्चे भनिएको देखिन्छ –

शंसा महान् इन्द्रं यस्मिन् विश्वा आ कृषयः काममव्यन् ऋग्वेद ३।४९।१

यस्तै गरी चामलको पीठोबाट तयार गरिएको पुरोडाश (भुङ्गेरोटी) खाउन् र हाम्रो कुरा सुनून् भनी इन्द्रलाई अनुरोध गरिएको समेत ऋग्वेद २।५२।३ मा पाइन्छ । यसका साथै ऋग्वेद प्रथम मण्डलको १।२३।१५, १।१७६।२ **(यवं न चर्कृषत् वृषा)** १०।३४।१३, १०।११७।७, १०।१४६।६, १०।१०१।४, ८।२०।१९ एवम् ८।२२।६ लागायत अनेकौं स्थलमा कृषि, यव, कृष, सस्य, हल, सीर (फाली) आदि शब्दहरूको प्रशस्त प्रयोग पाइएबाट पनि वैदिक आर्यहरू कृषि कार्य गर्दथे र त्यो उनीहरूको पेशा पनि थियो भन्ने कुरा स्वतः स्पष्ट हुन्छ र पश्चिमेली समीक्षकहरूले 'वैदिक आर्य घुमन्ते थिए, खेती गर्न जान्दा थिएनन्' भनी निराधार कुरा गरेका रहेछन् भन्ने तथ्य पनि प्रकाशमा आएको छ । अथर्व वेद ८।१०।२४ तथा श्रीमदभागवत्को पृथूचरित्रले यी कुरालाई अझ बढी पुष्टि दिएका छन् । विशेष गरेर वैदिककालका कृषिकार्य (अन्न बाली धान, गहुँ, जौ आदि खेती)को संबन्धमा अरू बढी अध्ययन अनुसन्धान गर्नका निम्ति निम्नाङ्कित मन्त्रहरूको अझ बढी परिशीलन हुनुपर्ने देखिन्छ

युनक्त सीरा वियुगा ....वा. सं. १२/६८ (यजुर्वेद)

सीरा युञ्जन्ति कवयो युगानि ....वा. सं. १२/६७ (यजुर्वेद)

सुनावमारूहेयम् .... वा.सं. २१/७ (यजुर्वेद)

येन वहसि सहस्रं .... वा.सं. १८/६२ (यजुर्वेद)

लाङ्गलं पवीरवत् .... वा.सं. १२/७१ (यजुर्वेद)

यवानां भागोऽस्य यवानाम् .... वा.सं. १४/२६ (यजुर्वेद)

प्रतिश्रुत् का वा अर्तन घोषा ....वा.सं. ३०/१९ (यजुर्वेद)

घान्यमसि धिनुहि .... वा.सं. १/२० (यजुर्वेद)

युञ्जाथां रासभं युवम् .... वा.सं. १२/२३ (यजुर्वेद)

ऋक् र अथर्व भन्दा विशेष गरेर विस्तृत रूपमा यजुर्वेदको बाह्रौं अध्यायको ६७–७१ मन्त्रहरूमा हलो जुवा र गोरुका नाम र अधिक हवि वा अन्न पर्याप्त उत्पादनका लागि जमिन जोत्ने हलो हलोमा गोरु बाध्ने जुवा र आवश्यकता एवम् शक्ति (क्षमता) अनुसार ३ वटा जुवामा ३ हल गोरुहरू १० वटा जुवामा १० हल गोरुहरू अथवा सोह्र वटा जुवामा १६ हल गोरुहरूद्वारा जमिन जोतेर धान जौ आदिका बीउ रोप्ने र ज्यादै छिटो अर्थात् ६० दिनमा नै पाक्ने सिरु (श्रृणि) धान रोप्ने र दाइँ गर्ने कुराको चर्चा भएको छ । कृषिकार्य गर्ने कृषकहरूले राम्रोसँग भूमि जोतुन् अनि राम्रो उत्पादन होस् भनेर वायु र सूर्यसँग प्रार्थना समेत गरिएको छ, किन भने वायुले समुद्रको पानी उठाएर सूर्यका किरणद्वारा शुद्ध पारेर आकाशमा बस्ने पानी पार्ने मेघ बनाउँछ । **समुद्रादूर्मिमधुमाँ उदार दुपांशुना सममृतत्वमानट् ......ऋग्वेद ४।५८।१ र वा.सं. १७।८९ तै.आ. १०।१०।२)** तथा **एता अर्षन्ति हृद्यात् समुद्रात् शतव्रजा.... ४।५८।५ ऋग्वेद**: अर्थात् समुद्रबाट पानीका यी बिन्दुहरू माथि आएर अनगिन्ती वर्षाका धार भएर धर्तीमा झर्दछन् । कृषि प्रसङ्गमा हलोको टुप्पोका फाली समेत असली फलामको बनाउ र त्यसले राम्ररी जमिन जोत भनिएको पाइन्छ । जमिन जोती कृषि योग्य जमिन बनाएर राम्रो अन्न बाली उत्पादन गराउने र त्यो अन्नले देवता पितृ मानिस तथा पशुपन्छी अर्थात् भेडा, बाखा, गाई, गोरु, घोडा आदिलाई आवश्यक खाना र दाना बनेर बलिया र पुष्ट बनाउँछ भनिएको छ । ती अन्नहरू सयौं प्रकारका छन् । विशेषतः धान्य जाति सात प्रकारका छन् :– धान, जौ, गहुँ, मकै, मुनिधान, कागुनु, मुगी, जो कि गाउँ बस्ती र जङ्गलमा समेत पाइन्छन् । माथिका यी प्रसङ्गले वैदिक आर्यहरू पशुपालन तथा कृषि कार्य गर्न जान्ने थिए र अनेकौं अन्न बालीको खेती गर्दथे भन्ने कुराको पुष्टि भएको छ। यस प्रकारका प्रमाणहरूले गर्दा "वैदिक आर्यहरू घुमन्ते थिए, खेतीपाति गर्न जान्दा थिएनन्" भन्ने पश्चिमी लेखक अनुसन्धाताहरूका निराधार एवम् मनगढन्ते कुराहरू समेत स्वतः खण्डित हुन्छन् ।

कृषि औजारहरू

कृषि औजारमा हलोको अतिरिक्त खनिय, कुदाल, दाम (चाँदे, कोदालो, कोदाली, कुटो, हसिया) आदिको प्रयोग भएको देखिन्छ भने धान खलोमा चुट्ने, दाइँ गर्ने, वलनीले छान्ने, शर्ष (नाङ्लो) ले छम्कने गर्दथे भन्ने पनि वेद मन्त्रको परिशीलनबाट स्पष्ट हुन्छ । धान सफा गर्ने, धान खेती गर्नेलाई धान्यकृत् भन्थे भन्ने पनि अथर्व वेद ११।१।१२, १२।१।१९ तथा ऋग्वेदको १०।९४।१३ र २।१४।१२ आदिबाट स्पष्ट हुन्छ । वैदिक यज्ञमा प्रयोग हुने चरु स्थालीपाक (पायस) पुरोडाश आदिका साथै पञ्चगव्य, पञ्चामृतको प्रयोग एवम् उपभृत् धुँवा,

स्रुक, सुची, जहु, दर्वी, पुरोडाशपात्री, द्रोण, द्रोणकलश, प्रोक्षणीपात्र, प्रणीतापात्र, शम्या, स्फ्य, पाश, अरणी, चात्र, नेत्र, मन्थ, आदि अनेकौं यज्ञपात्र समेतले पनि वैदिक आर्यहरूको समुन्नत, सहकार्य, सहजीवन, सहकारीता र समन्वयतात्मक जीवन चर्याको समेत सम्यक् पुष्टि दिन्छन्, तर दुखको कुरा के छ भने अब हामीले संस्कृत नपढ्दा केही नबुझ्ने भएर अरूले अर्थाई दिनु पर्ने भएको छ। जाम्बवानले हनुमानको शक्ति सम्झाए झैं हाम्रो प्राचीन मौलिकता र पहिचान गराइदिने अनुभवी बूढाहरूको खाँचो हुँदै गएको देखिन्छ।

कृषि कार्यका मुहूर्त ज्ञान

यस बारे वैदिक आर्य साह्रै सतर्क थिए। कृषि कार्यका हरेक पक्षलाई मुहूर्त अनुसार सम्पन्न गर्थे। जस्तै हलसारो गर्ने (जोत्ने, हिल्याउने) कार्यको निमित्त अश्विनी, मृगशिरा, पुर्नवसु, तिष्य, ३ वटै उत्तर र हस्त, चित्रा, स्वाती, विशाखा, अनुराधा, मूल, श्रवण, घनिष्ठा, रेवती नक्षत्रमा हल्सारो गर्ने, तर आइत, शनिवारका दिन, चौथी, षष्ठी, नवमी, चनुर्दशी, औंशी र पूर्णीमा तिथि छोडी पात्रोमा दिएको हलचक्र जुराई कृषि कार्य अर्थात् खनजोत गर्ने हिल्याउने काम सुरु हुन्छ। तर कर्कट, सिंह, तुला, मकर र कुम्भलग्नमा शुभ हुँदैन। रोपाइँ गर्दा रोहिणी, उ. फाल्गुनी, विशाखा, मूल तथा शतभिषा, पूर्वा भाद्र पद नक्षत्र पारी अशुभ बार अर्थात् मंगल र शनिबार छोडी, बीउ बिजन रोप्नु वा बिरुवा सार्नु शुभ हुन्छ भन्ने मानिएको छ।

यसै गरी खेतबारीमा बीउ बिजन छर्दा अश्विनी, रोहिणी, मृगशिरा, पुष्य, ३ उत्तरा हस्त, चित्रा, स्वाती अनुराधा, मघा, धनिष्ट र रेवती नक्षत्रमा पार्ने तर आइत, मंगल, शनिबार र चौथी नवमी, चतुर्दशी एवम् षष्ठी तिथि तथा कर्कट, सिंह, मकर, कुम्भ लग्न छोडेर फणीचक्र जुराउनु शुभ हुन्छ भनिएको छ।

यसैगरी अन्नपात भित्र्याउने क्रममा पहिलो मुठी लिदा, दाइँ गर्दा, भकारी भर्दा र अन्नपात किन्दा बेच्दा पनि पञ्चाङ्गमा दिएको साइत हेरी गर्ने परम्परा छ तर वर्तमानमा आएर यो क्रम क्रमशः टुट्दै गएको छ किनभने यस सम्बन्धी जानकारी दिन सक्ने वा लिन सक्ने जनशक्ति पैदा गर्ने परम्परा छुट्दै गएको छ। यस सम्बन्धी विषय वस्तु खोजी गरी पढ्ने पढाउने परम्परागत प्रथा लोपोन्मुख हुँदैछ। हाम्रा परम्परागत मूल्य मान्यता र धर्म संस्कृतिका मूल स्रोत संस्कृत शिक्षालाई प्रोत्साहन नदिएर अँग्रेजी भाषालाई मात्रै एकोहोरो प्रोत्साहन दिदै जाने हो भने कालान्तरमा नेपालीपन र परम्पराबारे जानकारी लिन शोध वृत्ति दिएर काम चलाउनु पर्ने अवस्था आउने छ।

मलखादको प्रयोग

वैदिक सहित्यको अनुशीलन गर्दा कृषि कार्य अर्थात् खेतीपातीमा गाईको मल (गोवर र गहुँत) को प्रयोग गरिन्थ्यो भने त्यसलाई करिष, वकर, अवकर, उत्कर आदि नामले व्यवहार गरिन्थ्यो। यज्ञ कार्यमा प्रयोग गरेर फालिने कुश, घाँस, तथा अन्य सड्ने गल्ने र मल वन्ने कुरा जम्मा गरी एउटा खाल्डोमा राखिन्थ्यो र त्यसरी फोहर जम्मा गर्ने खाल्डोलाई उत्कर भनिन्थ्यो। घर घरमा पनि करीष (गहुँत, गोवर तथा सड्ने गल्ने घाँस पात राख्ने जुठेन (खाल्डो) हुन्थ्यो र त्यो धेरै मलिलो हुनाले खेत बारीमा प्रयोग गरिन्थ्यो। तैत्तिरीय संहिता (१।८।१०।१) -कृष्ण यजुर्वेद अनुसार धानका तीन किसिम बताइएको छ -कालो धान, सेतो धान र महाधान। कालो धानभन्दा सेतो धान छिटो सर्ने र ६० दिनमा नै पाक्ने भनिएको छ। उस वेला आजभोलि झैं हिउँदे र वर्षे दुईबाली हुने गर्दथ्यो। हेमन्तमा रोपेको ग्रीष्ममा पाक्ने र वसन्त ग्रीष्ममा रोपेको शरद शिशिरमा पाक्ने हुन्थ्यो। वर्षेमा धान, मकै, कोदो, मास आदि एवम् हिउँदमा जौ, गहु, फापर, कागुनु, जुनेलो आदि बाली हुने गर्दथे।

वैदिक कालदेखि चलिआएको वस्तुको मलखाद प्रयोग गर्ने र हरियो परियो घाँस पतकर कुहाएर, गहुँत, गोवर मिसाई वनाइने करिष (मल, कम्पोष्ट मल) आज पनि गाँउघरमा प्रयोगमा ल्याउने गरिदैछ तापनि रासायनिक मलको प्रयोगले त्यो ठाँउ लिदैछ। पीना, भुस र भेडा वाखाको मल मिसाएर गहुँत, गोवरलाई खाल्डोमा पकाएर खेतबारीमा प्रयोग गर्ने वैदिक कालदेखिको परम्परा केही हदसम्म गाँउघरमा अझै चलिरहेको छ भने काठमाण्डौं उपत्यकामा नेवार समुदाय खासगरी ज्यापु समाजमा यो प्रचलन अझै पनि प्रशस्तै देखिन्छ। यसको साथै अन्न बालीमा मुसा लागेमा असुरो तीतेपाती अथवा रुख कटहरको बोक्रा र भेडे कुरो प्रयोग गर्ने प्रचलन गाँउघरमा अझै पनि चल्दैछ।

अन्न भोजन तथा उपयोग

वैदिक आर्यहरू आफ्ना कृषि उत्पादनले देवता, पितृ, अतिथि, पशु, पन्छी लगायत् सबैलाई पञ्च महायज्ञद्वारा भोजन दान गरी बाँकी अन्न आफ्ना परिवार बन्धुबान्धव सहित खाने र विनिमयद्वारा आफूलाई चाहिने सरसामानको जोहो गर्दथे। वैदिक समाजले अन्न खेती गर्दा देवता, पितृ, मनुष्य, पशु, कीट, पन्छी समेत सबैको सहयोग मिलेको हुँदा पहिले उनीहरू प्रति कृतज्ञता प्रकट गर्दै

यथोचित अन्नपानीको भाग तिनीहरूलाई अर्पण गर्दथे । स्वयंले भोजन गर्दा पनि विशेष नियम पालना गर्दथे । भोजन गर्नु अगाडि हातपाउ धोई मुख खोकली सफा सेतो वस्त्र पहिरेर कीटाणु नाशक गोभर गहुँतले लिपेको शुद्ध स्थानमा शुद्ध आसनमा पूर्व, उत्तर वा पश्चिम फर्केर बसी भोजन गर्दथे । भोजनको पात्र वरिपरि पानीले घेरा लगाउँदै यो मन्त्र पढ्दथेः–**यथा चक्रायुधो विष्णु स्त्रैलोक्य परिरक्षति । एवम् मण्डल मप्येतत् सर्व भूतानि रक्षतु ॥** (आह्निक सुत्र पृष्ठ २२९–२३६ भोजन नियम प्रक्रम ४०६–४३६ नारायण शर्मा मुम्बइ सन् १९५३ ॥) अर्थात् जसरी सुदर्शन चक्रद्वारा विष्णुले त्रिलोकको रक्षा गर्दछन् उसै गरी मेरो भोजनको वरिपरि चक्र झैं घुमाएको यो पानी अथवा भस्मका झैं हानिकारक सबै कीटाणुबाट सुरक्षित राखोस् । यति मात्र होइन भोजनको भाग पनि देवता, पितृ, गाई, काग, आदिलाई चढाएर मात्र आफूले खाने विधान छ । आफ्नो भोजन (दाल, भात, रोटी, तरकारी, अचार आदि) जे खाइन्छ अलिकति झिकेर माथि भनेको पानी घेरोमा पर्ने गरी १) **ॐ भूपतये स्वाहा** २) **ॐ भुवनपतये स्वाहा** ३) **ॐ भूतानां पतये स्वाहा** ४) **ॐ चित्रगुप्ताय स्वाहा** ५) **ॐ अग्नये स्वाहा** ६) **ॐ सर्वेभ्यो देवेभ्य स्वाहा** भनेर चढाइन्छ (आह्निक सुत्र पृष्ठ २२९–२३६ भोजन नियम प्रक्रम ४०६–४३६ नारायण शर्मा मुम्बइ सन् १९५३ ॥)

यसपछि **अन्नं ब्रह्मा रसो विष्णु र्भोक्ता देवो महेश्वरः । एवम् ध्यात्वा तु यो भुङ्क्ते सोऽन्न दोषैर्नलिप्यते ॥** (आह्निक सुत्र पृष्ठ २२९–२३६ भोजन नियम प्रक्रम ४०६–४३६ नारायण शर्मा मुम्बइ सन् १९५३ ॥) अर्थात् अन्न ब्रह्मा, रस विष्णु र भोक्ता महेश्वर हुन् भनी अन्न (भोजन) गरेमा दोष लाग्दैन । **ब्रह्मार्पणं ब्रह्म हविर्ब्रह्माग्नौ ब्रह्ममणा हुतम् । ब्रह्मैव तेन गन्तव्यं ब्रह्मकर्म समारभे** (आह्निक सुत्र पृष्ठ २२९–२३६ भोजन नियम प्रक्रम ४०६–४३६ नारायण शर्मा मुम्बइ सन् १९५३ ॥) अर्थात् यो हवि (खानेकुरा) ब्रह्मालाई चढाए, ब्रह्म अग्नि हो ब्रह्म अन्न हो चढाउने मन्त्र पनि ब्रह्म नै हो यसो भनेर ब्रह्म कर्म अर्थात् आत्मरूपी ब्रह्मलाई अन्नरूपी ब्रह्म चढाउन सुरु गर्दछु । **ॐ श्री कृष्णार्पणमस्तु जय श्री जगन्नाथ जी** भनी शिर न्युराएर मनमनै प्रार्थना गरी सुरुमा झैं दाहिने हत्केलामा पानी लिई भोजन थाली वरिपरि दाइने तिरबाट घुमाएर चढाइकन त्यो पानीलाई **ॐअमृतोपस्तरणमसि** (आह्निक सुत्र पृष्ठ २२९–२३६ भोजन नियम प्रक्रम ४०६–४३६ नारायण शर्मा मुम्बइ सन् १९५३ ॥) (अमृतको ओछ्याउने हउ) भनेर सुरुप्प खाने । त्यो पानी (अमृतको आसन) मुखमा पारेर घाँटीबाट पसी छातीमा पुगेपछि बुढी माझि र साहिली औंलाको टुप्पोले अलिकति दालभात तरकारी अचार आदि आफूले जुन ग्रहण गर्न लागिएको छ सो भोजन मुछेर लिइकन क्रमश १) ॐ प्राणाय स्वाहा २) ॐअपानाय स्वाहा ३) ॐ व्यानाय स्वाहा ४) ॐ उदानाय स्वाहा ५) ॐ समानाय स्वाहा (आह्निक सुत्र पृष्ठ २२९–२३६ भोजन नियम प्रक्रम ४०६–४३६ नारायण शर्मा मुम्बइ सन् १९५३ ॥) लगातका यी ५ मन्त्र पढी १–१ गरेर ५ गाँस खानु पर्दछ । यसपछि देब्रे हातका बूढी र साहिली औंलाका टुप्पा पानीमा चोभेर एकैपटकमा बूढीले देब्रे साहिली औलाले दाहिने आँखामा लगाए पछि नबोलीकन नआत्तिकन भोजन गर्नुपर्दछ । **प्राग्द्रवं पुरुषोऽश्नीयाद् मध्ये च कठिनाशनः । अन्ते पुनर्दवाशी तु बलारोग्ययुतो भवेत् – विष्णुपुराणम् ॥१॥ अश्नीयात् तन्मनाभूत्वा पूर्वन्तु मधुरादिकम् । लवणाम्लौ तथा मध्ये कटुतिक्तादिकं ततः – महर्षि पुलस्त्य ॥२॥** (आह्निक सुत्र पृष्ठ २२९–२३६ भोजन नियम प्रक्रम ४०६–४३६ नारायण शर्मा मुम्बइ सन् १९५३ ॥) अर्थात् भोजन गर्दा एकचित्त भएर पहिले नरम पदार्थ, बीचमा कठिन र अन्त्यमा तरल पदार्थ हुने गरी भोजन गरेमा स्वास्थ्य र बलको सन्तुलन रहन्छ ॥१॥ भोजन गर्दा एकचित्त भएर पहिले गुलीयो मीठो, बीचमा नुनिलो र अमिलो अन्त्यमा पीरो तीतो टर्रो आदि मिलाएर भोजन गर्नुपर्दछ ॥२॥ यसरी सबैले भोजनको सन्तुलन मिलाएर १ भाग अन्न, १ भाग तरकारी र १ भाग पानी समेत ३ भाग मात्र भोजन गरी चौथो भाग नखाई पेटमा वायु घुम्ने ठाउँ खाली नै राख्नु पर्दछ – **अन्नव्यञ्जनयोर्भागौ तृतीयमुदकस्यच । वायु सञ्चरणर्थाय चतुर्थमुपकल्पयेत्** ॥ या.शि.उत्तरार्ध ८२॥ अन्न भोजन गर्ने क्रममा **अष्टौ ग्रासा मुनेर्भक्ष्याः षोडशारण्यवासिनः । द्वात्रिंशत्तु गृहस्थस्यामितन्तु ब्रह्मचारिणः** –आचार्य आपस्तम्ब (आह्निक सुत्र पृष्ठ २२९–२३६ भोजन नियम प्रक्रम ४०६–४३६ नारायण शर्मा मुम्बइ सन् १९५३ ॥) अर्थात् ध्यानी त्यागी जोगीहरूले ८ गाँस, वानप्रस्थ (गृहत्यागी) ले १६ गाँस, गृहस्थले ३२ गाँस र ब्रह्मचारी वटुक (छात्रछात्रा)ले आफ्नो स्वास्थ्य र स्वाध्यायमा बाधानपर्ने गरी यथोचित गाँस खानुपदर्छ । भोजन गरीसकेपछि अघि सुरुमा झैं दाहिने हत्केलामा शुद्ध जल लिएर **ॐ अमृता पिधानमसि** (आह्निक सुत्र पृष्ठ २२९–२३६ भोजन नियम प्रक्रम ४०६–४३६ नारायण शर्मा मुम्बइ सन् १९५३ ॥) (अमृतको ढकनी हउ) अर्थात् भोजन अघि पनि अमृतरूपी जल भोजन पछि पनि अमृतरूपी जल भएपछि बीचको भोजन अमृत भएर पचोस् र शरीर हृष्ट पुष्ट भै मन सन्तुष्ट होस् भनेर त्यो जल सुरुप्प खाने अनि खाएको थालमा बाँकी रहेको १ चिम्टी खाने कुरा औंलामा लागेको चिल्लो दलेर जमिनमा राखि दिएर यो मन्त्र भन्नु पर्दछ**–रौरवे पूयनिलये पद्मार्बुदनिवासिनाम् । अर्थिनां सर्वभूतानां अक्षयमुपतिष्ठतु –नारदस्मृति** (आह्निक सुत्र पृष्ठ २२९–२३६ भोजन नियम प्रक्रम ४०६–४३६ नारायण शर्मा मुम्बइ सन् १९५३ ॥) अर्थात् कुनै कारणले धेरै वर्ष नरक परेर फोहोर पिप रगत खाने अवस्थामा परेकालाई मैले दिएको यो भोजन शेषले सयौं गुना भएर तृप्त र सन्तुष्ट पारोस् भनी भगवान्सँग प्रार्थना गरेर हातको चिसो राम्ररी भूइँमा पुछेर उठ्नुपर्दछ । यसपछि चुठ्दा पनि हात धेरै चिल्लो

भए गोवर अथवा चिनी सखरले धोएर सफा भएपछि न्युनतम ८–१२ पटकसम्म कुला गरी छेस्का वा दतिवन (वर्तमानमा ब्रस) ले दाँत सफागरी चिसा दुवै हात रगडेर दुवै आँखामा दली चिसो दाहिने हातले नाभिमा दल्दै यो मन्त्र पढ्नुपर्दछ – **अगस्त्यं कुम्भकर्णं च शनिं च वडवानलम् ॥ आहार परिपाकाय संस्मरामि वृकोदरम् ॥१॥ आतापिमर्धितो येन वातापिश्चैव पातितः ॥ समुद्रः शोषितो येन सोऽगस्त्यो मे प्रसीदतु** (आह्निक सुत्र पृष्ठ २२९–२३६ भोजन नियम प्रक्रम ४०६–४३६ नारायण शर्मा मुम्बइ सन् १९५३ ॥२॥) अर्थात् अगस्त्य कुम्भकर्ण शनिश्वर र समुद्रका पेटको आगो (बडवानल) लाई मैले खाएको अन्न पचेर शरीर पुष्ट र स्वस्थ्य बनोस् भनी स्मरण गदृछु ॥१॥ जुन अगस्त्य ऋषिले आतापि र वातापि भन्ने दुई राक्षस खत्तम पारे समुद्रको सबै पानी पिए ती अगस्त्य ऋषि प्रसन्न भै मेरो पेट स्वस्थ्य राखून् ॥२॥ यसपछि आफ्नो स्वास्थ्य अनुकूल हुनेगरी ल्वाङ्ग सुपारी सुकुमेल दालचिनी पान मसला खाएर केहीबेर विश्राम गरी सय पाइला हिडेर अनि एक छिन देब्रकोल्टो पल्टेर सुत्नु भनी आयुर्वेदाचार्य धन्वन्तरीले बताएका छन् –**भुक्त्वा राजवदासीत यावदन्नक्लमो गतः । ततः पदशतं गत्वा वामपार्श्वेन संविशेत् – धन्वन्तर** (आह्निक सुत्र पृष्ठ २२९–२३६ भोजन नियम प्रक्रम ४०६–४३६ नारायण शर्मा मुम्बइ सन् १९५३ ॥) यसपछि दैनिक कार्यक्रम अनुसार आ-आफ्ना जिम्मा वा पेशाका काम कर्तव्य गर्नु पर्दछ । भोजनको यो एउटा सामान्य नियम हो । उपनयन (व्रतबन्ध) पछि सबै जात वर्णले यसलाई पालना गरेमा अवश्य नै कल्याण हुन्छ । तर नारी र उपनयन नभएका पुरुषले मन्त्र बिना नै अन्नलाई ब्रह्मरूप मानी प्रणाम गरेर अन्न र जल चढाई आचमनपूर्वक भोजन एवम् अन्य नियम पालना गर्नु पर्दछ ।

प्राचीन कालमा कृषिकर्म

युग बदलिन्छ । विचार र मान्यता बदलिन्छन् । हरेक आजलाई भोलिले उछिन्छ । यसरी नयाँनयाँ विचार, नयाँ परिर्वतन र नयाँ आविष्कारले ठाउँ लिन्छन् तापनि हिजोकै आधार र प्रेरणाले कति कुरा आज नयाँ रूपमा परिष्कृत भएर हाम्रा अगाडि आएका हुन्छन् । त्यसैले हिजोलाई चटक्क बिर्सन र हिजो केही पनि थिएन भन्न सकिंदैन । पश्चिमको मोहले हो या हाम्रो परम्परागत सामाजिक व्यवहारमा अनेक अन्धविश्वास र कुरीतिहरू देख्दा दिक्क भएर हिजो केही पनि थिएन भन्ने खालका विचार आज प्रशस्त पाइन्छन् र त्यसैको प्रेरणा स्वरूप भने पनि हुन्छ यो हरफ कोरिंदैछन् । भूतकालका कुरा अनुपयोगी छन् भने निश्चय नै त्याज्य संझनुपर्छ, तर कुनै उपयोगी विषय छ भने त्यसको प्रसंग चलाउनु नराम्रो कुरा हो जस्तो लाग्दैन । त्यसैले यहाँ म पुरानो जमानाको खेतीपातीबारे आचार्य चाणक्यले लेखेका कुरा संक्षेपमा प्रस्तुत गर्दैछु । तर यसको अर्थ त्यसलाई आज पनि त्यसै रूपमा स्वीकार गर्नु भन्ने होइन, केवल हाम्रो अतीतमा पनि केही थियो भन्न खोजेको हो ।

कृषिकर्म, अर्थशास्त्रकै एक मुख्य अंग हो भन्ने आचार्य कौटिल्यले **मनुष्यती भूमिरर्थः** (मान्छे भएको जमिन नै अर्थ हो) भनेका छन् । फेरि मान्छेको जीविका जसबाट चल्छ त्यो पनि अर्थ हो (**मनुष्याणां वृत्तिरर्थः**) पनि भनिएको छ । यस्तै जुन शास्त्रले पृथ्वीको लाभ र मान्छेको पालन पोषणको उपाय निकाल्छ त्यो नै अर्थशास्त्र हो (**स्यः पृथिव्या लाभपालनोपायः शास्त्रमर्थशास्त्रम्म्**) भनिएको छ । यसरी मनुष्यवती भूमि नै अर्थ हो भनेर अर्थशास्त्रको परिभाषा गरिएको छ । यसबाट भूमिको महत्व सर्वोपरि रहिआएको बुझिन्छ । यो करिव ईशापूर्व तेश्रो शताव्दी तिरको कुरा हो । त्यसबेला मुख्य कृषि अधिकृतलाई सीताध्यक्ष भनिन्थ्यो । सीताध्यक्ष कृषिशास्त्र र शुल्वशास्त्र (अवल, द्वयम, सीम, चहार मलिलो एवम् रुखो र कुन माटोमा कस्तो उब्जा हुन्छ भनेर बताउन सक्ने बिद्या) को पूर्ण ज्ञाता हुनु पर्दथ्यो ।

अन्न उत्पादन गर्न लायक वर्षाको परिणामको पनि उत्तिकै ख्याल गरिने कुराको उल्लेख पाइन्छ । जंगली र मरुभूमिमा वर्षाको पानी नाप्ने कुण्डमा सोह्र द्रोण (३२ सेरको तात्कालीन नापो) पानी जम्मा भएपछि त्यस ठाउँमा पर्याप्त वर्षा भएको मानिन्थ्यो । हिमाली प्रदेशमा तथा नहर कुलाबाट पानी लगेर सिँचाइ गरिने ठाउँमा सामयिक वर्षाले काम चल्न सक्छ भनिएको छ । श्रावण र कार्तिक यी दुई महिनाको जम्माजम्मी वर्षको तृतीयांश र भदौ तथा असोज यी दुई महिनाको जम्माजम्मी वर्षाको आधा वर्षा भयो भने त्यो वर्ष सहकालको मानिन्थ्यो । ग्रह अनुसार पनि वर्षाको विचार हुन्थ्यो । यी बाहेक बादलको अध्ययन, वायु र सूर्यको विचारबाट पनि लोक कल्याणकारी वर्षाको अन्दाज गरिन्थ्यो ।

यसरी वर्षाको विचार गरेर थोरै पानीले हुने र धेरै पानी चाहिने अनाज फलफूलहरूको खेती गर्न सीताध्यक्ष आफ्नो कार्यारम्भ गर्थे । यसमा शाली (अगहनी धान), ब्रीहि (साठी दिने धान), कोदो तिल, कागुनो आदि अन्न वर्षाको सुरुमै रोप्ने र मुगी, मास, सिमी, बोडी वर्षाको मध्यसमयमा र मुसुरो, गहत, जौ, गहुँ, केराउ, तोरी आदि वर्षाको आखिरीतिर रोपे असल हुन्छ भनेर ऋतु अनुसारको रोपाइँ निश्चित गरिएको पाइन्छ । साथै सरकारी कुलो नहरबाट पानी लगेर सिँचाइ गर्नेले उब्जाएको तृतीयांश जलकर तिर्नुपर्ने उल्लेख छ । साथै कुन ठाउँमा कस्तो खेती गर्ने भन्ने कुरा सीताध्यक्षले निर्धारित गरेर थोरै मिहिनेतले धेरै उब्जा पाइने खेती गर्नु लगाउनुपर्ने नियम थिए ।

यसरी बीउ बिजन रोप्दा त्यसलाई कीटाणुरहित र विसंक्रमित बनाउन बीज संस्कार गर्ने विधिको पनि उल्लेख छ । जस्तै धानलाई ७

रातसम्म खुला ओसमा राख्ने (तुषार पाथन) र फेरि ७ दिनसम्म घाममा राख्ने (उष्णपायन) भनिएको छ । मास आदिलाई भने ३/३ दिन र रात ओस तथा घाममा राखे पुग्ने भनिएको छ । यसैगरी कपासका बीजमा गोबर दल्ने, सकरकन्द, आरु आदिका टुक्रामा गोबरका साथ घ्यू मह दल्ने र आंकुरा उम्रेपछि सिउँडीको दूधले सिँचाइ गर्ने विधि बताइएको छ । साथै रोप्ने बेलामा बिजनमा सुनपानी छर्कने उल्लेख पनि पाइन्छ । यसको वैज्ञानिक महत्व त विशेषज्ञहरूले नै विश्लेषण गर्न सक्छन् ।

यसको अतिरिक्त कृषियोग्य जमिन तयार पार्ने उपाय (भूमिच्छिद्र विधान) को प्रसंगमा कृषि अयोग्य जमिनलाई गौचरभूमि भनेर छुट्याउने र त्यस्तो बाँकी जमिनलाई ब्रह्मारण्य र सोमारण्य (शिक्षण संस्था र यज्ञ आदि) का लागि प्रदान गर्ने, खेती अयोग्य जमिनमा मृगवन बनाउने र त्यसलाई चारैतिरबाट खाल्टो वा पर्खालले घेरर बाटिकाहरू बनाएर रुख रोप्ने पोखरी खन्ने आदि तरिकाहरू सिकाइएको पाइन्छ । साथै दोपाया, चौपायाहरूको लगत राख्ने, प्रत्येक गाउँको जग्गाको परिमाण, नापीको विवरण, चौचरभूमि, बन्जर भूमि, शुल्क, त्यसको आयस्ता आदिको सम्पूर्ण विवरण समाहर्ता (राजस्व अधिकृत) ले राख्ने, जनसंख्या र परिवार संख्याको आधारमा भूमि वितरणसमेत गर्ने आदि कुराहरू पर्दछन् । पशुपालनको निमित्त छुट्टै गौचरको व्यवस्था गरी दिनभरि चरेर घर जाने गाई, घोडा आदि प्रति पशुको चौथाइ पण (पैसा), चरेर राती पनि खर्क वा चरनमै बस्ने गाईवस्तुको अष्टमांश पण, अर्काको खेती चराइदिनेलाई १२ पण दण्ड गर्ने र अर्मलसमेत भराउने व्यवस्था भएको पाइन्छ ।

किरा मुसा सलह पशुपंक्षीबाट अन्न बालीनाली जोगाउने व्यवस्थाको प्रसंगमा सम्बन्धित अधिकृतले त्यसको रोकथाम गर्ने भन्दै मुसा मार्न बिराला र न्याउरी पाल्ने, यसरी पालेका बिराला र न्याउरी मार्नेलाई १२ पणको दण्ड दिने, घरपाला कुकुर नियन्त्रणमा नराख्नेलाई पनि १२ पण दण्ड गर्ने, मुसा मार्न सिउँडीको दूध मिलाएको अन्न दिने र प्रत्येक व्यक्तिले कम्तीमा एकएक मुसो मारेर सरकारलाई बुझाउने गरी 'मुसकर' लगाउने इत्यादि उपायबाट अन्न बालीको सुरक्षा गर्ने भनिएको छ । यो त त्यसबेलाको कृषिकर्म सम्बन्धी एक संक्षिप्त चर्चा मात्र हो, विशेष विवरणका लागि सम्बन्धित ग्रन्थनै पढ्नु पर्दछ । त्यत्तिबेला 'मुसकर' तिर्नु पर्ने जस्ता कुरा निश्चय नै कम घतलाग्दा छैनन् ।

उपर्युक्त पृष्ठभूमिमा आज भूमि-व्यवस्था र कृषि सम्बन्धी विषयहरूमा बिचार गर्दा तात्कालीन समयको स्थितिमा पनि कृषिले त्यत्तिको महत्व पाएको देखिनु कम हो भन्न सकिदैन । यद्यपि आज भूमि-व्यवस्था र कृषि विकासका क्षेत्रमा क्रान्तिकारी परिवर्तनहरू भै सकेका छन् तर पनि कतिपय कुरामा अझै पनि हामी पछि नै छौं भन्नु पर्दछ । हाम्रा गाउँका कुना काप्चामा आज पनि सुनपानी छर्केर धान मकै छरिन्छ र त्यसो गर्दा किरा लाग्दैनन् भनिन्छ । धानलाई ओस र घाममा राख्दा र बीउ उम्रेपछि सिउँडीको दूध छर्केर किरा मार्छन् भनेर उतिबेला सोचिन्थ्यो र त्यसबेला त्यो भन्दा बढी अरू केही गर्न सकिदैनथ्यो । जे भए पनि यो केवल नारा नभएर व्यवहारिक प्रयोग थियो र आजको वैज्ञानिक युगमा त्यसको प्रभावकारिता नदेखिए तापनि तात्कालीन परिप्रेक्ष्यमा हेर्दा अवैज्ञानिक पनि भन्न सकिदैन ।

उसबेला जनसंख्याको कमी र भूमिको अधिकता हुँदा मानिसको परिश्रम खेर नजाओस् भनि कृषिको उन्नतीको लागि विशेष ध्यान दिएर देश र जनताको आर्थिक समुन्नतिको लागि प्रयास गरिएको थियो भन्ने कुरा माथिको विवरणबाट प्राप्त हुन्छ । छोटकरीमै भए पनि यसबाट हाम्रो अतीतको भूमि र कृषि व्यवस्थाको परिचय प्राप्त गर्न सहयोगी हुनेछ ।

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अन्य सन्दर्भ सामाग्री

ऋग्वेद संहिता, यजुर्वेद संहिता, तैत्तिरीय संहिता, कौषीतकी व्राह्मणम्, शतपथ व्राह्मणम् आह्निक सूत्रावली, वैदिक कोष, श्रीमद्‌भागवत महापुराण, नारद, पुलस्त्य, आपस्तम्ब, धन्वन्तरी सन्देश तथा विष्णु पुराण आदि ।

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उत्पत्ति एवम् वितरण

हिमालयको दक्षिण भेगमा धानको उत्पत्ति भएको र नेपाल पनि धानको उद्गम स्थान मध्ये एक रहेको मानिन्छ (Joshi 2005)। जोशी (२००५) का अनुसार नेपालमा ४ वटा जंगली धानहरू पाइएको छ र अरू केही धानका जंगली प्रजातिहरू पनि पाइएको छ। परवानीपुरमा २०४५/४६ सालमा ९ वटा जंगली धानहरूको संकलन थियो तर हाल यी धानको नेपालमा रेकर्ड देखिदैन। जोशी (२००५) ले रेकर्ड गरेका ४ वटा जंगली धानहरू र अरू धानका बंशहरू *Oryza nivara, O. rufipogon, O. granulata and O. officinalis* रहेका छन्। यी धानहरू नेपालका तराई र पहाडका विभिन्न भागहरूमा पाइन्छन् साथै झारको रूपमा पाइने धानका बंशहरू जस्तै *O. sativa* f. spontanea, र *Hygrooryza aristata* तथा *Leersia hexandra* धानका नजिकका बंशहरू समेत नेपालका विभिन्न भागमा पाइएको छ। यी धान जन्य बनस्पतीहरूलाई कतै जंगली धान त कतै विभिन्न झारको रूपमा लिइन्छ। यी मध्ये *O. rufipogon* बर्तमान *oryza sativa* L. को बाबु आमा मध्ये एक हो र यो धान नेपालको उत्तरी चिसो भूभागको संसारको सबभन्दा अग्लो स्थानमा पाइएको छ (Shresth and Upadhyay 1999)। यसैगरी वैदिक कालमा पनि धानको बारेमा ब्याख्या गरिएको पाइन्छ। वर्तमानमा खेती गर्ने गरिएको एसियन धान (*Oryza sativa*) को बारेमा शुल्क यजुर्वेदको १८ औं अध्याय १७ औं श्लोकमा चराचरका निर्माता भगवान ब्रह्माजीले ११ प्रकारका अन्नहरूको निर्माण गर्दा हाल खेती गरिएको धान (*Oryza sativa*) जस अन्तर्गत ब्रिही धान, शाली धान र जंगली धानहरू (*Oryza nivara)* र श्यामका (*Barn yard grass*) समेत सिर्जना गरेको उल्लेख छ (Shrestha and Shrestha 1999)। यसको अर्थ एसियन धानको उत्पत्ति हिमालयको दक्षिण भेग नेपाल, उत्तर भारत, उत्तरी बर्मा, थाइल्याण्ड, भियतनाम र दक्षिणी चीनसम्ममा भएको हुनु पर्दछ। यसैगरी अफ्रिकन धान (*Oryza glaberrima*) दक्षिण र केन्द्रीय अफ्रिका जसमा सेनेगलदेखि सुडानसम्ममा उत्पत्ति भएको मानिन्छ (Shrestha, Shrestha 1999)। हालसम्म संसारमा दुई वटा खेती गरिएका धान र २० वटा जंगली धानहरूको पहिचान भएको छ। ती मध्ये नेपालमा *Oryza sativa* का नजिकका जंगली र नातेदार धानहरू जस्तै *Oryza nivara, Oryza rufipogon* (*O. perenis*) नेपालगंज क्षेत्र र कपिलवस्तुको अजिगढ़ा ताल क्षेत्र, *Oryza granulata,* Nees et Arn. Ex Watt- चितवनको लोथर क्षेत्र, चुरेको तल्लो भाग र झापाको कन्काई नहरको सिरान (Shrestha 1988, Shrestha 1989), *O sativa* f. *spantanea*- काठमाण्डौं उपत्यका र १८०० मिटरभन्दा बढी उचाई क्षेत्र, *Oryza granulata Griff*– चितवनको लोथर क्षेत्रबाट पहलो पटक १९८८ मा संकलन गरिएको (Shresha 1989, Lu 1989) थियो। त्यसैगरी *Oryza officinalis* Wall ex Watt, कैलालीको सुन्दरपुर क्षेत्रमा (Shrestha and Shrestha 1999) संकलन गरिएको थियो र यो जात बाराको निजगढ साथै जनकपुर क्षेत्रमा पनि पाइएको छ, तर करिब करिब लोपोन्मुख भैसकेकाले यसको संरक्षण गर्न जरुरी छ। त्यसैगरी *Hygroryza aristata* र *Leersia hexandra* पोखरा उपत्यकाका तालमा पाइएको छ (Shrestha 1998)। जहाँसम्म झारको रूपमा गणना हुने धानका बशंजहरूको सम्बन्ध छ नेपालको १६० मिटरदेखि १६४० मिटरका उचाइमा १८ प्रकारका धान सम्बन्धी झारहरूको संकलन भएको पाइएको छ (Shrestha, Vaughan 1989a)। धान नेपालमा समुद्रको सतहबाट ६० मिटर अग्लो झापाको केच्नाकलनदेखि जुम्लाको ३०५० मिटर अग्लो छुम्चौर (जुन ठाउँ संसारको सबभन्दा अग्लो धान हुने स्थान) सम्म खेती गर्ने गरिन्छ (Mallick 1981, Paudel 2011)। नेपालमा मनाङ्ग र मुस्ताङ्ग बाहेक ७३ जिल्लाहरूमा धान खेती गरिन्छ (CDD 2015)। धान सम्बन्धी अर्को महत्वपूर्ण

पक्ष हाम्रो परम्परागत अभ्यासलाई हेर्दा सिँचाइ सुविधा र वर्षा भएसम्म धानखेत बाँफो राख्ने चलन छैन । जबकी हिउँदे बालीमा जग्गाको उपयोगमा यस्तो अभ्यास देखिदैन ।

धानको पौराणिक महत्व

ईशा पूर्व २८०० वर्ष पहिले पनि धानको बारेमा लेखिएका लेखोटहरू पाइएको छ र ऋग वेदमा ५ किसिमका धानहरू जस्तै शाली धान्य, बृहि धान्य, शुक धान्य, शिमी धान्य र चुद्र धान्यको वर्णन गरिएको छ (Mallick 1981) । वैदिक कालमा धान सम्बन्धी कश्यप ऋषिले लेख्नु भएको कृषि स्मृतिमा धान लगायत सम्पूर्ण कृषिको बारेमा लेखिएको पाइन्छ । यस्तै ऋग्वेद्मा पशुपालन, सुख्खा, खडेरी आदिको व्याख्या छ भने यजुर्देवमा अन्न बाली र यसबाट तयार हुने हविष्यको बारेमा वर्णन गरिएको छ । यी सबै वैदिक ग्रन्थहरूले हाल भैरहेको जल्दाबल्दा बहस जस्तै जलवायु परिवर्तित, तापक्रम वृद्धि, खडेरी, बाढी आदिको बारेमा समेत उल्लेख गरिएको छ । धानको उपभोग गरिबदेखि धनीसम्म, बच्चादेखि बृद्धसम्म सबैलाई समान छ ।

आर्थिक महत्व

धान नेपालको प्रमुख खाद्यान्न बाली हो । देशको कूल गार्हस्थ उत्पादनमा कृषि क्षेत्रको योगदान राष्ट्रिय अर्थतन्त्रमा करिब एकतिहाई रहेको छ । धानको कूल कृषि गार्हस्थ उत्पादनमा करिव २०% देन छ भने राष्ट्रिय अर्थतन्त्रमा करिब ७% योगदान छ । नेपालीको ५०% भन्दा बढी खाद्यान्नको स्रोत पनि धानबाट नै हुन्छ (Basnet 2015) । यसै परिप्रेक्ष्यमा नेपालमा पनि धान नै प्रमुख खाद्यान्न बाली भएकोले खाद्य सुरक्षामा धान खेतीको ठूलो महत्व रहिआएको छ । धानको क्षेत्रफल र उत्पादन अन्य बालीको तुलनामा फण्डै दोब्बर रहेको छ । एक दशक अघिसम्म नेपाललाई आफ्नै उत्पादित धानले खान पुग्थ्यो भने हालैका वर्षहरूमा धान र चामलको आयात बढ्दो क्रममा रहेको छ । आ.व. २०६६/६७ मा भारतबाट २ अरब रूपैयाँको चामल आयात हुन्थ्यो तर पछिल्लो आ.व. २०७१/७२ मा भारतबाट फन्डै २४. ८ अरब रूपैयाँको चामल आयात भएको छ (http://www.onlinekhabar.com) । नेपालमा हाल करिब ४४ लाख मेट्रिक टन उत्पादन हुने धानबाट करिब २६ लाख मेट्रिक टन चामल बन्छ तर नेपालमा चामलको माग ३२ लाख मेट्रिक टन भएकाले ६ लाख मेट्रिक टन चामल आयात गर्नु पर्ने देखिन्छ (http://www.onlinekhabar.com) । हालको मोटा चामलको बजार भाउ रू. ७० प्रति किलोका दरले ६ लाख मेट्रिक टनलाई ४२ अरब रूपैयाँ पर्छ । यसरी नेपालमै उत्पादन हुने धान पनि आयात गरी हामी परनिर्भर हुनुपर्ने अवस्था रहेको छ । यसरी धानको आर्थिक विश्लेषण गर्दा २६ लाख मेट्रिक टन चामलको हालको मोटा चामलको मूल्यमा १ खरब ८२ अरब नेपाली रूपैयाँ हुन आउँछ भने मोटामोटी रूपमा मसिनो र मोटा चामलको हिसाब २ खरब हुन आउँछ । त्यसैगरी करिब ७ अरब १६ करोड रूपैयाँ बराबरको पराल नेपालमा उत्पादन हुन्छ (CDD 2015) । धानबाट तयार हुने भुजा, चिउरा प्रमुख व्यवसायिक उप-उत्पादन हुन् । यसैगरी बढ्दो व्यवसायिक दूग्ध उत्पादनमा धान पराल, राइस् ब्रान, धानको ढुटो मुख्य पशु आहार हुन् भने च्याउ उत्पादनमा धानको पराल अत्याधिक प्रयोग हुने गर्दछ । धानमा आधारित कृषिजन्य उद्योग गाउँदेखि सहरसम्म प्रशस्त छन् जहाँ रोजगारको उपलब्धता बढी सुनिश्चित छ । स्थानीय बजारदेखि राजधानी लगायत देशका मुख्य बजारहरूमा, खाद्यान्न पसल लगायत सुपर मार्केट, डिपार्टमेण्टल स्टोरमा चामलको व्यापार हुन्छ । अतः यी उपर्युक्त तथ्यहरूको आधारमा नेपालको लागि धान बालीको ठूलो आर्थिक महत्व रहेको स्पष्ट हुन्छ ।

सामाजिक/सांस्कृतिक महत्व

नेपालमा धानको सामाजिक/सांस्कृतिक महत्व धेरै विशाल छ । बहुजाति र बहुसंस्कृतिले युक्त हाम्रो देश नेपालमा सबै जात र संस्कृतिमा धानको महत्व छ । सामान्य रूपमा प्रमुख खाद्यान्नबाली अन्तर्गत पर्ने धान नेपाली संस्कृतिको प्राण हो भन्दा अत्युक्ति हुँदैन । धान र अक्षता बिना नेपालमा सायदै कुनै धार्मिक वा सांस्कृतिक कार्य सम्पन्न हुन्छन् । नेपाली जातिका जन्मदेखि मृत्युसम्मका कर्ममा यसको प्रथम स्थान हुन्छ भने वर्षभरी मनाइने चाडपर्वमा यसकै प्रधान्यता रहन्छ । नेपाल भूमि सृष्टिको आदिदेखि संस्कारको सर्जक रहिआएको हाम्रा इतिहास पुराण, स्मृति, आरष्पक, उपनिषद् र वैदिक ग्रन्थहरूले पुष्टि गर्दछन् । यो हिमवत् खण्ड जहाँ शिवले तपस्या गरेर जीवनको रहस्य उद्घाटन गरे । वेदव्यासले कथा भनेर तत्वबोध गराए । पाणिनिले चिन्तन गरेर शब्दशास्त्र बनाए । महागुरू फाल्गुनन्द, शंखधर, स्वर्गद्वारीबाबा, खप्तडबाबादेखि स्वामी प्रपनाचार्य (कालेराई) सम्मले यो माटोमा निर्देशित गरेको धर्ममा १६ संस्कारका नामले परिगणित छन् । जस्तै १) गर्भाधान, २) पुंसवन, ३) सीमन्तोन्नयन, ४) जातकम, ५) नामकरण, ६) निठक्रमण, ७) अन्नप्राशन, ८) चूडाकर्म, ९) कर्णवेध, १०) उपनयन, ११) वेदारम्भ, १२) केशान्त संस्कार, १३) वेदस्नान, १४) विवाह, १५) विवाहाग्निपरिग्रह र १६) अन्त्येष्टि संस्कार । स्मृतिभेद, स्थानभेद आदिले संस्कार थपघट पनि देखिन्छन् । जे जस्ता प्रकारका संस्कार

भएता पनि सबै संस्कार धान वा अक्षता बिना असम्भव छन्। दीप, कलश, कूलदेवता, वास्तु, दिक्रवामी आदिको पूजन स्मरण बिना कुनैपनि संस्कार हुँदैनन् र यी कर्ममा धान वा चामलको उपयोग अपरिहार्य छ। जोगीहरू घरमा भिक्षा माग्न आउँदा समेत चामल दिने प्रचलन रहिआएको छ। हाम्रो परम्परामा प्रचलित रितिरिवाजहरू जसमा धानको वा धानजन्य परिवारको विभिन्न प्रयोगलाई नेपालमा मनाइने १२ महिनामा आउने अधिकांश चाडपर्वहरू कृषिसँग सम्बन्धित छन् र कृषि कर्ममा मध्य धानको महत्व अति प्रभावशाली छ। छोटकरी रूपमा १२ महिनामा पर्ने सामाजिक/सांस्कृतिक चाड–वाड र धानको महत्व देखाउने प्रयास गरिएको छ।

बैशाख

बैशाख १ गते नेपाली नयाँ वर्ष हो। यो दिन बिहान सबेरै उठेर स्नान आदि नित्यकर्म गरेपछि नयाँ वर्षको शुभकामना दिने र टीका लगाउने काम हुन्छ। टीका लगाउँदा दही, रातो रंग र चामल सहितकै टीका लगाइन्छ। बैशाख पूर्णिमा, बुद्ध जयन्ती र चण्डी पूर्णिमा यस महिनामा पर्ने ठूला चाड हुन्। पूर्वी पहाडका राई, लिम्बूहरूले यो दिन साकेला नाच र उभौली नाच गर्ने चलन छ। यसको अर्थ धानको सिजन सुरु भएको जनमानसमा सन्देश प्रवाह गराउँछ। मंसिरमा गर्ने उधौलीको तयारी यस महिनादेखि गर्ने चलन छ। अरू चाडमा झैं यो चाडमा पनि रमाइलो गरी मीठो मसिनो खाने चलन परम्परादेखि पूर्वी नेपालमा चली आएको छ र मीठो मसिनो भन्ने शब्दले चामलबाट बनाईएका विभिन्न खाद्य परिकारलाई नै औंल्याउँछ। बैशाख/जेठ महिनामा नेपाली परम्परा अनुसार जातीय समुदायले आ–आफ्नो रीतिरिवाज अनुरूप नयाँ वर्षको आगमन साथ दिवाली मनाई आ–आफ्नो कूल देवताको पूजा आजा गर्ने चलन रहिआएको छ। यस सन्दर्भमा नेवारी समाजमा देवाली मनाउँदा विशेष प्रकारको चामलको रोटी (चटामरी) बनाई देवतालाई चढाउने चलन छ।

जेठ

यो महिनामा वर्षे धानको बीउ राख्ने समय भएकाले प्रत्येक नेपालीले आफ्नो धेर–थोर खेतमा धानको बीउ राख्ने गर्दछन्। शुभ मुहूर्त हेरी नेपाली परम्परा अनुसार जेठ महिनामा धानको बीउ अधिकांश किसानहरूले राख्ने गर्दछन्। वर्षे धान खेत तयारीका लागि हलो, कोदालो, गोरु, राँगालाई तयारी अवस्थामा राख्ने चलन यही महिनादेखि सुरु गरिन्छ। असार र साउनमा धान रोपाइँमा घरका सबै परिवारहरू व्यस्त हुनु पर्दछ भनेर जेठमा नै धान मिलमा कुटेर चामल बनाएर दुई महिना भण्डारण गर्ने चलन थियो र अझै पनि ग्रामीण क्षेत्रमा यो विषयले निरन्तरता पाइरहेको पाइन्छ। साथै जेठको अन्तिम सातादेखि धान रोप्नको लागि बाँझो खेत जोत्ने कार्यको सुरु गरिन्छ भने पहाड र तराईमा स्थान विशेषको आधारमा चैते धान काट्ने कार्यको सुरु, मध्यम तथा अन्तिम भैरहेको हुन्छ। यसैगरी वर्षे धानमा सिँचाइका लागि छरछिमेक मिलेर कुलाई गरी कुलो, नहरको सफा एवम् मर्मत कार्य गरिन्छ।

असार

यो महिना मानो खाएर मुरी फलाउने बेला हो। धान रोप्ने कार्य मुख्य कार्य हो। पन्ध्र असार हामी नेपालीहरूको एउटा चाड नै हो। यो दिन दही चिउरा खाने, हिलोको टीका लगाउने र सबैले खेतमा काम गर्ने दिन हो। तसर्थ पन्ध्र असार कृषि कार्य मात्रै होइन यो त नेपाली संस्कृतिको एउटा परम्परादेखि चली आएको अविछिन्न सुसांस्कृतिक बिरासत हो। यसलाई शालीनता पूर्वक सांस्कृतिक धरोहरको रूपमा मनाउने लोक मान्यता रहिआएको छ। धान रोप्न पहिले-पहिले (२०२८ सालमा नयाँ शिक्षा योजना लागू हुनुपूर्व) नेपालका स्कुल र कलेज असार र साउन दुई महिना बिदा दिई भदौ १ गतेबाट संचालन हुने गर्दथे। यो सबै धान रोप्नको लागि दिएको छुट्टी हो।

साउन

साउने सक्रान्ति प्रायः जसो धान रोपिसके पछि गोरु नुहाउने दिन हो। यसलाई लुतो फाल्ने दिन पनि भनिन्छ। यस दिन असारभरि धान रोपेर थकित भएका परिवारका सदस्यहरू मीठो चोखो खासगरी स्थान अनुसार कतै चाम्रे/लट्टे (अनदीको चामल जुन गण्डकी क्षेत्रमा प्रसिद्ध छ। मसिनोको भात र घ्यू समेत खाने चलन छ। साउनमा रोपाइँको मैझारो गरी बस्ने दिन हो तर मनसुन समयमा नआउने हुनाले आजकल रोपाइँ केही ढिलो पनि हुने गरेको छ। साथै यस महिनामा हरिशयनी एकादशी पनि पर्ने र त्यस दिन विष्णु भगवान ४ महिना शयन गर्ने परम्परागत धारणा हुनाले मसिनो धानको रोटी र पुवा खाई शुद्ध बस्ने हिन्दु परम्परा समेत छ। यसैगरी यस महिनामा धान खेतमा राम्रोसँग पानी लागोस् र खेती राम्रो रहोस् भनी चामल र अक्षताको प्रयोग गरी नागको पूजा पानीको मुहान भएको स्थानमा गर्ने परम्परा छ। यसैगरी साउनमा खिर (दूध र चामल) खाने चलन पनि छ।

यस पश्चात् साउनको अन्तिम वा भदौको पहिलो सातातिर तागाधारीहरूले (बाहुन क्षेत्री) रक्षा बन्धन, जनै पूर्णिमा मनाउने गर्दछन्।

जनै पूर्णिमाको अघिल्लो दिन हविस्य (मीठो/चोखो) खाने गर्दछन् । हविस्यको रूपमा रोटी, लट्टे वा तेस्तै मसिनो चामलको भात खाने गर्दछन् । यसै महिनामा हिन्दु नारीहरूले धुमधामसँग मनाउने तीज पर्व पर्दछ । यो महिनामा ओमकार समूहले होम गर्ने र रुद्री गर्ने काममा धान चामल कै प्रयोग हुन्छ ।

भदौ

यस महिनामा चाडबाडको सुरुवात सहित हिन्दुहरूको चाड मध्ये जनै पूर्णिमा, श्रीकृष्ण जन्माष्टमी आदि चाड पर्दछन् । यी चाडहरूमा मीठो चोखो खाने, नेवार बस्तीहरूमा लाखे नाच गर्ने र सेलरोटी, चिउरा (घैया धान भदौमा तयार हुन्छ र सोबाट कुटिन्छ) खाई रमाइलो गर्ने चलन मध्य पहाडी भेगमा र सहर बजारमा प्रचलित छ । धान खेतमा रोग किरा नलागुन् भनेर हरेलो राख्ने (खेतको बीचमा पर्ने आलिमा सिमलीको डाँठमा कालो हाँडीमा भुस र तेस्तै बाल्ने चिज राखी धुवाउने) चलन छ । कृषि वैज्ञानिकहरूले यसलाई धान खेतमा रोग किरा धपाउने परम्परागत प्रविधि भन्छन् । यो प्रविधि हाल त्यति प्रचलनमा देखिदैन । भदौ महिनामा काठमाण्डौं उपत्यकामा कुमारी जात्रा गरी चामलबाट तयार गरेका विभिन्न व्यञ्जनहरू बडो हर्सोल्लास पूर्वक भोजन गर्ने परम्परा रहेको छ । यो महिना थारू समुदायको जितीया पर्व पर्दछ । यो परापूर्व कालदेखि मनाउने पर्व हो र यसमा चेलीबेटी माइती आएर मनाउने चलन छ । यो पर्वलाई धान बालीको रोपाइँको सन्दर्भमा अन्तिम दिनको रूपमा लिने गरिन्छ । किनभने परम्परागत खेती गरिने धानको जातहरूमा यस दिन बाला पसाउने (Panicle initiation) हुन्छ भन्ने भनाई छ । यसको अघिल्लो दिन सम्म रोपाइँ गरिन्छ भने यस दिन पछि धान रोपाइँ रोकिन्छ ।

असोज

असोज महिना अति रमाइलो र मौसम प्रिय महिना हो । यो महिनामा हिन्दुहरूको पितृ पक्ष पर्ने हुनाले चामलबाट तयार गरेका शुद्ध परिकार (सोह्र श्राद्धभरि) १६ दिनसम्म खाने गरिन्छ । धान बिना सोह्र श्राद्ध कल्पना गर्न पनि सकिँदैन । पितृहरूलाई स्वर्गमा तार्दा चामलबाट पिण्ड बनाई चढाउने र श्राद्ध गरी ब्राह्मणलाई सिदा दान र श्राद्ध ख्वाउँदा दालभात राम्रो चामलबाट तयार गरी श्राद्ध उम्काउने गरिन्छ । साथै यो महिनामा प्रायः पर्ने मुख्य चाड दशैं र तिहार हुन् । दशैंमा घरका सदस्यहरू मिलन हुने, मीठो मसिनो खाने, नयाँ लुगा लगाउने समय हो । मीठो मसिनो भन्दा मसिनो धानको भात, रोटी, चिउरा र चामलबाट बन्ने विभिन्न परिकार नै हुन् । धान बिना नेपालीमात्रका यी महान चाडहरूको कल्पना पनि गर्न सकिदैन । सबभन्दा महत्वपूर्ण तथ्य के छ भने दशैंमा नवदुर्गा भवानीको पूजाको प्रसाद धान, जौ, मकै, तिल जस्ता अन्नहरूबाट उमारिएको जमराबाट हुन्छ । नौ दिनसम्म जमरा पूजा गरी बडादशैंको दिन पहेंलो जमरासित रातो/सेतो टीका लगाउने कार्य सबैजसो हिन्दु र बौद्ध धर्मावलम्बीहरूको परम्परा हो ।

कार्तिक

यो महिनामा विशेष गरी हिन्दूहरूको दशैं पछिको अर्को प्रमुख चाड तिहार पर्ने गर्दछ । अधिक मास परेको अवस्थामा चाडवाडहरू एक महिना पर धकेलिने हुँदा कुनै वर्ष दशैं चाड पनि पर्ने गर्छ । तिहारमा गाईवस्तुलाई पिंडो (धानको लाहा बनाई तिहारको ३ दिन कुँडोमा मिसाई ख्वाउने) सहितको कुँडो ख्वाउने गरिन्छ । यस बाहेक यस महिनामा हरिबोधनी एकादशी पर्छ । उक्त दिन भरदिन निराहार बसी साँझमा मीठो चोखो खाने गरिन्छ । यी सबै प्रायः चामलबाट बन्ने परिकार जस्तै रोटी, पुवा, खट्टे आदि नै हुन् । कार्तिकमा अगौटे धान काट्न मुठी लिने (धानको पहिलो कटाई साइत हेरेर अन्नपुर्ण देवीको पूजागरी गर्ने) प्रचलन रहिआएको छ । यो महिनामा ओमकार समूहले होम गर्ने र रुद्री गर्ने काममा धान चामल कै प्रयोग हुन्छ । मध्य तराईमा मनाइने छट पर्वमा चामलको पीठोलाई भुटेर सख्खर, मरिच, नरिवल, छहरा मिसाई डल्लो लड्डु बनाइन्छ र छट परमेश्वरीलाई चढाइन्छ ।

मंसिर

यस महिना धान काटी दाइँ गर्ने र न्वागी (पहिलो पटक धानको चामल, दही र चिनी/महको मिश्रण बनाइ पूजागरी विधि पूर्वक नयाँ चामल) खाने गरिन्छ । प्रायः जसो हरिबोधनी एकादशीको भोलि पल्ट द्वादशीका दिन न्वागी खाने चलन मध्य पहाडी भेकमा प्रचलित छ । मंसिर महिनामा छिटो पाक्ने धान काट्ने, कुनियो हाल्ने, दाइँगर्ने, टौवामा पराल राख्ने, खलाबाट धान बेची वर्ष दिनको लागि नुन/तेलको जोहो गर्ने कार्य हुन्छ । असारमा रोपेको धान मंसिरमा थन्क्याउने कार्य नै यस महिनामा हुन्छ । यसको अलावा धार्मिक दृष्टिले यस महिनामा धान्याञ्चल (धान दान गरी गर्ने सामाजिक कार्य जस्तै मन्दिर, स्कूल, धर्मशाला, अस्पताल आदिको निर्माण) गरी धान जम्मा गर्ने कार्य पहिले पहिले हुने गर्दथ्यो । आजभोलि पनि सहर र गाउँ घरमा यस्ता सामाजिक कार्यहरू हुने

गरेको पाइन्छ । अतः धान्याञ्चल पर्व गरी धान दान गर्ने परम्परा धार्मिक दृष्टिले अति महत्वपूर्ण रूपमा सामाजिक सद्भाव र सामाजिकजन्य कार्य गर्न धानको ठूलो भूमिका रहेको छ । काठमाण्डौं उपत्यका लगायत नेवार समुदायमा मंसिर पूर्णिमालाई यःमरी पुन्हीको रूपमा लस्सा भएको विशेष धान (Glutinous rice) जस्तै ताईचुङ धानको चामलको पिठोबाट तयार गरिएको यःमरी खाने परम्परा छ । पूर्वी पहाडका राई लिम्बुहरूद्वारा मंसिर महिनामा उधौली पर्वमा धाननाच नाच्ने गरिन्छ । यसैताका वर्षको प्रमुख अन्न- धान भित्र्याइने भएको र यसै पर्वको अवसरमा धानको पूजाआजा गरी भकारीमा भित्र्याउने (थन्क्याउने) प्रचलन रहिआएको छ भने यो महिनामा ओमकार समूहले होम गर्ने र रुद्री गर्ने काममा धान (चामल) कै प्रयोग हुन्छ ।

पौष

यो महिनामा पछौटे धान अन्न भित्र्याउने (थन्क्याउने) कार्यहरू गरिन्छ । धानको पराल दाइँ गर्ने, गुन्द्री बुन्ने तथा परालको टौवा बनाउने कार्य हुन्छ । पौष १५ पनि १५ असार जस्तै मीठो–मसिनो खाने महत्वपूर्ण चाड हो र तमुहरूको नयाँ वर्ष पनि पौष १५ नै हो जसमा तमु (गुरूङ्ग) हरू लगायत सम्पूर्ण नेपालीहरूको यस दिनलाई पुसे पन्ध्र चाडका रूपमा मनाउँछन् । खासगरी धान थन्क्याएर आराम गर्ने महिना नै पौष महिना हो । यो महिना बीउको लागि राम्रोसँग बल्याएको धान छुट्याएर राख्ने गरिन्छ र जेठमा बीउको लागि प्रयोग गरिन्छ । मंसिर महिनाको अन्तदेखि धान खरिद बिक्रीमा संलग्न साना, मध्यम तथा ठूला व्यापारीहरूको चहलपहल सुरु हुने गर्दछ । यो महिनामा नयाँ धानको चिउरा खाने चलन अनुसार चिउरा मिलहरू चिउरा उत्पादन गर्नमा व्यस्त हुन्छन् ।

माघ

माघ १ गते माघे सक्रान्तिमा हाम्रा प्रसिद्ध धार्मिक तीर्थ स्थलमा माघे संक्रान्ति/माघी मेला भर्ने कार्य गरिन्छ । माघी थारू समुदायको महत्वपूर्ण चाड हो । थारू बाहुल्य क्षेत्रमा अरूको तुलनामा माघी धुमधामसँग मनाउने नेपाली परम्परा छ । थारू समुदायले माघे संक्रान्तिको दिन अनदी धानको चामल पकाएर केराको पातमा पोका बनाएर खाने एक प्रकारको चिचर परिकार हो । साथै, मगर समुदायले पनि यो चाडलाई अति हर्षोल्लासका साथ मनाउने गर्छन् । यो दिन नेपालीहरूले लड्डु, चाकु, लट्टे/चाम्रे, मीठो–मसिनो आदि असल धानका चामलबाट तयार गरिएका परिकार खाने काम हुन्छ । यसका अलावा माघ महिनामा चैते धानको लागि कुलो खन्ने र खेत जोत्ने कार्य सुरु गरिन्छ । यसै महिनामा श्रीपंचमीका दिन नयाँ जोताई सुरु हुनाले जोतेको पहिलो सियोमा दूध राखी भूमि पूजा गरी हल्सारो गरेर खेतीकार्य सुरु गर्ने प्रचलन पनि रहिआएको छ । यसको साथै आगामी वर्षको लागि खेती कार्यको सुरुवाती साथै माघको अन्त्यतिर चैते धानको बीउ राख्ने कार्यको लागि धानको ब्याडको लागि हरियो मल, असुरो, पाती जस्ता वनस्पति जम्मा गरी मलको लागि तयारी अवस्थामा राख्ने गरी खेती कार्यको सुरुवात गरिन्छ । यो महिनामा मास, चाम, हलेदो, अदुवा, घ्यू र नून मिलाएर बनाइएको खिचडी पकाएर खाने गरिन्छ ।

फागुन

यो महिनामा पाखो र खेतमा मकै छर्ने काम गर्नुका साथै चैतेधान रोप्ने कार्य र नयाँ बाली सुरु गर्ने महिना हो । फागुनको रंगेली याममा रंग लगाई मीठो–मसिनो व्यञ्जन खाएर खेती कार्य सुरु गरिन्छ । चैते धानको रोपाइँ सिँचाइ सुविधा क्षेत्रमा हुन्छ भने टार बेसीमा घैया छर्ने कामको लागि बारी खनजोत गर्ने कार्य पनि सुरु हुन्छ । हिउँदे वर्षा भएका स्थानमा घैया, मकै र पाउँदुरे कोदो छर्ने काम पनि हुन्छ । मंसिरमा काटेको धानको चामलमा पानी बढी हुने हुँदा गिलो हुने, कुट्दा चामल कम पर्ने हुने हुँदा फागुन महिनादेखि नयाँ चामलको भात खाँदा नरम, स्वस्थ र राम्रो हुन्छ भन्ने भनाई छ । प्रायः यस महिनामा शिवरात्री पर्ने हुनाले शिवको महिमा सहित घ्यू र लड्डु खाई शिवको धुनी ताप्ने कार्य पनि हुन्छ ।

चैत

चैतको १५ गतेसम्म चैते धान रोप्ने काम हुन्छ । यस महिनामा चैते दशैं समेत पर्छ । ठूलो दशैंको जस्तो धुमधाम त चैते दशैंमा हुँदैन तर पनि देवीको पूजा गरी बलि चढाई १-२ दिन भएपनि मीठा-मसिनो खाने अवसर सर्वसाधारणमा हुने गर्दछ । घैया छर्ने र चैते धानमा पानी लगाउने आदि यस महिनामा गरिने कृषिजन्य मुख्य कर्म हुन् । यो महिनामा ओमकार समूहले होम गर्ने र रुद्री गर्ने काममा धान चामल कै प्रयोग हुन्छ । जुम्लामा चैत १२ गतेभित्र परदेश गएको जुम्ली ब्याड राख्न घर फर्केन भने जुम्ली मरेको/विरामी परेको सम्झनु पर्ने परम्परागत चलन पनि रहिआएको पाइन्छ ।

जन्मदेखि मृत्युसम्म धानको महत्व

यी माथि बताइएका १२ महिनाका धानसँग सम्बन्धित कृषि कर्म बाहेक अब धान नेपाली संस्कृतिसँग कति गहिरो रूपमा अन्योन्याश्रित छ भन्ने विवरण मानिसको जन्मदेखि मरणसम्मका कर्महरू सहित व्याख्या गरिन्छ । प्रत्येक चाड पर्व धानसँग सम्बन्धित छन् र नेपाली संस्कृति कृषिसँग सम्बन्धित छ । नेपाली समाजमा धानसँग सम्बन्धित कर्महरू शुभ नक्षत्र, तिथि, बार जुराइ गर्नुपर्ने मान्यता छ । हाम्रा देवी, देवता र पितृको स्वाहास्वधामा धानको नै प्रधान्यता भएको हुँदा यसको उचित संस्कार गरी साइत जुराई पवित्रताका साथ देवी र देवता, पितृ, कुल आदिको स्मरण/कीर्तन पूर्वक यसका यावत् संस्कारहरू सम्पन्न गर्नुपर्दछ । हिमाल, पहाड, तराइमा बस्ने सबै जातजातिका प्रत्येक चाड पर्व र होम आहुति तथा जन्म मरण जस्ता अवसरहरूमा र चाड पर्वहरूमा टीका अक्षताको प्रयोग हुने हुनाले धान बिना यी संस्कारजन्य विधिहरू पूर्ण हुँदैनन् । उचित मुहूर्तमा गरेका कामले नै उत्तम फल दिने भएकाले यहाँ मुहूर्त शास्त्रानुसार धानसँग सम्बन्धित केही कर्महरूका शुभ मुहूर्त यहाँ प्रस्तुत गरिएको छ ।

जन्म

शिशु जन्मपछि जन्म दिने आमालाई पोषिलो खानको आवश्यकता पर्दछ । मसिनो चामलबाट तयार गरेको भात सुत्केरीलाई ख्वाउने सबभन्दा पहिलो प्राथमिकतामा पर्ने खाद्य परिकार हो । यदि भात नपाए मात्र अन्य अन्न ख्वाउने प्रचलन आम नेपालीको छ ।

न्वारन/नामकरण

मानिस जन्मिए पश्चात् केही दिनपछि शुद्ध बनाउन न्वारन गर्ने चलन छ । न्वारन गर्दा होम र धूप पूजा गर्दा रेखी वा टीका लगाउँदा धान चामल लगायतका वस्तुले होम हाल्ने र टीका/तरेखु लगाउने परम्परा हुन्छ । यी कार्य धान बिना हुँदैनन् ।

भातख्वाई

बच्चालाई आमाको दूधले पोषण नपुग्ने अवस्थामा र जन्मेको ५ वा ६ महिनापछि शुभ दिन हेरी भात खुवाउने चलन छ । तत्पश्चात् मात्र अरू अन्न ख्वाउने चलन छ । अध्याबधि यो चलन नेपालभरि कायम नै छ ।

चूडाकर्म

बच्चाको पहिलो कपाल काट्दा पण्डित ल्याएर विधि विधान अनुसार पूजा गरी कपाल फाल्ने काम गरिन्छ । पूजा गर्दा फूल, अक्षता आदि चामल बिना कार्य सपन्न हुन सक्दैन ।

व्रतबन्ध (भिक्षा, बान प्रस्थान, गृहस्थ, जग्गे)

व्रतबन्ध गर्दा वेदीमा गर्ने कार्यहरू जस्तै होम गर्ने कार्यमा चामल, जौ, तिल, र धूपबाट सुरु हुन्छ । यो कार्यमा चामल मुख्य वस्तु हो । त्यसै गरी व्रतबन्धमा गर्ने अरू कार्य जस्तै भिक्षा माग्ने, वन प्रस्थान गर्ने र गृहस्थ आश्रम गर्ने जस्ता कार्यहरूमा धान चामल कै प्रधानता रहन्छ । नेवारी समाजमा छोरी/चेलीबेटीहरूको शारीरिक वृद्धि विकासको क्रममा वेल विवाह (इही) गुफा राख्ने (बाह्रा तःयेगु) र विवाह गर्ने चलन छ । यसरी गुफा राख्ने बेलामा १२ औं दिनमा छोरीलाई नजिकका नातेदारले धानको भिक्षा दिने चलन छ र यसलाई नेवारीमा बाह्रा छुयेगु भनिन्छ ।

विवाह

विवाह गर्दा वेदी र जग्गेमा गर्ने कार्यहरू जस्तै आभ्युदायिक श्राद्ध गर्ने, होम गर्ने र स्वयंवर गर्ने जस्ता काममा धान चामल कै बाहुल्यता रहन्छ । घरमा बुहारी भित्र्याउँदा सासु बुहारीको पाथी चुल्ठो गर्दा चुल्ठाबाट १ पाथी चामल खन्याउने चलन छ ।

पूजा/होम/आहुति

सनातन संस्कृतिमा जुनसुकै शुभ कार्य गर्दा पूजा, होम, आहुति, रुद्री आदि गर्ने प्रचलन परम्परादेखि नै चली आएको हुनाले धान चामल नभई यी कार्यहरू गर्ने कल्पनासम्म गर्न सकिदैन ।

दुखः/आऔच

दुखः/आऔच फुकाउँदा शुद्ध हुन होम आहुति गर्नु पर्छ र धान चामलबाट नै होम आहुति गरिन्छ । दान पनि चामल र द्रब्यबाट नै गरिन्छ ।

मृत्यु

मृत्यु पश्चात् घरबाट मुर्दालाई घाटमा पुऱ्याउँदा बाटोमा अघि अघि लावा वा बुर्की (यस कार्य प्रयोग गर्ने चामललाई बुर्की भनिन्छ) छर्दै लास लाने चलन छ। किरिया सकेपछि ब्राहमण भोजन लागि पनि रोटी, पुलाउ आदि चामलबाट नै बन्ने परिकार हुन्। किरिया बस्दा एकछाक भात खाएर किरिया पुत्री बस्ने गर्दछन्। किरिया फुकाउँदा मलामीलाई ख्वाउने रोटी, मिष्ठान्न चामल कै परिकार हुन्छन्।

बर्खी

छोरा/छोरी, दाजु/भाइ, श्रीमतीले आफ्ना बुवा/आमा, दाजु/भाइ, श्रीमानको मृत्यू हुँदा ६ महिना वर्ष दिनसम्म चोखो खाने र दुख बार्ने काम शुद्ध भात खाएर गर्ने गर्दछन्। बर्खी फुकाउँदा गर्ने भोज भतेर पनि चामलबाट तयार भएका परिकारबाट नै हुन्छ।

श्राद्ध

यो एउटा अति महत्वपूर्ण पितृ कार्य हो। हिन्दु संस्कारमा बाबु/आमा र अन्य मान्यजनको सम्झनामा वर्षको १ पटक उनीहरूको मृत्यु भएको तिथिमा श्राद्ध गर्ने चलन हुन्छ। दशैंअघि पितृपक्षमा १६ श्राद्धको १६ दिन पितृ सम्झने पक्ष नै श्राद्धको लागि छुट्याइएको हुन्छ। यो कार्य गर्दा दान गर्ने, आफ्ना नातागोता र छिमेकी इष्टमित्रलाई बोलाएर ख्वाउने काम धान चामलबाटै बनेका परिकारबाट हुन्छ।

धान खेती सम्बन्धी संस्कार जन्य विधिहरू

यी तल दिइएका संस्कार जन्य विधिहरू ज्यो.पं. गङ्गा प्रसाद ढुंगाना (२०७२) को ज्वला ज्वाला पञ्चाङ्ग नेपाल देशीय पञ्चाङ्गम् २०७२ अनुसार लिइएको हो। नेपाली समाजमा धानसँग सम्बन्धित कर्महरू शुभ नक्षत्र, तिथि, बार जुराई गर्नुपर्ने मान्यता छ। हाम्रा देवी देउता र पितृको स्वाहास्वधामा धानको नै प्रधान्यता भएको हुँदा यसको उचित संस्कार गरी साइत जुराई पवित्रताका साथ देवी देउता, पितृ, कुल आदिको स्मरण-कीर्तनपूर्वक यसका यावत् संस्कारहरू सम्पन्न गर्नुपर्दछ। उचित मुहूर्तमा गरेका कामले नै उत्तम फल दिने भएकाले यहाँ मुहूर्त शास्त्रानुसार केही कर्महरूका शुभ मुहूर्त प्रस्तुत गरिन्छ। विस्तृत जानकारीका लागि यस्तै विधि शास्त्रको अध्ययन गर्नु पर्दछ।

बीउ छर्दा मुहूर्त

बीउ राख्ने शुद्ध नक्षत्र यस प्रकार छन् : आस्वनी, रोहणी, मृगशिरा, पूष्य, ३ उत्तरा, हस्त, उत्तरा, हस्त, चित्रा स्वाती, अनुराधा, धानिष्टा र रेवती नक्षत्रमा रवि, भौम, शनिबार ४, ६, ९ र १४ तिथि ४, ५, १०, ११ लग्न छोडी फणि चक्र जुराई बीउ छर्नु पर्दछ।

रोपाइँ गर्दा मुहूर्त

रोपाइँ गर्ने मुहूर्त निम्नानुसार छन् : रोहिणी, उत्तर फाल्गुणी, विशाखा, मूल, सतभिषा, पूर्वषाडा यी ६ नक्षत्रमा भौम, शनि बार छोडी बीउ छरेको ठाउँबाट अन्त सार्नु, रोप्नु शुभ छ।

मुठी लिदा मुहूर्त

मुठी लिंदा निम्नानुसार शुद्ध मुहूर्त हुनु पर्दछ : भरणी, कृतिका, मृगशिरा, आद्रा, पूष्य, अश्लेषा, मघा, ३ उत्तरा, हस्त, चित्रा, स्वाति, जेष्ठा, मूल, पूर्वषाडा, श्रवण, धनिष्ट, पूर्वभाद्रपदा यी १९ नक्षत्रमा ४, ९, १४ तिथि र मंगलवार र शनिवार छोडी पाकेका अन्न काट्नु, टिप्नु उखेल्नु बेस छ।

दाइँ गर्दा मुहूर्त

दाइँ गर्दा निम्नानुसार शुद्ध मुहूर्त हुनु पर्दछ : रोहणी, मघा, पूर्व फाल्गुणी, उत्तर फाल्गुणी, अनुराधा, जेष्ठा, मूल, शतभिषा, रेवती यी ९ नक्षत्रमा दाइँ गर्नु, चुट्नु, झार्नु बेस छ।

भकारी भर्दा मुहूर्त

भकारी भर्दा निम्नानुसार शुभ मुहूर्त हुन पर्दछ : अश्विनी, रोहणि, मृगशिरा, पुनर्वशु, पूष्य, ३ उत्तरा, मूल, हस्त, चित्रा, स्वाती, अनुराधा, श्रवण, धनिस्ट, रेवती यी १६ नक्षत्रमा र रवि, भौम, शनिबार १, ४, ७ लग्न छाडी तयार भएको अन्न भएको अन्न भकारीमा थन्क्याउनु बेस छ।

हलसार मुहूर्त

हलसार गर्दा निम्नानुसार शुद्ध मुहूर्त हुनु पर्दछ : अश्विवनी, रोहणी, मृगशिरा, पुनर्वशु, तिष्य ३ उत्तरा, हस्त, चित्रा, स्वाती, बिशाखा, अनुराधा, श्रवण, धनिस्ट, शतभिषा, रेवती यी १८ नक्षत्रमा रवि, शनिबार ४, ६, ९, र १४ तिथि र ४, ५, ७, १०, ११ लग्न छाडी हल चक्र जुराई हलो प्रवेश गर्नु औसी र पूर्णिमा बर्जित छ ।

नबान्नप्राशान (न्वागि खाने) मुहूर्त

नबान्नप्राशानको लागि निम्नानुसार शुद्ध मुहूर्त हुन पर्दछ : अश्विनि, मृगशिरा, पुष्य, अश्लेषा, जेष्ठा, हस्त, चित्रा, स्वाती, अनुराधा, श्रवण, धनिस्ट, शतभिषा, रेवती यी १३ शुभ नक्षत्रमा १, ६, ११ तिथि र शनि, मङ्गलवार चैत्र, पौस, विष घटि छाड्नु ।

शुभसाइत

घरबाट बाहिर देश विदेश जाँदा आफूले सोचेको कार्य राम्रोसँग सम्पन्न एवम् सफलता होस् भनी शुभसाइत जुराई आफ्ना आमा बाबुबाट रातो टीका (चामलको अक्षता) निदारमा लगाई प्रस्थान गर्ने चलन हाम्रो नेपाली समाज छ ।

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नेपालमा धान भकारी र धर्म भकारीको ऐतिहासिक समीक्षा

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परिभाषा : नेपाली बृहत् शब्दकोशका अनुसार अनिकाल परेको बेला काम चलाउनको लागि राखिएको वा स्थानीय जनताबाट सामाजिक कल्याणका लागि उठाएर जम्मा गरिएको अन्नकोषलाई धरमभकारी वा धर्मभकारी भनिन्छ । अर्को एक परिभाषा अनुसार स्थानीय जनताबाट सामाजिक कल्याणका लागि उठाएर जम्मा गरिएको वा गाउँको खरखाँचो टार्न वा विकासको कार्यमा सघाउ पुऱ्याउनका निम्ति गाउँलेहरूबाट उब्जनी आयस्ताको केही प्रतिशत छुट्याएर वा अन्य किसिमले संकलित साझा अन्नराशी जसलाई धरमभकारीका साथ अन्नकोष, धर्म ढुकुटी र गाउँकोश पनि भनिन्छ ।

परिचय

अन्नहरूमा सर्वोत्तम अन्न धान हो । नेपाली समाजमा तीन वटा कुराले अति महत्व राख्दछ । ती तीन कुराहरू हुन्: धन, धान र सन्तान। नेपाली समाजमा परापूर्व कालदेखि यी तीन कुरालाई सफलताको कडी मानेर आशीर्वाद दिँदा पनि "धन–धान्य–सुतान्वित" भनिन्छ। धान र सन्तान बिनाको धन अपूर्ण वा असन्तुष्ट गृहस्थी जीवन मानिन्छ। यसबाट वैदिक युगदेखि नै धानको ठूलो महत्व रहेको छ।

हिन्दु र बौद्ध समाजमा दान, धर्म, पूजा, जन्म संस्कार, मृत्यु संस्कार, भोजभतेर, पास्नी, चूडा व्रतबन्ध, विवाह, चाड पर्व जेमा पनि धान अति आवश्यक मानिन्छ। हिन्दु र बौद्ध दुवै धर्ममा धान र चामलको ठूलो महत्व र आवश्यकता छ। पूजामा गणेश, दीयो, कलश, स्थापनादेखि पूजा सामग्रीको एक महत्वपूर्ण तत्व अक्षता चामलकै हुन्छ। पूजामा चढाइने अक्षता आफ्नो परम्परा अनुसार विभिन्न रंगमा रातो, पहेंलो, निखर सेतो र पूजाको किसिम अनुसार पनि फरक–फरक हुन्छ। हिन्दु विवाहमा दुलही भित्र्याउँदा सासु र बुहारीले माना पाथी भर्ने र चामलमा बलेको बत्ती पैतालाले टेकेर निभाउँदै मुख्य कोठामा पस्ने प्रचलन समेत रहेको छ।

नेपालमा धान भकारी/धर्म भकारी

धानको उत्पत्ति, फैलावट, विकास, अनुसन्धान र वर्तमान अवस्थाबारे यस संकलनको विभिन्न अध्यायहरूमा यस विषयका विज्ञहरूबाट चर्चा भै सकेको छ। यो छोटो लेखमा बिगतमा नेपालमा सामुदायिक धान भकारी/धर्म भकारी, धानको जोगावट, भण्डारण, विविध उपयोग र वितरण बारेमा चर्चा गरिएको छ।

लिच्छवी र मल्ल कालमा धान भकारी

लिच्छवी र मल्ल कालमा (वि.सं. ३०० देखि १७७९) काठमाण्डौं उपत्यका धान उत्पादनको दृष्टिले अति अब्बल थियो र आज पनि बचेको जमिनमा अब्बल धान फल्दछ। उपत्यकाका राज्यहरूमा धानको प्रचूरता र जनसंख्या कम भएका कारण खास अनिकाल पर्दैनथ्यो र बाढी, पहिरोका समस्या पनि थिएनन्। आसपासका पहाडी जिल्लामा जस्तो धान भकारी वा धर्म भकारीको प्रचलन खासै पाइन्नथ्यो तर नेवारी समुदायमा गुठी प्रथा ज्यादै व्यवस्थित र उपयोगी रहेकोले एक आपसमा परेको समयमा आर्थिक र सामाजिक सहयोग गर्ने प्रचलन अति राम्रो रहेको थियो र आज पर्यन्त छ।

प्राचीन नेपालमा धान भकारी

नेपाल एकीकरण हुनुभन्दा पहिलेका बाईसी चौबिसी राज्यमा राज्यको समृद्धि मापन गर्ने आधार कुन राज्यमा कती धान खेती हुने खेतहरू छन् र धान कति उत्पादन हुन्छ भन्ने थियो। एक राज्यले अर्को राज्यमा आक्रमण गर्ने मुख्य उद्देश्य पनि धान उत्पादन क्षेत्र हत्याउनु नै थियो। त्यस समयमा राजा रजौटाहरू आफ्ना रैतीबाट कुतका रूपमा धान असुल गर्दथे। धान नहुने क्षेत्रका

रैतीबाट मास वा यस्तै मूल्यवान जिन्सी असुल गर्दथे । राज्य कोष वा भण्डारमा धान र अन्य नगदी उपज र केही मात्रामा धातुका सिक्का वा मुद्रा हुन्थे जो बाह्यदेशबाट सामान खरिद वा बिनिमयमा खर्चिन्थे । राज्यका सेवक वा कर्मचारीलाई दिईने मासिक वा वार्षिक तलव (खान्की) जिन्सीमै राज्यको भण्डारबाट वा सोझै तोकिएका रैतीबाट उठती गरेर लिने व्यवस्था थियो । धान कम हुने छिमेकी राज्यबाट प्राप्त गरिने अन्य उपज र सामग्रीको भुक्तानी सटही प्रथाद्वारा अनुसार धानबाटै गरिन्थ्यो । राज्यका भाइ, भारदार, ठूला ठालुसँग धानको भकारी हुन्थ्यो । त्यही धान उनीहरू आफ्नो खेती–पाती लगाउन, आफ्ना नोकर चाकरलाई भुक्तानी दिन र आवश्यक सामाग्री सटही गरी व्यवहार चलाउन उपयोग गर्दथे । राजा रजौटा र ठूलाबडाहरू रैती रैतानलाई आवश्यक परेका बेला उधारोमा दिन, गरिबहरूलाई अनिकाल र दूर्भिक्ष्यका बेला सहयोग गर्न पनि यी नै धान भण्डारबाट सहयोग गरिन्थ्यो । समाजका गन्यमान्य व्यक्तिहरू मिलेर पुण्य कमाउन र जनतालाई आवश्यक परेका बेला (जस्तै अनिकाल, दैवीप्रकोप, बाढी पहिरो, आगलागि आदि) मा सहयोग गर्न स्थानीय स्तरमा धर्म भकारीको नाममा धान भण्डार पनि गरिन्थ्यो । यस्ता धर्म भकारी गाँउका दयावान् ठूलाबडा, जसलाई पञ्च भलाद्मी पनि भनिन्थ्यो । उनीहरूको सक्रियतामा वा राजा रजौटाका ग्रामीण प्रतिनिधि, द्वारे, थरी, मुखिया आदिको सक्रियतामा पनि यस्ता धान भकारी वा धर्म भकारी स्थापना गरिन्थे । यस्ता धान भकारी/धर्म भकारी सामाजिक सेवा र धनीमानीका व्यवसायिक कृयाकलाप भित्र पर्दथे ।

नेपाल एकीकरणपछि धान भकारी

वि.सं. १७७९मा पृथ्वी नारायण शाहको नेपाल एकीकरणपछि सैनिक, भाइ-भारदार र सरकारी कर्मचारीहरूलाई जिन्सिमै खान्की तोकी जमिन र रैती तोकिदिने, जागिरदारले रैती मोहीबाट खान्की उठाउने प्रथा वि.सं. २००० सालसम्म रह्यो । शाह र राणाकालमा राष्ट्र सेवा गरे बापत जमिन दिने (ब्राम्हणलाई कुस बिर्ता र अन्य भारदार वा प्रशासन सेवाका कर्मचारीलाई जागिर बिर्ता) प्रचलन कायम रह्यो । जागिरदारले कुन कृषकबाट खान्की उठाउने भन्ने निश्चित गर्न तिर्जा (एक प्रकारको अख्तियारी पत्र) दिइएको हुन्थ्यो । त्यही तिर्जाको आधारमा जागिरदारले धान उठाउने र मोहीले धान बुझाउने पद्धति थियो । जिल्ला इलाका र तालुकमा खटिएका कर्मचारी वा स्थानीय द्वारे, मुखिया, जिम्मावाल, थरी सबैले खान्की बापत मोहीबाट धान वा मास उठाउँथे । आफै जान असमर्थ कर्मचारीहरूले उठती पुठती गर्न गाउँका ठूला ठालुलाई आफ्ना प्रतिनिधी (एजेन्ट) पनि तोकेका हुन्थे । ती एजेन्टहरू मध्ये कतिपयले जागिरदारसँग केही परिमाण सहयोग मागेर गाउँमा धर्म भकारी स्थापना पनि गर्दथे । कतिपय गाउँमा गाउँकै ठूला साहुकार र गन्यमान्य व्यक्ति मिलेर पनि आपत्कालीन धर्म भकारी स्थापना गर्ने प्रचलन थियो । यस्ता धर्म भकारीहरू परोपकारी भावनाले संचालन गर्ने र पञ्च भलाद्मीको निर्णय अनुसार आपत्कालमा दान सहुलियतमा बिक्री वितरण गर्ने सकारात्मक कार्य पनि गाउँ-गाउँमा थियो ।

धान धेरै हुने साहुकारहरूले महँगोमा बिक्री गर्न आफ्नै घरमा धानका भकारी राखेर चाडबाड र अनिकालका बेला महँगोमा बेचेर धन कमाउने धन्दाका लागि घर/धन्सारमा धान गोदाम गर्ने चलन पनि थियो ।

जग्गाको तिरो बापत नगद बुझाउन नसक्ने मोहीबाट जिम्मावालाले धानै संकलन गरेर गोदाम गर्ने अनि नाफामा धान बेचेर सरकारी तहबिलमा नगद बुझाएर बीचमा नाफा खाने जिम्मावालहरू पनि थिए ।

नेपाली समाजमा धानको यस प्रकारको बिनिमय र व्यापार हुनमा नेपाली रितिरिवाज, धर्म संस्कार र धानलाई अति पवित्र अन्न र मान प्रतिष्ठासँग जोडिएको अन्न भएर पनि हो । धानै उब्जनी नहुने हिमाली र लेकाली भेकमा पनि दशैं, तिहार, माघे संक्रान्ति, साउने संक्रान्ति, श्राद्ध, पूजा, पास्नी, क्षवर, चूडा, विवाह, व्रतबन्ध आदि उपलक्षमा धानचामल नभै नहुने वस्तु भएकोले विगतमा विभिन्न प्रकारका धान भकारी, धर्म भकारीहरूको महत्व र प्रचलन व्यापक थियो । व्यक्तिगत रूपमा बेसी क्षेत्रमा उब्जनी हुने धान हिमाली र लेक क्षेत्रमा उत्पादन हुने आलु, मुला, चाना र जडिबुटीसँग साट्ने व्यवस्था पनि व्यापक थियो । यसरी धान व्यापार, विनिमयको माध्यम पनि थियो ।

नेपालमा खाद्यान्न कारोवार र त्यसको आपूर्तिको संस्थागत व्यवस्था सरकारी स्तरमा तात्कालिन राणा प्रधानमन्त्री जङ्ग बहादुरको पालामा भएको पाइन्छ । गुठी र रैकर जग्गाहरूबाट तिरोभरोका रूपमा त्यसबेला जिन्सी धान नै संकलन हुने प्रचलन थियो । संकलित धान जङ्गी र निजामति कर्मचारीहरूका अतिरिक्त धार्मिक कार्यहरू र पाकशालामा उपलब्ध गराउनको लागि राणा प्रधानमन्त्री जङ्ग बहादुर राणाले थापाथलीमा रशद गोदाम अड्डाको स्थापना गरी त्यसको प्रमुखमा प्रधान सेनापति रहने व्यवस्था भएको देखिन्छ ।

१९९० सालको भूकम्प र नेपालमा समेत ठूलो प्रभाव पारेको १९९८/९९ सालको बङ्गालको अनिकाल पश्चात् आपत्कालीन अन्न भण्डार वा धान भण्डार स्थापना गर्न नयाँ आवश्यकता उब्जायो । यस समयमा नेपालको तराई र पहाडी क्षेत्रमा परोपकारी भावनाले यस्ता धानभकारी वा धर्मभकारीहरू स्थापना गरिए । आवश्यकता र अवस्था अनुसार यी धर्मभकारीहरूबाट सहुलियतमा बिक्री गर्ने, दान दिने वा सामाजिक र धार्मिक कार्यमा खर्च गर्ने गरिन्थ्यो ।

नेपालमा प्रजातन्त्र स्थापनापछि राणाकालदेखि संचालन गरिदै आएको थापाथलीको रशद गोदाम अड्डालाई २००८ सालमा आएर खाद्यान्न आपूर्ति व्यवस्थालाई प्रभावकारी एवम् जनमुखी बनाउने प्रयास स्वरूप प्रादेशिक खाद्य नियन्त्रण अड्डा नामाकरण गरियो । वि.सं. २०१३ सालमा प्रादेशिक खाद्य नियन्त्रण अड्डाको नाम परिवर्तन गरी खाद्य संचय बिक्री संस्थान रहन गयो । साविकमा खाद्यान्न बिक्री गर्ने तर्फमात्र सोचिएकोमा यसपछि खाद्यान्न संचयतर्फ ध्यान केन्द्रित गरी देशका विभिन्न ठाउँमा धरमभकारी निर्माण गरी खाद्यान्न भण्डारण गरेको देखिन्छ । अर्को एक सन्दर्भ अनुसार वि.सं. २००८ सालमा राजनीतिकर्मी बखानसिंह गुरुङ्गको नेतृत्वमा पश्चिम चितवनमा बस्ती बसाउने कामको सुरुवात भएको थियो । पहाडबाट बसाइँ सारेर ल्याइएका किसानहरूलाई सामूहिक आर्थिक क्रियाकलापमा सरिक गराउने उद्देश्य अनुसार बखानसिंह गुरुङ्गकै सक्रियतामा वि.सं. २०१३ साल चैत्र २० मा सहकारी पनि गठन गरियो । यसलाई नेपालकै पहिलो सहकारी मानिन्छ । यस सहकारीमा बचत र ऋण चुक्ता गर्न मात्रै होइन बसाइँ सरेर आउने व्यक्तिहरूलाई सहयोग गर्न अन्न राख्ने धरम भकारी पनि खडा गरिएको थियो । आवश्यक भएकाहरूलाई सोही भकारीबाट अन्न झिकेर दिने गरिन्थ्यो । यसरी सुरु भएको धरम भकारी अभियानलाई पंचायतकालको प्रारम्भिक कालतिर देशव्यापी बनाइयो ।

पञ्चायत कालमा धान भकारी

२०२१ सालसम्म ग्रामीण क्षेत्रमा परम्परागत धान भकारी वा धर्म भकारी प्रचलनमा थियो र स्वेच्छाले दिइने दानमा संचालित थियो । २०२१ सालमा नेपालमा स्वर्गीय राजा महेन्द्रले जमिनदारी प्रथा र बिर्ता उन्मुलन गरी भूमिसुधार कार्यक्रम लागु गरे । यस कार्यक्रमले धेरै जग्गा बिहिनहरू जमिनका मालिक बने । भूमिसुधार कार्यक्रमको राम्रो पक्ष भनेको अनिवार्य बचत योजना पनि थियो । यो बचत योजना उत्पादनको आधारमा लगाइयो र प्रधानपञ्च वा वडा अध्यक्षको जिम्मामा रहने व्यवस्था मिलाईयो । गाउँ पञ्चायतको प्रत्येक वडामा वडा सदस्यको पहलमा सम्बन्धित वडामा रहेका किसानहरूसँग बाली भित्र्याउने बित्तिकै उत्पादनको आधारमा अन्न (धान, मकै, कोदो, गहुँ आदि) संकलन गरिन्थ्यो । संकलित अन्न वडा सदस्यकै घरमा वा अन्य कुनै उपयुक्त घरमा राखिन्थ्यो । यो संकलन सबै ठाउँमा एकैनास हुँदैनथ्यो । तर ठाउँ अनुसार उठाइने अन्नको प्रतिशत कम/बेसी भए पनि सरदर ५ देखि १० प्रतिशत (एकमुरी बराबर १ पाथी वा चार माना) भने हुनजाने कुरा कतिपय स्थानीयबाट जानकारी पाइएको छ । यसरी उठाइएको अन्न गाउँमा खाद्यान्नको अभाव भएपछि किसानको मागअनुसार केही ब्याज लिनेगरी वितरण गरिन्थ्यो । धरम भकारीको यो व्यवस्थाले गर्दा स्थानीय गरिब किसानहरूले अन्नको खोजीमा अन्यत्र भौतारिनु पर्ने समस्यामा कमी आएको थियो तर यस व्यवस्थामा विकास हुन पुगेका कतिपय विकृतीले यसलाई उद्देश्य अनुसार विकास हुन दिएनन् । एकातिर धरम भकारीमा संकलित अन्न जुन घरमा राखिन्थ्यो उसै घरका व्यक्तिहरूले हिनामिना गर्न थाले भने अर्कोतिर गाउँका कतिपय धाक रवाफ भएका टाठाबाठाहरूले व्याजसहित फिर्ता गर्नेगरी लगेको अन्न फिर्ता नै गर्न छाडे । यसले गर्दा यो व्यवस्था लामो समय टिक्न सकेन (गोरखा, मसेल गाविसका ७८ वर्षीय पूर्व शिक्षक श्री टंक प्रसाद बगालेसँग ज्योतिलाल बनले लिनु भएको वार्तामा आधारित) ।

राजा महेन्द्रको स्वर्गारोहणपछि यो बचतको राम्रो व्यवस्थापन हुन नसक्दा अलपत्र परेर गयो । केही बदनियत पञ्चहरूले बचतको यो रकम हिनामिना गरेका र हिनामिना गर्ने पञ्च र महापञ्चहरूलाई कारबाही गर्न नसक्दा बचत कार्यक्रमको कालान्तरमा अवसान भयो । त्यसपछि यस्ता धान भकारी, धर्म भकारी वा अनिवार्य बचतको व्यवस्था नै लोप भयो । बचत कार्यक्रम चल्न नसक्नुमा जनता प्रति उत्तरदायी नेतृत्व नहुनु र सरकारी हेल्चक्राइँ मुख्य कारण रहेका थिए ।

उपसंहार

नेपालको लामो ऐतिहासिक काल खण्डमा धार्मिक वा नाफामूलक जुनसुकै कारणले भए पनि धानभकारी वा धर्मभकारी संचालनमा थिए । आवश्यक परेको बेलामा जनताको र संचालक दुवैको गर्जो टर्ने गर्थ्यो । कृषि व्यापार व्यापक भएको र खाद्य संकलन एवम् वितरण नेपाल खाद्यसंस्थानले लिएको अवस्थामा धानभकारी वा धर्मभकारी एउटा दन्त्य कथाको रूपमा परिणत भएको छ ।

Rice Science and Technology in Nepal (MN Paudel, DR Bhandari, MP Khanal, BK Joshi, P Acharya and KH Ghimire, eds).
Crop Development Directorate (CDD), Hariharbhawan and Agronomy Society of Nepal (ASoN), Khumaltar.

धान बाली बखानः टिपन टापन

सत्यमोहन जोशी
इतिहास एवम् संस्कृतिविद्

नेपाल भन्नु नै हिमाल, पहाड र मधेशको त्रियोगद्वारा निर्मित भूबनोटमा सिञ्चित कृषि प्रधान देश हो । सृष्टिको प्रारम्भिक कालमा नेपाल मण्डल अर्थात् वर्तमान काठमाण्डौं उपत्यका नीलवर्ण पानीले भरिएको एक दर्शनीय विशाल ताल थियो । कालान्तरमा एक जना पुरुषार्थी दुरदर्शी बोधिसत्व मञ्जुश्रीले दहको पानी बाहिर पठाउने निकास पत्ता लगाई काठमाण्डौं उपत्यकामा मानव वस्ती बसालेको भन्ने लोककथन रहेको छ । तदुपरान्त काठमाण्डौं उपत्यकामा बसोबास गर्ने आदिवासी कृषकहरूले सेरोफेरोका खेतमा (दहको पानी सुकेपछि जमेको हिलो जुन प्राकृतिक मलको रूपमा कालीमाटी भएर परिणत भैसकेको थियो त्यसैलाई प्राकृतिक मलको रूपमा प्रयोग गरेर) धान रोपी अन्न बाली फलिफलाप गरेर जीवनयापनको क्रमलाई विकसित गरेको इतिहास पाइन्छ । तिनीहरूले नै बागमती नदिको सेरोफेरोमा अनेकन कलाकृतिहरूद्वारा भरिएका पाटी पौवाहरू भवन मन्दिर र विहार, इनार र ढुंगेधारा, देवस्थल, तीर्थस्थल आदि निर्माण गरेर तथा तीसँग सम्बन्धित पूजाआजा, बाजागाजा, नाचगान, चाडवाड, उत्सव आदि मनाएर बागमती सभ्यतालाई विकसित गरी संस्कृतिलाई पनि उत्कृष्ठ र उच्च पारेका थिए । उक्त परिपेक्षमा इतिहासका विभिन्न कालखण्ड पार गरी काठमाडौं उपत्यकाभित्र अनवरल बगिरहने बागमती नदीमा कति पानी बगी सके र अझ कति बगिरहने हो त्यसको लेखाजोखा समयले नै गर्ला । तर प्रकृतिको विधानमा पनि कहिलेकाही सुख र कहिलेकाही दुःखका दिनहरू पनि आउने जाने गर्दारहेछन् ।

नेपाल मण्डल काठमाण्डौ उपत्यकामा (आठौं शताब्दी) राजा नरेन्द्रदेवका समयमा योगी गोरखनाथले वर्षा गराउने नागहरूको आसन गरी तपस्या बस्नाले पानी नपर्दा खडेरीले गर्दा धानका बाला लहलहाउँदो गरी झुल्ने खेतको रोदन सुनिन थाल्यो । अनिकालले मुख बाउन थाल्यो । यस विषम परिस्थितिमा राजा नरेन्द्रदेव आफ्ना सल्लाहकार आचार्य बन्धुदत्तको सुझाव अनुसार एकजना सहायक भरिया ललिते ज्यापु (रथनचक्र) सहित तीनजनाको टोलीको नेतृत्व गरेर छिमेकी प्रदेश कामारूपकामाक्ष (आसाम) पुगे र त्यहाँको राजासँग अनुनय विनय गरेर कल्याण मूर्ति परोपकारी राजपुत्र (मत्स्येन्द्रनाथ) लाई नेपालमा ल्याई पुऱ्याए । योगी गोरखनाथ आफ्ना गुरु मत्स्येन्द्रनाथ आएको थाहा पाई उनको दर्शन गर्न आसनबाट उठेपश्चात् वर्षा गराउने नागहरू स्वतन्त्र भए । फलतः आकाशमा कालो बादल मडारिन थाल्यो । मनग्ये वर्षा सुरु भयो । चारैतिर किसानहरू (ज्यापुहरू) हर्षित भई आ-आफ्ना खेतमा धान रोप्न पाएकोले रोपाइँ गीत धन्काउन थाले, हिले खेतमा जात्राले रोपारहरूलाई नचाउन थाल्यो । धानमा बाला लटरम्म हुन थालेपछि किसानहरूको हर्षको सीमा नै भएन । सबैले धान काटेर अन्न बाली घरमा भित्राए । नेपाल मण्डल, काठमाण्डौं उपत्यकामा चारैतिर सर्वत्र सहकाल मुस्कुरायो । त्यसैवेलादेखि लोककल्याणकारी मत्स्येन्द्रनाथलाई जनताले बोधिसत्व, करुणामय, लोकनाथ, बुंगद्यः (पाटन सहर भित्र प्रवेश गर्नु अघि बुंगमतिमा बास गरेर आएकाले बुंगद्यः भनेर पुकार गरिएको) भनेर श्रदाभक्तिभावले पूजाआजा गर्न थाले । मत्स्येन्द्रनाथकै लागि दुइवटा मन्दिर वने- एउटा बुंगमतिमा र अर्को पाटन सहरी इलाका टंगलमा । तदुपरान्त मत्स्येन्द्रनाथको प्रत्येक वर्ष रथजात्रा गर्ने परम्परा नै वन्यो, अनि यही परम्पराभित्र राष्ट्रकै सर्वोपरि प्रमुख राजाको समुपस्थितिमा भोटो देखाउने जात्राले पनि राजकीय मान्यता प्राप्त गऱ्यो र भोटो देखाउने जात्राको दिनमा सरकारी सार्वजनिक विदा नै हुने परम्पराले पनि औपचारिक रूप लियो । अन्ततः सहकालमा देवता मत्स्येन्द्रनाथको नेपाल प्रवेशबाट सिनाज्या (रोपाइँ गीत) को भाकाका लोक गीत र शास्त्रीय संगीतका गीतले तथा भक्तिभावको स्तोत्र र भक्तिसंगीतले नेवारी समुदायका कृषकहरूको मातृभाषा (नेवार भाषा, नेपाल भाषा) लाई लोक साहित्य विधामा निकै धनी वनाइदियो ।

अन्तत : २०६२/०६३ को जनआन्दोलनको परिणाम स्वरूप नेपालमा संघीय लोकतन्त्रात्मक गणतन्त्रको स्थापना भयो । मुलुकमा आएका अनेकन परिवर्तनहरूमा धान्य पूर्णिमाले पनि काँचुली फेऱ्यो । धान खेती र धान बालीका लागि अनवरत पसिना चुहाउने नेवार समुदायका कृषक ज्यापुहरूले योमरी रोटीको महिमा र गरिमा जगाउने धान्य पूर्णिमाको दिनलाई ज्यापू दिवसमा परिणत गरी राष्ट्रिय दिवसको रूपमा मनाउने परम्परा सुरु गरे । उक्त दिन नेपाल सरकारले सार्वजनिक विदा दिने घोषणा गऱ्यो ।

उक्त परिपेक्षमा राजधानी काठमाण्डौको मुटुमा अवस्थित बसन्तपुरमा नेवार समुदायका ज्यापुहरूले मनाउँदै आएको राष्ट्रिय १३औं ज्यापू दिवसको भव्य समारोहमा विशाल जनसमूह समक्ष प्रमुख अतिथि सम्माननीय प्रधाानमन्त्री पुष्पकमल दाहालज्यूको ऐतिहासिक भाषणमा धान्य पूर्णिमा संस्कृतिको महत्व र महिमा तथा जीवित परम्परा विषयक सारगर्भित उद्‌गारहरू समेत व्यक्त भएका थिए ।

यसै वर्ष (२०७३) धान बाली प्रवर्द्धनलाई लक्षित गरी प्रधानमन्त्री कृषि आधुनिकिकरण परियोजनाको नाममा एउटा नौलो अभियानको पनि थालनी भयो । देशका सम्मामनीय प्रधानमन्त्री पुष्पकमल दाहाल पूर्वाञ्चलमा विर्तामोड झापा पुग्नुभयो । यसबारेको प्रांसगिक समाचार राष्ट्रिय छापा तथा बिद्युतीय संचार गृहहरूमा प्राथमिकताका साथ प्रकाशन समेत भए । यसै क्रममा कान्तिपुर राष्ट्रिय दैनिकको २० पौष २०७३, बुधवारको अंकमा उक्त प्रसंग यसरी उल्लेख गरिएको थियो-

“प्रधानमन्त्री पुष्पकमल दाहालले मंगलबार खेतमा धान रोपेका छन् । धान रोपाइँको यो उपयुक्त सिजन नभएपनि प्रधानमन्त्री कृषि आधुनिकीकरण परियोजना अन्तर्गत झापाको सुपरजोन उद्‌घाटनको क्रममा धान रोपेका हुन् । झापा स्थित बनियानी धान खेतमा प्रधानमन्त्री दाहालले बोरो धानको बेर्नालाई मेसिनले रोपेर उद्‌घाटन गरे । परियोजना ईकाइका प्रमुख मेघनाथ तिमिल्सेनाका अनुसार प्रधानमन्त्रीले रोपेको धानको बेर्ना १५ दिनमा तयार भएको हो । उनले भने- धान भने १०५ दिनमा पाक्नेछ । सरकारले देशभर विभिन्न बालीका सातवटा सुपरजोन स्थापना गरेको छ । झापा भने परियोजना अन्तर्गत धानका लागि छनौटमा परेको हो ।”

कृषि प्रधान देश नेपालमा अन्न बालीमा सबभन्दा प्रमुख स्थानमा पाइआएको धान को ब्युत्पत्ति खोज्दै जाँदा नेपाली पञ्चाङ्ग (पात्रो) मा मार्गशीर्ष शुल्क पक्षको पूर्णिमाको नाम नै धान्यपूर्णिमा भएको पाइन्छ । यही धान्य शब्द अपभ्रंश भएर धान भएको हो । अनि धान रोपाइँको क्रममा बीउ हाल्ने, धान रोप्ने, धानको बोट गोड्ने, धान काट्ने, धान चुट्ने (दाइँ गर्ने) धान बाली भित्राउने, धान कुट्ने, चामल बनाउने, चामलको पीठो बनाउने आदि कार्यहरू सम्पन्न भएपछि जीवनयापनका लागि प्रचुर मात्रामा खाद्यान्न परिपूर्ण भएको खुशियालीमा नेपाली कृषकहरूको जन जीवनमा धान्य पूर्णिमा एउटा नौलो सँस्कृतिको रूपमा परिणत भएको हामी पाउँछौं । यसैबेला कृषक समुदायहरूमा कही गेडे पूजा, कही गोठ पूजा, कही धनेश्वर मेला, कही प्रकृती पूजा, कहीं उधौलीका अवसरमा धान नाचको मेला आदि भैरहँदा काठमाण्डौ उपत्यकामा नेवारहरू (विशेषत कृषक ज्यापुहरू) नयाँ भित्र्याइएको चामलको पिठोबाट बनाइएको योमरी रोटी (बफाएर पकाइने तील र चाकु संयुक्त चुच्चे रोटी) तथा चामलकै पिठोबाट बनिएका मायोबायो आदि ग्रामीण देवताहरू र परिचारिकाहरू पनि धानको भकारी तथा घ्याम्पोमा राखेर पूजा आजा गर्दछन् । ललितपुर पाटनका नेवार समुदायका कृषक बन्धुहरू चाहि सर्वप्रथम मत्स्येन्द्रनाथलाई नै धान बाली भित्र्याउन पाएको खुशीयालीमा हर्ष विभोर भई कृतज्ञता ज्ञापन गर्न योमरी रोटी चढाउन पुग्दछन् । तत् पश्चात् बाजा बजाई नाच गर्ने कुल देवता स्थानमा पनि चतामरि र योमरी चढाई देवाली पूजामा धूमधामसँग भोजभतेर गर्छन् । काठमाण्डौं ज्यापु वन्धुहरूले त धान्य पूर्णिमालाई राष्ट्रिय ज्यापु दिवस कै रूपमा धूमधामसँग मनाउने परम्परानै वसालेका छन् ।

एउटा थप प्रसंग जोडौं । एशिया महाद्विप माझमा भुपरिवेष्टिक नेपाल एक सानो मुलुकनै भएपनि विश्वको सर्वोच्च हिमशिखर सगरमाथाद्वारा यो मुलुक सुशोभित छ । अनि यही मुलुकको मध्य सुदूर पश्चिमाञ्चल जुम्लाका जिउलाहरूमा (धान रोप्ने समथर फाँटहरू) धान खेती हुने गर्दछ। यहाँको छुमचौर जिउलो ३०५० मिटर उचाइमा छ। यो ठाउँ संसारमा सवभन्दा उच्च जिउलाहरूमा धान खेती हुने भूभाग हो । यस्तो उच्चो ठाउँमा धान रोप्ने प्रथा कुन वेला कसले सुरु गरेको भन्ने प्रश्न उठ्न सक्छ । जुम्ली बंशावली अनुसार आठौं शताब्दी तिर एकजना सिद्धपुरुष चन्दननाथले काश्मीरबाट धानको बीउ ल्याई राखेकोमा उनले आफ्ना एकजना भक्त लछाललाई दिएको रे त्यसैबेलादेखि त्यस अञ्चलमा धानको खेती भएको भन्ने कथन छ । अझ धानको खेती कसरी गर्ने भनी लछालले प्रश्न गर्दा गुरु चन्दननाथले जुन तरिकाबाट बताए त्यही तरीका अद्यापि त्यहाँ चलेकै छ । धान रोप्नका लागि बीउ र राख्नका लागि पनि ग्रामीण देवता मष्टोका धामीसँग साइत माग्नु पर्ने चलन छ । त्यसपछि वैज्ञानिक तरीकाले तोकिएको दिन यो यो काम गर्ने भनेर तोकिएको दिनमा काम सम्पन्न गर्नुपर्ने हुन्छ, जस्तो -

चैत्रको १२ दिन जाँदा धानको बीउ पानीमा भिजाउने, चैत्रको १६ दिन जाँदा धानको बीउ पानीबाट उतारी घाममा सुकाउने, त्यसपछि ४ दिनसम्म घरभित्र बीजलाई लुगा ओढाइराख्ने, चैत्रको २० दिन जाँदा गडो (बीउ उमार्ने बेन्नु) मा त्यो टुसाएको धानको बीउ छर्ने र जेठ महिनामा रोप्ने चलन छ ।

यही प्रणाली यही परम्परा आजतक पनि चलेकै छ । तर यहाँ धान पाक्नालाई लामो समय लाग्छ । तर यहाँको जुम्ली मार्सी (काली

मार्सी पनि भनिन्छ) ज्यादै पोसिलो र मीठो हुनेमा नाम कहलिएको चामल हो ।

अनि काठमाण्डौ उपत्यका धानको खेतीमा खडेरी पर्दा, जल वृष्टि गरी सहकाल ल्याइदिने मत्स्येन्द्रनाथका झैं नै कर्णाली अञ्चल जुम्लामा धानको खेतीको थालनी गर्ने गराउने सिद्ध पुरुष चन्दननाथसँग जोडिएका अनेकन् पूजाआजा, बाजागाजा, नाचगान, पर्व उत्सव जात्राहरू जीवन्त भई चलिआएकै छन् । यसको साक्षी प्रमाण स्वरूप चन्दननाथ मन्दिरको परिसरमा गगन चुम्बी लिंगहरू फरफराएर अद्यापि ठडिएकै छन् ।

नेपाल देश कृषि प्रधान देश भएपनि नेपाली कृषि विज्ञान र कृषि प्रणाली तथा कृषि साहित्य विषयक अध्ययन अन्वेषण गरी नेपाली कृषि विद्हरूद्वारा लिखित कृषि ग्रन्थहरू कमै मात्र देख्न र पढ्न पाइन्छ । कृषि विभाग अन्तर्गतको बाली विकास निर्देशनालय र एग्रोनोमी सोसाइटीबाट प्रकाशन हुन लागेको यो धान सम्बन्धी ग्रन्थ निकै ठूलो राष्ट्रिय उपलब्धीको रूपमा देखा पर्दा नेपाली कृषि तथा कृषि जन्य विधा निकै उच्च र धनी भएको महसुस भएको छ । हुन त यसअघि नेपाली कृषिविद्हरूद्वारा लेखिएका दुइवटा मौलिक ग्रन्थहरू (कृषि विद् गंगा प्रसाद सिजापतिद्वारा लिखित कृषिजन्य **"उद्यान"** र नरबहादुर साउदद्वारा लिखित **"नेपालका बालीनाली र तिनको दिगो खेती"** ले नेपालको प्रतिष्ठामूलक मदन पुरस्कार पाएका सन्दर्भहरू उल्लेखनीय भएका छन् । तर यी दुवै ग्रन्थ नेपाली भाषामानै सीमित भए । यिनीहरूको अन्तराष्ट्रिय भाषा अंग्रेजीमा स्तरीय अनुवाद हुन सकेको भए राष्ट्रिय र अन्तराष्ट्रिय कृषि जगतमा नेपाली कृषिको ठूलो नाम र चर्चा हुने थियो ।

एउटा प्रासंगिक चर्चा गरौं-अमेरिकी लेखिका पर्ल बकद्वारा लेखिएको The Good Earth (द गुड अर्थ) नामक ग्रन्थको । अमेरिकाको वेष्ट भर्जिनियाराज्य निवासी एकजना चिनियाँ भाषा पनि जान्ने विद्धान अ. सिडेनष्टिकर क्रिश्चियन धर्मग्रन्थ बाइवललाई चिनियाँ भाषामा उल्था गर्ने काममा चीनमा जाँदा उनले आफ्नो परिवारमा छोरी पर्ल बकलाई पनि साथमा लिएर गएका थिए । अनि चीनमा चिडिङकीयाङ प्रान्तमा बस्दा पर्ल बकले याङसी नदीका किनारामा धान खेती गर्ने चिनियाँ कृषकहरूको कृषि विज्ञान र प्रणाली तथा चिनियाँ कृषकहरूको जीवन पद्धति र दर्शनको विशेष रुचिका साथ अध्ययन अन्वेषण गरिन्, चिनियाँ भाषा साहित्य त उनले चिनियाँ स्कुलबाट सिकिसकेकी थिइन् । पछि चीनमै बस्दा उनको बिहे त्यसबेला चीनमै बस्नुहुने एकजना अमेरिकी कृषिविद् डा. जोन लोसिङगसँग भयो । अनि सन् १९३८ मा पर्ल बकद्वारा लेखिएको The Good Earth ग्रन्थलाई संसारभरको सवभन्दा ठूलो प्रतिष्ठामूलक नोबेल पुरस्कार प्राप्त भयो । The Good Earth को शाव्दिक अर्थ हुन्छ - असल पृथ्वी । त्यसवेला धेरै विज्ञान विद् र साहित्यकारहरूले यही सम्झन पुगेका थिए कि पर्ल बकद्वारा लेखिएको त्यो ग्रन्थ सूर्यको वरिपरि घुम्ने पृथ्वीकै बारेमा लेखिएको हुनुपर्दछ । तर वास्तवमा पर्लबकले The Good Earth को लाक्षणिक अर्थ असल माटोको रूपमा लिएकी रहिछन् । अर्थात् याङसी नदीका सेरोफेरोका खेतमा धान रोपी खाद्यान्न उब्जाउने कृषि प्रणाली तथा ती खेतका माटोमा धान रोपी जीवन यापन गर्ने चिनियाँ कृषकरुको काव्यात्मक वर्णन । तदुपरान्त नोवल पुरस्कार प्राप्त The Good Earth ग्रन्थले कृषि जगत्मा धान बालीका बिरुवा मात्र होइन, अन्य बाली फलफूल पैदा गर्ने सबै प्रकारका बिरुवाका लागि पनि सबभन्दा ठूलो एक मात्र आधार त पृथ्वी (यहाँ माटो) नै रहेछ भन्ने सार बोकेको थियो ।

अत : हाम्रा कृषिविद्हरूले पनि नेपाली माटो कै पृष्ठभूमिमा आफ्ना मौलिक परम्परा र विशेषता भएका एकसे एक उत्कृष्ट ग्रन्थहरू प्रकाशनमा ल्याउन सकेको खण्डमा राष्ट्रकै महिमा र गरिमा स्वतः बढ्ने थियो, अझ अन्तराष्ट्रिय भाषामा अनुवाद गरी वा गराई सम्प्रेषण गर्न सकेमा अन्तर्राष्ट्रिय जगतमै पनि नेपाली माटोमा अनेक उपलब्धी हासिल गर्न सकिने हुन्थ्यो ।

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पृष्ठभूमि

आयुर्वेद एक प्राचीन चिकित्सा पद्धति एवम् सिद्धान्त र जीवनोपयोगी मार्गदर्शन समेत समावेश भएको वैज्ञानिक ग्रन्थहरूको सँगालो हो । विभिन्न स्थानहरूमा औषधीय गुणयुक्त व्यको वर्णन गरी तिनको चिकित्सकीय उपयोगिताका साथै मानव शरीरलाई आफ्नो प्रकृति सुहाउँदो आहार विहारको भोजन गरी दीर्घायु रहने सूत्र समेत आयुर्वेदमा सुन्दर ढंगले वर्णित छ । आयुर्वेदको अध्ययनका लागि उपलब्ध विविध संहिताहरूमध्ये चरक संहिता, सुश्रुत संहिता र अष्टाङ्गहृदय, यी तीन ग्रन्थहरूलाई विशेष रूपमा लिइन्छ । चरक संहिता इ.पूं १००० वर्षअघि आचार्य आत्रेयका शिष्य अग्निवेशले अग्निवेशतन्त्रको रूपमा रचना गरे, जसलाई इ.पू. २०० मा आचार्य चरकले प्रतिसंस्कार (विस्तृत) गरी चरक संहिता नाम दिए । वृद्ध सुश्रुतले इ.पू. (१०००-१५००) मा धन्वन्तरीको उपदेशलाई संग्रह गरी शल्यप्रधान (सर्जरी) शास्त्र सुश्रुत संहिताको रचना गरे, जसलाई दोस्रो शताब्दीमा द्वितीय सुश्रुतले प्रतिसंस्कार गरी सुश्रुत संहिता नामाकरण गरे । ई.सं.को प्रारम्भसँगै यी दुवै ग्रन्थको सार तत्वलाई एकत्रित गरी आचार्य बाग्भटले अष्टांङ्गसंग्रह एवम् अष्टाङ्गहृदयको रचना गरेको इतिहास रहेको छ ।

आयुर्वेदका संहिताहरूमा धानको महत्व

चरक संहिता

चरक संहिता सूत्रस्थान, अध्याय २७ मा अन्नपानविधि प्रकरणमा अन्नको विशेष वर्णन गर्ने क्रममा प्रचलित अन्न भोज्यजन्य आहारको वर्गीकरण, गुण, श्रेष्ठत्व र हीनत्व (गुण कम भएको) भनी वर्णन गरिएको छ । अन्न शब्द 'अद् भक्षणे' धातुमा 'क्त' प्रत्यय लागेर बनेको हुन्छ । अर्थात् जो भक्षण (मुखबाट खाने) गर्न सकिन्छ वा गरिन्छ, त्यो अन्न हो । यस अन्नपानविधि अध्यायमा यिनै अन्नको स्वभाव अर्थात् रस, गुण, वीर्य (potency), पिपाक (विशिष्ट रस), प्रभाव एवम् कर्म आदिको बारेमा उल्लेख भएको छ (Acharya et al 2013)। यसमा आहार द्रव्यहरूको वर्गीकरण निम्न प्रकारले गरिएको छ :

शूकधान्यवर्ग : यस वर्ग अन्तर्गत शालीधान्य र ब्रीहिधान्य गरी विभिन्न धान्य अर्थात् अन्न (धान, गहु, जौ, कोदो आदि) पर्दछन् । शाली भन्नाले हेमन्त ऋतुमा फल्ने धान बुझिन्छ । ग्रीष्म ऋतुमा फल्ने धान षष्टिकधान्य (साठी दिनमा तयार हुने) तथा शरद ऋतुमा हुने धानलाई ब्रीहि धान्य भनिन्छ ।

शिम्बीधान्य : जुन अन्न कोशा लागेर फल्छ, त्यो शिम्बी हो । अर्थात् विविध मास, मुसुरो, रहर आदि गेडागुडी र दालका प्रजाति शिम्बीधान्य अन्तर्गत पर्दछन् ।

कृतान्नवर्ग : रोगी र चिकित्साक्रममा पथ्यका लागि भोजन क्षमतामा कमी भएका व्यक्तिहरूलाई तयार पारिएका धन्य अन्न जस्तै मण्ड (माड), पेया, मांसरस, अन्य (सातुको घोल) आदि । (Acharya et al 2013)।

शूकधान्यवर्ग

धान, गहु तथा कोदो जस्ता बाला लाग्ने प्रकृतिका बालीहरू शुकधान्य वर्ग अन्तर्गत पर्दछन् । यस वर्ग अन्तर्गत निम्नानुसारका विभिन्न पन्ध्र प्रजातिका शालीधान्य धानहरू उल्लेखित छन् :

१) रक्तशाली (रातो धान), २) महाशाली, ३) कलम (जुन उखेलेर पुनः रोपिन्छ), ४) शंकुनाह्त, ५) तूर्णक, ६) दीर्घशूक, ७) गौर धान्य, ८) पाण्डुक, ९) लागुले, १०) सुगन्धिक (वासमति), ११) लोह्वाल (फलामको जस्तो दह्रो बाला लाग्ने), १२) सारिवा, १३) प्रमोदक, १४) पतंग र १५) तपनीय (Acharya et al 2013)।

यसका अलावा सुश्रुत संहिता सुत्रस्थानमा केही प्रजाती थप गरी अठार र पछि बाग्भटद्वारा लिखित अष्टाङ्गसंग्रह ग्रन्थमा २७ प्रजातिका शालीधान्य उल्लेखित छन्। सबै प्रकारका शालीधान्य मधुर रसयुक्त विपाक (पाचनपश्चात् बन्ने विशिष्ट रस) मा मधुर, वीर्य (शरिरमा पार्ने प्रभाव) मा शीतवीर्य (Cold potency) हुन्छन्। कुनै प्रजातिका धान वात दोषको वृद्धि गराउने, मल बाँधिएको (पूर्ण पाचन प्रक्रिया पश्चात मानव मलद्वारबाट हुने Excretion) र थोरै मात्रामा निकाल्ने स्निग्ध (Onctus) चिल्लो पदार्थको मात्रा रहेको), वृहण (Causing strengthening), शुक्रल (Spermo poetic) हुन्छन् (Acharya et al 2013)।

शालीधान्य भित्र श्रेष्ठ धान

सबै शाली धान्यमध्ये रक्तशाली श्रेष्ठ हुन्छ। त्यो धान तृष्णानाशक (Relief from thirst) तथा त्रिदोषनाशक (वात, पित्त र कफ तिनै दोषलाई शमन गर्ने) हुँदा त्रिदोषजन्य व्याधि (Cronic diseases)मा पनि उपयोगी हुन्छ। रक्तशाली पश्चात् महाशाली तथा कलमशाली गुणवान हुन्छन् र उत्तरोत्तर गुण कमी हुदै जान्छ (Acharya et al 2013)।

षष्टिकधान्य

साठी दिनमा पाक्ने धान शीतवीर्य, स्निग्धर, थोरै मधुर रसयुक्त तथा त्रिदोषनाशक हुन्छन्। यी शरीरलाई स्थिरता प्रदान गर्ने खालका हुन्छन्। षष्टिकधान २ प्रकारका हुन्छन् १) गौर र २) कृष्णगौर। गौर धान प्रवर (श्रेष्ठ) र कृष्ण धान त्योभन्दा थोरै गुण कम हुने हुन्छ। सुश्रुत संहिता सुत्रस्थानमा पनि षष्टिकधान्यका विभिन्न एघार प्रजाति तथा गुण र कर्म शालीधान्य समान हुने कुरा उल्लेख गरिएको छ (Acharya et al 2013)।

चरक संहिताका अन्य अध्याय (अध्याय २७ बाहेक) मा धानको प्रसङ्ग

चरक संहिताको अन्य स्थान विशेषमा पनि धानको गुण र कर्मको उल्लेख गरिएको छ। जस्तै सठीयाधान स्तन्यजनक (Increasing lactation) हुन्छ। शीतलताकारक हुने हुँदा ग्रीष्म ऋतुमा सेवन गर्न योग्य हुन्छ। रसायन (वृद्धावस्थामा शरीर क्षय कमी गर्ने) कर्मका लागि ब्रह्मरसायन नामक विशेष औषधी बनाउन अन्य पाँच द्रव्यको जराका साथ यो धानको प्रयोग गरिन्छ। त्यसैगरी आमलकी घृत (घ्यू), आमलकी (अमला) रसायन आदि सेवन गर्ने क्रममा पनि शालीधानको भात नै पथ्य हुन्छ। रक्तपित्त (Hemorrhage) को रोगीलाई शालीधान, साठीधान, कोदो आदि पथ्य हुने तथा औषधीलाई दूधको साथ पिउन दिने र पछि शालीधानको भात ख्वाएमा उपयोगी हुन्छ। गुल्मरोग (Abdominal lump or tumor) मा शालीधान अन्य लघु तथा पाचनीय आहारको साथमा सेवन गरेमा पथ्य हुन्छ। प्रमेह (Diabetes) मा पुरानो शालीधानको भात, राजयक्ष्मा (Tuberculosis) मा विविध औषधीय द्रव्ययुक्त पानीमा पकाएको शालीधान्यको भात, रक्तार्श (Bleeding piles) मा अन्य औषधीका साथ शालीधानलाई पकाई बाख्राको दूधका साथमा खुवाउने तथा वातजकास (Dry cough) मा शाली वा षष्टिधान्यको भात, जौ, गहुँको रोटी मांसरससँग पथ्य हुने कुरा उल्लेख गरिएको छ। त्यसै गरी अतीसार (Diarrhoea) ग्रस्त रोगीलाई शालीधान्यमा काँचो बेलको गुदी, तिल, घ्यू मिसाई पकाएको भात ख्वाउँदा शरीरगत धातुक्षय परीपुरण हुन्छ, भने बिसर्प (Erysepelas) रोगीमा रक्तशाली, श्वेतशाली, महाशाली तथा षष्टिकको पुरानो धानको भात बनाई माड निकालेर अथवा त्यसमा गहुँ र जौको मिश्रण गरी खान दिएमा उपयोगी हुन्छ। तृष्णा (Hypovolemia) मा शालीधान्यको भातमा चिनी वा मधु मिलाई चिसो बनाएर खुवाउने र त्रिमर्मधान (Injury to the vital points) मा शालीधान्यलाई शतावरी (कुरीलो), गोक्षुर (गाइखुरे), कुशको जरा आदिसँग पकाएर खान दिने उपचार विधि समेत चरक संहितामा उल्लेख गरिएको छ। चरक संहिता सुत्रस्थान एंव चिकित्सास्थानका विभिन्न अध्यायमा वर्णन गरिएका यी कुरा सुश्रुत संहिता एंव अष्टाङ्ग संग्रहकारले पनि समर्थन गरेका छन् (Acharya et al 2013)।

सुश्रुत संहितामा धानको महत्व

सुश्रुत संहिता, सूत्रस्थान अध्याय ४६ मा विभिन्न फरक-फरक स्थानमा लगाइएको धानको फरक-फरक गुण र कर्म हुने कुरा बताइएको छ। दग्ध वा जलेको माटोमा लगाइएको छिटो पाक्ने, कषाय (टर्रो) रसयुक्त, मलमूत्र रोक्नेवाला, रुक्ष र कफलाई कम गर्ने हुन्छ। त्यस्तैगरी पानी कम हुने स्थानमा उत्पादित धान कफपित्त नाशक, कषायरस, थोरै तिक्तरस, मधुर विपाक तथा थोरै मात्रामा मल निस्कासन गर्ने गुणको हुन्छ। पानी प्रशस्त हुने स्थानको धान मधुर, शुक्रवर्धक, बलकारक, पित्तनाशक, पाचनमा धेरै

समय लाग्ने, मलकारक तथा कफबर्धक हून्छ । जुन धान एक स्थानबाट उखेलेर अर्को ठाउँमा रोपिन्छ, त्यो गुणमा श्रेष्ठ हुन्छ । यसमा शीघ्र पाचन हुने, दोषको नाश गर्ने, बलकारक तथा मूत्रको मात्रा बढाउने गुण रहेको हुन्छ ।

प्रयोगको आधारमा पनि यस शल्यप्रधान (सर्जरी) शास्त्रमा विभिन्न स्थानमा धानको विशेष उपयोगिता बताइएको छ । जस्तै, अग्निकर्म अर्न्तगत यदि अतिदग्ध (पोल्ने) भयो भने शालीधानको चामलको पिठो घ्यूको साथमा लगाउनाले शीतलता दिन्छ । कार्श्य (दुब्लोपन) रोगीमा अश्वगन्धा, शतावरी, बला, नागबला तथा अन्य औषधीय द्रव्यको साथमा दही, घ्यू, मांस र शालीधान्यको भात पकाई रोगीलाई खान दिएमा उपयुक्त हुन्छ । विरेचन (Purgation) गर्नुपर्ने रोगीमा विरेचनयोग्य द्रव्यको जराको क्वाथ (Decoction) मा शाली चामललाई धुने र कुट्ने, केही चामललाई त्यही क्वाथको वाफमा पकाउने, दुवैलाई मिसाउने, अन्य औषधी मिसाई चिकित्सा गर्ने गरेमा फलदायी हुने कुरा समेत सुश्रुत संहितामा उल्लेख गरिएको छ (Ghanekara 2009) । त्यसैगरी सुत्केरी अवस्थामा स्तन्य वृद्धिका लागि मातालाई प्रसन्नचित्त राख्ने र जौ, गहुँ, शालीधान, साठीधानको भात मांसरसका साथमा लसुन, जेठीमधु, शताबरी आदि मिसाई खान दिने गरेमा उपयोगी हुन्छ (Sharma 2013) । सुश्रुत संहिताकै उत्तरतन्त्रमा नवजात शिशुको ग्रह सम्बन्धी रोगमा बली, मन्त्र, पाठका साथमा रात्रिकालमा गायत्री मन्त्रद्वारा मन्त्रित जलले स्नान गराई नयाँ शालीधान, जौ र गुग्गुल बितभद्रको अग्निमा होम गर्ने भनी उल्लेख गरिएको छ (Sharma 2013) । रोगविशेष वर्णन गर्दा अतिसार (Diarrhoeal disease) मा शालीधानको वा साठीधानको चामल १ ग्राम पिनेर उखुरस वा महसँग मिलाई खान दिई उपचार गर्न सकिने समेत उल्लेख छ (Sharma 2013) । राजयक्ष्मा (Tuberculosis) रोगीलाई चिकित्सा गरिसकेपछि जौ, गहुँ र शालीधानको भातलाई जंगली जनावरको मांसरसको साथमा खुवाएर उपचार गर्न सकिन्छ (Sharma 2013) । पित्तशूल (Abdominal pain due to ulceration) मा गुड, शालीधानको भात, जौ, दूध र घृतपानपश्चात् जंगली प्राणीको मांसरस खान दिएमा निको हुने उल्लेख छ (Sharma 2013) । रक्तपित्त (Bleeding) रोगीलाई शालीधान र साठीधानको चामललाई मटरका साथमा पकाई पिउन दिई उपचार गर्न सकिन्छ (Sharma 2013) । मूर्छा (Fainting disorder) रोगीलाई मधुरवर्गका द्रव्यबाट सिद्ध गरिएको दूध, दाडिम (अनार) युक्त जंगल प्राणिको मांसरस, जौ एवम् शालीधानको भात सधै पथ्य हुन्छ (Sharma 2013) । छर्दिबाट (vomiting) ग्रस्त रोगीमा शालीधानको बोक्रालाई चार गुणा पानीमा पकाएर तयार पारिएको यवागूसँग मह मिसाएर खान दिई उपचार गर्न सकिन्छ (Sharma 2013) । मूत्राघात (Obstructive uropathy) रोगीले तालको जरा पिनेर तयार पारिएको चट्नी वा कल्क (चटनी जस्तै देखिने) शालीचामलको चौलानीमा मिसाई सेवन गरेमा उपयोगी हुन्छ (Sharma 2013) ।

अष्टाङ्गहृदयमा धानको महत्व

आचार्य बाग्भटद्वारा लिखित अष्टाङ्गह्दयमा पनि चरक संहिता एवम् सुश्रुत संहितामा वर्णित कुरा नै सर्मथन गरिएको छ । त्यसबाहेक बाग्भटले उल्लेख गरेका विशेष तथ्य यस प्रकार छन् । सूत्रस्थान अध्याय ३ मा ग्रीष्म ऋतुमा गर्ने आहार विहार अर्न्तगत कुन्दपुष्प एवम् चन्द्रमा समान शालीधान्यको भात मांसरसको साथमा सेवन गर्न निर्देश गरिएको छ । सोही शालीधानको भात शरद ऋतुमा पनि तिक्त रसयुक्त द्रव्य, अमला, परवर तथा जगंलीमांसको साथमा सेवन गर्ने भनिएको छ । जो मनुष्य चिकित्साकर्म एवम् औषधीको कारणले जीर्ण हुन्छ उसलाई शालीधान, साठीयाधानको भात, गहुँ, मुँग, मांस, घृत आदि सेवन गर्न दिने उल्लेख गरिएको छ (Gupta 1970) । अध्याय पाँचमा वर्षातको पानीको शुद्धता जाँच्न चाँदीको थालमा शालीधानको भात राखी थाललाई वर्षा भैरहेको ठाउँमा राख्ने र यदि भातको रङ्गमा कुनै परिवर्तन आएन भने त्यो शुद्ध र पिउनयोग्य पानी हुन्छ, जसलाई गंगाजल भनिन्छ (Gupta 1970) । चोटपटक वा घाउ लागेको रोगीले नियमित भोजनका साथ पुरानो शालीधानको भातलाई घ्यूसँग र थोरै मात्रामा जंगली प्राणीको मांसरसका साथमा सेवन गर्नाले घाउ चाँडै भरिन्छ (Gupta 1970) । त्यसैगरी शरीरस्थान, अध्याय दुईमा गर्भपात (Miscarriage) भएकी स्त्रीलाई शालीधान्य, बला (वलू), अतिबला, मुलेठी (जेठीमधु) आदिले सिद्ध गरिएको दूध पिउन दिने र रातो धानको भातलाई मह, मिश्री मिसाएर दूध अथवा जंगली प्राणीको मांसरससँग खान दिनु अत्यन्तै उपयोगी हुन्छ भनिएको छ (Gupta 1970) । चिकित्सास्थान अध्याय तीनमा कासरोग वा खोकी (Coughing disorder) मा बाखा, सुँगुर, बंगुर आदि घरपालुवा पशुको वा माछाको मांसरससँग शालीधानको भात, जौ, गहुँ, या साठीयाधानको भात ख्वाउने भनी उल्लेख गरिएको छ (Gupta 1970) । उरःक्षत वा छातीमा चोटपटक लागेमा तत्कालै दूधमा लाहा (Lac) मिसाएर खाने, उक्त औषधीको पाचन पश्चात् शालीधानको भातसँग मिश्री मिसाएको दूध खाएमा उत्तम हुने उल्लेख छ तथा खकारसँग रगत मिसिएर आउने भएमा पुनर्नवा, शालीधानको

चामल, कनिकालाई चूर्ण बनाई दूध अथवा घ्यूसँग ख्वाउने गरेमा निको हुने उल्लेख छ (Gupta 1970)। खोकी एवम् छाती दुख्ने रोगीले, शालीधान, साठीयाधान, गहुँ, जौ, मास तथा गहतको नियमित सेवन गनुपर्छ (Gupta 1970)।

निष्कर्ष

यस अध्ययनबाट संहिताकालदेखि नै शालीधान्य, ब्रीहिधान्य आदि धानका विभिन्न प्रकारहरूको दैनिक भोजनका रूपमा तथा रोगका उपचारको क्रममा विविध पथ्यका रूपमा प्रयोग हुँदै आएको कुरा स्पष्ट हुन्छ। धानको प्रयोग दैनिक भोजनको रूपमा विशेष पौष्टिक, स्वास्थ्य संरक्षण र सम्वर्धनमा पनि उपयोगी भएको बुझ्न सकिन्छ। त्यसबाहेक रोगको उपचारको क्रममा यसको विविध रूपमा प्रयोग हुनसक्ने र ती रोगहरूको निवारण हुने तथ्य पनि प्रमाणित हुन्छ।

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नेपालमा सर्वप्रथम वि.सं. २००६ सालमा लम्जुङ्गे ब्राह्मणहरूले हलो जोत्ने गरेको सकारात्मक प्रभावको असर नै भन्नुपर्छ वि.सं. २०३५ सालमा लम्जुङ्गमा कृषि कलेज स्थापना भयो र कृषि सम्बन्धी अध्ययन सुरु भै स्नातक स्तरको जनशक्ति लम्जुङ्गबाट पनि विकास भै राखेको छ। यसको श्रेय परोक्ष रूपमा हाम्रा भविष्य द्रष्टा अग्रजहरूलाई जान्छ। उनीहरूले आजभन्दा छ दशक पहिलेको रुढिवादी समाजमा पनि ब्राह्मणले हलो जोती 'हलो क्रान्ति' जस्तो सांस्कृतिक एवम् आर्थिक क्रान्ति सुरु गरेका थिए तर नेपालमा आजका दिनसम्म तत् पश्चातका कृषिलाई प्राथमिकता दिए पनि व्यवहारमा महत्व नदिएका हुनाले नेपालको कृषि आजसम्म उपलब्धी मूलक बन्न सकेको अवस्था छैन। फलस्वरूप नेपाल र नेपालीको आर्थिकस्तर आशातीत रूपमा परिवर्तन हुन सकेको छैन। वि.सं. २००६ सालमा नै कृषिको महत्व यति स्पष्टसँग बुझेका हाम्रा अग्रजहरूलाई हृदयदेखि स्मरण गर्दै हलो क्रान्ति गरी धान उत्पादनमा दिएको प्राथमिकताप्रति हार्दिक कृतज्ञता प्रकट गर्ने परम कर्तव्य ठानेका छौं। यसै सन्धर्भमा हलो क्रान्तिका नायकको सम्मान पाएका २७ ब्राह्मण मध्येका अन्तिम नायक मायानाथ पौडेल मात्र जीवित थिए। तर यसैवर्ष ९१ वर्षको उमेरमा पौडेलको निधन भएपछि उनीहरू अब स्मृतिमा मात्र बाँकी रहे। यिनै हलो क्रान्तिका नायकले पुऱ्याएको देनलाई स्मरण योग्य बनाउने उदेश्यले यो आलेख तयार गर्न अभिप्रेरित छौं।

फोटो १: हलो क्रान्तीका अभियन्ताहरू मध्ये एकः स्व. श्रीकान्त अधिकारी

ब्राह्मणले हलो जोत्न हुन्छ र यस कार्यलाई धार्मिक शास्त्र र तत्कालीन कानूनले पनि कतै रोकतोक गरेको छैन भनेर लमजुङ्ग दुराडाँडाका दूरदर्शी अभियन्ताहरू श्रीकान्त अधिकारी र उनका काका लेफ्टिनेण्ट शेषकान्त अधिकारीले २००६ सालको सुरुतिर हलो चलाउने निधो गरे। यस कुरालाई अरू थप दुराडाँडा निवासी पं. तोयनाथ अधिकारी र मु. हरिभक्त पौडेल आदि पनि सहमत भए। त्यसपछि पं. तोयनाथ अधिकारीको लमजुङ्ग, दुराडाँडा अर्चले बेसीको घर नजिकको उनैको पाखोबारी तेर्सोबाटोसँगै रहेको ठूलो गरामा राणा शासनकै पालामा २००६ साल साउन ११ गते 'हलोक्रान्ति' को थालनी गरेर हलो जोते। त्यो नेपालकै इतिहासमा पहिलो दिन थियो बाहुनले हलो जोतेर गर्न थालेको सांस्कृतिक तथा आर्थिक क्रान्तिको परिवर्तन 'हलो क्रान्ति' को अभूतपूर्व अभियान। त्यो खबरले लमजुङ्गको डाँडोखोलो हल्लियो। दुराडाँडा लमजुङ्गको त्यो 'हलो क्रान्ति' तुरुन्त वनको डढेलो फैलिए झैं बाहुन समुदायमा एककान दुईकान मैदान भएर तुरुन्त लमजुङ्गभर, कास्की, तनहुँ, स्याङ्जा र गोरखा जिल्लामा समेत फैलियो। तर केही वर्षसम्म ती हलो जोतेका बाहुनहरूको भातभान्सा काढियो, याने कि तिनीहरूलाई समाजले भान्सामा गएर भात खान रोके र तिनीहरूको बिहावारी समेत बन्द गर्ने, केटी नदिने भन्ने भयो। यतिसम्म कि, हलो जोत्ने बाहुनको घरमा अन्य जातिका परम्परागत हलीहरूले समेत भात खाएनन्। हुनु-नहुनु भयो। पत्याउनै नसकिने जस्तो भयो।

अनि, तात्कालीन राणा शासनका बडाहाकिमले जोताहा बाहुनहरूलाई तुरुन्त पोखरामा झिकाएर थुनामा राखे। तर थुनामा परेका अभियन्ताहरूले बडाहाकिम कहाँ शास्त्र प्रमाण वा कानूनमा भएदेखि देखाउनु पर्यो र थुनेको प्रमाण पुऱ्याउनु पर्यो भनेर बहस गर्दा

तात्कालीन प्रशासनले प्रमाण पुऱ्याउन नसकेपछि उनीहरू जेलबाट छुटे । तैपनि समाजका विरोधी बाहुन समुदायले नै भित्र-भित्रै जनबोलीको रूपमा गीत र कविता लेखेर बाँडे । बिरोधी कविताको नमुनाहरू मध्ये एउटा यस्तो थियो :

"नारी गोरु दुई गजुवा–पुवाँले,
हो र ! भाइ–पच् पच् ! भनी बाहुनले जोत्न थाले,
शेषकान्त लप्टन तोयनाथ तिघ्रे,
हलो जोतेर दुराडाँडे बिग्रे ॥१॥"

बिरोधीहरूको निकोचाला छैन भन्ने बुझेर हलो जोत्ने पक्षले पनि जुवारीको रूपमा जवाफ दिएका थिए, जसमध्ये एक फाँकि कविता यस्तो थियो ।

"ए नानी ! टपरी भक्त ! तिम्रा पूर्वजहेरुको,
हैन, यो युग हो यौटा मान्छेको र विकासको,
बालबच्चाहरू तिम्रा रोइरन्छन् धुरुधुरू,
तस्मात् अल्छी कुरा छोड जोतीहाल खुरुखुरू ॥१॥"

यस्तै प्रकारले नेपथ्यमा विरोधीहरूले खुट्टा तान्ने प्रयास गर्दै रहेका थिए । तर साथ-साथै पक्षबाट समेत अभियन्ताहरूले केही वर्षपछि हलो अभियानलाई झन् तीव्र पार्दै लगे । हली पाल्न नसक्ने गरिब बाहुनहरूले त खुशी भएर आफ्नो हलो आफैं जोतेर अभियान स्वीकारे र राहत समेत महसुस गरे । वि.सं. २०१३/०१४ सालतिर लमजुङ्गको धेरै गाउँमा हलो अभियानले गति लिन थाल्यो । अनि तनहुँ, गोरखा, धादिङ्ग, कास्की र स्याङ्गजा जिल्लामा समेत अभियानले क्रमिक रूपमा गति बढायो । पछि वि.सं. २०१७ सालमा दौडाहा टोलीको अध्यक्षको पद सम्हालेर महाकाली अञ्चल प्रस्थान गरेर श्रीकान्त अधिकारीले त्यस भेगमा पनि 'हलो क्रान्ति' को अभियानलाई निरन्तरता दिए । त्यतातिर पनि खुबै प्रचारप्रसार भयो । हली पाल्न नसक्ने बाहुनहरूले 'के निहुँ पाऊँ कनिका बुकाऊँ' भने झैं हलो अभियानलाई सहर्ष स्वीकार गर्दै आफ्नो खेतबारीमा आफैं हलो जोत्न थाले र काम चलाए । समयमा खेत रोपिन थाल्यो र कृषि क्रान्तिको लहरको रूप लिएर नेपालभरि हलो अभियान फैलियो । दुराडाँडे बाहुनहरूले थालनी गरेको हलो अभियान सामाजिक र सांस्कृतिक क्रान्तिको प्रतीक थियो र सामाजिक परिवर्तन एवम् समतामूलक समाज स्थापनाको पृष्ठभूमि थियो । त्यती बेलाको समय र समाजमा 'छी ! के गरेका होलान्' भनेर कुरा काट्नेहरूको लागि राम्रै निहुँ बनेको थियो होला र समाजका लागि अमान्य पनि । तर पचास वर्ष पछिका पुस्ताले सह्राउने छन् र भविष्यमा यसको प्रशंसा हुनेछ भन्ने कुरा हलो अभियानका अभियन्ताहरूले राम्ररी बुझेका थिए र त्यसैमा उनीहरू अडिग थिए । अहिलेको नेपालभरि बाहुन लगायत सबैले हलो जोतीरहेकै पनि छन् । धन्य हो ! हलो अभियन्ताहरूको प्रयासको सफलता ।

अस्ताए हलो क्रान्तिका अन्तिम नायक

हलो क्रान्तिमा संलग्न लम्जुङ्गे बाहुनहरूले हलो जोत्नु नहुने पुरातन सोंचलाई चुनौती दिन निस्किएका थिए । २००६ साउन ११ मा बाहुनको छोराले गोरु नारेर हलोको अनौ समाउनु कम चुनौतिपूर्ण काम थिएन । समाजलाई चुनौती दिएर हलो क्रान्तिका ' नायक' को सम्मान पाएका २७ ब्राह्मणमध्ये मायानाथ पौडेल मात्र जीवित थिए । जेठ अन्तिम साता २०७३ मा ९१ वर्षको उमेरमा (वि.सं १९८२–२०७३) पौडेलको निधन भएपछि उनीहरू अब स्मृतिमा मात्र बाँकी रहे । बाहुनले हलो जोत्नु हुन्न, जोतेमा दलित सरह भइन्छ भन्ने पुरातन मान्यतालाई चुनौती दिँदै दुराडाँडा ६ अर्चल्यानीको बाटेगरामा पण्डित तोयानाथ अधिकारीको नेतृत्वमा उनीहरूले अनौ समातेका थिए । पौडेल तीमध्येका कान्छा २१ वर्षका थिए । हलो क्रान्तिमा सहभागी सबैको निधन भइसकेको हलो क्रान्ति नेपाल तथा तोयानाथ स्मृति प्रतिष्ठानका सचिव दीपक पौडेलले बताए । यहि २०७३ साउन ११ मा ६७ औं हलोत्कर्षण (हलो क्रान्ति) दिवस

फोटो २: हलो क्रान्तीका अन्तिम नायक मायानाथ पौडेल

मनाउने तयारी भइरहेको थियो । पौडेलको निधनबाट उक्त कार्यक्रम खल्लो भएको छ । यसअघि दुराडाँडा ४ का विष्णुप्रसाद अधिकारीको ०७१ फागुन अन्तिम साता ८९ वर्षमा निधन भएको थियो । अधिकारी र पौडेलले आधा दशकभन्दा बढी हलोत्कर्षण दिवसमा निरन्तर सहभागिता जनाएका थिए । पौडेलको समेत निधन भएकाले हलो क्रान्तिलाई बुझ्न चाहनेले अब शोधग्रन्थ र इतिहासकै भर पर्नुपर्ने उनका भतिजा सन्तोष्का पौडेलले बताउँछन् । मायानाथका एक मात्र छोरा नारायणको दुई वर्षअघि निधन भएको थियो । बुहारी र दुई नाति चितवन बस्दै आएका छन् । पत्नीको निधनयता एकल जीवन बिताउँदै आएका उनलाई खाना पकाएर दिने मान्छे समेत थिएनन् । छिमेकी लक्ष्मी पौडेलले उहाँको पछिल्लो अवस्था निकै दयनीय भएको बताइन् । केही समयअघि मायानाथले बताए अनुसार सबैभन्दा कान्छो भएकाले पण्डित तोयानाथले गोरु खोजेर ल्याउन लगाएका थिए । गोरु फुकाएर ल्याई उनले बाटेगरामा पूर्वतिर फर्केर नारिदिएका थिए ।

यसरी लेफ्टिनेन्ट शेषकान्त अधिकारी, मुखिया हरिभक्त पौडेल, श्रीकान्त अधिकारी, विष्णुप्रसाद अधिकारी, हरिलाल पौडेल लगायतका ब्राह्मणहरूले हलो जोत्न सुरु भए पश्चात् सरकार विरोधी काम गरेको आरोपमा तात्कालीन सरकार प्रमुख श्री ३ मोहन शमशेरको आदेशमा पण्डित तोयानाथ, शेषकान्त र श्रीकान्तलाई गिरफ्तार गरी पोखराको गोश्वरामा समेत पुऱ्याएको र पछि वेदमा बाहुनले हलो जोत्न हुँदैन भन्ने उल्लेख नभएकाले ४८ घण्टामा थुना मुक्त भई पुनः हलो क्रान्तिको अभियानको निरन्तरता भएको ईतिहास नेपालमा रहेको छ ।

सन्दर्भ सामाग्री

श्रीकान्त अधिकारी स्मृति ग्रन्थ, एपोलो अफ्सेट प्रेस प्रा.लि., काठमाण्डौं, पृष्ठ संख्या ६०० ।

कान्तीपुर दैनिक. असार २, २०७३. अस्ताय हलो क्रान्तिका नायकहरू ।

कता हराए यी धानहरू ?

आर डी प्रभास चटौत

असार १५ गतेलाई राष्ट्रिय धान दिवसका रूपमा मनाउने गरेका छौं । हुन त असार १५ को दिन त्यो सप्ताहलाई गत धान दिवसको प्रगति वा परिणाम विश्लेषण गर्ने अवसरको रूपमा मनाउनु पर्ने हो, तर त्यसो नभई परस्परमा हिलो छयाप्दै, धान रोप्दै राष्ट्रिय धान दिवस भनेर औपचारिकतामा यसलाई कैद गर्ने गरिन्छ । यसपालि पनि प्रधानमन्त्री भक्तपुरमा पुग्नु भयो र गृहमन्त्री कैलाली धनगढी । धानको बोट र हिलोलाई छुनु भयो के मजा हुन्थ्यो यदि त्यो स्पर्श गोल्डन टच भई दिन्थ्यो भने तर त्यसो भएन । एकछिन किसान हौसिए, कृषि वालाले कृषि गीत गाईन, ढोलकको ढम-ढम सुनियो बस औपचारिकतामा सबै कुरा सिद्धियो । हुन त विश्व मै कहलिएका नारी दिवस, बाल दिवस, मानव अधिकार दिवस, युवा वर्ष, बृद्ध वर्ष जस्ता सबै वर्ष यसरी नै औपचारिकतामा बिलाउँछन भने धान दिवस मात्रै किन अपवाद हुन्थ्यो ? हो पोखरामा देख्दा केही पर्यटक धान दिवसको बेला मन, बचन र कर्मले रमाएका । यस अवसरलाई धान दिवसीय पर्यटक सप्ताहको स्वरूप दिनसके एउटै नौलो संस्कृतिको सुरुवात हुन्थ्यो । असार १५ लाई दहीच्युरा खाएर रमाउने दिन पनि भनिन्छ । कृषक त्यै दही र च्युराका जन्मदाता हुन् तर उनीहरू अब पुर्खाको इतिहास हो सम्झदै रित्तो आँखाले धर्तीतिर हेर्दै बेला बिताउँछन् । माटो पानीबाट टाढै बस्नेहरू दहीच्युरा दिवस मनाएर रमाउँछन् र कस्ता नियति, कस्तो संस्कृति ? 'मानो रोपी मुरी फलाउने' उखान आज बखानको रूपमा मात्रै रहेको छ । आकाशको पानीको भर छ । बेलामा न मल पाइन्छ, न ओखतीमुलो पाइन्छ, बीउको त के कुरा गरौं गत वर्ष दाना नभएको मकैका घोगा जन्मे त्यो सरकारी बीउ नै थियो । भोको पेट, कति दिनदेखि पर्खिबसेका किसानहरू रोए कराए तर सबै अरण्य रोदन भयो ।

यधपि यहाँ नार्क छ, सार्क छ, आधुनिकिकरणका थुप्रै नारा छन् तर ती सबै किसानका निम्ति आकाशका तारा छन् । कृषिका निम्ति मनग्गे बजेट राखेको कुरा रेडियोले फुक्छ, अखबारहरूले लेख्छन् तर अन्ततः त्यो सबै बालुवामा परेको पानी झैं हुन्छ । हिजो त्यही भयो, आज त्यस्तै छ, भोलि के हुने हो खै ? हरियो वन पल्लो घरको धन भए झैं हिमालदेख तराईसम्मको सम्पदा तँछाडमछाड गरी दोहन भइरहेको छ हेर्ने फुर्सद कसैलाई छैन । नेपाल र नेपालीको अवस्था प्वाल परेको गाग्रीमा पानी भरे झैं छ । युवा पुस्ताले अर्काका देशका निम्ति पसिना बगाइरहेको छ । बूढो पुस्ता दैलो रुडी काल पर्खने विवशतामा छ । यो अन्तहीन पीडाको कथा कसले कसलाई सुनाउने ? विगतमा जुन देशको अन्नभण्डार वरपरका देशका निम्ति पनि वरदान हुन्थ्यो, आज त्यसै देशको निवासी क्षुधा मार्न परमुखापेक्षी भएर घरि मर्दै, घरि बाँच्दै गरी जीवनयापन गरिरहेका छन् । कहिले सडेगलेको चामलले ज्यान लिन्छ, त कहिले गिट्टा–भ्याकुरले । यस्तै छ यो देशका जनताको नियति । यो पीडालाई बुझ्दै नबुझ्केकाहरू जनता जनार्दन, जनताको सर्वोच्चता जस्ता नारा दिएर कुर्सी युद्धमा जनताको आशा भरोसालाई होमिरहेका छन् । नेपालको शताब्दीऔं पुरानो इतिहासतिर फर्केर अन्नभण्डारको आधारभूत धरातलतिर हेर्दा अचम्म त लाग्छ, आफना पुर्खाले संन्चित गरी राखेका विविध विषयका अति प्राचीन र महत्वपूर्ण अभिलेखहरू यो पङ्तिकारसँग सुरक्षित छन् । तीमध्ये १९६० सालतिर लेखिएको धानका एकसट्टी वटा जाति र प्रजातिहरूको नाम लेखिएको अभिलेख छ र पुस्तौंपुस्ता पहिलेदेखि उक्त धानका जाति र प्रजातिहरू प्रयोगमा अवश्य ल्याएका होलान् । लिपिबद्ध मात्रै वि.सं १९६० सालतिर अर्थात् धेरैपछि गरियो होला । हाम्रो विगत कति समृद्ध थियो भन्ने कुरा यस्ता अभिलेखहरूले प्रष्टाउँछन् । ती धानका नामहरू जनसमक्ष आइसके पश्चात् आशा गरौं सम्बन्धित निकाय कृषिशाली किसान आदिको ध्यानाकर्षण यो विषयतिर होला र केही परिणाम निस्कला । शताब्दी पुरानो अभिलेखमा रहेका धानका नाम तल उल्लेख छन् :

१.गौरी धान, २. सालो धान, ३. रातो सालो धान, ४. जौ धान, ५. केशरी धान, ६. बास्ना धान, ७. उहरी धान, ८. कुमुद धान, ९. अदरमो धान, १०. चिनामुरी धान, ११. बरार पास्या, १२. ढाण्या, १३. पातल्या, १४. माल्टना, १५. माछ्या, १६. मैरु, १७. जयन्ती ,१८. जाउल्या, १९. स्यामजिरो, २०. फल्या धान, २१. फलम्या झाप्री, २२. चुच्या, २३. पेल्या, २४. दामदरया, २५. दुदी, २६. सलौंजी, २७. कालुझोपडी, २८. ताकमारो, २९. कलिउरया, ३०. नानागोजी, ३१. ठुली गोजी, ३२. मोथो, ३३. सुनकेसरी, ३४. नन्दबिरी धान, ३५. निमै धान, ३६. गानामुथो धान, ३७. राज्या धान, ३८. लिमठी, ३९. लैबिरी खोई धान, ४०. भुरया धान, ४१. मधना गौरीधान, ४२. हंसराज, ४३. बासमती, ४४. सुनखडी, ४५. अन्जना, ४६. कृस्न भोग, ४७. जाडना, ४८. गुर्धौली, ४९. मार्सो, ५०. मार्सी, ५१. लामइ, ५२. स्याउडो, ५३. थापा चिनी, ५४. ताक्मासे, ५५. बाठी, ५६. झिली, ५७. जड्न, ५८. तौली, ५९. राईमनुवा, ६०. पासडो धान, ६१. सुजी (शताब्दी पुरानो अभिलेखबाट)

(प्रस्तुत लेख कान्तिपुर दैनिकमा २०६८ असार २० गते तदनुसार जुलाई ४, २०११ मा प्रकाशित भएको हो)

धान खेती सम्बन्धी चलन चल्तीका केही ठेट नेपाली शब्दावलीहरू

संकलक

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नेपालीको जीवन पद्धति नै कृषिमुखी हो । यहाँका वासिन्दाको खेतीपाती नै दैनिकी हो । हाम्रो भेषभूषा, रहन सहन र राय रमाइलो मात्र हैन बोलीचालीको भाषा समेत कृषिसँग सम्बन्धित शब्दावली यति प्रयुक्त छन् कि तिनी बिना हामी अधुरा हुन्छौं । समयले कोल्टे फेर्दै गर्दा कृषि सम्बन्धी ठेट शब्दावलीहरू नयाँ पिँढीले बिर्सने सम्भावना बढेकाले केही नेपाली जनजिब्रोमा प्रचलित कृषि र अझ विशेषगरी धान खेतीसँग सम्बन्धित शब्दहरू समावेश गराउने जमर्को गरिएको छ । यी शब्दावलीहरू थपिँदै जाने छन् र परिमार्जित पनि हुँदै जाने छन् भन्ने अपेक्षा गरिएको छ । यी शब्दहरू पूर्ण नहुन सक्छन् । तसर्थ, यिनको सुधार एवम् परिमार्जन आगामी दिनहरूमा विद्वान वर्गबाट हुँदैजाने छ। पाठकको जानकारीको लागि यहाँ धानसँग सम्बन्धित केही ठेट नेपाली शब्दाबलीहरू दिइएको छः

अगहनी : मंसिरमा फल्ने वा हुने (मार्सी आदि धान वा अरू अन्न) बाली

अगेनो : मझेरीमा ओछ्यानका छेउमा आगो बाल्न बनाइएको स्थायी अग्निकुण्ड

अगौटे : छिट्टै पाक्ने धान/बाली

अनरसा : चामलको पिठो, घ्यू, चिनी ठिक्क मात्रामा मिलाई मुछेर तिल वा बिरौंका दानामा पथारी घ्यूमा पकाइएको पुरीजस्तो गोल आकारको नेपाली रोटी, अर्नसा, चिनीरोटी

अनौ : खेतबारी जोत्नाका लागि प्रयोग गरिने, हलीले हातद्वारा समात्ने र त्यसै आधारमा हलोलाई निश्चित दिशामा जोत्ने गरी चलाइने हलाको हातो वा मुठ

अम्खोरा : बिट फर्की मुख केही सानो भएको पेट फुकेको, पानी खाने भाँडो, आम्खोरा

अर्चाप्ने : आरनमा लगेर औजारहरू धारिलो बनाउने काम

अर्नी : दिउसो खाइने खानेकुरा, खाजा, दोपहरे

आग्लो : काठ/फलामको दुइवटा ढोका थुन्ने डन्डी

अधियाँ : जग्गा-जमिनमा हुने उब्जा मोही र तल्सिङमा आधा-आधा गरी बाँड्ने चलन, बटैयादारी

अक्षता : चामलका सग्ला गेडा, देवपितृ-कार्यमा चढाउन, पूजा गर्न वा टीका लगाउन प्रयोग गरिने चामलका भिजाइएका गेडा, जोखना आदिमा प्रयोग गरिने चामलका गेडा, अछेता

आरन : फलाम पोल्ने अगेनु, फलाम पोल्ने आगाको भट्टी

अर्सा : खुदोमा वा चिनीको रसमा पिठो मुछेर पातलो गरी बेलेर घ्यूमा पकाइएको रोटी विशेष

आरी/कोशी : अचार बनाउने वा अचार हाल्ने काममा आउने काठ, माटो आदिको सानो भिउँट, बिट नफर्किएको काठ वा माटाको फराकिलो भाँड

आली काटिदिने : पानी चोरेको खेतको आली पानी चोरे बापत मुख्य पालो वालाले भत्काइदिने दण्डित गर्ने कार्य

आली लगाउने : आली तासेर ठिक्क पारेको वा सम्बन्धित लाठेले हिलोबाट प्रत्येक डिलमा पानी नजाने गरी हिलोले डिल लगाउने काम

इत्ला तास्ने : खेत रोप्ने दिन पानी लगाएर हिल्याएको गह्रामा छेउपट्टिको आली पातलोसँग कोदालीले सफा गरी आली लगाउन योग्य बनाउने कार्य

ऐंचोपैंचो : खाँचो भएको अन्नपात वा अन्य वस्तु पैंचो दिने र पैंचो लिने काम

ओखल : चिउरा, धान आदि कुट्न खोपिल्टो पानी बनाइएको काठ वा ढुङ्गाको साधन

कटेरो : गाईवस्तु बाँध्ने ठाउँ, गोठ, ग्वाली

कनिका : काटिएको चामलका मसिना टुक्रा

करुवा : पेट फुकी घाँटी सानो भएर मुखमा छाताजस्तो भई बिट फर्केको, पेटको माथिल्लो भागमा ठाडो टुटी लागेको पानीको भाँडो, हलोलाई स्थिर गर्ने फलामको सि आकारको पिन

कसार : विवाह, व्रतबन्ध आदि शुभ कार्यमा खट्टेको पीठो र खुदो मुछी मुठीले बटारेर बनाइएको लड्डु

कसौंडी : मुख केही सानो भएको र पेट फुकेको, दालभात आदि पकाइने, काँसको वा कुनै धातुको भाँडो, कसुणी

काट्टो : मरेका एघारौं दिनमा मृतकका उद्देश्यले खुवाइने भोजन तथा दान गरिने वस्तु

कान्लो : खेत, बारी आदिको वरिपरिको अग्लो डिल, पाटाको डिल, माटाको ढिस्कुरो, काँल्लो

कुट : गाईवस्तुलाई खुवाउन टुक्रा पारी काटेको घाँस-पराल

कुटो : फूलबारी, करेसाबारी आदिमा गोडमेल गर्दा प्रयोग गरिने कोदालाका आकारको हलुका सानो फलामे हतियार

कुना खन्ने : जसरी गराको छेउ खनिन्छ त्यसरीनै कुनापट्टी खन्ने कार्य

कुनिउँ फोर्ने : धान झाँट्ने बेलामा कुनियोको टुप्पोबाट धानका मुठा निकाली धान झाँट्ने कामको सुरुवात गर्ने काम

कुनिउँ लगाउने : धानका धेरै बिटा एकठाउँमा जम्मा गरी बनाएको धान पराल सहितको थुप्रो

कुराउनी : धेरै बेर दूध तताएर बाक्लो पारी बनाइएको खाने कुरा, खुवा, कुरौनी

कुले गह्रो : खेतको सबभन्दा माथिल्लो गर्हो जहाँबाट कुलो लगिन्छ र साथ साथै खेत पनि रोपिन्छ

कुलो सोहोर्ने : खेत रोप्नु भन्दा पहिले खेतमा पानी पट्याउने कुलो गाउँले मिली सफा गर्ने सामुहिक काम

कोठो : मान्द्रो/गुन्द्रीबाट बनाइएको धान राख्ने सानो भकारी

कोदाली : छोटो बिंड र चाक्लो पाता भएको दुवै हातले समाई खेतबारी खन्ने फलामे हतियार

कोदालो : लामो काठको बिंड र लाम्चो पातो हुने, खेतबारी खन्ने काममा प्रयोग गरिने फलामे हतियार

कोरली : बहर वा साँढेसँग नमिसिएकी, तरुनी (गाई)

खट्टे/मुर्ही : विशेष किसिमको धानलाई भिजाएर हाँडी/कराइमा भुटेर फुल उठाई तयार गरिएको बनि बनाउ सुख्खा परीकार जसलाई मासु, तरकारीसँग भोज भतेर वा खाजाको रूपमा चिउरा जस्तै खाने गरिन्छ

खट्टे : हाँडीमा चामल भुटेको खानेकुरो

खडेरी : खेतीपाती गर्ने वर्षायाममा वा पानी पर्नुपर्ने समयमा पानी नपरी सुक्खा लागेको अवस्था, लामो समयदेखि पानी नपरेको अवस्था, सुक्खा, अनावृष्टि

खन्चुवा : धेरै खाने स्वभावको, खाइरहन खोज्ने, खन्चुरो

खरुहन : एक डेढ महिनाको धानको गाँजबाट धानको सरा च्याती साउन/भदौतिर खोलाले बगाएको खेत पुनः रोप्दा त्यसरी च्यातेको सरा रोप्ने कार्य

खरेटो : मसिना पात हुने, डाँठबाट बढार-कढाँर गर्न कुचोको काम लिइने एक जातको बटुने

खलो : काटेर, टिपेर वा उखेलेर ल्याइएका डाँठसहितका अन्न थुपार्न, माड्न, चुट्न वा दाइँ गर्न खेतबारीको कुनै भागलाई

ताछतुछ पारेर लिपेर सफा बनाइएको ठाउँ

खलियान : खलाहरूको समूह

खले गह्रो : खलो बनाउने गह्रो

खलो खुर्किने : धान थन्क्याउन गह्रामा सफा र लिपपोत गरी बनाएको क्षेत्र

खलो पोत्ने : खलो बनाएपछि धान राम्रोसँग जतन होस् भनी गाईको गोबर र चिम्ट्याइलो माटोले पोतेको स्थान

खहरे : वर्षा याममा मात्र भेल आउने सानोतिनो खालो खोल्सा

खावा : किल्ला, सहर आदिको सुरक्षाका निमित्त हाता वरिपरि खनेर बनाइएको जलपूर्ण खाडल, खाई

खिर : दूधमा पकाइएको भात, दूधमा चामल, चिनी, मसला आदि हाली पकाइएको स्वादिष्ठ खाद्य पदार्थ, पायस, तस्मै

खुदो : बाक्लो लस्सादार लेदो हुने गरी पकाइएको उखुको रस

खुरमुनिको धान: दाइँ गरेपछिको केही माटो सहितको सफा गर्नु पर्ने धान

खुर्पा : हँसियाभन्दा ठूलो फलामे काट्नको लागि प्रयोग गर्ने औजार

खुर्पी : सानो गोडमेल गर्ने फलामे औजार

खेत बिराउने : खोलाले बगेको स्थान छोडेपछि उक्त स्थानमा गह्रा बनाई खेत रोप्ने काम

खेत लग्यो : धेरै पानी/पहिरो आएर खेत बगाउनु

खेतालो : ज्याला लिएर खेत, बारीमा काम गर्ने व्यक्ति, पारिश्रमिक लिएर अर्काको काम सघाउने व्यक्ति, ज्यालादार

खेदुवा : खेदिएको, लखेटिएको

खोरिया : बाली लगाउनाका लागि रूख, बुटा आदि काटी, फाँडी प्रायः डढेलोसमेत लगाएर बिराएको जमिन, पाखाभित्ताको बाँझो जग्गा, भस्मे, लोहोसे

खोरेत : गाईवस्तुको खुर र मुखभित्र खटिरा आउने एक प्रकारको रोग, खोरैंत, खोर

खोला खेत : बाह्रै मास प्राय पानी पट्याउन मिल्ने खोला नजिकको सबभन्दा उर्बर खेत

खोले : पिठो, कनिका आदिमा साग-सिस्नु मिसाई पकाइएको लेदो खाद्य पदार्थ, गरिब-गुरुवाहरूको निम्न स्तरको भोजन

गाँजिनु : कनै बोटबिरुवा हाँगाबिँगाले युक्त हुनु, झाडिनु, झाम्टिनु, मौलाउनु, फैलिनु

गरालो : तगारो बन्द गर्न दुइतिरको तगारोमा छिराउने काठ

गर्भे हिलो : धान रोपे पछि जमेको हिलो

गरो : पानी जमाएर धान रोप्न डिलमा आली लगाई बनाइने खेतका अलग-अलग भाग, फोगटो

गाँस : एकपल्टमा मुखमा हाली खाइने खानेकुराको परिमाण, गप्फा

गाँज : धान, कोदो, घाँस आदिको फेददेखि पलाएको एउटै बुटो, झाङ्गिन सकेजति समूह

गाड कुलो : बाह्रै मास ठूलो पानी आउने कुलो

गुन्द्री बुन्न/ढकिया बुन्ने/सिखा बुन्ने : धानको दाइँ गर्नुभन्दा पहिले धान झाँटी लामो नल हुने धान जस्तै अनदी र मसिनोको पराल जुन गुन्द्री, ढकिया, सिखा आदि बुन्ने काममा प्रयोग गरिन्छ

गुन्द्री : पराल, पाट वा बाबियाका डोरीहरूको तान लगाई गुँद, पराल आदिबाट बुनेको सुकुल जस्तो ओछ्याउने

गैह्री खेत : खोला खेत तर खेतमा पानीको मूल भएको र सँधैभरी पानी भै रहने, धान खेतीमात्र हुने खेत

गोठ सार्ने : हिउँदमा गाई-वस्तुलाई बारीमा अस्थायी गोठ बनाइ बारी मोल्न सार्ने प्रक्रिया

गोठ : पराल, खर, स्याउला आदिले छाएको गाई-वस्तु राख्ने वा बाँध्ने घर, ठूलो कटेरो, गोशाला

गोठाला : गोठको काम गर्ने मानिस र खेतीमा काम गर्ने ज्यामी, साधारण श्रमिकवर्ग

गोरु धपाउने : दाइँ गर्न खलोमा बाँधिएका गोरुहरूको समूहलाई खलामा घुमाउने काम

गोरु नुहाउने : मैझारोपछि गोरुलाई यस वर्ष हिलोमा काम सकियो भनि धानको बेर्नाले हिलो धोई सफा गरिदिएको

गौरेटो : घरको ढोकाभित्र पसेपछि एउटा टाँड बनाई माथि पानीका गाग्री/घैंटो राख्ने, तलतिर चुलो पोत्ने माटो, गोबर र तेस्तै कुड़ो आदि पकाउने भाडा वर्तन राख्ने ठाउँ

घुन/पुत्ला : धानको भण्डारणमा लाग्ने किरा

घैया बारी : बैसाख/जेठमा सुख्खा बारीमा/टारमा छरुवा खेतीको रूपमा गरिने धान खेती

घ्याम्पो : अन्न राख्ने वा बिहा आदि कार्यमा पानी भरेर राख्ने माटो, पित्तल, तामा आदिको ठूलो गाग्रो, बिर्को लगाउन हुने धातुको ठूलो भाँडो

चामल फल्ने : वर्षा याममा भण्डारण गरेको चामल चिलिसा पर्ने हुँदा भात पकाउनुभन्दा पहिले ढिकीमा सुस्तसँग कुटी चिलिसा हटाउने काम

चामलबाट बन्ने विभिन्न परिकारहरू : कसार, फिनी, अर्सा, अनरसा, झिलिंगा, भुजा, लड्डु, आदि

चिउरा : धान भिजाएर हाँडी/कराइमा भुटेर ढिकी/मसिनमा कुटी तयार गरेको पातलो चेप्टो तयारी सुक्खा परिकार जसलाई मासु, तरकारीसँग खट्टे/मुर्ही जस्तै भोज वा खाजाको रूपमा खाने गरिन्छ

चुल्हो/चौको : अगेनोभन्दा माथिल्लो भाग जुन शुद्ध हुन्छ र दाल भात पकाउने गरिन्छ, भान्सामा प्रत्येक व्यक्तिलाई बस्ने स्थानलाई चौको भनिन्छ । चौकोमा पञ्चायान देवताको पूजा गर्ने स्थान

चुहाने गह्रो : सबभन्दा पुछारको खेतको गह्रो

चोइली : भात पस्किदा पनियोले काढी थालमा दिने भातको डल्लो

चोया काढ्ने : धानको मुठा बाँध्ने र बिटा बाँध्ने कामको लागि बासको पातलो बाँध्न योग्य बाहिर पट्टिको नरम ३–४ फिट लामो, १–२ से.मी. चौडा भाग

चौलानी : चामललाई पखालेर निकालेको पानी

छत्री : चोयाद्वारा आँखै-आँखा पारेर बुनेको छाताको आकार जस्तो चित्रामा भोर्ला, साल, नेभारो आदिका पात छापिएको ओढो, बाटुलो घुम, छत्तरी

छापो : छोपिएको स्थिति, ढाकिएको अवस्था, छोप्ने काम

जग्गे : व्रतबन्ध, विवाह, पुराण वा कुनै यज्ञयागादिका लागि तयार गरिएको वेदी, यज्ञमण्डप

जन्ती पर्सिने : जन्तीलाई दुलही पट्टिकाले दुलहीको घरमा जन्ती पुगेपछि फूल अक्षताले हिर्काइ स्वागत गर्ने परम्परा

जन्ते बाखो : जन्तीले दुलही भित्र्याउनु पहिले भतेर खाँदा तरकारीको रूपमा खाने खसी/बोका

जरुवा : नसुमरिएको गोरु/खहरे खोलाको मूल

जाँतो : ढुङ्गा कोत्रेर दाँत निकालको एक फग्लेँटो (पोथी फग्लेँटो) तल राखी त्यसको बीचमा माने जडी त्यसै गरी कोत्रेर दाँत निकालिएको अर्को फग्लेंटो (भाले फग्लेँटो) को बीच प्वालमा तल्लो फग्लेँटोको माने घुसारी दुवै फग्लटाँलाई खप्टाई मानेको प्वालबाट अन्नको घान छिराई माथिल्लो फग्लेँटोको एका छेउको डोबमा जडिएको हातो पक्री सो फग्लेँटोलाई घुमाई दुई फग्लेँटाका सङ्घर्षबाट अन्न पिँध्ने एक ढुङ्गे यन्त्र

जाउलो : चामलमा नुन मिसाई धेरै पानी हालेर पकाएको गिलो भात, जाउली

जुठेल्नो : घरको बाहिर पट्टि प्राय आँगनको छेउमा रहेको भाडा माझ्ने ठाउँ

जुरी बाध्ने : कुनियो गोलाकार घरजस्तो बनाई टुप्पोमा पानी परे पनि भित्र नपस्ने गरी बनाइएको गजुर आकारको टुप्पो

जुवा : गोरु वा राँगा नार्दा दुवैका काँधमा राखेर जोतारुले बाँधिने दुई वा चारवटा सोइला भएको काठ

जोतारो : जुवाका सोइलामा बाँधेर गोरुका गलामा बाँध्ने डोरी, जोती

झारा जान : सामुहिक काम गर्न प्रत्येक परिवारबाट दिने श्रमदान जस्तै बाँध बाध्ने, कुलो खन्ने आदि

झिलियाँ : झाँझरबाट लेदो पिठो चुहाएर घाममा सुकाइपछि घ्यूतेलमा फुकाउन मिल्ने गरी बनाइएको खाद्य वस्तु, झिनियाँ

टपरी : बाँसको सिन्काले गाँसेर बिट उठाई बनाइएको, साल आदिका पातको थालजस्तो भाँडो, पत्तल, ठहर

ट्वांटा : पुराना भाँडा वर्तन मर्मत गर्ने स्थानीय कालिगढ

टाँड : काठ/बाँसबाट बनेको भाँडा कुँडा राख्ने वा सुत्न बनाइएको मचान

टाट्नो : बाख्रा, पाडा आदिलाई घाँस खुवाउन लहरै घोचा गाडी बनाइएको टाँड, टाट्नु

टारी/पाखा खेत: वर्षाको पानीको भरमा रोपाइँ गर्ने खेत/यस्ता खेतमा वर्षायाममा मात्र पानी लगाउने कुला/पैनी हुन्छ

टौवा : गाह्रो नलगाई थाम र दलिनहरू मात्र हालेर बनाइएको हावादारी घर, अग्लो मचान

ठाँटी : बटुवाहरूलाई विश्राम लिन र आराम गर्नका निम्ति बाटाघाटामा बनाइएको चिटिक्क परेको पाटी, पौवा मचान

ठेडी : हरिषको टुप्पो र फेद, अनौको ह्यान्डलमा जडान गरिएको काठको सानो ४–५ इन्च लामो डण्डी

डकर्मी : घर बनाउँदा माटो, बज्र, सिमेन्ट आदिले जोडी ढुङ्गा, इँट आदिको गारो लगाउने मानिस

डाँडो : पराल वा खरले घर छाउँदा हालिने ठाडो काठ, छानाको मुसी

डालो : निगाला आदिका चोयाले बुनेको, अन्नपात हाल्ने, फराक मुख भएको केही गहिरो भाँडो

डिङ्गो : जवान अवस्थाको गाई वा गोरु, वस्तुभाउ

डुँड : पानी ल्याउन वा पठाउनका निम्ति हालिने ढुङ्ग्रोजस्तो वा करलेसोका ढाँचाको माटो, टिन, भाटा आदिको कोप्रो पारिएको वस्तु

डेहरी : धान राख्न बनाएको माटोले पोतेको तराईतिरको प्रचलन

डोको : बाँस, निगाला आदिका चोयाले बुनेको, ठूलठूला आँखा वा प्वाल हुने, मालताल हाली नाम्लो वा खकन समेत लगाएर पिठिउँमा बोकिने सोलीजस्तो भाँडो

डोरी : बुन्ने, बाँध्ने आदि काम लिइने कपास, ऊन, पाट आदिको बाटिएको वा बटारिएको तन्तु, धागो, सूत

ढकने : चामल घ्यूमा भुटेर दूधमा पकाई चिनीसमेत हालेर तयार पारिएको स्वादिष्ट खानेकुरा

ढाप : पानी नसुक्ने खालको जमिन, थलथले सिम, धाप

ढिकी : प्वाल पारेका दुइटा खाँबा गाडी त्यसका बीचमा आग्लो हाली अडचाएर तेर्स्याइएको छ फिटजति लामो र अगाडि (टाउका) पट्टि एक फिटजति वर मुस्ली जोडिएको तथा पछाडि (पुच्छर) पट्टि एक फिटजति छोडिएको भागमा उभिएर खुट्टाले थिचेर उचाल्दै-छोड्दै गरी धान, चिउरा आदि अन्न कुट्ने काठको चारपाटे यन्त्र विशेष

तगारो : गाई/वस्तु नपसुन् भनी बनाएको छेको

तरेखु : होम गरेको डढेको चामल बाट तयार गरिएको घ्यूसँग मोलेर लगाउने कालो टीका

तसला : तामा, पित्तल वा अन्य धातुको पातलो पाताले बनेको ठूलो मुख भएको पकाउने भाँडो

ताउलो : तामा/पित्तलको फराकिलो मुख भएको धेरै मान्छेलाई दाल भात पकाउने दुईतिर समाउने र काठ छिराएर उतार्न सकिने भाँडो

तान : गुन्द्री बुन्ने डोरी, हत्तासो र धानको डाँठको सहायताले गुन्द्री बुन्ने स्थानीय मेसिन

ताई : तामा/फलामको रोटी पकाउने भाँडो

भुजुङ्गो : तामो, पित्तल आदि धातुको बाटाका आकारमा बनेको केही ठाडो तर बिट नफर्केको पकाउने भाँडो

तोरण : विवाह, उत्सव आदि सम्पन्न हुने ठाउँमा घुमाउरो पारी फूल, रङ्गिन कपडा आदिबाट बनाइने शोभाद्वार, सिंहद्वार, प्रवेशद्वार, बहिर्द्वार

थारो : बच्चा जन्माउन असमर्थ (भैंसी, गाई इत्यादि), धान/पराल राख्ने कटेरो

थाल : फराक भुइँ भई अलिकति बिट उठेको गोलाकार वा चारपाटे भाँडो, थलिया, थाली

थुन्से : प्रायः पहाडखण्डमा चिजबीजहरू पिठचूँमा बोक्न प्रयोग गरिने, बाँस वा निगालाका चोयाले बुनिएको कतै पनि आँखा वा प्वाल नभएको, डोकोजस्तै एक साधन

थैलो : कुनै पनि चिज राख्नका लागि एक भागमा खुला मुख राखी बाँकी भागमा बन्द गरी सिइएको कपडा आदिको भाँडो, झोला, नाम्जा

थोरे : भैंसीको जवान पाडी, ब्याउने बेला भएको तर नब्याएको पाडी

दयँरे : दाइँको लाठे खेतालो, दाइँ गर्दा पराल छिरल्ने र बिटा आदि पार्ने काम गर्ने ज्यामी, खेतालो, दहेँरे

दाँई गर्ने : खलामा मियोका वरिपरि गोरु घुमाई धान आदि अनाजका बोटहरू कुल्चाइ रहलपहल अनाज झार्ने काम

दाम्लो : वस्तु भाउलाई बाँध्ने पाट, छालाबाट बनाइएको गलामा बाँध्ने डोरी

दूध पसेको : धानको दानामा दूध लागेको

दुना : दुईटा पात दोब्र्याएर बाँसका सिन्काले खुटी कचौरा जस्तो बनाइएको भाँडो, पातको कचौरा

दुहुनो : दूध दिने, लैनो (गाई, भैंसी आदि)

धन्सार : धान राखिने घर, ढुकुटी

धर्म भकारी : गाउँमा सबै घरबाट गच्छे अनुसार भोकमरि र त्यस्तै भवितव्यमा प्रयोग गर्ने गरी साझा रूपमा जम्मा गरिराखिएको धान

धाँजा : चिम्टयाहा माटो भएको जमिन सुकेर चरचरी चिरिएको ठाउँ, धरातल चर्किंदा बनेको छिद्र

धान चुट्ने/झाँटने/ठटाउने : खलोमा ल्याएको धान केही समय कुनियोमा राखेपछि उक्त धानबाट पराल छुट्याउने काम, खेतालाले कुनियोबाट प्रत्येक मुठालाई फेदमा समाती बालातिर ढुङ्गो वो काठमा पिट्ने कार्य गरी धान पराल छुट्टयाउने काम र यो काम दाइँ गर्ने दिनमा पनि गरिन्छ, दाइँभन्दा पहिले पनि गरिन्छ

धान बत्ताउने : चुटेको धानलाई हावामा फाली नाङ्लाले सफा गर्ने काम

धामी : भूत, प्रेत, बोक्सी, डाइनी, लागो आदिको आशङ्कामा सो रोग निको गराउन शरीरमा देवीदेउता वा भूत प्रेत आदिको प्रवेश गराएर तन्त्रमन्त्र प्रयोग गरी झारफुक गर्ने व्यक्ति, झाक्री

धुले ब्याड : राम्रोसँग खन जोत गरी मल राखी धुलो पारेर धानको बीउ बाक्लोसँग नर्सरी ब्याडमा खसाल्ने, यस तरिकाबाट बीउ खसाल्दा जमिन राम्रोसँग भिजेको हुनु पर्छ

नाङ्लो : बाँसका चोयाबाट बुनेर गोलाकार रूपमा बिट राखी बनाइएको, ठूलो थालजस्तो, अनाजहरू निफन्ने साधन, सुपो

नाम्लो : पिठ्युमा भारी अडयाएर बोक्नाका निम्ति पाट, चोया, छाला आदिबाट बनेको थाप्लोमा लाउने चेप्टो पातो भएको एक प्रकारको डोरी, चेप्टो पातो भएको डोरी थाप्लोमा अड्याई पिठ्युमा भारी बोक्ने साधन

नारा : हलाको हरिसमा जुवा झुन्ड्याइने छालाको डोरी, हल्लुँड

निहिन : काटेपछि खेतमा नलसितै पातलो गरी फिँजाएर सुकाइएको धान

न्वागी : हरेक वर्ष नयाँ धान बाली पाकेपछि काँचो चामल र दही, केरा आदि एकै ठाउँ मिलाई मुछेर देवता तथा पितृहरूलाई चढाई पछि आफूले खाइने दही-चामल, नवान्न-प्राशनको वस्तु, न्वागी

पँधेरो : पानी भर्ने सार्बजनिक कुवा/धारो

पंचभलाद्मी : खेत र पानी सम्बन्धी विवाद मिलाउने गाउँका भद्र व्यक्तिहरू

पतर्सिएको : रोपो एकदम राम्रो तर राम्रोसँग नफलेको अवस्था

पयो/डोरी : गुन्द्री बुन्न पटुवाबाट तयार गरेको डोरी वा बाबियोबाट बेनेको डोरी

पर्म : आफू-आफूमा आलोपालो गरी एकले अर्काको काम गरिदिने चलन, परेली, पालो, बोझे

पसेरी : पाँच सेरको तौल, पाँच सेरको ढक

पाँजा सुकाउने : धान काटेर खेतमा प्रत्येक मुठी पातलोसँग सुकाउने काम

खोक/पाटा लगाउने : हिल्याएको खेतमा हिलो सम्याउन काठको मुढोमा बसी फँड्याउने काम

पाथी : आठ माना अटाउने भर्ने भाँडो, आठ मानाको परिमाणको वस्तु अटाउने नाप्ने भाँडो

पाथी (चुल्ठो) : विवाह गरेर भित्र्याएकी बुहारीलाई सासु बुहारीको चुल्ठो जोडी एकपाथी चामल टाउकाबाट खन्याउने काम

पानी चोर्ने : अर्काको पालोको पानी आफ्नो खेतमा लुकी/छिपी लगाउने काम

पानी मार्ने : कुलोबाट आफ्नो खेतमा पानी बन्द गर्ने काम

पानी सोझ्याउने : कुलोबाट आफ्नो खेतमा पानी लगाउने काम वा आफ्नो पालोमा खेतमा पानी लगाउने काम

पिँढी : बस्न र केही राख्न हुने गरी गाराको सट्टा थामहरू हाली बनाइएको, घरको गाराबाहिरको भाग, दलान, पिँडी

पिठो कुट्ने : रोटी बनाउन भिजाएको चामल ढिकीमा/जातोमा पिनी मसिनो गर्ने काम

पैंचो : जसरी ल्याएको हो उसैगरी तिर्ने कार्य जस्तैः व्यक्ति आएको भए व्यक्ति र जिन्सी आएको भए जिन्सी तिर्ने कार्य

पोगटो : भित्र खाली भएर वा सुकेर स्याप्प परेको धान, भित्र चामल नभएको सेप्रो धान, फोस्रो धान, पगटो

पोटाएको : धान फूल फुल्ने अवस्थामा भएको

पोतारी : गोबर र माटो मिलाई चुलो, दैलो, मझेरी आदि पोत्न राखेको भाँडो

फाली : हलाका टुप्पापट्टि जडिने फलामको तिखो अवयव, फाल

फिनी : नचिरेको पन्जाफीजस्तो एक प्रकारको बाटुलो रोटी

फोगटो : सानो आँठो वा आली लगाई बनाइएको, खेतको सानो गरो/गोरु जोत्न नमिल्ने, फगटो

बकेर्नो : दूध थाक्ने बेला भएको दुहुनो (गाईभैंसी)

बगर खेत : नदीका दायाँबायाँ रहेको बलौटे जमिन, बलौटे वा ढुङ्गे जमिन

बटुको : वृत्ताकार घेरो र मुख भएको कचौरो

बलो : छानाको दाँतीमाथि बीचमा र धुरीमा रहने लामो काठ, धुरी अड्याउने तेर्सो काठ

बहर : नसुमेको गोरु, नडामेको बाछो

बाँझो मार्ने : खेत रोप्नुभन्दा पहिले गत वर्ष धान काटे पछिको बाँझो जमिन जोत्नु

बाँध बाध्ने : कुलोको मुहान खोलाले बगाएको/भत्काएको अवस्थामा उक्त कुलोबाट सिँचाइ गर्ने सबै किसानहरू मिली बाँध मर्मत गर्ने काम

बाँध : खोलाले खेत बगाउनबाट रोक्ने ढुंगाको पर्खाल

बाउसे गर्ने : खेतको हिलो सम्याउने काम गर्ने पुरूष

बाता काढ्ने : बाँसको चोया जस्तै तर एउटाबाट दुइटा चोया निकाल्न हुने बाँसको भाग

बाता भिजाउने : पुराना बाता भएमा नरम बनाउन पानीमा भिजाउने काम

बान्नो/पर्खाल : खेत/बारीमा गाई/वस्तुले नोक्सान नगरुन् भनी बनाएको ढुंगाको बन्देज

बार बन्देज : खेत/बारीमा गाई/वस्तुले नोक्सान नगरुन् भनी बनाएको वनस्पतिको बन्देज

बासिबिदो : निकै दिनसम्म लगातार पानी बर्सिएर बीचमा एक रात रहेको पानीको अडान

बिट मार्ने : गुन्द्री बुनेपछि अन्त्यमा टुङग्याउने कार्य ।

बिटा बाँध्ने : प्रत्येक मुठालाई एकजनाले बोक्न सक्ने गरी बनाएको भारी

बिटा बोक्ने : बाँधिएका बिटा बोकेर खलोमा पुऱ्याउने काम

बियाँ : चामलमा बाँकी रहेका नकुटिएका केही धानहरू

बिरौटो : बिराएको जग्गा, नयाँ आबाद गरिएको जग्गा

बिस्कुन : घाममा सुकाउनका निम्ति पाँजिएको वा फिँजारिएको अन्न

बीउ थन्क्याउने : बल्याएको धान बीउको लागि छुट्टै थन्क्याउने प्रक्रिया

बीउ बल्याउने : बीउको लागि जातीय शुद्धता कायम गरी बीउको लागि छान्ने प्रक्रिया

बीउ/दल राख्ने : धान रोप्नुभन्दा करिब १ महिना पहिले धानको नर्सरी राख्ने प्रक्रिया

बुटा टिप्ने : धान रोपिसकेपछि पहिलो पटक झार हटाउने/टिपेर फाल्ने काम

बुर्की : मुर्दा घाटमा लैजाँदा बाटामा छरिने वा शवका छातीमा राखिने धान, लावा, चामल आदि

वेदी : होम गर्ने कुण्ड

बैद्य : आयुर्वेदिक डाक्टर

बोहोतो : सालका हरिया पात सिन्काले खुटेर गाँसिने, चार कुना परेको वा बाटुलो ठूलो दुनु, बोता

ब्याड/दल राख्ने : हिले र धुले ब्याडमा धानको बीउ राख्ने प्रक्रिया

भकारी भर्ने : सफा गरेको धान खलाबाट घरको/धन्सारको भकारीमा थन्क्याउने काम

भकारी : बाँस, निगालो आदिका चोयाले मान्द्रोजस्तो पारेर बुनेको अन्न राख्ने ठूलो भाँडा

भतुवा : कामकाज नगरी खाएर मात्र बस्ने, भातमारा

भतेर : निम्तारु अथवा अन्य धेरै मान्छेलाई खान तयार गरिएको भातभान्सा

भत्खेरु : बिहेमा जन्तीको खबर लिएर दुलहीका घरमा जाने दुलहा तर्फको मानिस, वर यात्रीको अग्रदूत, भत्खरु, भत्खौरे

भदैया : भदौमा पाक्ने धानको एक जात, घैया

भल छोप्ने : टारी खेत रोप्न भल आएको समयमा खेत रोप्ने कार्य

भल : आकाशबाट पानी पर्दा वा बाढी आउँदा पाखामा बगेको पानीको प्रवाह

भाटा : काठका मसिना डण्डी, जसले डाँडा र खरसँग संयोजन गरी घर/गोठ छाउने काममा प्रयोग हुने लट्ठी

भातमारा : अर्काका घरमा लाजै पचाएर बस्ने र बिनाकामै भात मात्र खाने

भाते : कुनै काम, इलम नगरी बसेर मात्र खाने, भातमारा

भान्सा : दालभात, तरकारी आदि भोजन बनाउने वा पकाउने ठाउँ, भान्साको कोठो वा घर, भान्छा

भार : दाउरा, बिस्कुन आदि सुकाउन अगेनामाथि बनाएको टाँड, चाङ

भुस : धान, गहुँ, कोदो आदि अन्न काटेर वा पिँधेर केलाउँदा बोक्राका रूपमा आउने खोस्टा

भ्वाङ : कुनै वस्तु वा ठाउँमा फाटेर/चिरिएर परेको ठूलो प्वाल, ठूलो प्वाल वा दुलो

मझेरी : घरभित्र चुलो, ओछ्यान र कोठाका अतिरिक्त खाली छोडिएको बीचको ठाउँ, छिँडीको भुइँ, मझेरा, मजेरी

माँड पानी : धान रोपे पछि हिलो नबगाउने अवस्थामा पहिलो पटक खेतमा लगाएको पानी

माड : भात पकाउँदै गर्दा पाक्ने समयमा निस्कने बाक्लो लेदो

माना : दस मुठी बराबरको अनाज आदि भर्ने भाँडो, मानु

मानी : घट्टको माथिल्लो तथा जाँतोको तल्लो फग्लेँटोको प्वालमा राखिने र घुम्न सजिलो पार्ने काठ, फलाम आदिको डन्डी, माने

मान्द्रो : बासँको चोयाबाट चित्रो बने झैं चल्ठमेसो पारी बुनिने तर चित्रोमेसोमा झैं एक-एक पात नटिपी दुई-दुई पात टिपेर बुनिने, बिस्कुन सुकाउने, कठघरामा ओछ्याउने आदि काम लिइने वस्तु

माल पुवा/अपुंगो : गुलियो पदार्थ र मसलाहरू हाली घ्यूमा पकाइएको, गहुँको थेप्चो बाटुलो आकारको रोटी विशेष

माल बाध्ने : दाइँ गर्दा गोरुको समूहलाई मियोमा बाध्ने दाम्लाको झुण्ड

मियो गाड्ने : धान चुटेर थन्क्याए पछि परालालाई दाइँ गर्न गोरुहरू लहरै बाध्न खलोको बीचमा गाडिएको सालको टुप्पोमा पातसहितको लिङ्गो

मुजुरी : मजदुरी, ज्यालाबनी

मुठा बाध्ने : पाँजा सुकाएर राखेको डाँठ सहितको धान दुई हातले झ्याउने गरी बाँधिएको मुठा

मुठी लिने : धान पाकेपछि शुभ दिन हेरी पहिलो पटक पूजागरी धान काट्ने कामको सुरुवात

मुरी : नापतौलको भराइका पद्धतिमा बीस पाथी अन्न आदिको परिमाण

मुसल : चिउरा आदि काट्ने काठको साधन, लुसी

मुहान सोझ्याउने : कुलोको मुहानबाट कुलोमा पानी लगाउने काम

मुहाने गह्रो : कुलोको पानी सबभन्दा पहिले लाग्ने खेतको गह्रो

मेलो : एउटा कामदारले दिनभरीमा खेतबारीमा गर्ने काम

मैझारो : कामको समाप्ति, टुङ्ग्याउने

याम : प्रचलित घडीका हिसाबले तीन घण्टा र पानी घडीका हिसाबले साढे सात घडीको समय, प्रहर

रेखी हाल्ने : धान चुटेर पिरामिड आकारमा बनाएको धानको रासलाई खरानीको घेरोले घेर्ने काम

रोपाइँ सुरु गर्ने : हिल्याएर, बाउसे गरेपछि सम्म भएको र हिलो प्रशस्त मात्रामा भएपछि रोपाहारले धानको बेर्ना एकनासले रोप्ने काम

रोपाहार : खेतमा धानको बीउ रोप्ने खेताला (प्रायः स्त्रीहरू)

रोपो : बीउ रोपेपछिको धान वा कोदोको गाँजे अवस्था

लट्टे/चाम्रे : भिजाएको अनदीको चामल पानी नहालीकन घ्यू वा तेलमा भुटेर खुदो आदि गुलियो मिसाई पकाएको खानेकुरो, चाम्रे, ढकनी

लाठे : रोपाइँमा कोदालीको काम गर्ने पुरुष खेताला

लावा : धान भुटेर तयार पारिने पूजा र मङ्गलकार्यमा समेत प्रयोग गरिने सेतो, हलुको खाद्य पदार्थ, लाजा

लिउन : गोबर, भुस आदिको अनुपात मिलाई घरको भित्तामा लेपिने पदार्थ

लिंडुल्को : जोतेको डल्ला फोर्ने र सम्म पार्ने काठको लाम्चो गिँड

लुँडी बाध्ने : धान कुट्दा बाहिर जाने धानलाई ओखल तिर ल्याउने काठको (४–५ फिट लामो) चोर ओंला जत्रो ब्यास भएको, टुप्पामा कपडाको सानो एक मुठी बराबरको पोको

लुँडो बाट्ने : परालको भारी बाध्न बनाइने परालको कच्ची लामो डोरी जस्तो

लैनो : भर्खर ब्याएको (गाइवस्तु)

लोटा : अम्खोरा जस्तै भाडो तर अंखोरा भन्दा होचो र थ्याच्च परेको पानी खाने भाँडो

लोटाउनु : गोबर आदिको डल्लो गुडाएर खाएका ठाउँको जुठो, फोहोर आदि सफा गर्नु, चोख्याउनु

विभिन्न प्रकारका यःमरी : नेवारी संस्कृतिमा आवश्यक पर्ने पिठोमा सक्खर, चिनी, तिल, चना आदि दालको पिठो र घ्यू आदि मिसाइ बन्ने रोटीहरू जस्तै यःमरी, चटामरी आदि

समाहा : खेतमा बढ्ता भएको पानी निकाल्ने निकास

सम्याउने : सायर (साहुने) काम सकेपछि उबड खावड भएको स्थानमा समथर पारी एकनासले पानी बग्ने बनाउने काम

साँध : जमिनका भिन्न-भिन्न टुक्रालाई छुट्ट्याउने दुई जमिनका बीचको भाग वा छेउ, भिन्न-भिन्न टुक्रा जमिनको सन्धिरेखा, सिमाना, सीमा

सह जान/नजाने : धान थन्क्याएपछि भकारी आदि भण्डारणमा धानको नोक्सानी नहोस् भनी गरिने कार्य जसबाट धानको सह रहोस्

साहने : हिल्याएको खेतमा पाटा लगाई हिलो बनाइ सडाउने काम

साहा : खेत हिल्याएपछि सम्याउने दाँदे जस्तो कृषि औजार

सिकर्मी : काठको चौकोस, झ्यालढोका र दराज आदि बनाउने कर्मी, काठको काम गर्ने कालिगढ

सिखा : घरको दलिनमा झुन्ड्याएको पराल/बाबियोले बनाएको कसौंडी, ताही आदिमा रोटी, भात आदि सुरक्षित राख्ने तरिका

सिरौंला : धान उसिनेर सुकाइसकेपछि भुटेर बनाइएको चामल

सुरो : होम गर्दा घ्यू हाल्ने काठको साधन र होम गरिने अन्न

सुक्खा लागेका : समयमा पानी नपरी धान उत्पादनमा ह्रास आउने अवस्था

सुर्को : खेतबारीको लाम्चो गह्रो

सुर्कासुर्की : सानातिना धेरै सुर्का

सेपिलो : कान्ला, रुख आदिका सेपले पहार लाग्न नपाउने, ओसिलो, सर्दी लाग्ने, चिसो

सेलरोटी/बाबर रोटी/गोरु रोटी : धानका चामलको पिठोमा दाउन र गुलियो मिलाई पानीमा ऱ्यालेर ताई आदिमा तातेको घ्यूतेलमा रिङ आकारको पारेर बनाइने रोटी, घुमाउने रोटी, जेब्रे

सोइला : गाडी वा हलामा लगाइने, गोरु वा राँगाका जुवामा ठोकिने काठको छोटाछोटा डन्डी

स्याखु : घामपानीमा ओढ्ने एक प्रकारको घुम

हँसिया : हातले बिँड समातेर घाँसपात आदि काट्ने, टुप्पासम्म घुमेको फलामे हतियार, आँसी

हतासो : गुन्द्री आदि बुन्ने हाते साँचो

हरिस : एक छेउमा हलो र अर्को छेउमा जुवा रहने हलाको ठाडो लामो काठ

हरूवा : खेतबारीमा हलो जोत्ने व्यक्ति

हरेलो गर्ने : खेत जोत्नुभन्दा पहिले कुनै विघ्न नपरोस् भनी किसानले सखारै खेतमा गएर गर्ने भूमिपूजा, धान रोपिसकेपछि रोपाइँ सिद्धिएको उपलक्ष्यमा तीजपछिको मङ्गलवारका दिन खेतमा गरिने कृषिका अधिष्ठाता देवताको पूजा

हल बाँध्ने : दुईवटा गोरुमध्ये एकाघरमा एउटा र अर्को घरमा अर्को गोरु गरी १ हल गोरुको जोडा मिलाउने

हली : खेतीकमाई गर्नका लागि हलो जोत्ने मानिस

हलो क्रान्ति : वि.सं. २००६ साल साउन ११ गते लम्जुङ्गे ब्राह्मणहरूले पहिलो पटक हलो जोतेको दिन

हलो : गोरु, राँगा आदिले तानेर खेतबारी जोत्ने फाली, अनौ, हरिस, जुवा र जोतारो भएको साधन, हल, हर

हस्किएको : गाँज लागेको तर नफलेको धान

हातो : जाँतो घुमाउन समातिने बिँड

हिले ब्याड : पानी लगाई जोती समथर बनाई हिलो पारी तयार गरेको हिले नर्सरी ब्याडमा धानको बीउ खसाल्ने

हिल्याउने : रोपाइँ गर्दा खेतको माटोमा पानी लगाई जोती वा खनी हिलो पार्नु बाउसे गर्नु, टाकुचे गर्नु

ह्रास ठड्याउने : धान चुटेपछी सफागरी पिरामिड आकारको थुप्रो बनाउने काम

Chapter II

(अध्याय २)

2. Technical Aspects of Rice in Nepal
(नेपालमा धानखेती सम्बन्धी प्राविधिक पक्ष)

Food and Nutrition Security
(खाद्य तथा पोषण सुरक्षा)

Green Revolution: Global Effects and Impacts in Nepal

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सारांश

हरित क्रान्ति सन् १९४० को दशकमा अमेरिकन कृषि शास्त्री डा. नर्मन बोर्लगले मेक्सिकोमा रोग प्रतिरोधक र बढी उत्पादन दिने गहुँ विकास गरी सुरु भएको कृषि क्रान्तिलाई भनिन्छ । यस कार्यमा कम उचाई भएको जापानिज गहुँको नोरिन-१० जिन ल्याई गहुँको उचाई कम गर्ने काम अन्तराष्ट्रिय गहुँ तथा मकै अनुसन्धान केन्द्र, मेक्सिकोमा गरिएको थियो । सन् १९५० को दशक पश्चात् यो कार्य अरू प्रमुख बालीहरू जस्तै धान र मकैमा पनि सुरु भयो । १९६२ मा इरि, फिलिपिन्समा आईआर-८ नामको चामत्कारिक धानको विकास पश्चात् धान बालीमा हरित क्रान्तिको चमत्कार संसारभरि फैलियो । फलस्वरूप, यी बालीहरूको उत्पादनमा उल्लेख्य वृद्धि भैं भोकमरी र कुपोषणले ग्रसित देशहरूको अवस्था सुध्रिन गै संसारलाई कुपोषण र भोकमरीबाट बचाएको हुनाले डा. बोर्लगलाई सन् १९७० मा नोबेल शान्ति पुरस्कार प्राप्त भयो । हरित क्रान्ति ठूला र धेरै कृषि उत्पादनका सामाग्री (रासायनिक मल, बिषादी, सिँचाइ, कृषि औजार र राम्रो जमिन) प्रयोग गर्न सक्ने किसानको पक्षमा भएको र साना तथा सिमान्त किसानको पक्षमा नभएको भनी आलोचना गरिएको छ । यसको अलावा हरित क्रान्तिले खाद्यान्न बालीका रैथाने तथा स्थानीय बालीको विनास पनि गरेको भनिएको छ । सन् १९६५-१९८५ सम्मलाई पहिलो हरित क्रान्ति र तत् पश्चातको २१ औं शताब्दिको अवधिलाई पहिलो हरित क्रान्तिको कमजोरी हटाई अविछिन्न राख्नु पर्ने राय वैज्ञानिकहरूको छ । नेपालमा पनि हरित क्रान्तिले धान, मकै र गहुँ बाली लगायत अन्य बालीमा उत्पादनमा वृद्धि भएको साथै रैथाने बालीमा ह्रास भएको वैज्ञानिकहरूको ठम्याई रहेको छ । साथै प्रस्तुत लेखमा हरित क्रान्तिले नेपालमा पारेको प्रभावबारे पनि संक्षिप्त उल्लेख गरिएको छ ।

Summary

Green revolution was initiated in Mexico during 1940s when a concept evolved there to increase production of major food crops-wheat, rice and maize. The contribution of green revolution goes to Dr. Norman E. Borlaug who was awarded the Nobel Peace Prize in 1970 for developing high yielding, disease resistant, short stature wheat varieties in CIMMYT, Mexico. Since 1960s onwards the impact of wheat varieties developed by Borlaug got disseminated across the world and quantum leap in green revolution began almost worldwide in major three staple crops of wheat, rice and maize. The short stature genes called *Norin-10* taken from Japanese wheat established that plant height and above ground yield is independent and short plant with robust stalk can withstand heavy panicle and grain weight. By incorporating *Norin-10* gene from Japanese wheat to wheat grown in Europe and America, there was tremendous yield increase in wheat developed in Mexico. As a result during green revolution period other varieties of major food crops were developed and disseminated through CGIARs in the world. In 1962, IRRI developed IR-8, a miraculous rice variety as the fame of green revolution. Green revolution is broadly classified into two parts: Green revolution first (1966-1985) and post green revolution period as the next two decades. Consequently, after green revolution, many food deficit countries became food sufficient and hunger and malnutrition in developing countries was reduced largely. Green revolution is not immune to criticisms in the sense that there was massive erosion of local land races of crops due to spread of uniform improved varieties across large geographical area, rural unemployment, and high inputs responsive varieties in favor of resource rich farmers. Nepal is also impacted by the green revolution because she adopted improved varieties of rice, maize and wheat and there was an upsurge in yield of these crops as well. This paper tries to explore pros and cons of green revolution by looking at evidences from literatures available in the subject.

Keywords: Green revolution, Hunger, Norman E Borlaug, Rice, Yield

Introduction

Green revolution was contributed by the dwarf gene available in short stature Japanese wheat variety Norin-10. The interest in breeding for shorter plants has actually begun before the onset of the green revolution, mainly to improve lodging tolerance. Most of the dwarf and semi-dwarf wheat lines from Europe have the Japanese variety Akakomugi among their ancestors (Borojevic et al 2005). The variety Akakomugi was the donor of the reduced height gene *Rht8* and the daylight-insensitive gene *Ppd-D1*, both genes are closely linked and located on chromosome 2D. Borojevic et al (2005) provided an interesting historical account of the transfer of *Rht8* from Japan to western wheat lines for genes *Rht-B1* and *Rht-D1* which also have a Japanese origin from the wheat variety Norin-10. Reduced height genes *Rht-B1* and *Rht-D1* were first transferred to US cultivars, then to CIMMYT lines and later to many other countries (Hedden 2003).

Green revolution has been classified in two parts; Green revolution first (1966-1985) and post green revolution period as the next two decades (Pingali 2012). The developed world had already adapted technology advances for the major staple crops- wheat, rice, and maize and during green revolution these countries advanced those technologies to developing countries (Hazell 2010). Many of the cultivars available at the beginning of the 'Green revolution' responded to the higher inputs of fertilizers by developing taller plants, prone to lodging and devoting a large proportion of assimilates that increased biomass instead of grain production. Consequently, the stem of taller plants could not support the grain weight obtained under newly introduced production practices. In 1944, Borlaug, a trained plant pathologist, left the US for Mexico to fight stem rust, a fungus that infects wheat. Borlaug and his colleagues spent the next decade crossing thousands of strains of wheat from across the globe, ultimately developing a high-yielding, disease resistant variety. Unfortunately, it couldn't stand, heavy with grain.

So, Borlaug crossed it again with Japanese dwarf wheat to produce so-called semi dwarf wheat, both shorter (and therefore not prone to tipping over with all the grain load at the tip) as well as disease resistant and amenable to fertilization and where the variety was planted, yields soared. By growing high yielding and input responsive wheat variety, Mexico became self-sufficient in grain. Then effect of green revolution was seen in India and Pakistan, where yields doubled (htpp://www.scientificamerican.com) in other cereals also. A green revolution was evident in the fields of Asia and helped combat fight against famine predictions. For this work of developing high yielding rust resistant wheat varieties that led to tremendous increase of crop production, NE Borlaug was offered Nobel Peace Prize in 1970 (htpp://www.nobelprize.org).

History of green revolution

Green revolution refers to the renovation of agricultural practices beginning in Mexico in the 1940s and because of its success in producing more agricultural products, its technologies spread worldwide in the 1950s and 1960s. As a result there was a significant increase in production per unit of land in agriculture (htpp://www.en.wikipedia.org). The beginnings of the green revolution are often attributed to Norman E. Borlaug, an American scientist, interested in agriculture. In the 1940s, Borlaug began research in Mexico and developed new disease resistance high-yield varieties of wheat. By combining Borlaug's wheat varieties with new mechanized agricultural technologies, Mexico was able to produce more wheat. As a result it became exporter of wheat by the 1960s. Prior to the use of these varieties, Mexico was wheat importer of almost half of its wheat requirement (http://www.geography.about.com). So, NE Borlaug is also known as the father of green revolution. Borlaug was very critical about food security of the world and he used to say, "Food is the moral right of all who are born into this world". From the unrest prevailed in the contemporary word Borlaug was seriously concerned and his famous saying about world peace was, "The world peace will not be built on empty stomachs and human misery." Because of such concepts, emphasis was given to increase food production. Hence, green revolution, basically was spear headed to feed the hungry mouth by enhancing food production throughout the world.

Likewise, other countries all over the world also benefited from the research result of Borlaug and his associated research institution established in 1963 in Mexico called the CIMMYT (International Maize and Wheat Improvement Center) (htpp://www.cimmyt.org). Similarly, in 1960, IRRI (International Rice Research Institute) was established in Manila, the Philippines. These institutions started research work on major food crops: wheat, maize and rice globally. Initially these institutes were established with the financial support of the Ford Foundation and Rockefeller Foundations. After this, CGIAR (Consultative Group on International Agriculture Research) supported many research institutions globally and research works on potato, vegetables, grain legumes, and many agricultural commodities encompassing crops and animal were established across the world. These research institutions emphasized research work on respective commodities for which they were given mandates for developing technologies. IRRI in 1962 developed rice variety IR-8 by crossing between Geo-woo-gen and Peta (htpp://www. fao.org). IR-8, a short stature photo-insensitive improved rice variety produced high yield compared to other traditional varieties and was termed as "miraculous variety." Consequently, green revolution was geared up by CGIARs for important food crops of wheat, maize and rice during 1960s onwards with the development of high yielding modern varieties of these crops in Mexico and Philippines where CIMMYT and IRRI are stationed. Technology developed by the CGIARs spread across the world for other crops as well, radiating high yielding and input responsive varieties of crops particularly in developing countries where there is easy access of these institutions, so far as advanced technology of important food crops is concerned. After 1960s due to the increase in crop production many food importing countries of the world became food exporting countries mainly due to the spread of technology based on green revolution.

Green revolution and its impacts in Nepal

In Nepal, after the inception of five crop commodity programs- rice, maize, wheat, potato and sugarcane under the Department of Agriculture (DoA) in 1972, formal research on these crops had been started. This was in line with the coordination of Nepal with the CGIARs which were geared up for initiation of the green revolution during 1960s onwards. Most of the genotypes of these crops were received from the IRRI, CIMMYT, ICARDA and other CGIARs so far as their evaluation is done in Nepal. Thus, Nepal was formally linked with CGIARS as one of the partners associated with green revolution representing developing countries. Many scientists working on these crops were trained academically and non-academically from the IRRI and CIMMYT and this trend is being continued to this day. These crop commodity programs in Nepal started research on breeding, agronomy, plant nutrition, plant protection, post-harvest related activities and testing on-station developed technology in on-farm conditions in general and particular to the improved varieties of these crops. As a result, tonnes of improved seed of major staple crops-rice, maize and wheat were disseminated as minikit, pouch containing 1-1.5 kg of seeds of each of improved varieties with a leaflet describing agronomic practices of particular variety in question. Feedback from the farmers across the country were collected with the help of extension personnel working in areas where these varieties were tested under farmers' field, nationwide. On the basis of this research-extension-farmers linkage, improved varieties of major staple crops were tested and released given their performance in farmers' field. In this way advanced technologies generated in research stations were tested and disseminated in farmers' field for major staple crops in Nepal. Like in other developing countries, Nepal is also loosing local land races of crop varieties because of uniform and higher adaptability of improved varieties of staple crops and other crops developed from CGIARs in the course of green revolution. This is a serious implication of genetic erosion of location specific local land races which are building blocks to develop high yielding stress resistant varieties in coming days ahead.

Impacts in major staple crops in Nepal

In Nepal, as of now 73 varieties of rice (CDD 2015), 16 varieties of maize and 22 varieties of wheat have been released (AICC 2016). Besides from this, many improved varieties of other crops have been also been released and registered in the country (AICC 2016).

In 1966 first four varieties of rice- Taichung-176, Chainung-242, Tainan-1 and Chainan-2 (Joshi 2015) with their origin in Taiwan having yield potentiality of 6.6 to 7.9 t/ha (AICC 2016), were released in Nepal. However, these Japonica varieties could not be popularized as Nepalese prefer Indica varieties for table rice purpose except for their utilization for bitten rice in Kathmandu valley and periphery region of hills and mountains. However, rice variety Masuli, a cross among Mayang Ebos 80*2/Taichung 65, originated in Malaysia and recommended for irrigated and rainfed low land medium deep growing condition under Tarai and inner Tarai with yield potentiality of 3.5 t/ha, and released in 1973, was most popular followed by Sabitri, a cross among IR 1561-228-1/IR 1737//CR 94-13, originated in IRRI and recommended for irrigated condition under Tarai and inner Tarai with yield potentiality of 4.0 t/ha, and released in 1979. Although, Masuli was rejected by researchers because of its heavy infection of blast (*Pyricularis patho* var. *oryzae*) complexes like seedling blast, leaf blast and neck blast for further multiplications, however, there are areas where farmers are still growing this variety due to its tall stalk for animal feed and palatability for table rice purpose. Sabitri is still popular in wider domains of mid hills and Tarai region of the country because of its yield stability and preferable taste and adaptability under rice based cropping systems. Most of released rice varieties in Nepal are received from the IRRI, CGIARs, and some of the varieties are selected from local land races while some originated from other countries. Nepal is almost self-sufficient in rice production except in the few years of global food crisis scenario of 2008 and last decades of the 20th century where there was a slackness in global food production.

For maize and wheat Nepal used to receive most of the germplasms from the CIMMYT, Mexico and mainly open pollinated maize varieties (OPV) are released. From 1966 to 2015 some 26 OPV of maize and two hybrids have been released (NMRP 2015). In 1966, Khumal Yellow and Rampur Yellow were the first improved OPV of maize, developed from Antigua G2D and J-1, originated in IACP, with yield potentiality of 4.0t/ha, and recommended for hills (NARC-CIMMYT 2001). However, while Rampur Composite, an OPV, developed from crossing between DMR Version of Thai Composite-1/Suwan-1, originated in J-1IACP, with yield potentiality of 4.5 t/ha, released in 1975, and recommended for Tarai, inner Tarai, and low hills, is the most popular maize variety having wide adaptation up to mid hills condition (1600 m). All of the released varieties of maize are semi-flint type preferred by Nepalese growers. Maize grains are used as green cobs, roasted grain, grits and flour for table purpose and animal feed. By product as shelled cobs, stalks, and husks are popularly used for fuel wood and animals fodder. Grain yield of local maize is around 1.5 t/ha while improved maize varieties give higher yields and respond well to application of chemical fertilizers and improved husbandry practices, are higher yielder than those of native land races.

Likewise for wheat, from 1960 to 2012, 22 improved varieties have been released in Nepal. As in the maize, most of the testing genotypes are received from CIMMYT, and ICARDA and some of the varieties have been developed from accessions originated from India and Nepal as well. First improved variety of wheat released in 1960 in Nepal was Lerma-52, crossed between Mentana/Kenya- 324, originated in Mexico, yield potentiality of 5.0 t/ha, and recommended for hills. After this in 1967, three wheat varieties- Lerma Rojo-64, Sonora-64 and Pitic-62 originated from Mexico, had been released (NARC-CIMMYT 2001). Four years later in 1971, two wheat varieties RR-21 and S-331 originated from Mexico were released in Nepal, However, of the two, RR-21, a crosses among *1154-388/AN/3/YT54/N 1 OB//LR64,* with a yield potentiality of 4.0 t/ha, and recommended for hills and plains of Nepal became so popular that this variety was taken up almost by every wheat grower nationwide. Due to extensive cultivation of RR-21 in Nepal, there was heavy pressure of stresses on this variety particularly rust complexes and as a result of this, the variety was de-notified few years back by the GoN. However, some of the wheat farmers are still growing this variety in some regions, mainly in hills.

Surge of yield of major crop of rice maize and what was mainly attributed to the improved technology especially crop varieties developed from the CGIARs in Nepal. Therefore, in one way or other Nepal is benefitted from the yield increase of major food crops, the impact of green revolution initiated from CIMMYT, Mexico in the guidance of NE Borlaug, the Noble laureate for peace prize in 1970 and has helped feed Nepalese despite higher growth rate of population than that of agriculture production in late 1990s and early decades of 2000s.

Global effects of green revolution

The result of green revolution is the integrated combination of basic sciences- biology, chemistry, and physics. Genetic improvement of high inputs responsive variety development was biological aspect, priority for chemical fertilizer and pesticides application were chemical approaches while use of modern farm implements like, tractors, combine harvester, irrigation facilities, and creation of post harvest and processing facilities were physical aspects of basic sciences. Above all, development of photo-insensitive high input responsive varieties coupled with high sink-sources harnessing capacity of modern varieties of crops developed and disseminated during green revolution were also combined approaches of basis sciences in agriculture for enhancing per unit productivity of major food crops across the world.

The crops developed during the green revolution produced high yield which responded well to application of fertilizers, pesticides and irrigation thereby yielding increased amount of grains in general and more favorably in fertile land. Crops developed during green revolution have high harvest index, photosynthate allocation, and insensitivity to day length. After selectively breeding, these plants have the characteristic of larger seeds. These larger seeds then created more grain yield and a heavier above ground product. Finally, by selectively breeding plants that were not sensitive to day length, researchers were able to double a crop’s production across the world where availability of light, moisture and inputs do not become limitations for these modern crops.

Modern varieties of crops demand high inputs and are largely favored for big and resource rich farmers who can afford for irrigation, fertilizers, pesticides and improved agriculture implements required for cultivation, processing and post-harvest facilities. Since, green revolution changed agricultural practices because the modern high yield varieties cannot grow successfully without the help of massive supply of production inputs.

Irrigation also played a large role since it forever changed the areas where various crops can be grown. Before the Green revolution, agriculture was severely limited to areas with a significant amount of rainfall, but by using irrigation, new area were brought under cultivation putting more land into agricultural production leading to increase in crop production to a vast expanse.

Finally, the use of green revolution technologies exponentially increased the amount of food production in the world. Countries like India and China that once feared food shortage have not experienced it since implementing the use of modern varieties of crops.

Merits of green revolution

Green revolution brought a paradigm shift in the history of modern agriculture. Modus operandi and radiating impact of green revolution was almost affected in one way or other at the nook and corner of the world. This revolution is unique in the sense that it saved poor and under nourished population of the world from the disasters of hunger and starvation and made farmers more confident than ever before. Some of the important merits of green revolution are clearly noticed in the modern agriculture of the world as delineated below.

Increase in agriculture production

Green revolution has influenced the economy and way of life of farmers in developing countries to the extent that it increased production in agricultural crops particularly in food-grains. Green revolution was also termed as grain revolution. Consequently, after 1967 onwards to the end of 20th century, it was like a Grain revolution because of wide scale increase in grain production in regions where this movement got accelerated. Among food crops the increase in grain production was mainly for the major cereal crops of wheat, rice and maize. In green revolution, the priority for high inputs and high costs favored by rich farmers in productive lands ultimately resulted into high yields per unit area of crops that were given high priority.

Favor for resource rich big farmers

It has been found that green revolution brought happiness to the big and resource rich farmers who have capital to invest for factors of production and big land holdings in general and particular to developed countries. Resource rich farmers can invest on inputs of production like HYV seeds, fertilizers, machines, irrigation, and pesticides as a result there was the surge of capital for those famers leading to encouragement of capitalistic system of farming. Contrary to this, small and marginal farmers could not invest capital in farming and whatever increment was there for yield it went to pay for the inputs applied to the modern crop varieties. For small farmers, green revolution was just a plenty in poverty. Green revolution to small and marginal farmers was not effective to support the change in the mode of production, even to cover the added cost of inputs from the added returns.

With the increase in farm production due to the application of production inputs of improved seed, chemical fertilizers, irrigation, farm machinery and pesticides big farmers having more land were able to increase crop production. They were able to invest more on inputs demanded by modern crop varieties developed by the green revolution. Big farmers became prosperous while small and marginal farmers in developing countries were lagging behind due to their inability to invest more on the production inputs in agriculture.

Food self sufficiency

One of the main benefits of green revolution was the increase in food grain production resulting in food self-sufficiency that led to a drastic reduction in import of food grains. Many food deficient countries before green revolution became self-reliant during green revolution and there was reserved balance of food grains in many of the developing countries as well. Per capita food consumption in India increased from 395 g per day in early 1950s to the level of 436 g in 2003 despite the rapid increase in population. This trend followed in other green revolution friendly countries across the world.

Circulation of profit

Green revolution helped increase profit for big farmers. This consequently facilitated their surplus profit to reinvest in agriculture productivity such as linking farm product to market and invest more in ware house and post-harvest and processing related activities. This, coupled with getting soft loans and subsidy from the government for such activities was a great leverage to the flourishing of big farmers. Also big farmers invested more on increasing their livelihood in non-farm activities such investing on children’s education, health and other socio-economic activities.

Agro-industrialization

Green revolution brought about farm mechanization that enhanced demand for different types of machines required for farming and post-harvest-cum-processing of raw materials in agro-industrialization. These include investment on machines such as tractors, threshers, combines, pumping sets, diesel engines, electric motors and air conditioners to fit in the cold storages for regulation of environment. These industries were generally booming in neo-industrialized nations of Asia, Africa and Latin America. Brilliant examples are China, India, neo-industrial countries in South East Asia, South Africa, Brazil and many more. Aside from this, demand for chemical fertilizers and pesticides also increased rapidly due to intensive farming for higher productivity during green revolution.

Employment generation

Farming was very intensive due to increase in agriculture production. As a result there was high demand of skilled and unskilled labor force in this sector. In countries where green revolution took momentum and jobs were created for youths in areas where there were big farmers and farming was mechanized. In India alone, agricultural universities contributed immensely in developing new technologies to address issues of increasing crop productivity. Many graduates were absorbed in different pre-production and post–production jobs created in farming due to radiating effect of green revolution. This helped create jobs in rural and urban areas. Rural employment not only created jobs for youth but also they brought back new ideas, technology and money required in these areas.

Although, the effect of green revolution was not directly visible in countries like Nepal except some increase in the yield of major food crops, however, rural youth from Tarai of Nepal, Bihar and Uttar Pradesh of India migrated to Punjab and Haryana, the major states of green revolution in India, during peak period of wheat planting and harvesting. This has had certainly helped enhance livelihood in areas of labor migration for farming which was a regular phenomenon effective in green revolution. HYV of crops coupled with application of irrigation and fertilizers in already irrigated areas absorbed rural youths in agriculture and created jobs in some ways even in Nepal in river basin areas having perennial irrigation facilities that geared up intensive cropping round the year. In such ways, some employment generation could be observed in potential agriculture areas during green revolution. Nonetheless, sizeable employment generation in rural areas for small and marginal farming community could not be widely experienced during green revolution.

Change in the mind set of farmers

Farmers in developing countries are generally practicing traditional farming since time immemorial. However, green revolution exposed them to modern farming with the introduction of HYV of crops, improved husbandry practices, use of chemical fertilizers, and pesticides. These practices changed traditional mind sets of farmers in developing countries and encouraged them towards modern farming for commercialization of agriculture system such that modern agriculture could enhance their livelihood. Now, farmers even in developing countries are in contact with modern technology which could increase agriculture production many folds compared to traditional farming. This is the result of change in the mind set and attitude of farmers brought about by the green revolution.

Demerits of green revolution

Despite the overwhelming increase in food grain production, green revolution has some of its own inherent lacunas in the modern agriculture. Ever since its inception, the income gap between large, marginal and small farmers has increased. The gap between irrigated and rainfed areas has widened and some crops have benefited more than the others, sometimes even at the cost of other crops. The weariness of the green revolution could be visible in and around developing countries. Some of the important demerits of green revolution are briefly discussed below.

Priority for few crops

More or less almost all food crops including cereals, pulses, fodder and some plantation and horticultural crops have gained from green revolution. However, the highest yield increase was for food grain in general, particularly to the three major crops: wheat, maize and rice. Still among these crops wheat benefitted the most especially in India and Pakistan where yield increase and control of disease was visually observed due to the impact of green revolution. The high yielding varieties of other crops had either not been developed at all or they are not developed to fit to the need and demand of farmers. Accordingly, their cultivation is fast becoming uneconomic and they are often given up in favor of wheat or even rice. Consequently, an excess of production of food grains of wheat and rice on the one hand and shortage of most of the other food crops on the other hand. This created change in the food habit of people who previously used to consume many varieties of crops that were rich in nutrition for different age level people. In the long run, nutritional related problems surfaced thanks to the consumption of food based on few crops.

Important cash crops like cotton, jute, tea and sugarcane were almost unaffected by the green revolution. In India, growth rate of production declined from 1-39% per annum in the pre-green revolution period while its decline was 0-79% per annum during green revolution period from 1967-68 to 1994-95 (http://www.yourarticlelibrary.com/tag/articles-on-Green-revolution). This has created imbalanced growth of agriculture in countries where green revolution geared up with high speed growth rate of food grain production.

Economic discrepancy

Resource rich farmers were the ones who had been benefitted most due to development of high input responsive crop varieties. It gave rise to economic disparity among farmers with and across the community and countries. Green revolution favored the areas having an availability of year round irrigation facility, road access, and big and rich farmers who could afford high cost of cultivation with respect to chemical fertilizers, pesticides, irrigation, and agriculture implements. Green revolution did not impact farmers who were residing in marginal land and dependent on minor crops of millet, legumes, who raised small ruminants, grew native crops and maintained native animal breeds of animals. In gist, it could be said that green revolution favored those areas which were already better off as a result gaps between rich and poor spanned widely. Finally, regional disparity on income, living standard and production skewed largely in favor of resource rich and big holdings farmers. Contrary to this, small and marginal farmers did not have the financial resources to purchase inputs as demanded by the HYV and were deprived of the benefits of technology adaptation in green revolution. In Nepal, majority of the farmers have the land holding size of 0.68 ha (MoAD 2015) where the impact of green revolution is hardly noticeable.

Unemployment

Green revolution helped accelerate job creation in pre-harvest and post-harvest related activities in urban areas. However, farm mechanization has created widespread unemployment in rural areas. Besides, sustainable farming was highly disturbed by the use of high input demanding crop varieties of major cereals. This has led to decrease in the yield of these crops since these were introduced in the marginal and resource poor environment of upland, sloppy lands and marginal hill terrace where traditional farming was practiced by many indigenous communities in the form of conservation agriculture. Under integrated farming systems where crops and livestock are so integrated and interlinked that mono culture could not be imagined in absence of either crops or animal. In green revolution, mono cropping of single crops is favored rather than multiple cropping or integrated farming system. This has seriously disturbed traditional and sustainable farming system of small and marginal farmers in the third world countries where majority of the people are poor, landless and live in the marginal ecosystems.

Genetic erosion of local land races of crops/animal breeds

Due to adaptation of genetically uniform, high-yielding varieties since 1900s some 75% plant genetic diversity has been lost as farmers gave up cultivation of multiple local varieties and land races worldwide (FAO 1999b). Today only three crops- rice, maize and wheat contribute nearly 60% of calories and proteins requirements obtained by humans from plants. Of the known 250 000 to 300 000 edible plant species, only 150 to 200 are used by humans (FAO 1999b). At present, 75% of the world's food is generated from only 12 plants and five animal species.

Rapid depletion of natural resources

Because of the rapid expansion of industrial and green revolution agriculture, some production systems select genetically modified varieties and breeds in mono culture preferring relatively few crop varieties. Also domestic animal breeds or fish, are reared in a limited number ((IUCN/DFID undated). Furthermore, nearly all countries confirm genetic erosion is taking place and that is a serious problem (FAO 1996). These days, some activists are raising voices against rapid genetic erosion of plant and animal species worldwide. What these activists claim is that there are no miracle seeds/varieties instead these are highly responsive to certain production inputs. They claim that indigenous varieties/breeds could also be high yielding given the required quantity of inputs as that of improved varieties/breeds. Green revolution has created environmental imbalance and rapid depletion of resources due to an excessive use of chemical fertilizer, pesticides, animal feeds, and pumping of underground water used for these high input responsive varieties/breeds. This will ultimately lead to unsustainable depletion of natural resources proving detrimental to future generation.

Conclusion

Green revolution increased crop productivity and calorie consumption was also increased. However, dietary diversity decreased for many poor people, and micronutrient malnutrition continued. Traditional crops that were important sources of critical micronutrients were displaced in favor of the higher-value staple crops (Webb 2009). Advanced technologies often bypassed the poor because of inequitable land distribution with insecure ownership and tenancy rights in general and poorly developed input distribution systems and subsidies distribution for mechanized farms in particular (Pingali 2012). Also advanced technology geared up in the green revolution could not address slow growth in the nonfarm economy that was unable to absorb the rising numbers of rural unemployment (Hazell 2003). Policies that promoted staple crop production and high investment on production inputs (fertilizer, credit subsidies, price supports, and irrigation infrastructure particularly for rice) tended to replace the production of traditional non-staple crops, such as pulses and legumes in India (Welch and Grahman 2000). The challenge for agriculture now is to integrate smallholders into value chains, maintain their competitiveness and close the urban–rural income discrepancy (Hazell 2003). Global population is projected to increase about one-third by 2050 and this will necessitate a 70% increase in food production (FAO 2009). To meet this requirement, green revolution-2 must continue to focus on shifting the yield frontier for the major staples (Pingali 2012). Increasing cereal productivity meets demand for staples, allows the release of land to diversify into growing other high-value crops and movement of labor out of agriculture. Consequently, this will encourage other economic opportunities to provide greater returns enhancing livelihood of people.

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Role of Rice in Ensuring Right to Food in Nepal

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सारांश

खाना बिना जिउन असम्भव छ । तसर्थ खाना माथिको अधिकारलाई निःशर्त मानव अधिकार मानिन्छ । खानामाथिको अधिकार स्थापनाले खाद्यसुरक्षा हुने मात्र नभई समग्र मानव विकास र राष्ट्रिय आर्थिक वृद्धिमा पनि टेवा पुऱ्याउँछ । जब अधिकार स्थापनार्थ आवश्यक खाका तय गरिन्छ, तब जिम्मेवारवाला, अधिकारवाला र यस प्रक्रियाका सहजकर्ताहरू (जस्तैः निजी क्षेत्र, नागरिक समाज तथा अन्तराष्ट्रिय समुदाय) को भूमिकालाई पनि प्रष्ट्याउनु पर्ने हुन आउँछ । यस प्रक्रियामा विश्वव्यापी रूपमा विभिन्न प्रावधानहरू स्थापित गरिएका छन्, जसले राष्ट्रिय स्तरमा आफ्ना स्थानीय परिस्थिति अनुरूप आवश्यक नीति नियमहरू बनाउनमा सहयोग गर्दछ । यसरी नीति नियमहरू बनाउँदा कार्यक्षेत्र बिभाजन, जिम्मेवारी बाँडफाँड, आवश्यक बजेट बिनियोजन गर्नु जरूरी हुन आउँछ । त्यसैले खाद्य अधिकार सुनिश्चित गर्न समग्र खाद्य सुशासनको प्रत्याभूति हुन जरूरी हुन्छ । नेपालको परिप्रेक्ष्यमा धान एक प्रमुख खाद्यान्न भएकाले खाद्य सुरक्षामा यस बालीको अहम् भूमिका रहेको छ । यसका अलावा धानले आर्थिक, सामाजिक, सांस्कृतिक तथा वातावरणीय पक्षका साथै राष्ट्रिय सम्प्रभुता जोगाउनमा समेत टेवा पुऱ्याउँछ ।

Summary

No one can survive without food. Therefore, right to food (RtF) is right to life. Right to food with dignity therefore is not only a matter of feeding people but is equally crucial for overall human development and contribution to national economic growth. When rights exist, there are obvious roles of the state as duty bearer (DB) and people as right holders (RHs) as well as responsibility bearers (RBs) such as: the private sector, civil society communities and global actors. There exist many different international instruments that guide nation states to translate those standard procedures into practice befitting the national context, yet without compromising core values and principles of human rights. While defining the rights frameworks; it requires well-defined functions, functionaries and allocation of adequate funds. Therefore, to ensure right to food for all, the overall governance system should remain functional and accountable. In Nepal, rice being the main staple food crop, it has a crucial role not only to ensure food but also to economic, social, cultural and environmental services and sovereignty of the country.

Keywords: Duty bearers, Food aid, Food governance, Human rights, Institutional frameworks, Responsibility bearers, Right to food, Rights holders, Trade

Background

For the purpose of this paper, importance of rice in ensuring right to food is explained in reference to the concept of RtF (Right to Food) and its relevance in particular to Nepal. In recent decades, the overall trend of agricultural production, youth out-migration, global trade dynamics and climate change are impacting overall food basket composition, consumer's food habit, food safety norms and utilization patterns. Nepal, being situated in the Asian continent, has its food security system largely dependent on rice production, its trade and consumption habit. At the same time, during disasters and emergencies (human-induced or natural), food aid largely denotes rice or rice based food supply. Moreover, blanket approach of relief supports mostly overshadows the issues related to choices, needs and concerns of the people- the RHs. To address the common and global concerns over RtF, there are certain international instruments established at global level. The notion states as DBs through its government have to ensure its national system to comply with the values, principles and commitments to operationalize for progressive realization of right to food as provisioned in those international instruments. Some of the provisions are legally binding and others have moral obligations in fulfilling their duties towards people.

Therefore, it is very crucial for each nation state to devise policy and institutional frameworks according to its local context. In devising such policies, it is important to understand and analyze which theories actually would guide them to prepare the best.

Some theories and concepts around right to food

There are certain theories, concepts and approaches that guide the overall framework of the state to ensure right to food. It is important to understand that the nation state has the choice to make decisions on what kind of frameworks and system to be established as per the local political, social and economic situation but without compromising the basic human rights standards. Some of the commonly used theories, concepts or approaches are briefly presented in this section. Some of the relevant theories are illustrated in **Figure 1** below.

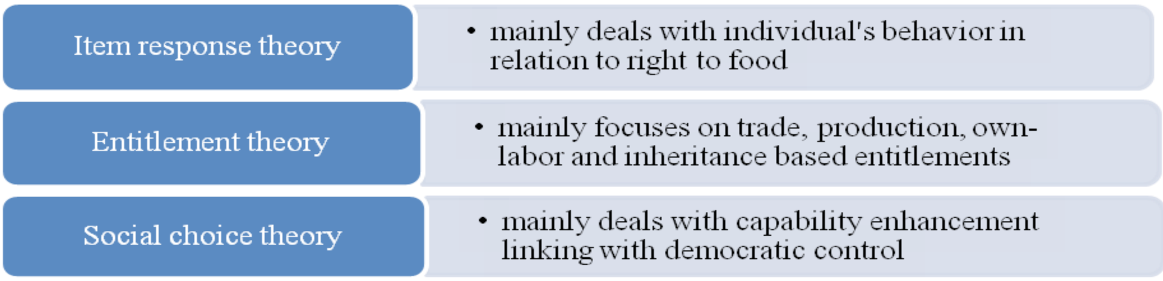

Figure 1. Some theories that guides RtF discourse

To make sure the DB and RH are to be responsive, some of the approaches such as capability approach, which considers overall issues such as food entitlement, nutritional requirements and the capability of demand (from people) and supply (from state) sides to fulfill the requirements plays a crucial role (Sen 1984, Burchi and De Muro 2012).

In making the provisions operationalized, it is equally important to understand the basic concepts around food and food system related governance. **Figure 2** below provides specific focus contained by different concepts.

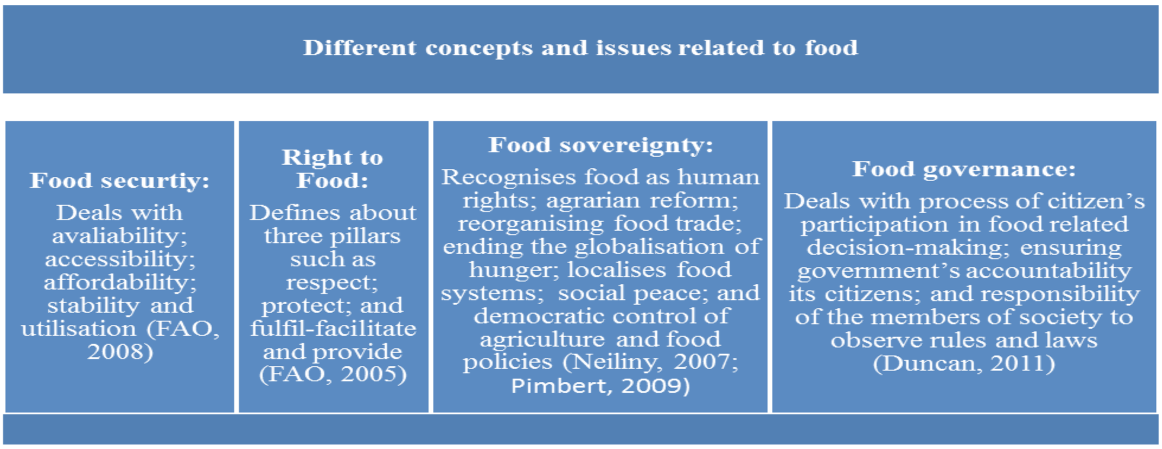

Figure 2. Different concepts and issues related to food

Proper understanding of the concept helps a nation state and its government to define appropriate food policies, establish required institutions and elaborate programs with clearly defined functions, functionaries and funds allocation. In doing so, it is important to ensure effective mobilization of other actors; private sector, civil society, indigenous customary institutions such as *guthi* as responsibility bearers (RBs). It therefore confirms that the process is participatory and adopts multi-pronged approaches including proper food governance system in place. To ensure and facilitate operationalization of theories and concepts into reality, it is important to take reference of existing international instruments devised at the international level.

International frameworks

There exist many international instruments that guide nation states in translating them into the national frameworks. The Universal Declaration of Human Rights (UDHR) 1948 is the first formal instrument that advocates for the right to food. Article 25.1 of the UDHR says, *"Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care and necessary social services, and the right to security in the event of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control"* (OHCHR 1948 p.7). Some international frameworks, their main focus in relation to RtF and the dates ratified by Nepal are presented below (**Table 1**).

Table 1. Some international frameworks, main focus on RtF and the dates ratified by Nepal

SN	Instruments	Date of Signing/ Ratification	Major provisions
1	Universal Declaration on Human Rights (UDHR), 1948		*Article 25:* Right to food, clothing and shelter for all
2	International Covenant on Civil and Political Rights, 16 December 1966	14 May 1991 a	*Art. 1:* …pursue their economic, social and cultural development, Art. 6; Right to life
3	International Covenant on Economic, Social and Cultural Rights, 16 December 1966	14 May 1991 a	*Art. 1:* …pursue their economic, social and cultural development; *Art. 2.1* and *3*: …. full realization of the rights and guarantee economic rights, *Art. 7:* employment and fair wages, *Art. 9:* social security, *Art. 11:* adequate food, clothing and housing
4	Convention on Elimination of all forms of Discrimination against Women (CEDAW)	22 Apr 1991	*Art. 14g:*equal treatment in land and agrarian reform as well as in land resettlement schemes; *Art. 15:* …contracts and to administer property
5	Convention on Biological Diversity (CBD)	15 Sep 1993	Local community rights over biodiversity, its use and benefit sharing
6	World Trade Organization (WTO)	23 Apr 2004	*Article 27.3b* of TRIPs: patent rights
7	Convention on Child rights (CRC)	14 Sep 1990	*Art. 24c;* provision of adequate nutritious foods and clean drinking water,
8	International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)	2nd Jan 2007	*Art.1:* fair and equitable sharing of the benefits arising out of their use; *Art. 5:* exploration, conservation and sustainable use of plant genetic resources for food and agriculture; *Art. 6:* sustainable use of plant genetic resources; *Art. 9:* farmer's rights: protection of traditional knowledge, right to equitably participate in sharing benefits and right to participate in making decisions

SN	Instruments	Date of Signing/ Ratification	Major provisions
9	International Labor Organization (ILO) 169	22 of August 2007	Rights of local and indigenous communities over natural resources eg *Art. 14.1:* The rights of ownership and possession over territorial land; *Art. 15.1:* The rights of the peoples concerned to the natural resources, right to participate in the use, management and conservation; *Art. 17.1:* transmission of land etc.

Source: Ghale and Bishwokarma 2013.

Moreover, FAO has developed a voluntary guideline in operationalizing the concept of RtF. The guideline recommends to adopt three major pillars which are: i) respect ii) protect and iii) fulfil through facilitation and provide to the needy through safety net provisions and direct supplies during disasters and emergencies (FAO 2004). Nepal being a party to and a signatory to many different global frameworks, it has defined policies and frameworks that promote right to food, which are briefly explained in the section below.

National frameworks

Government of Nepal (GoN) has devised many different framework documents that acknowledge RtF in certain ways. The Constitution of Nepal is the most vital framework that provides basis for establishing the necessary laws and structures on right to food and food sovereignty (CA 2015). Likewise, some specific Acts such as Consumer Protection Act, Food Act and the periodic plans play a crucial role in translating the commitments into practice.

Since two third of the Nepalese population rely on agriculture for their food and livelihoods, agriculture is the fundamental sector in ensuring right to food. Cargill (2014) points out that some of the major areas for the government to engage in ensuring RtF are: i) investing in agriculture and food ii) supporting small-holder farmers iii) harmonizing food safety standards iv) enabling market space v) reducing environmental impacts vi) balancing production and trade and vii) facilitating emergency food aid. It confirms importance of agricultural policies and programs in ensuring RtF. In this context, the Agriculture Development Strategy (ADS) 2015-2035 is one of the important milestones in the journey of ensuring food security and RtF (GoN 2015). Some of the major provisions on RtF as spelled out in those major documents are summarized below (**Table 2**).

Table 2. Some of the major national framework documents and provisions related to RtF

Constitution of Nepal (2015)	*Article 36.1*-"Each citizen shall have the Right to Adequate Food" *Article 36.2*-"Every citizen shall have the right to be protected from a state of starvation, resulting from lack of food stuffs" *Article 36.3*-"Every citizen shall have the Right to Adequate Food sovereignty as provided for in law" (CA Secretariat, 2015; P. 15) *Article 42.2*-Right to social justice to those Citizens who are economically very poor and communities on the verge of extinction on food among other needs (CA Secretariat, 2015; P. 18) *Article 44.1*-"Each consumer shall have the right to quality foodstuffs and services" (CA, 2015; P. 18) *Article 51.h.12*-State-supportive measures to enhance productivity for ensuring the food sovereignty (CA, 2015; P. 26)
Food Act (1966)	*Preamble:* legal provisions to maintain proper standard of food, prevent any undesirable adulteration in foodstuffs, and prevent from reducing in, or extracting, any natural quality or utility from foodstuffs

Consumer Protection Act (1998)	*Preamble:*make provisions for protecting consumers from irregularities concerning the quality, quantity and prices of consumer goods or services, as well as, ensuring that no one lowers or removes the attributes or usefulness of consumer goods or services, preventing circumstances in which monopolies and unfair trading practices may lead to an increase in prices, as well as false and misleading propaganda about the use and usefulness of consumer goods or services, selling, supplying, importing, exporting and storing safe and quality consumer goods or services, and protecting the rights and interests of consumers through the establishment of an agency for redressing the hardships of consumers, and thus maintaining the health, convenience and economic welfare of consumers.
13th three years plan (2013/14 to 2014/15)	*Long term vision:* Ensure food sovereignty rights of citizens through strengthening all aspects of food and nutrition security *Objectives:* Improve food and nutrition security through supply of basic food items and ensure food security of food insecure groups through improved access to quality food items. *Strategies:* Devise national food and nutrition security policy; promote locally potential and high value products in food insecure areas; protection, promotion, utilization of agricultural biodiversity, and respond to climate change specific concerns; and ensure effective regulatory frameworks for food safety. *Operational strategies:* Effective implementation of Food Sovereignty Act and National Food and Nutrition Security Plan; improve access to nutritious animal products; institutionalization of Nepal Food Security Monitoring System; prepare district level food and nutrition security programs based on Integrated Planning Committee and mobilize food security networks; maintain food stock with proper inter-ministerial coordination and among center, regional and districts; devise "productivity improvement plan for food security" to respond to food insecurity in the long run; promote locally potential crops and crop improvement practices for food insecure districts; priority program on high value crops for improved income to the food insecure districts; promote agro-based industries for commercialization, processing and value addition; promote climate responsive technologies; develop physical infrastructure and promote nutritious and high value crops; promote food diversification and promote regulatory and monitoring mechanisms.
ADS (2015)	*Goal:* "A self-reliant, productive, sustainable, competitive, and inclusive agricultural sector that drives economic growth, and contributes to improved livelihoods, and food and nutrition security." *Four Pillars:* Governance, Productivity, Profitable Commercialization and Competitiveness

Source: Ghale and Pyakuryal (forthcoming).

Role of rice in ensuring right to food in Nepal and its status

Nepal still has an agrarian based economy. Two third of its population is engaged in agriculture as the source of livelihood and it contributes to at least one third of the national gross domestic product (GDP). Rice in Nepalese context mainly has following relevance in terms of RtF.

Relevance by area, production and distribution

Rice remains as the main staple food in Nepal since long time and the term food immediately signifies rice. Tarai, the southern belt of Nepal is known as the food-belt of the country. However, paddy is produced throughout Nepal although the area of production and productivity varies according to climate and supply of quality production inputs. Rice still occupies the largest share in terms of area and production. Unfortunately, both area and production are decreasing year by year. Paddy plantation area has decreased by 7.42% and production by 9.95% compared to the five year average respectively (MoAD, FAO and WFP 2015). The main reasons of decreasing paddy production are said to be erratic monsoon, inadequate supply of chemical fertilizers and improved seeds, among others. It shows how alarming the situation is in regards to ensuring availability, accessibility and affordability of rice as one of the main food items in Nepal. However, it does not necessarily mean that the need and demand of rice is declining, but that the country is relying more on the import led supply system. It clearly shows how the food system is governed by the market and how vulnerable the poor families are to secure food. Region-wise, the central region produces the largest amount of paddy followed by the eastern region. Likewise, paddy produced in Tarai is the highest amount as compared to the hills and the mountain belts. However, due to absence of proper mechanisms for collection, storage and distribution, majority of the population in the remote and hilly areas suffers the most due to inaccessibility: paying higher prices and has fewer choices and faces uncertainty of the quality. The trend is quite alarming as the country is becoming more dependent on external supplies rather than enhancing its in-house capacity. It will lead the country to either to rely on the market or on food aid to ensure food supply if the production, storage and distribution system is not improved with proper emphasis on holistic management such as land management, varietal research, technological innovation, timely supplies of production inputs, regulating market system and quality assurance. This is where the role of state and government come towards ensuring availability; accessibility and affordability of sustained food supply through own production where possible and meet the gaps through imports and aid as and when required only.

Relevance in trade, market and distribution system

Around the time of introduction of Structural Adjustment Programme (SAP) during the eighties, Nepal gradually became a net-food-importing country. It clearly shows the inter-relation and impact of trade policies in the food supply system. The recent data shows Nepal imports quite a substantial amount of husk, husked, semi-milled and wholly milled paddy from China, India, Italy, Korea, Republic of Thailand and UK (GoN 2015).

Nepal is also a member of various regional and global trade frameworks. Within the framework of the World Trade Organization (WTO): Agreement on Agriculture (AoA), Sanitary and Phytosanitary Agreement, Technical Barriers to Trade (TBT) and protecting its genetic resources and farmer's rights (Trade Related Aspects of Intellectual Property Rights-TRIPs especially of patents) are some of the agreements that directly relate with the food trade including rice. The proponents of life-science technology promoters and genetic engineering claim that only hybrid and other Genetically Modified (GM) rice varieties are the means to resolve food insecurity and malnutrition in the world (PANAP, undated). Nepal is abundantly rich in its rice genetic diversity. However, unfortunately it is gradually being dependent on import-led rice supply for its food security. This has posed threat farmer's rights as well as national sovereignty due to increasing concentration of power at the hands of profit-oriented companies. The figure below depicts how the market can weaken state and farmers' rights which is threat to operationalize right to food and food sovereignty into practice.

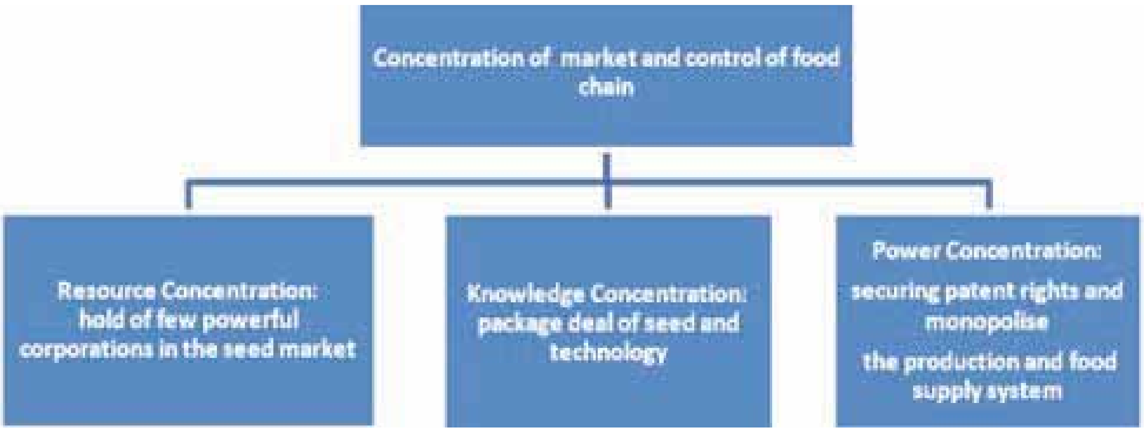

Figure 3. Power concentration chain

Source: Ghale 2011.

Relevance to manage food aid

Nepal is prone to natural disasters. In those harsh situations, the country receives food aid from different sources. Among the bulk of relief materials, food stuffs account to quite a substantial share. Within food also, rice and rice based food items are heavily used. Sometimes, political instability also invokes disruption of regular supply of goods including rice. It directly impacts on artificial shortages, price hikes and inaccessibility to the remote areas. More than that, as a continuum, hidden hunger still continues. In Nepal, 25% of its population is below poverty line. Moreover, 4.5 million Nepalese are undernourished, 41% children under five are stunted, 21% are underweight and 11% are wasted[1]. To respond to the need of the communities, the government also supplies subsidized rice, school feeding programs, and promotes food for work programs. In terms of subsidized program, the total supply exclusively establishes the concept of only rice as food, which completely undermines the efforts around conservation, protection and promotion of other food crops available in that particular locality. In a nutshell, it undermines the capacity of people as right holders to express their demand to enjoy their right to choice, right to enjoy the food of their need as per the age, cultural needs, and health conditions.

Relevance to social, cultural and environmental significance

Nepali society is very much associated with rice in their day to day language. When one asks as a courtesy to other whether they had meal or not, they say *bhat khayeu? (Have you had rice?)*. Likewise, in most remote and poverty stricken area, people desperately aspire to have full stomach of rice during the major festivals such as *dashain*. Moreover, our food supply system also considers rice as the staple food and government supplies subsidized rice to remote areas for example Karnali. Many of our cultural rituals are associated with the use of rice from birth to the last rituals. As for instances: farmers celebrate *harelo* in the rice field wishing to have good harvest of rice; *garbhe dhan* is widely used in *chhat* which is mainly celebrated by Tarai communities; *tika* is used mainly by *Hindu* communities on different occasions. If not conserved, utilized and promoted properly, it will jeopardize cultural practices and diminish identity specific specialties. It is an important pillar of RtF and food sovereignty to have local food production within the control of people supported by the nation state. Increasingly, impacts of climate change are becoming more prevalent even for the rice production system. Nepal being largely dependent on monsoon for rice production, erratic rainfall largely determines its production every year. Nepal being rich in its diversity for example; floating rice genes found in the wetlands that suits for flooded situations, different varieties promoted by Nepal Agricultural Research Council (NARC) suitable for dry land cultivations that suits for drought prone areas can be very well conserved, protected and promoted in response to the climate change. Rice production in Nepal especially in lowland is also a common practice of promoting integrated farming system, where poultries such as ducks and or fishes can be grown together. It does not only signify the economic benefits, but also helps in soil aeration and weed control to a certain extent. Therefore, it is very important to have properly functioning food system that ensures rights and responsibilities of DBs, RBs and RHs that takes care of holistic perspectives of rice system development including social, cultural and environmental aspects of rice production system along with its economic and food security values, at large.

Relevance and scope for global and regional collaboration

Rice is one of the most potential crops that can be widely used for regional and global collaboration through research programs and other safety net provisions. Since Nepal holds many different varieties for example; aromatic to normal variety, high altitude to low altitude, upland to low land rice, coarse to fine rice, floating rice, sticky rice and rice suitable for some other specific purposes such as puffed rice, beaten rice etc., it has ample of opportunities to contribute in regional and global sharing for research and innovations. Nepal, therefore, has a high scope of contributing to and collaborating with the International Rice Research Institute (IRRI) and other global institutions such as Consultative Groups of International Agricultural Researches (CGIAR) as well as a bright scope for maintaining national genebank. It is quite important when the indigenous seeds which are largely protected and promoted in the ex-situ situations also open

1 https://www.wfp.org/countries/nepal, accessed on 13 July 2016

scope to have in-situ conservation and protections. Having such genetic resources in the public domain also helps the country with source of origin to protect from bio-piracy and entitle for benefit sharing of the genetic resources from Nepal that are used for commercial purposes by other countries and companies with prior informed consent (PIC) and legal arrangements. Likewise, considering the possible famines due to natural and or human-induced disasters, South Asia Association for Regional Collaboration (SAARC) has a provision of food bank. Due to the commonality in production spheres and consumption pattern of the region, rice occupies large share in the food bank stock as well. It shows the significance of rice in the region in fulfilling the state's responsibility to contribute in regional initiatives in ensuring right to food ie direct deliveries during emergencies. Likewise, SAARC has also established a seed bank and rice plays quite important role in this platform as well.

Conclusion

It is obvious right to food is right to life. The overall scenario shows that there are different global and national frameworks established to ensure right to food for all. Among the staple food crops, rice stands as the major crop especially in Asia. Rice in particular does not have only food security and economic values; it equally carries its importance in fulfilling the social, cultural and environmental services when there are possible negative consequences of climate change. In Nepal, area and production of rice is decreasing gradually and Nepal is becoming more and more dependent on import and food aid to meet its food requirements. However, Nepal has immense potential to promote rice production as well as diversify its food basket considering the diverse caste/ethnicity and their cultural food habit and genetic and ecological diversity to ensure progressive realization of right to food. It has immense potential to invest in research, innovations and genetic resources sharing within the country, regional and among global institutions. Rice for Nepal therefore has significance of economic, social, cultural and environmental services and the national sovereignty.

Acknowledgements

Author would like to appreciate the initiatives taken by Dila Ram Bhandari, Director General of DoA, for bring out this publication. Thanks also goes to those who have supported directly or indirectly during preparation of this manuscript.

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Role of Rice in Food and Nutrition Security in Nepal

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सारांश

धानको उत्पादनमा हुने उतार चढावले नेपालीको खाद्य सुरक्षामा समेत असर गरेको हुन्छ । नेपालीलाई चाहिने कूल खाद्यान्नको पचास प्रतिशत भन्दा बढी र क्यालोरी आवश्यकताको तीस प्रतिशतभन्दा बढी योगदान धानको हुने भएकाले खाद्य सुरक्षाको प्रत्याभूतिका लागि धानको भूमिका महत्वपूर्ण रहेको छ । धानले जति अन्य खाद्यान्नबालीले बढ्दो जनसंख्याको खाद्य सुरक्षालाई सम्बोधन गर्न नसकेका कारण पनि नेपालमा धानको महत्व प्रचुर रहेको छ । नेपालमा खाद्य असुरक्षालाई गरिबीसँग जोडिएर हेर्ने गरिएको भएता पनि मूल्य वृद्धि, बेरोजगारी, कम उत्पादकत्व, राजनैतिक अस्थिरता आदि कारणहरू पनि खाद्य असुरक्षाका लागि प्रधान रहेका छन् । त्यसैगरी नेपालीको विहान वेलुका खाना फाल्ने अविवेकी बानीका कारण समेत खाद्यान्न नोक्सान भई खाद्य सुरक्षामा प्रतिकूल असर पारिरहेको देखिन्छ । नेपालमा वार्षिक १५८९६७.०२ देखि २९१४३९.५४ मे टन खाना नोक्सान भइरहेको छ र नोक्सानको मुख्य भाग भात नै रहेको देखिन्छ । यसबाट खानाको उपभोगमा हुने नोक्सानीलाइ कम गर्न मात्र सकियो भने खाद्य सुरक्षामा टेवा पुग्नुका साथै चामलको बढ्दो आयातलाई कम गर्न सकिन्छ । सामान्यतया, नेपालमा सेतो र खैरो चामल उपयोग गरिन्छ भने नेपालीहरू खस्रो चामलबाट मसिनो चामल खाने बानीमा क्रमश रूपान्तरण भइरहेको अवस्था रहेको छ । नेपालमा धान कार्तिकदेखि चैत्र सम्म बढी उपलब्ध हुने तथा बैसाखदेखि आश्विन सम्म खाद्यान्नको कम उपलब्धता हुने गर्दछ । मौसमी प्रभाव, उत्पादनोपरान्त भण्डारण, कमजोर ढुवानी व्यवस्था तथा कमजोर बजार व्यवस्था आदि कारणबाट मौसमी खाद्य संकट समेत पर्ने गरेको छ । नेपालको मध्यपश्चिम र सुदूरपश्चिमका उच्च तथा मध्य पहाडी जिल्लाहरूमा उच्चतम खाद्य असुरक्षा तथा गरिबी देखिन्छ भने पूर्वी पहाडी भूभागहरूमा तुलनात्मक रूपमा गरिबी र खाद्य असुरक्षा कम रहेको देखिन्छ । आम नेपालीहरू दिनको दुई छाक नै भात खान रूचाउने कारण नेपालमा चामलको माग बढ्न गइ घरेलु उत्पादनले धान्न नसकेको अवस्था रहेको छ । तसर्थ, नेपालमा खाद्य सुरक्षा सुनिश्चिताका लागि उत्पादकत्वमा वृद्धि, उत्पादन, बजारीकरण, भण्डारण र वितरण प्रणालीको सुदृढीकरणका लागि भौतिक पूर्वाधारहरूको प्रर्याप्तता, भात मात्र खाने बानीमा परिवर्तन गरी मकै, गहुँ तथा अन्य स्थानीय बालीको उपयोगमा जोड तथा जलवायु परिवर्तनको अनुकूलनका लागि उपयुक्त विकल्पहरूको पहिचान तथा प्रयोग आदि मुख्य रहेका छन् । प्रस्तुत लेखमा धान र खाद्यसुरक्षाको अन्तरसम्बन्धलाई प्रकाश पार्दै नेपालमा खाद्यसुरक्षाको अवस्थाको बारेमा चर्चा गर्ने प्रयास गरिएको छ ।

Summary

Ups and downs in production of rice is generally linked with food security in Nepal as it contributes more than 50% of grain requirement and more than 30% of calorie requirement. No other sector of the economy is likely to bring a sustainable level of food security for the fast growing population as effectively as the rice industry is doing at present. Rice loss during consumption constitutes the major part of food loss in Nepal. The annual food loss or waste in Nepal is estimated to be in range of 158967.02 to 291439.54 tonnes. Minimization of loss of rice during consumption can certainly reduce the annual import of rice in Nepal. The consumption pattern for rice has changed from consuming coarse and medium to fine and aromatic rice in present days. Rice is available in Nepal from Oct/Nov to Mar/Apr. In the period of May/June to Sept/Oct, rice is generally deficit in Nepal. Seasonal food shortages are quite common in many parts of Nepal as a result of monsoonal influences in production, poor post-harvest storage and handling, and weak transport infrastructure and market integration. Populations living in the mountains and mid and far western hills have the highest rates of poverty and relatively high rates of food insecurity. The eastern hill region has a relatively low proportion of the population experiencing food poverty. Because of nationwide preference of rice consumption in Nepal, domestic production has not been enough to meet the rice demand. In order to ensure the food security situation in Nepal: increase in productivity of major cereals crop, adequate infrastructures for strengthening rice production, marketing, storage and distribution system, change of food habit from consuming only rice to consumption of maize, wheat and other local crops as staple food, adaptation of appropriate mitigation and coping strategy for adverse impact of climate change in agriculture could be the appropriate ways out.

Keywords: Climate change, Distribution system, Food loss, Food security, Import, Rice

Background

Food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO 2010). When food security is supported by an environment of adequate sanitation, health services and care, the situation can be considered as food and nutrition security (Wustefeld 2013). Food availability, the first pillar of food security, refers to the physical availability of adequate levels of food in a particular location and domestic production is the main source of availability, with imports augmenting the shortfalls. In Asia, where 90% of rice is produced and consumed, rice security is equivalent to food security. Dependence on rice on the scale shows rice is still the most affordable way to maintain a sustainable calorie intake as it is the cheapest and most effective means available. Food security now is recognized as being more than just providing people with enough calories to live on, but ensuring people have enough nutrients for optimal health too. Foods rich in whole grain cereals may help reduce hunger as they are relatively bulky (Holt et al 1999, Saltzman et al 2001) and adequate calorie intake helps proper micronutrient metabolism thus reducing under nutrition.

Nepal is a food deficit, land locked and least developed country, having a population of more than 26 million. About 24% people in the country live below poverty level (MoF 2015) and thousands of under-five children are chronically malnourished. Widespread poverty is generally regarded as the major cause for food insecurity in Nepal. However, under-nutrition, social, education, healthcare and employment deprivations, low productivity in agriculture (low food and livestock production) are also the major contributors to food insecurity in Nepal. Price hiking, decreased remittance and income, conflict, low development indicators and recurring natural disasters have further exacerbated precarious food security in Nepal.

Rice is considered as an important staple crop to contribute to ensure food security in Nepal. Rice contributes about 20% to National AGDP and supplies more than 50% of grain requirement and more than 30% of calorie requirement for Nepalese people.

Food security situation in Nepal

Out of 75 districts, 33 were found to be food deficit during 2014/15. Due to unequal distribution of land and production constraints, the mountains and the hills are more hit by food deficit. Within the ecological belt, the people of one community are hungrier than those of other community depending upon social and economic status. Although Nepal was considered as a food exporting country till mid-1980s, gradual rise in imports is evident since 1991. Of three ecological belts (mountains, hills and Tarai), Tarai is considered as the granary of the country from where most of the marketed surplus of the country is generated and significantly contribute in food security. The mountain and hill districts are generally food deficit and mostly populated with low income and vulnerable population and poor road network. Because of nationwide preference of rice consumption in Nepal, domestic production has not been enough to meet the rice demand. The demand for rice is increasing by about 10% each year. However, as the local production of rice is not enough to meet growing demand, the country relies on India for both paddy and rice imports.

Populations living in the mountains and mid and far western hills have the highest rates of poverty and relatively high rates of food insecurity. Households in the mid and far western rural Tarai have the second highest rate of food poverty. The eastern hill region has a relatively low proportion of the population experiencing food poverty, ie the value of the diet consumed by most households is enough to cover a basic diet of sufficient calories. Nevertheless, a significant proportion of the population consumes sufficient calories by spending a very high share of their income on food. Across ecological zones, there were dramatic differences in the prevalence of nutritional status indicators, with a much higher prevalence of stunting in the mountains than in the hills or Tarai, and a two-fold higher burden of wasting in the Tarai than in the mountains, and almost a three-fold higher prevalence than in the hills (NPC 2013).

Rice and food security

Rice has a level of flexibility in terms of its adaptation to environment conditions that is not found in other staple crops. It can grow in diverse soils and climates, ranging from saline to alkaline to acidic soils and from hot humid tropical rainforests to swamps and arid deserts. Rice can be grown in three distinct seasons - namely rainy season, spring season and winter season. No other sector of the economy is likely to bring a sustainable level of food security for the fast growing population as effectively as the rice industry is doing at present. The food security with respect to its four pillars are availability, access, utilization and stability in Nepal.

Availability

Out of total edible cereals production of 6085777 tonnes in FY 2014/15, rice has the highest share (46%) and fulfills around 53% of the total edible grain requirement followed by maize around 25- 29% and wheat around 23- 27% respectively (MoAD 2015). In case of Nepal, rice calorie intake is 31.28% total calorie requirement/day, rice calorie intake per capita is 836 kcal/day with fat 3.92% of total calorie requirement/day and protein 24.03% total calorie requirement/day (http://www.ricestat.irri.org).

Access

Edible cereal grain production and requirement of Nepal shows total food surplus of 155558 tonnes with 33 food deficit districts (MoAD 2015). Lack of access to food is the core long-term food insecurity issue specially in the hills and mountains of the far and mid-western Regions because of lack of road infrastructure, low purchasing power and extremely high market prices. The monthly prices for three years from May 2004 to April 2007 show that the rice price in the mountain markets was on average 177% higher than the rice price in the Tarai markets of the mid-western region and 123% higher than in the eastern region. Furthermore, rice eating culture is in increasing in hills and mountains where food security is a burning issue. Increasing demand for rice in the hills and mountains with improved road infrastructures and market facilities, rice transportation to the hills and mountains have increased sharply these days. Similarly, the data on food aid supplied from World Food Program in these food deficit remote districts of Nepal shows the share of 65.96% of rice on a weight basis during 1998-2012. Similarly, the subsidized rice distributed from Government owned Nepal Food Corporation emphasizing the remote mountainous districts was around 15762 tonnes in 2014/15 (MoF 2016) for addressing food insecurity situation of the areas.

Utilization

Rice is a preferred food for almost entire population in the country. It plays a pivotal role in all spheres of life and when it comes to food security of the rural farmers it is the most important commodity in terms of livelihood and food. Rice is still the dominant source of energy and protein in an average Nepalese diet. With an average 174 kg per capita consumption, rice is the single most important food item in terms of calorie intake, providing, on average, around 39% of energy, 29% of protein (16.62 g/capita/day) and 7% fat (2.11g/capita/day) in the Nepalese diet. The actual intake of rice is about 416 g per capita per day. Of the 2830 kcal, 69% of the total calorie and 50% of total protein come from it. On an average, 62% of household consumption is spent on food expenditures in the country (CBS 2011). The National Living Standard Survey (NLSS) of the year 2010/11 showed that some 16% of the people in the country had inadequate consumption of food during 2010/11 compared to 31% during 2003/04 (CBS 2011). According to FAO, 119 kg food is needed for an adult person per year. Around 90 kg of this requirement is contributed by rice (75%). Currently, the contribution of home produced cereals is almost 50% in the food basket of which around 21% is contributed by rice alone (ZHC 2016-2025). The estimates of elasticity of household consumption demand functions for rice shows that people have very strong preference for rice. The demand for fine rice increase by 0.9% with every percent increases in the income, whereas the demand for maize would decline with rise in income (CDD 2015).

Pattern of rice consumption in Nepal

Nepalese people consume all three types of rice ie coarse, medium and fine. During the earlier age of rice consumption and varietal development, people used to prefer only medium and coarse rice with belief that coarse rice provided the more energy. However, the dietary pattern of people started changing with the change in living standard and economic status of people. People of middle and higher income groups started preferring fine and aromatic rice instead of coarse rice. Now a day, fine and aromatic rice is available in most of the restaurants, hotels, supermarkets and even in hotels in bus parks. Moreover, it's very interesting to see younger generation of present day preferring fine rice than medium and coarse rice. They are often mindful on quality of rice before deciding a hotel or a restaurant for dinner or meal. Nepalese people generally consume rice twice a day which differs in some communities consuming only once to thrice in a day. For example, *Tharu* communities of Tarai and inner Tarai of central region often consume rice three times a day, while people from some parts of mid hills and high hills of mid and far western region consume rice once in a day. The consumption pattern of rice in Nepal is presented below (**Table 1**).

Table 1. Food consumption pattern in Nepal

SN	Food name	Per capita consumption g/day		
		All	**Poor**	**Non-Poor**
1	Fine rice	71.1	16.6	89.4
2	Coarse rice	245	238.5	247.2
3	Beaten, flattened rice	14	5.2	16.9
4	Total rice per person per day in g	330.1	260.3	353.5
5	Total rice per person per year in kg	120.5	95.0	129.0

Source: Derived from NLSS III CBS 2010/11.

Among the total cereal consumption rice contributes more than two third ie 121 kg among 168 kg of cereal consumption per person per year (**Table 1**). The non-poor populations consume more rice (including more fine rice) than poor population in Nepal.

Among South Asian countries, per capita consumption of milled rice is highest in Bangladesh (173.3 kg) followed by Bhutan (172 kg) and Nepal (122 kg). Afghanistan (17 kg) and Pakistan (17 kg) have lowest per capita consumption of milled rice among South Asian countries as shown in **Table 2**. India, one of the major rice producing country, has only 68.2 kg per capita consumption of milled rice. This shows that per capita consumption of milled rice in Nepal is 53.8 kg more than in India.

Table 2. Rice consumption pattern in South Aisan countries

Countries	Population (millions)	GNI per capita (PPP $)	Milled rice consumption kg per person per year	Rice production (million tonnes)	Rice Yield (t/ha)
Afghanistan	31.4	1,060	17	0.672	3.23
Bangladesh	148.7	1,940	173.3	50.061	4.28
Bhutan	0.725	5,480	172	0.070	3.14
India	1,200	3,590	68.2	143.9	3.28
Nepal	28.5	1,260	122	4.66	3.2
Pakistan	176.8	2,870	17	7.235	3.06
Sri Lanka	21	5,520	103.8	4.3	4.06

Source: GRiSP 2013, MoAD 2015.

Health effects of consuming rice only

Consumption of balanced amount of rice helps to provide fast and instant energy, regulate and improve bowel movements, stabilize blood sugar levels, and slow down the aging process, while also providing an essential source of vitamin B1 to the human body. Other benefits of balanced consumption of rice include its ability to boost skin health, increase the metabolism, aid in digestion, reduce high blood pressure, help weight loss efforts, improve the immune system and provide protection against dysentery, cancer, and heart disease. Rice is a fundamental food in many cultural cuisines around the world, and it is an important cereal crop that feeds more than half of the world's population. Despites of various beneficial effects of health for human being, there are several negative effects of frequent and regular consumption of rice as staple food. High-consumption of white rice to be associated with an increased risk of developing type 2 diabetes. The increase in risk is especially noted in Asian populations. White rice is considered a high glycemic index food or fast carb. This means it is rapidly broken down into sugar in the body. This can contribute to insulin resistance, glucose spikes after eating white rice. Each additional daily serving of white rice may increase the high risk for developing type 2 diabetes by 10% and also causing obesity (Sifferlin 2012). Vitamin A and riboflavin are the major nutritional constraints in rice-eating populations (Bamji 1983).

Nutritional importance of rice

Cereals are staple foods, providing a major source of carbohydrate, protein, B vitamins and minerals for the world's population. Within common varieties of cereals, 25–27% of starch is present as amylose, while in waxy varieties (eg rice and corn) most of the starch is amylopectin. Cereals contain about 6–15% protein (Goldberg 2003). The major storage proteins in rice are glutelin (oryzenin) (Kulp and Ponte 2000). Rice has the highest protein digestibility and energy digestibility among cereals, probably in part because of its low dietary fiber and tannin content (http://www.fao.org). Rice is a good source of thiamine, riboflavin and niacin. Rice contains the highest level of selenium among the cereal grains, providing between 10 and 13 mg per 100 g. On a dry weight basis, brown rice contains 0.89% of phytate, a type of anti nutrients (Cheryan 1980). Phytic acid can act as an antioxidant, particularly in regards to iron. Phytic acid's ability to sequester and trap iron is beneficial**.** In fact, it does such a good job of binding to iron that it can effectively neutralize any free radical.

White, long-grain rice

Raw, long-grain white rice is a relatively good source of energy, carbohydrates, calcium, iron, thiamin, pantothenic acid, folate and vitamin E, compared to maize, wheat and potatoes. It contains no vitamin C, vitamin A, beta-carotene, or lutein+zeazanthin, and is notably low in fiber.

White and brown rice

Brown rice contains many vitamins and minerals as well as fiber in the bran layer. Polishing removes roughly 80% of the thiamine from brown rice. Brown rice in averages contains 9.5% protein. Rice bran contains a high proportion of fiber and contains vitamin-E (known to have antioxidant properties).

Black, purple and red rice

Though not commonly grown in Nepal, black and purple rice have their bran layer intact hence are more nutritious. In particular, red rice are known to be rich in iron and zinc, while black and purple rice are especially high in protein, fat and crude fiber. The color of black, purple and red rice is derived from anthocyanin pigments in the bran layer. Anthocyanin pigments are known to have free-radical-scavenging and antioxidant capacities. Generally, it contains 2–3 milligrams of iron per kilogram (ppm) of rice, reaching a maximum of 5 ppm in some cases. Breeders at IRRI are working to create 'iron-clad' rice with a minimum of 14 ppm of iron.

Common practices of rice in Nepal: Effects on nutrition

Washing or rinsing rice before cooking

Rinsing rice, sometimes multiple times, results in the loss of water-soluble nutrients, including starch, protein, vitamins, minerals and fats. Similar nutrient loss would also occur, however, if rice is pre-soaked and then drained before cooking.

Cooking

Cooking milled (polished/white) rice by boiling in water (without washing) results in the loss of up to 7% of protein, 36–58% of crude fat, 16–25% of crude ash, 21% of calcium, 47–52% of thiamine, 35–43% of riboflavin, and 45–55% of niacin.

Parboiling

Parboiling rough rice before milling allows a portion of the vitamins and minerals in the bran to permeate the endosperm and be retained in the polished rice. This treatment also lowers protein loss during milling and increases whole-grain recovery.

Rice availability season in Nepal

As rice is generally harvest in the month of Oct/Nov, rice is available in Nepal from Nov/Dec to Mar/Apr. In the period of May/June to Oct/Nov, rice is generally deficit in Nepal. Seasonal food shortages are quite common in many parts of Nepal as a result of monsoonal influences in production, poor post-harvest storage and handling, and weak transport infrastructure and market integration (Shively et al 2011). July-August and January-March are traditionally agricultural lean seasons and a resultant seasonal deterioration in the food security situation is expected (Nepal Food Security Monitoring System 2013a, Nepal Food Security Monitoring System 2013b). Mountainous areas especially experience seasonal deterioration in the food security situation between November and March (Nepal Food Security Monitoring System 2013). Household food stocks are depleted during this period and some households are unable to afford some essential non-food expenditures without engaging in irreversible coping strategies (Nepal Food Security Monitoring System 2013b).

Food losses and food waste

Food losses refer to the decrease in edible food mass throughout the part of the supply chain that specifically leads to edible food for human consumption. Food losses take place at production, postharvest and processing stages in the food supply chain (Parfitt et al 2010). Food losses occurring at the end of the food chain (retail and final consumption) are rather called "food waste", which relates to retailers' and consumers' behavior (Parfitt et al 2010).

Food waste or loss is measured only for products that are directed to human consumption, excluding feed and parts of products which are not edible. Per definition, food losses or waste are the masses of food lost or wasted in the part of food chains leading to edible products going to human consumption (FAO 2011).

Generally, food loss or waste occurs in five segments of Food Supply Chain (FSC) ie agricultural production, post harvest handling and storage, processing, distribution and consumption (FAO 2011). Among them, empirical evidence show that drivers of consumer food waste include stocking too much food; over-preparing or not cooking it properly (eg burning food); leaving food on dishes after meals or not willing to consume leftovers, and decaying of prepared food after long or inappropriate storage.

Roughly one-third of the edible parts of food produced for human consumption, gets lost or wasted globally, which is about 1.3 billion tonne per year. Food is wasted throughout the FSC, from initial agricultural production down to final household consumption. In medium- and high-income countries food is to a great extent wasted, meaning that it is thrown away even if it is still suitable for human consumption. Significant food loss and waste do, however, also occur early in the food supply chain. In low-income countries food is mainly lost during the early and middle stages of the food supply chain; much less food is wasted at the consumer level (FAO 2011) **(Figure 1)**.

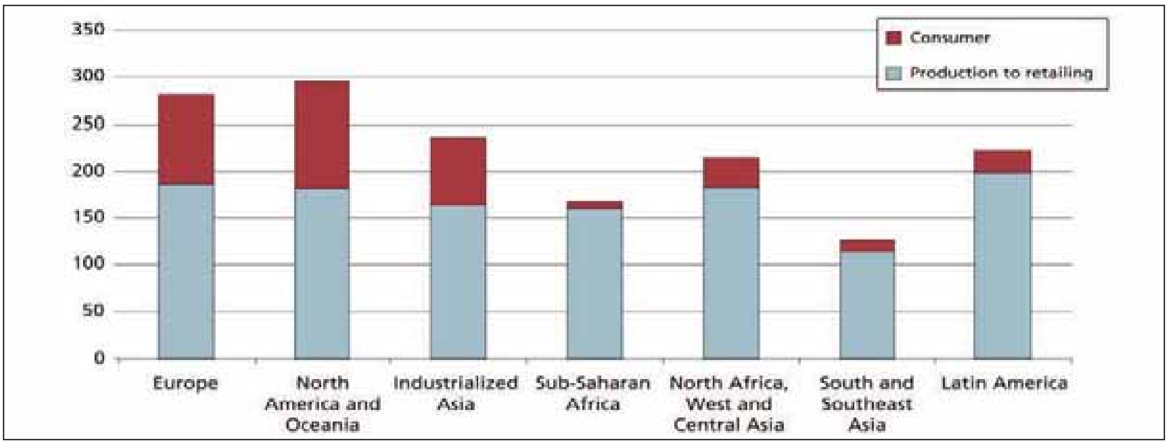

Figure 1. Global food loss or waste (kg/capita/year)

Source: FAO 2011.

Figure 1 shows that the per capita food loss in Europe and North-America is 280-300 kg/year. In sub Saharan Africa and South/Southeast Asia it is 120-170 kg/year. The total per capita production of edible parts of food for human consumption is, in Europe and North-America, about 900 kg/year and, in sub Saharan Africa and South/Southeast Asia, 460 kg/year. Per capita food wasted by consumers in Europe and North-America is 95-115 kg/year, while this figure in sub-Saharan Africa and South/Southeast Asia is only 6-11 kg/year. Food losses in industrialized countries are as high as in developing countries, but in developing countries more than 40% of the food losses occur at post-harvest and processing levels, while in industrialized countries, more than 40% of the food losses occur at retail and consumer levels. Food waste at consumer level in industrialized countries (222 million tonnes) is almost as high as the total net food production in sub Saharan Africa (230 million tonnes) (FAO 2011). Similarly, the total cereal loss during consumption shows lesser percent of loss during consumption in South/South East Asia as shown in **Figure 2**.

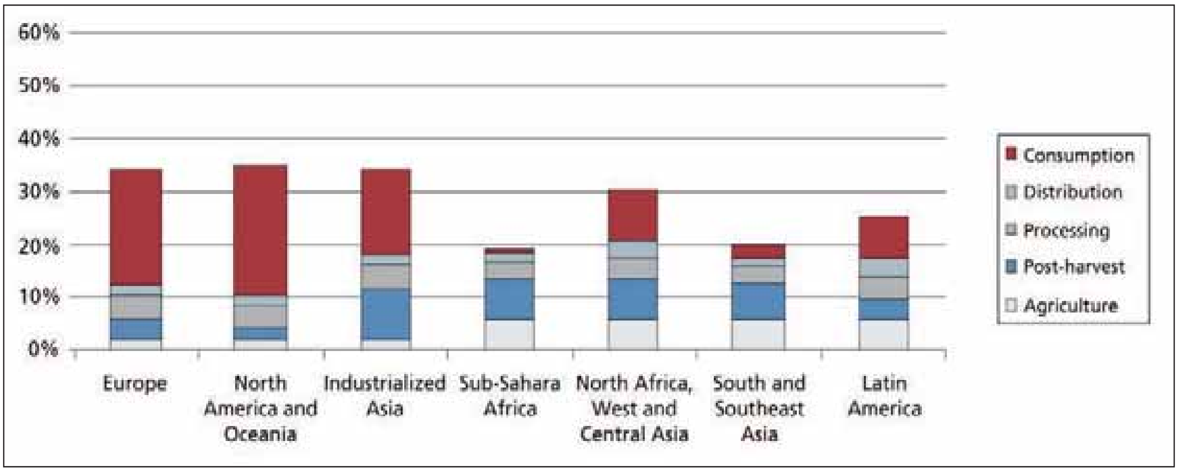

Figure 2. Food loss/waste in cereals in world

Source: FAO 2011.

Food loss or waste in Nepal has become a burning issue for food security in Nepal. In addition to food loss during production, processing and storage, several thousand tonnes of food is lost or wasted during consumption. Majority of food loss during consumption constitute waste of rice in Nepal. With reference to food loss estimated by FAO (2011) for South Asian country ie 6-11 kg/person/year, the annual food loss or waste in Nepal is estimated to be in range of 158967.02 to 291439.54 tonnes. Rice loss during consumption constitutes the major part of food loss in Nepal. This clearly shows that reduction in food loss can significantly contribute to reduce import and also enhance the food security situation of Nepalese people. More specifically, minimization of loss of rice during consumption can certainly reduce the annual import of rice in Nepal.

Table 2. Annual food loss in Nepal

Particular	Estimate
Population	26494504 (CBS 2011)
Food loss/waste rate (consumption loss)	6-11 kg/person/year (FAO 2011)
Total food loss (at 6 kg/person/year)	158967.02 tonnes (FAO 2011)
Total food loss (at 11 kg/person/Year)	291439.54 tonnes

Source: CBS 2011, FAO 2011.

Conclusion and suggestions

Because of unequal distribution of land and production constraints, the mountains and the hills are more hit by food deficit. Populations living in the mountains and mid and far western hills have high rates of food insecurity in comparison to population of eastern hills. Lack of access to food is the core long-term food insecurity issue specially in the hills and mountains of the far and mid-western Regions because of lack of road infrastructure, low purchasing power and extremely high market prices. The food security has remained as serious and burning issues in Nepal. Almost all Nepalese people are habituated with consumption of rice as staple food in one hand and they often prefer fine rice in the other hand. This has created huge demand of rice in Nepal and thus the domestic production cannot fulfill the demand for rice. This has resulted in huge import of rice from India and third countries. Moreover, the food loss during consumption has stayed as one of the serious issue in food security in Nepal. As rice bears the major role to ensure food security in Nepal, its production has not met the grain demand of Nepalese population. Increase in productivity, adequate infrastructures for strengthening rice production, marketing and distribution system, change of food habit of consuming only rice to consumption of maize, wheat and other local crops as staple food, adopting appropriate mitigation and coping strategy for adverse impact of climate change in agriculture could be the appropriate ways out for improving food security situation in Nepal.

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Nepal Food Corporation in Supplying Rice to Maintain Food Security Situation in Nepal

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सारांश

नेपाल खाद्य संस्थान नेपालमा रहेका ३७ सार्वजनिक संस्थाहरू मध्येको एक हो । नेपाल खाद्य संस्थानको इतिहास राणाशासन कालसम्म पुग्छ तर अहिलेको अवस्थामा यो संस्थानको स्थापना 'संस्थान ऐन, २०२१ अन्तर्गत २०३१ साल मार्ग १७ गते भएको हो । यो संस्थान स्थापना गर्नुको मूल लक्ष देशमा खाद्य सुरक्षाको अवस्था बनाई राख्नु तथा खाद्य सामग्रीमा हुने मूल्यको उतार चढावबाट जनतालाई बचाउनु रहेको थियो । यो लक्ष प्राप्तिको लागि नेपाल खाद्य संस्थानले विभिन्न खाद्य सामग्रीहरूको खरिद र बिक्रीमा आफ्नो भौतिक, आर्थिक र मानव स्रोतको परिचालन गरी रहेको छ । यस संस्थानले राष्ट्रिय खाद्य मौज्दातमा २५,००० टन तथा सार्क खाद्य सुरक्षा बैंकमा ८,००० टन खाद्यान्न राख्ने काम पनि गर्दै आएको छ । नेपाल खाद्य संस्थानले कारोबार गर्ने धेरै किसिमका सामग्रीहरू मध्येमा चामल सबैभन्दा महत्वपूर्ण रहने गरेको छ । नेपाल खाद्य संस्थानले तीन विभिन्न स्रोतबाट चामल प्राप्त गर्ने गर्छ । त्यो चामल बिक्रिको लागि संचालक समितिले धेरैजसो दूर्गम पहाडी जिल्लामा पर्ने विभिन्न ८१ स्थानको लागि चामलको बिक्री मूल्य निर्धारण गरी दिन्छ । यो लेखमा बिगतमा खरिद तथा बिक्री भएको धानको परिमाण तथा त्यसको खरिद एवम् बिक्री मूल्यको ट्रेन्ड विश्लेषण गरिएको छ । यो विश्लेषणबाट निस्केको नतिजाले बिगतमा खरिद तथा बिक्री भएको परिमाण घट्ने वा बढ्ने काम एकनासले नभएको तर मूल्यको हकमा खरिद तथा बिक्री दुवै मूल्य एकनासले वृद्धि भएको देखाउँछ । बिक्रि परिमाणसँग सम्बन्धित विश्लेषणले कारोबार भएको परिमाण नेपाल खाद्य संस्थानको विद्यमान क्षमताभन्दा सधै कम रहेको देखाउँछ । यसरी क्षमताभन्दा न्यून परिमाणको मात्र कारोवार भइरहँदा नेपाल खाद्य संस्थान सधै घाटामा चल्न गई कूल संचित नोक्सान आ.व. २०७२/७३ को अन्त्य सम्ममा रू एक अर्ब दश करोड दश लाख पुगेको छ । नेपालजस्तो स्रोतको अभाव रहेको देशमा भएका स्रोतको उपयोग गर्न नसकी संस्थान घाटामा जानुले राम्रो संकेत गर्दैन । तसर्थ, भविष्यमा धानको कारोबार बढाउन नेपाल खाद्य संस्थान र सरकार दुवैले आवश्यक रणनीतिहरूको विकास गर्ने तर्फ तत्काल ध्यान दिनु पर्ने देखिन्छ ।

Summary

Nepal Food Corporation (NFC) is one among the 37 public enterprises in Nepal. The history of NFC dates back to the Rana regime, but this corporation gained in its current form in 1974 under the Corporation Act, 1964. The main goal of establishing NFC was to maintain a food security situation in the country and protect people from price volatility of food items. To achieve this goal, NFC is mobilizing its physical, financial and human resources for the purchase and sell of different food items. The NFC also has to maintain a national food buffer stock of 25000 tonnes and SAARC food security bank of 8000 tonnes. Although the NFC transacts several items, rice is the most important among them. The NFC receives rice from three different sources. The Board of Directors fixes the selling price of rice for 81 sales outlets, most of them located in remote hilly regions. In this paper, past trend of quantity purchase and sell as well as the buying and selling price of rice are analyzed. The result observed from the analysis suggests that the trend of quantity purchase and sell was found not uniform, but in case of price, both buying and selling prices had increased at a uniform trend. The analysis related to the volume of transaction also suggests that the quantity transacted remained always lower than the existing capacity of the NFC. Due to lower volume of transaction, the NFC was running at loss and the value of total accumulated loss reached NRs 1,101 million in 2015/16. For a country like Nepal, where resources are scarce, accruing loss by not utilizing the available resources is not a good gesture. Therefore, urgent attention needs to be paid by the NFC and the Government to develop strategies to increase the transaction of rice in future.

Keywords: Food security, NFC, Price, Rice, Trend

Introduction

Nepal Food Corporation plays a crucial role in rice marketing in Nepal. This corporation transacts not only rice bust also other food items that are demanded in the market as well as mandated by the government.

Wheat, pulses, sheep and goats are other main items, which are handled by the Nepal Food Corporation (NFC). Considering the choice of urban dwellers in recent years, NFC is bringing agricultural produce: such as buckwheat, millets, oats, and beans from remote mountainous region and selling them in the market in Kathmandu for the last three years. NFC transacts all other items occasionally, but transacts rice regularly since the day of its establishment.

History of Nepal Food Corporation

The history of NFC dates back to the Rana regime. *Rashad Godam* (food store) established during the reign of Janga Bahadur Rana is considered the initial form of Nepal Food Corporation (Chudal and Bimali 2056). This store did a commendable job in 1934 by distributing food materials to earthquake victims. In 1951, this store was amalgamated with Rice Milling Department (*Dhan Kutani Bibhag*), which was established in 1948 to supply milled rice to army, police and civil servants. The amalgamated organization was named Central Rice Store (*Sadar Dhan Godam*). Several transformations took place in this organization from 1951 to 1964 till the promulgation of Corporation Act, 1964. The organization was restructured in 1964 to form Food Management Corporation under the Corporation Act, 1964. With the purpose of supplying fertilizers, pesticides, improved seeds, and food items to people through a single door, the government decided to merge Food Management Corporation and Agriculture Supply Corporation in 1973 and formed Agriculture Buy and Sell Corporation. However, the integrated corporation could not deliver its services as per the expectation. It was realized later that performing all these functions through a single organization was difficult. Therefore, the Agriculture Buy and Sell Corporation was then dissolved and two separate corporations, namely Agriculture Inputs Corporation and Nepal Food Corporation were established on 2nd December 1974 under the Corporation Act, 1964. Although several political changes have taken place in the country following this date, no significant changes have been made in the structure and functions of NFC.

Objectives of Nepal Food Corporation

The main purpose of NFC is to maintain a food security situation in the country and protect people from price fluctuations by purchasing major food items from the regions where they are produced abundantly and supplying them in the regions where they are scarce. To attain this purpose, the NFC has set following objectives.

- Effectively implement the food policy of Nepal,
- Transport cereals in food deficient regions and supply them in reasonable prices,
- Construct store houses to collect cereals as well as to maintain the buffer stock,
- Purchase cereals from farmers at the prices fixed by the Government and
- Follow Government policies to make the institutional export of cereals effective.

All these objectives are related to the transaction of cereals. Being a principal cereal crop, the NFC is focusing all its efforts on rice. Hence, the infrastructure, facilities, and human resources of this corporation have been developed to continue the transaction of rice regularly.

Arrangement of resources and mobilization

To achieve its objectives, NFC arranges and mobilizes its physical, human, and financial resources through approved institutional arrangements. The corporation is led by the Board of Directors and General Manager is the Chief Executive. To deliver the services all over the country, there is one head office, eight zonal offices, 26 branch offices, one modern rice mill, and 59 depot offices (NFC 2016). However, the corporation has only 31 office buildings of its own. Till now, the corporation has 164 store houses with the capacity of storing 99,310 tonnes of food grains. In addition, the corporation is constructing four more store houses with the capacity of storing 15,000 tonnes of food grains. Similarly, the corporation has three rice processing mills, one each in Rajapur, Janakpur, and Mahendranagar. The processing capacity of Rajapur and Janakpur mills is 2 tonne per hour, whereas the capacity of Mahendranagar mill is 0.5 tonne per hour. Another rice processing mill is under construction in Bhairahawa.

NFC has the strength of 350 staff to run its offices as well as to use its infrastructure and facilities (MoF 2016). Out of them, 82 are working at officer level and 268 are working at assistant level. By the nature of job, 33 of them are technicians and the remaining 317 are non-technicians. The number of working staff has been drastically reduced if we compare this figure to the past.

Nepal Food Corporation is one among the 37 public enterprises, which are financed by the Government. There is sole investment of the Government of Nepal in the share capital, which was NRs 990 million by the end of Fiscal Year 2014/15 (MoF 2015). The Government also provides budget to NFC to subsidize the transport of rice in 23 remote hilly districts and pay the interest of the capital that is invested in maintaining food buffer stock. The amount of subsidy that was provided to NFC in 2014/15 was NRs 401 million. In addition, NFC received NRs 347 million from different banks in the form of loan. Receiving bonus from the investment in the share capital of Bishalbazaar Company Ltd. and Sajha Bhandar Pvt. Ltd. as well as the operating profit from the transaction of rice received under grant aid, are the other sources of finance for the NFC.

Despite the mobilization of resources received from different sources, the NFC could not earn profit and accrued a net loss of NRs 43 million in 2015/16. With this, the accumulated loss of NFC reached NRs 1,101 million by 2015/16 (MoF 2016).

Transaction of rice at NFC

Nepal Food Corporation purchases milled rice, paddy, wheat, pulses, oil, sugar, millets, buckwheat, and sheep and goats from different sources. Being a Government owned corporation, NFC has to maintain 25,000 tonnes of food at the national food buffer stock and 8000 tonnes at South Asian Association for Regional Cooperation (SAARC) food security bank. In addition, the NFC receives and sells the rice received as a grant from different sources to the Government of Nepal.

Although the NFC transacts several items, more than half of its resources are mobilized for the transaction of rice. In FY 2014/15, the NFC purchased 8,650 tonnes of rice, 29,023 tonnes of paddy, 20 tonnes of pulses, and 588 goats (*khasi/boka*) from different sources. In the same year, the NFC sold 15,762 tonnes of rice, 1300 tonnes of wheat (including flour), one tonne of pulses, and 588 goats (MoF 2016). These figures show that the major focus of NFC is on rice.

Despite these efforts, the rice supplied through NFC shares a small proportion of total national supply. The quantity of rice supplied through NFC against the total national supply is compared in **Annex 1.** The data presented in this annex suggests that the total rice supplied from NFC was sufficient to cover the buffer stock requirement only in FY 2011/12 and less than the requirement in rest of the four fiscal years. From 2010/11 to 2014/15, the proportion of rice supplied through NFC ranged from 0.2 to 1.48% of the total national supply. Since the quantity of rice supplied through NFC is low, the role of NFC in controlling the market price is insignificant. However, this corporation is playing a crucial role in maintaining the food security situation in remote mountainous region of the country.

Purchase of raw and milled rice

Nepal Food Corporation purchases both raw paddy from its offices located in Tarai region of Nepal and milled rice from its offices located in Tarai as well as in Kathmandu. A four-member Primary Purchase Committee is formed under the chairmanship of Chief District Officer (CDO) of concerned district to purchase raw paddy. This committee has the right to fix the buying of price, which should be equal or above the minimum support price declared by the government. Due consideration is given to local and national production situation while fixing the buying price.

Paddy purchase

The quantity of paddy purchased by the NFC in past ten years is presented in **Annex 2.** The data presented in **Annex 2** shows an increasing trend of paddy purchase with rise and fall in some years. The quantity of paddy purchase reached 29023 tonnes in 2014/15 from 265 tonnes in 2005/06. The figure jumped to 29023 tonnes in 2014/15 from 11278 tonnes in 2013/14 (MoF 2016). The disturbances caused during the time of conflict and the damage done in Rajapur rice mill took some years for the NFC to return to its normal business. The paddy purchased by this committee is processed in the mills established by the NFC in different locations. The processed rice is then packed in appropriate sized bags and transported to different points of sale along with directly purchased rice or the rice received under grant assistance.

Rice purchase

The milled rice is purchased through tender process. The tender is called as per the provision of Public Procurement Act, 2007 (Sarbajanik Kharid Ain 2063) and Public Procurement Rules, 2007 (Sarbajanik Kharid Niyamawali 2064) as well as the internal procedure of the NFC. The total quantity of rice purchased by NFC from 2005/06 to 2014/15 is presented in **Annex 2.** While observing the data presented in this Annex, we do not find uniform trend of rice purchase in this duration. In 2005/06, NFC purchased 11881 tonnes of rice. The quantity of purchase increased gradually from 2005/06 to 2008/09 and reached 20674 tonnes. In 2009/10, the quantity of purchase dropped down to 15000 tonnes. Again, the quantity of purchase increased gradually and reached 23815 tonnes in 2011/12. Due to various reasons, the NFC did not purchase rice in 2012/13 and 2013/14. However, NFC purchased 8650 tonnes of rice in 2014/15. The quantity of rice purchase has an impact on rice sale in these years.

Supply trend

The rice managed from three different sources (rice purchase, rice prepared by milling purchased paddy, and rice received under grant) is sold from different outlets of the NFC scattered in different parts of the country. However, remote mountainous districts are the targeted areas for rice supply. There are District Food Management Committees in these districts to manage smooth distribution of rice. The total quantity of rice supplied through NFC from FY 2005/06 to 2014/15 is presented in **Annex 3.** The quantity of rice supply was fluctuating in these years and the total supply decreased to 15,762 tonnes in 2014/15 from 20,741 tonnes in 2005/06 with minor increase in some years within the period. The NFC did not sell any rice in 2013/14.

Price trend

Being a public sector organization, the prices of rice fixed by the NFC become the bases for price fixation in the open market. However, the proportion of rice transacted by the NFC is too small in comparison to the total national requirement to control the market price. Price fixation is done for buying paddy and rice, and for selling rice.

Purchasing price

The Primary Purchase Committee formed in the district, in which paddy is going to be purchased, is given the authority of fixing the buying price. This committee considers the cost of production, local situation, and overall production situation to fix the buying price of paddy (S Sapkota, personal communication, June 5 2016). Buying prices of different varieties of paddy from 2007/08 to 2015/16 is presented in **Annex 4**. The Annex shows that the prices of paddy increased uniformly over the period. In these years, the NFC bought paddy from 12 different offices located in Tarai and inner Tarai. The price difference between coarse and fine paddy remained around NRs 200-300 till 2014/15, but the variation was quite high in 2015/16. The price of basmati (a superfine rice variety) remained almost double the price of coarse rice in this duration.

The three aspects, which are considered in fixing the buying prices of paddy, are also taken into consideration while estimating the maximum price of rice purchased through tender process. The board of directors estimates the buying price of rice for bidding from different locations. If the prices of different types of rice quoted by bidders are higher than the maximum prices estimated by the board, prevailing rules and regulations will not allow NFC to accept the tender. NFC could not purchase rice in 2013/14 due to this reason. In some years, bidders bid at low prices to get the contract, but could not supply rice at those prices later. Due to this reason, the NFC could not purchase rice in 2012/13. The buying price of rice from 2006/07 to 2014/15 is presented in **Annex 5.** Buying prices of rice are fixed for 12 different locations in Tarai. Prices are fixed for coarse, some popular medium fine to fine rice varieties, and basmati. Since different rice varieties are purchased from different locations, it is difficult to estimate the price differences between varieties. However, we can observe the changes in price of same variety over the period. The price of coarse rice reached NRs 3,775 in 2014/15 from NRs 1,650 in 2006/07 in Nepalgunj. Similarly, the price of sona mansuli reached NRs 3,278 in 2014/15 from NRs 1,870 in 2006/07 in Birtamod. In this duration, a uniform trend was observed in the price rise.

Selling price

The selling price of rice is fixed by the board of directors. Purchasing price, operational expenses, and transport subsidy provided by the Government for 23 remote districts are taken into consideration while fixing the selling price. General Manager has the right to increase the price by ten percent and decrease the price by five percent to manage the local situation. Prices are fixed for all the outlets of the NFC. So, the list of selling prices of rice is long. In the past, selling prices of rice was increased at a uniform trend. The minimum and maximum range of selling prices fixed by the board on April 21, 2016 is presented in **Annex 6.** Prices of 12 different varieties of rice for 81 locations of 35 districts are presented in this Annex. The Annex shows that most of the outlets of the NFC are located in remote mountainous districts. Prices of rice are different for general public and civil servants. General public needs to pay a slightly lower price for the same variety of rice in the same place compared to civil servants. Price difference is very high if the same variety is sold in the remotest part of the country, such as Humla and the most accessible part, such as Bardiya and lowest if it is sold in similar locations. In this Annex, the price difference of Sanwa Mansuli is lowest, ie NRs 700 between Surkhet and Jumla. Similarly, the price difference of Basmati is highest, ie NRs 3000 between Kathmandu and Janakpur.

Conclusion

The discussion concludes that the structure of NFC is shrinking over the years to minimize the accumulated operational loss. Since the overall transaction of NFC has also been declining in recent years, the organizational restructuring only could not help NFC to minimize the operation loss as per the expectation.

Rice being the principal food crop of Nepal, the NFC has prepared its resource base to transact rice all over the country. NFC is transacting rice received from three different sources: by processing locally purchased paddy, purchasing milled rice directly through tender process, and getting rice from development partners received under grant assistance to the Government of Nepal. Although some of the rice is sold in accessible market centers, the focus of NFC is to sell major volume of rice in the food deficit hilly region. The role of NFC in maintaining food security situation in remote areas of Nepal is commendable. In addition, rice is kept in storage by the NFC to maintain the national food buffer stock and SAARC food security bank. However, the total volume of rice transacted by the NFC is not even sufficient to maintain the buffer stock in some years. In summary, we can conclude that the resources of NFC are underutilized and the prospect of utilizing the resources at full swing relies heavily on rice.

On the basis of this conclusion and discussions above, following recommendations can be made:

- The only way of reducing accumulated loss and increasing profit of the NFC is to increase the volume of transaction. Therefore, a plan of actions has to be developed as soon as possible to increase the transaction of rice through the NFC.
- The NFC should give priority to purchase paddy rather the purchase of rice. Since the purchase of paddy can be done directly by the decision of primary purchase committee, the quantity of purchase

can be increased as well as the established infrastructure and facilities (rice mills and store houses) of the corporation will be utilized more. Increasing paddy purchase will also benefit farmers as more rice producers will have the opportunity to sell their produce directly to a public enterprise.

- One of the objectives of NFC is to make the institutional export of cereals effective. Nepal is not in a position to export cereals in recent years. Instead of cereals, it is better to seek measures to export value added food products through NFC.
- Proper attention should be paid in maintaining the buffer stock in reality. Buffer stock is for managing crisis, which is unpredictable.
- The decision on the quantity of sale and selling prices from every sales outlet should be taken well in advance. This will benefit the people living in food deficit regions and NFC both.

For a country like Nepal, where resources are always scarce, it is extremely unwise to underutilize the available resources. Therefore, urgent attention is required to be paid by NFC as well as the Government to develop strategies to increase the volume of transaction of rice. This will ultimately help in the full utilization of physical, financial, and human resources of NFC as well as in maintaining the food security situation of the country.

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Annex 1. Share of NFC in total rice supply (Quantity in tonnes)

SN	Year	Paddy production	Milled rice	Import	Total rice supply	NFC supply	Share of NFC (%)
1	2010/11	4,460,000	2,676,000	103,897	2,779,897	31,959	1.15
2	2011/12	5,072,000	3,043,200	162,045	3,205,245	47,315	1.48
3	2012/13	4,505,000	2,703,000	265,400	2,968,400	20,726	0.70
4	2013/14	5,047,047	3,028,228	296,954	3,325,182	6,767	0.20
5	2014/15	4,788,612	2,873,167	343,649	3,216,816	26,064	0.81

Source: MoF 2016 and 2013. Economic Survey of FY 2015/16 and FY 2012/13.

The import data of FY 2013/14 and 2014/15 are extrapolated from the price of import published in the Kathmandu Post of July 1, 2015. The newspaper reported that rice worth NRs 12.40 billion was in first 10 months of FY 2014/15 and the figure was 9.75 billion exactly in the same duration of FY 2013/14. Price per kg of rice was calculated by increasing 10% per year as ascertained from the past data of TEPC.

Annex 2. Quantity of rice and paddy purchased by NFC (Quantity in tonnes)

SN	Type	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15
1	Rice	11881	15278	11483	20674	15000	19000	23815			8650
2	Paddy	265	87	532	1176	7500	3015	7500	3884	11278	29023
3	Rice grant	8282	5520	5545	7104	9660	11150	19000	18396		
	Total	20428	20885	17560	28954	32160	33165	50315	22280	11278	37673

Source: MoF 2006/07 - 2015/16. Yellow Books.

Annex 3. Quantity of rice sale by NFC (Quantity in tonnes)

SN	Type	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15
1	Rice	20741	24363	21274	17278	27258	21120	25105		20295	15762

Source: MoF 2006/07 - 2015/16. Yellow Books.

Annex 4. Purchasing price of paddy in different years Price: NRs/qt

SN	Year	Type	Mahendranagar	Dhangadhi	Rajapur	Nepalgunj	Betahani	Dang	Bhairahawa (off)	Bhairahawa (dep)	Birgunj	Janakpur	Lahan	Biratnagar
1	2007/08	Coarse	1050											
		Medium	1075											
2	2008/09	Coarse	1250		1360									
		Medium	1275		1425									
		Fine	1350		1550									
		Sona Mansuli										1475		
		Mansuli										1650		
		Basmati										3500		
3	2009/10	Coarse	1450		1400									
		Medium	1475		1685									
		Fine	1550											
		Makar kaddu			1680									
		Basmati										3650		

SN	Year	Type	Mahendranagar	Dhangadhi	Rajapur	Nepalgunj	Betahani	Dang	Bhairahawa (off)	Bhairahawa (dep)	Birgunj	Janakpur	Lahan	Biratnagar
		Coarse	1625		1615									
		Medium	1650		1700									
		Fine	1725											
4	2010/11	Sona Mansuli										2000		
		Ram bilash										2100		
		Makawanpur			1685									
		Basmati										3140		
		Coarse	1500	1505	1495									
5	2011/12	Medium	1550		1625									
		Sona Mansuli										1625		
		Makawanpur			1600									
		Coarse	1800	1750	1725	1825	1900	1900						
		Medium	1850	1775	1835	1925	2050							
		Fine		1850							2850			
6	2013/14	Makawanpur			1840									
		Gorakhnath							2600	2550				
		Sona Mansuli									2250	2250	2220	
		Jira masino											2750	
		Basmati										2100	5050	
		Coarse		2000	2000	2150	2100							
		Medium		2125	2250	2250	2200							
		Fine		2225	2300									
7	2014/15	Makawanpur			2200									
		Sona Mansuli											2100	2124
		Jira masino									2125			
		Radha 12												2080
		Coarse		1900		1925								
		Medium				2025								
		Makawanpur			2100									
8	2015/16	Sona Mansuli							2250		2250	2140	2041	
		Gorakhnath							2500					
		Jira masino									3150		3025	
		Basmati										3550		

Source: NFC 2016. Unpublished official data.

Annex 5. Purchasing price of rice in different yearsPrice: NRs/qt

SN	Year	Type	Dhangadhi	Tikapur	Nepalgunj	Surkhet	Dang	Bhairahawa	Kathmandu	Birgunj	Janakpur	Lahan	Biratnagar	Birtamod
		Coarse	1649		1650									
		Sona Mansuli						1880		1880	1800	1875	1875	1870
1	2006/07	Sanwa Mansuli						2190						
		Aruwa Mansuli							2390					
		Bindeshwari					1900							
		Basmati									3400			

SN	Year	Type	Dhangadhi	Tikapur	Nepalgunj	Surkhet	Dang	Bhairahawa	Kathmandu	Birgunj	Janakpur	Lahan	Biratnagar	Birtamod
		Coarse	2049		2131									
2	2007/08	Sona Mansuli							2694	2322		2250	2250	2331
		Sanwa Mansuli						2681						
		Bindeshwari					2131							
		Coarse	2483		2429									
3	2008/09	Sona Mansuli						2429	2671	2450		2429	2465	2411
		Mansuli							2591					
		Coarse	2594				2685							
4	2009/10	Sona Mansuli							2991	2825		2807	2751	
		Sanwa Mansuli						3833						
		Jira masino								4237				
		Coarse	3091		3125									
		Sabitri			3420									
5	2010/11	Jira masino								3986				
		Sona Mansuli						3351	3437	3250		3204	3097	3125
		Kanchhi Mansuli											2997	3025
6	2011/12	Sona Mansuli							3370	3489		3473	3370	
7	2013/14	Sona Mansuli			3218			3633						3658
		Coarse	3897	3897	3775	3922	3441							
8	2014/15				3291	3430								
		Sona Mansuli						3658	3775	3151		3374	3400	3278

Source: NFC 2016. Unpublished official data.

Annex 6. Selling price of rice fixed in April 21, 2016 in different parts of the countryPrice: NRs/qt

SN	District	Point of sale	Aruwa coarse		Sona Masuli		Aruwa Sabitri		Aruwa Kanchhi		Makawan pure		Sanwa Masuli		Japanese/ American		Basmati		Jeera Masino		Gorakh nath		Ram bilash		Makar kaddu	
			Public	Civil	Public	Civil	Public	Civil	Public	Civil	Public	Civil	Public	Civil	Public	Civil	Public	Civil	Public	Civil	Public	Civil	Public	Civil	Public	Civil
1	Jhapa	Birtamod																								
2	Taplejung	3 places																								
3	Morang	Biratnagar																	5200							
4	Sankhuwasabha	3 places							4700	4800																
5	Bhojpur	2 places																								
6	Siraha	Lahan																								
7	Khotang	5 places			3500	3700																				
8	Okhaldhunga	Okhaldhunga																								
9	Solukhumbu	3 places																								
10	Dhanusha	Janakpur															6500									
11	Kathmandu																9500				5200		3325			
12	Kaski	Pokhara																								
13	Tanahu	Bimalnagar																								
14	Manang	2 places																			5200	5400				

SN	District	Point of sale	Aruwa coarse		Sona Masuli		Aruwa Sabitri		Aruwa Kanchhi		Makawan pure		Sanwa Masuli		Japanese/ American		Basmati		Jeera Masino		Gorakh nath		Ram bilash		Makar kaddu	
			Public	Civil	Public	Civil	Public	Civil	Public	Civil	Public	Civil	Public	Civil	Public	Civil	Public	Civil	Public	Civil	Public	Civil	Public	Civil	Public	Civil
15	Mustang	2 places							3600	3700																
16	Gorakha	3 places																								
17	Dang	Tulsipur													3400										3400	
18	Rolpa	2 places																								
19	Rukum	2 places																								
20	Surkhet	Surkhet											4300													
21	Dailekh	2 places																								
22	Jajarkot	5 places																								
23	Dolpa	5 places									5200	5700														
24	Jumla	3 places											5000													
25	Humla	3 places	5200	5700	6100	6600	6100	6600			5200	5700							7000	7700	6200	6700				
26	Mugu	4 places													5100	5600										
27	Kalikot	4 places																								
28	Kailali	Dhangadhi																								
29	Bajhang	4 places													2900											
30	Bajura	2 places																								
31	Achham	3 places																								
32	Baitadi	3 places																								
33	Darchula	3 places																								
34	Banke	Nepalgunj	4t																						3500	
35	Bardiya	Rajapur	3175	-			3400				3250															

Source: NFC 2016. Unpublished official data.

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Rice Distribution in Remote Areas of Nepal through World Food Program

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सारांश

खाद्य सुरक्षाको प्रत्याभूति दिन नसक्नु नेपाली कृषिको लागि एक ठूलो चुनौती हो । खाद्य सुरक्षा प्रत्याभूतिका लागि स्थानीय स्तरमा कम उत्पादन हुनु र विशेष गरेर धान र चामल जन्य उत्पादनमा आश्रित खाद्य प्रणाली हुनु चुनौती रहेका छन् । नेपाल खाद्य संस्थान र विश्व खाद्य कार्यक्रमले खाद्यान्न सहयोग कार्यक्रमहरू संचालन गरिरहेका छन् । खाद्य असुरक्षा कम गर्नु, आपतकालीन अवस्थाको परिपूर्ति गर्नु र दीर्घकालीन रूपमा खाद्य सुरक्षा प्रत्याभूतिका लागि आधार तयार पार्नु विश्व खाद्य कार्यक्रमको खाद्यान्न सहयोग कार्यक्रमको उद्देश्य हो । विभिन्न दातृ राष्ट्रिय तथा अन्तराष्ट्रिय वित्तीय संस्था सरकारी तथा गैह्रसरकारी र अन्य विभिन्न संस्थाहरूले खाद्यान्न सहयोगका लागि कोष उपलब्ध गराउँछन् । विभिन्न विकास कार्यक्रमहरूमा सहभागिता श्रमदानका आधारमा स्थानीय गैह्रसरकारी संस्थाहरू मार्फत् खाद्यान्न उपलब्ध गराइन्छ । सन् १९८८ देखि ८८८०७९.३८ मे. टन चामल कर्णाली क्षेत्रमा वितरण भएको छ । सन् २००८ मा सबैभन्दा बढी (६३६९९.३८ मे. टन) खाद्यान्न वितरण भएको छ । उक्त वर्ष नेपालमा समेत विश्वव्यापी खाद्यान्न संकटको प्रभाव र खाद्यान्न मूल्यको मुद्रास्फिтиको प्रभाव थियो । समग्रमा सन् १९९८ देखि २०१२ को बीचमा खाद्यान्न सहयोगको ६५.९६ प्रतिशत हिस्सा चामलले ओगटेको छ । तथापि, केही जनताहरू कामका लागि खाद्यान्न कार्यक्रममा सामेल हुने अनिच्छा, खाद्यान्न प्राप्तिको अनिश्चितता, लामो लाईन बस्नुपर्ने, भेदभाव, लामो पर्खाई आदि विभिन्न कारणले यस कार्यक्रम प्रति नकारात्मक धारणा राख्दछन् । खाद्यान्न असुरक्षित क्षेत्रमा खाद्यान्न सहयोगको प्रमुख हिस्सा चामल हुँदा त्यस क्षेत्रको धान/चामलमा आधारित खाद्य संस्कृतिलाई परिवर्तन गर्न बाधा पुग्ने सम्भावना समेत रहन सक्छ । अतः आगामी दिनहरूमा खाद्यान्न सहयोग कार्यक्रममा अधिक मात्रामा चामल वितरण गर्दा त्यस क्षेत्रको खाद्यान्न सुरक्षा तथा विकासमा परेको प्रभाव तथा खाद्य सुरक्षाका लागि धान र चामलमा निर्भरतामा परेको असरबारे समेत गहिराइमा अध्ययन हुनु जरूरी छ ।

Summary

Food insecurity is one of major challenges in Nepal. Low level of local production and food preferences, especially to rice are challenging factors to improve the food security situation. The Nepal Food Corporation (NFC) and the World Food Program (WFP) are major organizations providing food aid in Nepal. The aim of WFP is to prevent food insecurity, meet emergency needs, and build assets to promote long-term food security. Different donor countries, international financial institutions, I/NGOs and other organizations provide fund to WFP for food aid. WFP distributes food based on peoples' involvement in development work. Food aid is distributed through local non-governmental organizations. Since 1988, WFP has distributed 888079.38 tonnes of rice in the Karnali region of Nepal. The maximum amounts of rice (63699.36 tonnes) was supplied in 2008. Nepal faced hard hit by the global food crisis and experienced steep food price inflation in 2007/08. On an average, food aid comprised 65.96% of rice on a weight basis during 1998-2012. Some people perceived negative feeling to food aid because they lacked interest to participate in food for work program for reasons such as: uncertainty of getting food, long lines, favoritism, harassment, extortion and long waits. Rice is major food provided as food aid, which in turn may retard the rate of changing system of rice based food habit. Therefore, there is a need to conduct in-depth study on impact of rice distribution as food aid on food security and development as well as a dependency on rice/food aid.

Keywords: Distribution, Food aid, Food crises, Remote area, World Food Program

Introduction

Poverty and food insecurity are the major problems of Agriculture in Nepal. In Nepal, 25.2% people lives below the poverty line (NLSS 2011) and 38 districts are still food deficit (MoAD 2015). The far western and midwestern regions and the mountain districts have poverty rates well above 40% (ADB 2016). Karnali region faces high levels of malnutrition and food insecurity (McDonough, 2014). Poor access to food is one of the contributing factors for food security in these areas. Food aid today is widely and accurately considered an instrument for addressing acute and chronic food insecurity in low-income communities. GOs and INGOs are working to enhance the food availability through the means of food aid to respond food crisis. However, low level of local production and food preferences, especially to rice are challenges to improve the food security situation. This review aims to analyze the situation of rice supply and its impact on the livelihood of farmers in those areas, primarily based on data of food aid distribution by WFP. It does not include those distributed by NFC and other organizations.

Food aid in Nepal

The Nepal Food Corporation (NFC) and the World Food Program (WFP) are major organizations providing food aid in Nepal. The World Food Program has three categories viz; program, emergency, and project giving emphasis on emergency and project aid. The aim of WFP food aid is to prevent food insecurity, meet emergency needs, and build assets to promote long-term food security. However, NFC aims to carry out the government's food policy, which includes supplying subsidized food to 30 rural districts in Nepal, selling non-subsidized food throughout Nepal, maintaining buffer food stocks to respond to deficits, and managing food imports from foreign countries. Because of rice based food habit and cultural aspects, rice is of the most distributed food through these food aid activities (McDonough 2014). Different donor countries, international financial institutions, I/NGOs, private donors and other organizations provide fund to WFP for food aid. WFP distributes food based on peoples' involvement in development work. Food on aid is distributed through local non-governmental organizations. These programs employ local villagers to work and generally pay participants 3-5 kg of rice for a day's work. Participants might be paid entirely in food or in a food/cash combination.

Amount of rice distribution in food aid

Nepalese people prefer to have rice as staple food. Despite government's effort to diversify food options, rice still is the most preferred staple food in daily life of Nepalese people. Even for poor people who cannot buy rice for daily consumption rice based food is most desired at least during festivals.

Since 1988, WFP distributed 888079.384 tonnes of rice in the Karnali region of Nepal. Distribution of rice on food aid varied widely over the years. The maximum amounts of rice (63699.36 tonnes) was supplied in 2008. Nepal was hard hit by the global food crisis and experienced steep food price inflation in 2007/08. Nepal has not experienced the considerable food price deflation which occurred across much of the region during the late 2008 and 2009 (MoAC/WFP 2010). Official year-on-year food price inflation is still very high.

Various food materials, including beans, maize, lentil, biscuits, and vegetables have been distributed on food aid. Rice is a major constituent of food aid in Nepal. On an average, food aid comprised 65.96% of rice on a weight basis during 1998-2012. However, it occupied only 11.5% of the total weight in 1989 and it reached the maximum 87.86% in 1993.From 2000 to 2012, it has remained around 50-85%. (FAO 2016).

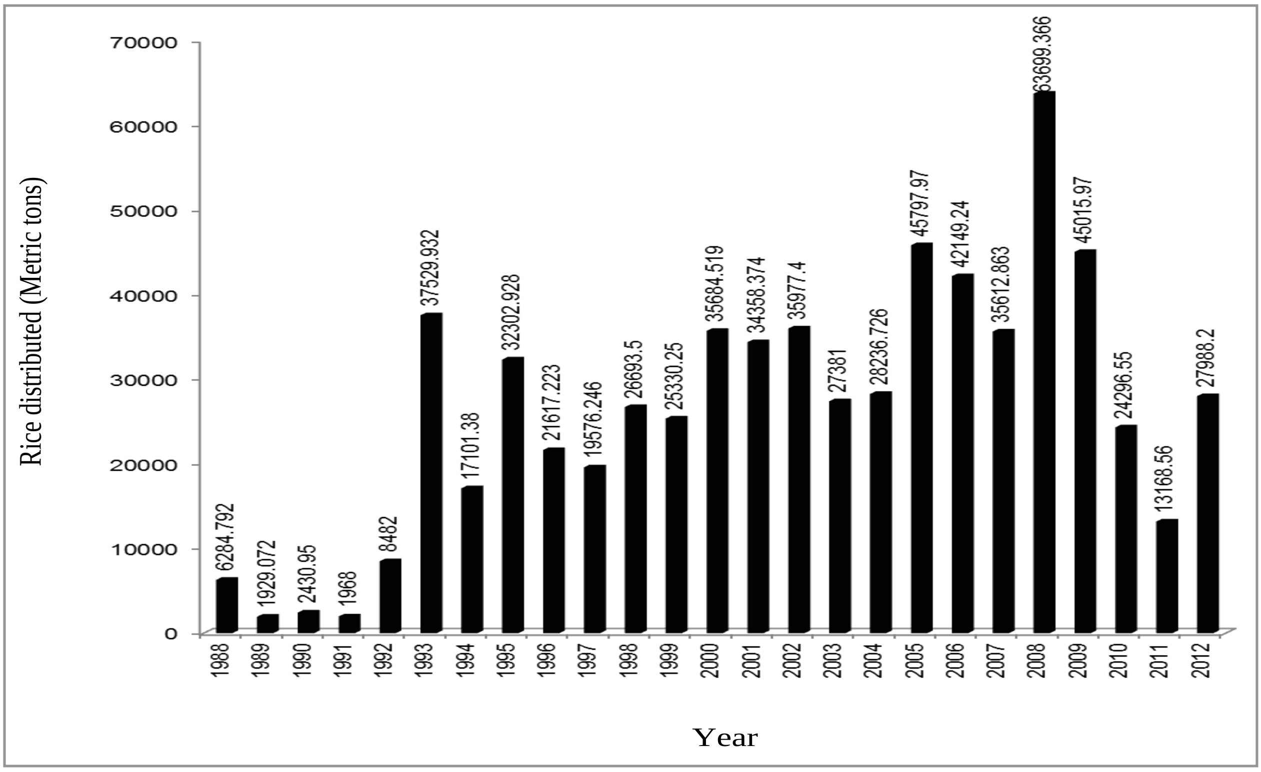

Figure 1. Amount of rice distributed for food in different years

Source: WFP 2016

Food aid and sustainability

People have perceived positive as well as the negative effect of food aid. No interest to participate in food for work programs for: uncertainty of getting food, long lines, favoritism, harassment, extortion and long waits, are reasons cited for the negative feelings (McDonough 2014) on food aid program.

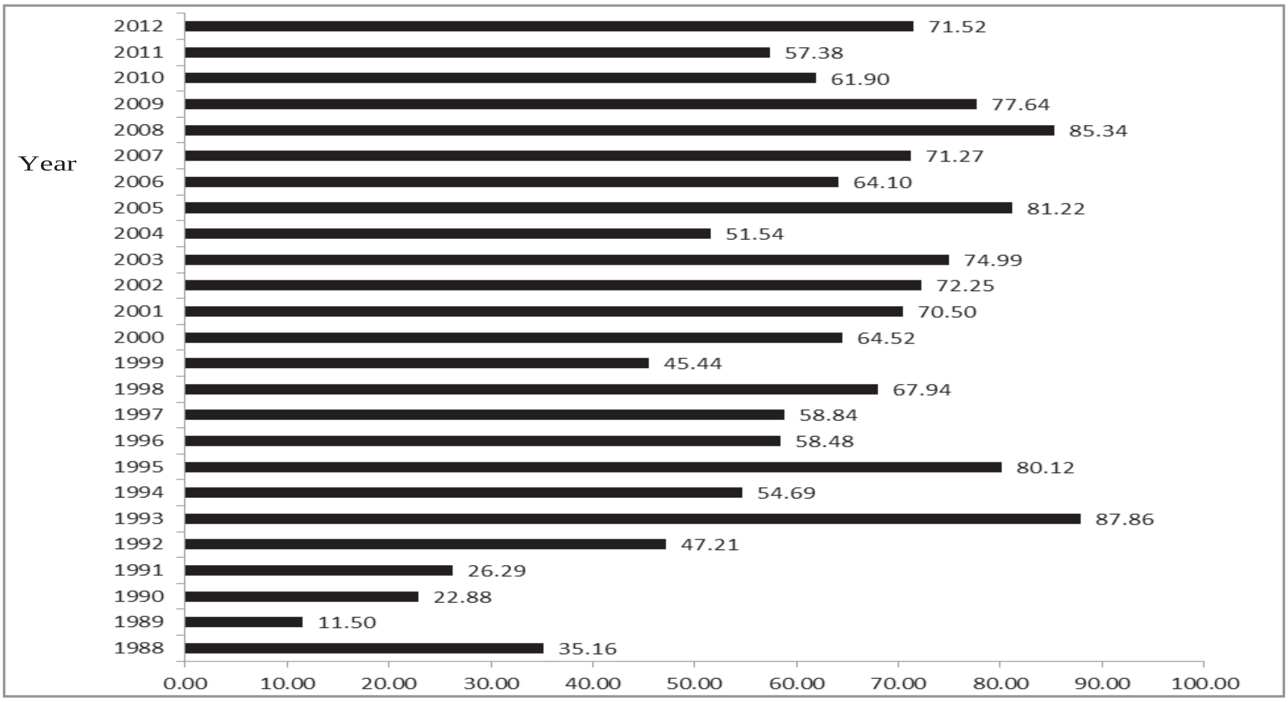

Figure 2. Proportion of rice in food aid

Source: WFP 2016

Increased dependency is a central issue in the historical controversy of food aid. There can be negative and positive outcomes from dependence (Bishokarma 2012). Positive dependence occurs when food aid acts as a safety net for communities, emergency support, supporting livelihoods, preventing destitution, and increasing the resilience of communities. Negative dependence occurs when food aid reduces the potential of the community to support itself in the future. Food aid supported some development activities at local level and to cope with food insecurity during hard times. Negative dependence can lead to unsustainable livelihoods and increased vulnerability. Also, rather than two categories, dependence should be thought of as a continuum, with varying levels of positive and negative impacts. Food aid are not certain and irregular but can generate increased expectation and reduced interesting enhancing productivity, promoting local crops and expanding diversity in food habit. Rice as the major food of the food aid program may retard the rate of food changing system by reinforcing rice based food habit on beneficiaries.

Summary and conclusion

Poverty and food deficit are major challenges in the western hills of Nepal. WFP, NSC and other organizations are providing food aids to support the livelihoods of people. Since 1988, WFP has distributed 888079.384 tonnes of rice. On an average, food aid comprised 65.96% of rice on a weight basis during 1998-2012. Distribution of rice at a significantly higher rate helps to cope with food insecure situation, emergency period and support development works, but may lead to persistency of rice based food habit, increased dependency on rice and reduced interest on cultivation of local crops for food purpose and initiatives to enhance productivity. People have positive as well as negative outlook on food aid provided by WFP as well as NFC. Therefore, there is a need to conduct an in-depth study on impact of rice distribution as food aid on food security and development as well as a dependency on rice/food aid.

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Changing Dietary Pattern for Consumption of Rice in Nepalese Society

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सारांश

यो अध्ययनमा विशेषत विभिन्न ठाउँबाट हाल काठमाण्डौंमा बसोबास गर्दै आएका विभिन्न उमेर समूहका मानिसको खानपानको स्थितिबारे अध्ययन गरिएको थियो । समग्र अध्ययनले चामल (भात) मुख्य खानाको रूपमा रहेको देखिएको छ । ज्येष्ठ नागरिकहरूसँगको अन्तरक्रिया अनुसार पहिला पहाडमा स्थानीय धानको उत्पादन कम हुनु, चामल किन्ने आम्दानीको स्रोत कम हुनु, स्थानीय बजारमा चामल सहज रूपमा उपलब्ध नहुनु, मकै तथा कोदोको राम्रो उत्पादन हुनाले मकै तथा कोदोबाट बन्ने आँटो, ढिडो र रोटी मुख्य खानाका रूपमा पर्दथे । तर, अहिले चामल किन्न आम्दानीको स्रोत बढ्नु, स्थानीय बजारमा चामल सजिलै उपलब्ध हुनु र खानेबानीमा परिवर्तन भै मीठो मसिनो चामल खोज्नु जस्ता कारणले पहिलेको तुलनामा चामल (भात) खाने प्रचलन बढ्दै गएको छ । भारतबाट आउने करिब ९५ प्रतिसत चामल स्टीम गरिएको मसिनो चामल पर्दछ । बजार अवलोकन गर्दा मसिना तथा बासनादार चामल सबै सुपरमार्केट, डिपार्टमेन्टल स्टोर, रेष्टुरेन्ट, वसपार्क वरिपरिका होटलहरू सबैमा उपलब्ध भएको पाइयो । मसिना तथा बासनादार चामलको माग हुनाका प्रमुख कारणहरूमा आम्दानीमा वृद्धि तथा गुणस्तर र स्वादमा सचेतना आदि प्रमुख रहेका पाइयो । यसै पृष्ठभूमीलाई मध्यनजर गर्दै नेपाल सरकारले मसिना तथा बासनादार धान प्रवर्द्धनका कार्यक्रमहरू समेत कार्यान्वयन गर्दै आइरहेको छ ।

Summary

This study was conducted to examine the rice preference with reference to changing dietary pattern of people currently living in Kathmandu district. Overall finding of the study revealed that rice was most preferred food; however, maize (aanto and dhido) was in the first position in terms of consumption followed by millet (*dhindo*) and rice (*bhat*) in the past, especially in hilly regions. For the past few years, it has been found that rice is in the first position in terms of consumptions as major staple food followed by bread (wheat/oat), *Dhido/Aanto* (maize) and *dhido* (millet). 95% of rice imported from India was found to be steamed fine rice. Nepalese food habit has changed along with the rise in living standard due to which national-wide preference of fine rice consumption has increased in the past few years creating the need for rice import. The observation at market showed that the fine and aromatic rice was available in most of the restaurants, hotels, supermarkets and even in hotels near the bus park. Increase in income level and living standard, awareness in taste and quality were the most influencing factors for consumption of fine rice. Realizing the demand for fine rice in Nepal, government of Nepal has started in formulating and implementing the fine and aromatic rice promotion program in recent years.

Keywords: Fine and aromatic, Import, Preference, Program, Rice

Introduction

Food security has emerged as a major global concern to end the hunger, poverty and malnutrition. The Agriculture Development Strategy (ADS) has clearly mentioned to achieve food and nutrition security leading to food sovereignty in its vision statement. Rice is the main staple food crop in Nepal. Because of nationwide preference of rice consumption in Nepal, domestic production has not been enough to meet the rice demand. The demand for rice is increasing by 10% each year. However, as the local production of rice is not enough to meet growing demand, the country relies on India for both paddy and rice imports. In Nepal per-capita rice consumption is 100 kilograms annually (The Himalayan Times 2015). Rice contributes around 20% to the agricultural gross domestic product and fulfills more than 50% of the total calories requirement of Nepalese. But since we have little possibility of increasing the size of arable land in our country, it is important that we increase the productivity per hectare by using technology and innovative farming methods. Nepal has released and registered 107 rice varieties in the last 50 years.

Methodology

With the objective of assessing changing Dietary pattern on consumption of rice in Nepalese Society, study was conducted in Kathmandu district. The primary data was collected by interviewing the selected respondents administering the semi-structured interview schedule in July 2016. Besides, a group discussion with senior citizen (more than 60 years old) and key informant survey with rice wholesale traders was made separately to gather the information about rice preference with reference to dietary pattern from past to present. The relevant information was collected from the secondary sources.

Major Findings

National Cereal Food Availability

Nepal has diversified climatic conditions which are suitable for growing a large number of cereal crops. MoAD estimated the total cereal production for 2014/15 at 9.26 million tonnes. After the deduction of losses and other usage (seed and feed), the quantity of cereals available for human consumptions has been recorded at 5.5 million tonnes whereas, national requirement is 5.53 million tonnes. **Figure 1** shows the total edible cereals production and requirement illustrating the trend of maintaining an edible cereal surplus above the national requirement for the past few years. However, it is interesting to note that there is the misunderstanding of among people to place Nepal as a food deficit country calculating only the import aspects of fine milled rice, basically from India. But it is not true when analyzed by total edible cereal availability to the total population.

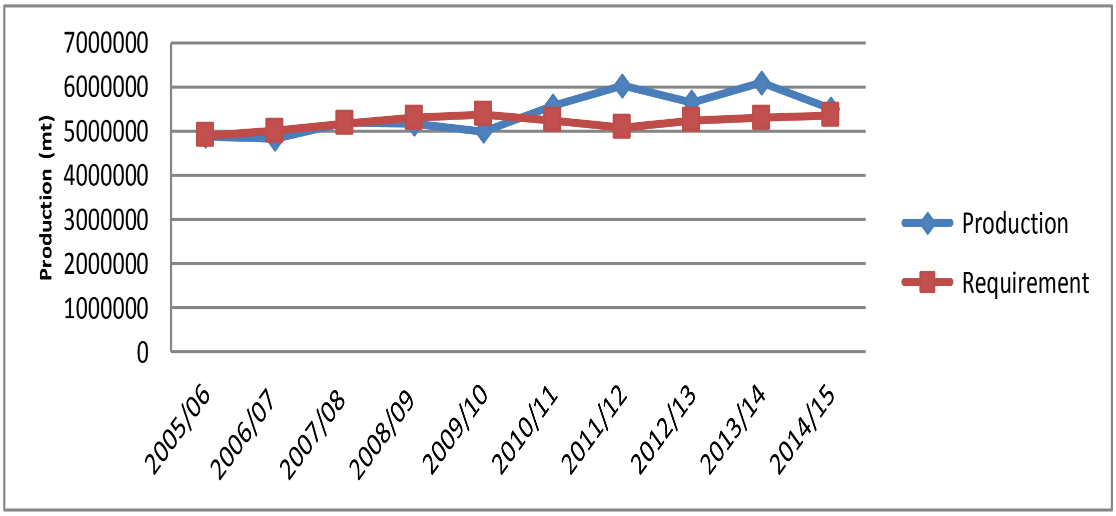

Figure 1. Total edible cereal production and requirement in different years

Source: MoAD 2014/015.

An overview of rice import

National-wide preference of fine rice consumption in Nepal has resulted in the increase in demand creating difficulties to fulfill through domestic production. Rice imports constitute a large portion of cereals imports to meet the demand. The volume of rice import has increased significantly from 96824.7 tonnes in 2008/09 to 375458.8 tonnes in 2015/16 (**Figure 2**). In Nepal, milled rice is mainly imported from India, China, Italy, Malaysia, USA, Vietnam and Thailand. However, about 99% import is from India. Basically four forms of rice (rice in the husk, husked brown rice, milled polished rice and broken rice) is imported in Nepal. Among them milled polished rice constitute a large portion (about 70%). The country in 2014/015 imported rice worth 14,708.6 million rupees. (TPC 2015).

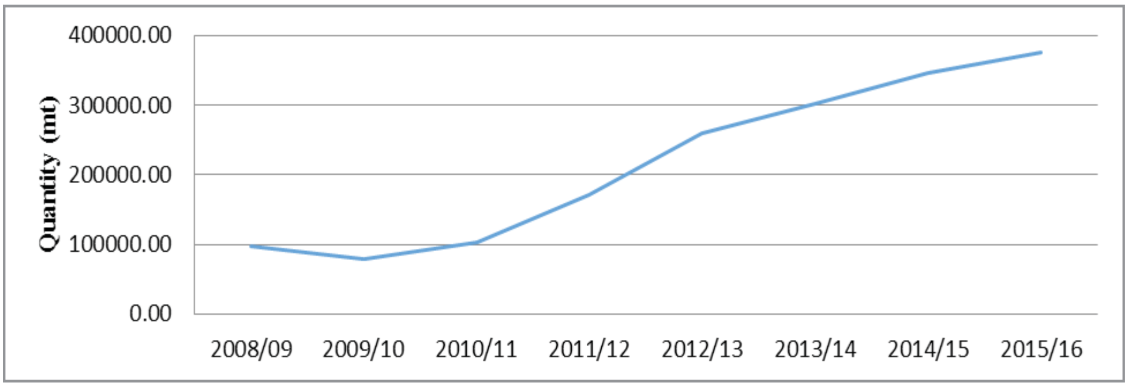

Figure 2. Trend of rice import in Nepal during different years. Data for 2015/016 is provisional
Source: TPC 2016.

Rice preference and its position

Literatures show that in Nepal rice has been in a high preference traditionally. However, due to different reasons there was individual difference on preference. In this study major preferred food has been shown in **Table 1**. Indexing has been done for preference analysis. The result shows that *dhido/aanto* (maize) was commonly preferred staple food followed by *dhido*/bread (Millet), rice and wheat bread. It was also verified through the group discussion with senior citizens. In the focus group discussion, the senior citizens from hilly areas from their long experience shared that rice was considered as dignified and high status food that only rich could afford to eat regularly whereas finger millet was generally looked down upon as poor person's food. Due to this reason, rice was a preferred food. Besides, they also opined that rice was an important food in celebrating festivals like *Dashain, Tihar*, and on life cycle events like naming of baby, rice feeding ceremony, *bratabandha*, wedding ceremony and funerals. Most of the respondents in group discussion reported that rice was the most preferred food, however, maize (*aanto* and *dhido*) was in the first position in terms of consumption followed by millet (*dhindo*) and rice (*bhat*). The senior citizens from their long experience opined that the first reason was low productivity of local variety of rice in the hilly areas as high yielding improved variety was not introduced. Secondly, the source of income was limited to buy rice as it was comparatively more expensive. Thirdly, there was the much more production of millet and maize which could be produced even in upland with no irrigation facility. Fourthly, hilly areas were

Figure 3. Fine rice available in supermarket
Source: P Devkota 2017.

not linked with motorable road to import and carry fine rice from Tarai and India. It clearly shows that diversified food was consumed in the past in the hilly areas.

Table 1. Common referred food at home during childhood period

Major food	5	4	3	2	1	Total	Index	Ranking
Rice	8	9	13	7	23	60	2.15	III
Dhido/Bread (Millet)	30	10	7	7	6	60	3.85	II
Dhido/Aanto (Maize)	42	9	5	2	2	60	4.45	I
Bread (Wheat/Oat)	4	7	9	12	28	60	2.11	IV

Table 2 shows that among the different staple food, rice was ranked as the most preferred and common food followed by bread (Wheat/Oat), *Dhido/Aanto* (Maize) and *Dhido* (Millet). Millet is highly nutritious food, however, it is becoming less preferred food. Group discussion with senior citizen also verified it. In the focus group discussion, the respondents said from their personnel experience and judgment that there has been a drastic change in food habit compared to the past. In the recent years, Nepalese food habit has changed along with the rise in living standard due to remittance, employment, business and growing of high value crops in the country and urbanization. Source of income has increased due to remittance, road link with market center to sell local products such as fruit, goat and other products so that purchasing power of rural people for rice has increased. Easy accessibility of packed fine rice is mainly due to linkage of road network. Habitual for steamed fine rice mostly imported from India is due to its unique taste. In addition, there is comparatively low productivity of rice and encroachment of productive land for other uses rather than agriculture production due to poor implementation of land use policy. Due to these reasons, the trend of importing fine and aromatic rice has increased in Nepal for the past few years.

Table 2. Common preferred staple food at home currently

Major food	5	4	3	2	1	Total	Index	Ranking
Rice	39	8	6	4	3	60	4.26	I
Dhido (Millet)	5	6	8	13	28	60	2.11	IV
Dhido/Aanto (Maize)	12	9	12	6	21	60	2.75	III
Bread (Wheat/Oat)	27	10	7	7	9	60	3.65	II

Key respondents' (rice wholesaler in Kathmandu) perception on changing pattern of rice consumption

According to Manish Kumar Gupta from Champaran traders Kathmandu, about 70% of rice sold in Kathmandu is imported from India having Indian brand. Only remaining 40% is from Nepal out of which 80% is steamed rice. Basically, about 95% of the rice imported from India is steamed rice. From his 20 years' long experience of rice trading as a wholesaler in Kathmandu, he added that the demand of fine rice is increasing by 10% each year. He further informed that Indian fine rice in the name of steam *Jeera Masino* is most popular and ranks the first rank in Kathmandu because of its better taste and affordable price, followed by coarse rice named steam Sonam and aromatic rice named Indian rich rice. The demand of fine rice is about 60% followed by 30% of coarse rice and 10% aromatic long grain basmati rice. Currently, the young generation having good income source is more attracted to aromatic basmati rice. Additionally, he said that the relative better taste and price advantages of imported fine rice have reduced the competitive ability of locally marketed Nepalese rice varieties. He further opined that due to unavailability of sufficient demanded variety of rice, insufficient support to steamed rice mills from government, power shortage and comparatively high milling cost have caused the price advantage to import Indian fine and steamed rice which ultimately motivates businessman to trade Indian steamed fine rice in Nepal. The demand of fine rice and aromatic rice are popular in urban areas like Kathmandu whereas Sona mansuli and other coarse rice consumption is high in rural areas.

Madan Prasad Gupta, a rice wholesaler in Kuleswor Kathmandu shared his experience that there was a low demand of beaten rice (*Chiura*) in Kathmandu 15 years back. Compared to that time, there is now 20 times more demand of beaten rice. He also said that 95% beaten rice is from Nepalese paddy and very negligible quantity is imported from India. The major cause is transportation difficulty from far distance as beaten rice breaks and is deformed during loading and unloading process. Moreover, of total domestic production of paddy sold, 65% goes for rice and remaining 35% beaten rice. This also hampers the availability of domestic fine rice resulting in demand for import.

So, it seems that increased per-capita income thanks to the remittance leading to an increase in the purchasing power for fine rice, transportation facility, change in food habit and decreased production of millet, oat in hilly areas (due to shortage of labor force creating the more fallow land)have all led to an increase in the demand of rice (especially fine rice) in Nepalese kitchen. This has ultimately created difficulties in fulfilling the demand from domestic production alone.

Pattern of consumption of rice

During the earlier age of rice consumption and varietal development, the focus was mainly on consumption of medium and coarse rice. People used to consume coarse rice as they believed that coarse rice provides more energy. However, as time passed on, income level of people started increasing and as the standard of living of Nepalese people became better off, people started preferring fine and aromatic rice instead of coarse rice. Research institutes of Government of Nepal, which previously had given priority to varietal development of coarse rice, has now started conducting research for generation of fine rice varieties. Khumal-4, Khumal-10, Khumal-11, Ramdhan, Lalka Basmati, Sunaulo Sugandha, Pokhareli Jethobudho, Swarna Sub-1, Samba Mansuli Sub-1 are some of the promising and popular fine rice varieties released by government of Nepal in recent years.

Technology dissemination

Realizing the demand for fine rice in Nepal, government of Nepal has started formulating and implementing fine and aromatic rice promotion program in recent years. Mega rice program and fine and aromatic rice promotion programs are some of the programs led by CDD/DoA to promote fine and aromatic rice in Nepal. Moreover, NARC, an autonomous entity for agricultural research in Nepal, has also worked for varietal development of fine rice in Nepal.

Availability of fine and aromatic rice in the market

A general observation during the study period showed that the fine and aromatic rice was available in most of the restaurants, hotels, supermarkets and even in hotels near the bus park. This shows that the dietary pattern for consumption of rice has changed a lot as people have gradually shifted towards consuming fine rice from medium or coarse rice in recent days.

View of young generation on rice quality

Discussion with some of the youths of Kathmandu valley revealed that the young generation of present day is very much concerned about rice quality. They generally prefer fine rice than other medium and coarse rice. There are often mindful on the quality of rice before deciding a hotel or a restaurant for dinner or meal.

Conclusion

Based on the study, we can conclude that rice is the highly preferred staple food in Nepal and faces a huge and growing demand especially due to its easy accessibility and change in food habit. Nepalese food habit has changed along with the rise in living standard. Because of nation-wide preference of rice consumption in Nepal, domestic production has not been enough to meet the rice demand. Due to these reasons, the trend of importing fine and aromatic rice has increased in Nepal for the past few years because of its better taste and price advantage. Crop diversification with productivity increments and the utilization of locally available food through product diversification will be effective to offset the import of fine rice.

Acknowledgements

The authors take opportunity to thank Mr. Dila Ram Bhandari, Director General, Department of Agriculture for providing an opportunity to prepare this article. I would also like to acknowledge Mr. Prakash Acharya, Senior Crop Development Officer of CDD/DoA for his constructive suggestions and feedbacks during preparation of manuscript.

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Brown Rice: Nutritional Composition and Health Benefits

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सारांश

प्रस्तुत लेखमा खाद्य तथा पोषण सुरक्षा सुनिश्चिताका लागि महत्वपूर्ण खैरो चामलबाट स्वास्थ्यमा हुने फाइदाहरू र उक्त चामलमा पाइने पौष्टिक तत्वहरूको बारेमा चर्चा गर्ने प्रयास गरिएको छ । डिहलिङ पश्चात् प्राप्त हुने खैरो चामलको पौष्टिक गुण अधिकतम हुन्छ भने त्यस पश्चात् प्रशोधन गरी बनाइने सेतो चामलको पौष्टिक गुण भने खस्कँदो हुने गर्दछ । खैरो चामलमा स्वास्थ्यका लागि फाइदाजनक वस्तुहरू स्टेरोल, फाइवर, प्रोटिन आदि पाइन्छ । सेतो चामलको तुलनामा खैरो चामलमा फाइवर ३ गुणा बढी पाइन्छ । त्यसैगरी भिटामिनको कमीबाट लाग्ने रोगहरूसँगको प्रतिरक्षाको लागि समेत खैरो चामलले महत्वपूर्ण भूमिका खेलेको हुन्छ । पछिल्ला खोजहरूले खैरो चामलको उपभोगले मानिसलाई रोगी हुन नदिने प्रशस्त सम्भावनाहरू भएको देखाएकाले पूर्ण प्रशोधन गरिएको चामललाई दैनिक उपभोगमा खैरो चामलले प्रतिस्थापन गर्नुपर्ने महसुस गरिएको छ । खैरो चामलको रिकभरी प्रतिशत (७३.१५%) सेतो चामल (६६.०८%) को भन्दा बढी छ । तर पनि नेपालको सन्दर्भमा ५० मे. टन उत्पादन क्षमता भएको खैरो चामल उत्पादन गर्ने एउटा कम्पनी रहेको तर नेपालमा वार्षिक ३००० मे. टन खैरो चामल भारतबाट आयात भएको देखिन्छ । त्यसैले नेपालमा खैरो चामलको प्रर्वद्धन गर्न आवश्यक नीतिगत तथा पूर्वाधार व्यवस्था हुनु आवश्यक रहेको महसुस गरिएको छ ।

Summary

This article attempts to deal with the nutritional and health benefits of brown rice that plays vital role in ensuring food and nutritional security. The de-hulling of paddy results in brown rice with least damage to its nutritional quality; but further milling and polishing to obtain white rice results in significant losses of vital nutrients. Dietary fiber, bran oil, un-saponifiable matter, sterols and protein as rice bran's are healthful components in Brown rice. Brown rice generally contains three times more fiber than white rice. Similarly, B-vitamins present in the brown rice play a significant role in preventing diseases associated with vitamin deficiencies. The evidences suggest that brown rice has disease preventing potentialities, and therefore, it is highly recommended to substitute brown rice for milled rice in diets. Though the average price recovery of brown rice in Nepal is found to be 73.15% which is more than that of white rice (66.08%), the commercial brown rice production has started in only one industry with a total production of less than 50 tonnes and there is import of 3000 tonnes brown rice from India annually. Thus, policy arrangement and infrastructural arrangements are felt necessary to promote the production of brown rice in Nepal.

Keywords: Brown rice, Disease preventing potentialities, Milled rice, Nutritional quality, White rice

Introduction

Malnutrition and chronic diseases are widespread in most of the developing countries where white rice is the main staple food (Dipti et al 2012).While many researchers have reported that brown rice contained the essential nutrients like iron, zinc, thiamine, niacin, vitamin E, dietary fiber, protein and carbohydrate (Pascual et al 2013, Sabularse et al 1991). Furthermore, bioactive constituents such as γ-oryzanols, tocotrienols, polyphenols have also been identified from brown rice (Leardkamolkarn et al 2011). In addition, some varieties of brown rice were found to be low in glycemic index (GI) (Brand-Miller et al 1992, Jenkins et al 1981) and evidences have shown that low GI food has many health benefits such as to control type-2 diabetes (Greenwood et al 2013), to prevent coronary heart diseases (Hallfrisch et al 2003, Mirrahimi et al 2014), obesity and cancers (Nagle et al 2013, Romieu et al 2012). However, GI of rice were reported to be affected by various factors like variety, geography, method of processing conditions (Brand-Miller et al 1992), nature of the starch, cooking method, presence of fiber, and other nutrients content such as fat and protein (Wolever and Mehling 2002). Hence, brown rice has potential to reduce the prevalence of malnutrition and chronic disease (Anderson et al 2009, Dipti et al 2012).

In this article, we discuss the nutritional composition of brown rice and losses during milling and the health benefits of brown rice over milled rice.

Brown rice

Brown rice is whole grain rice with intact bran layer and the inedible outer hull removed (**Figure 1**). It is the unmilled rice containing the pericarp, the seed coat and nucellus, the germ or embryo, and the endosperm (Ajimilah and Rosniyana 1995). The dark color of brown rice is due to the bran layer and is rich in vitamins like thiamine, niacin, pyridoxine, and minerals like manganese, phosphorus, and iron (Babuet al 2009). It is mostly consumed by a limited number of health conscious and nutritionally aware people (Roy et al 2008), probably because of its longer cooking time, instability during storage, strong bran flavor, and undesirable texture.

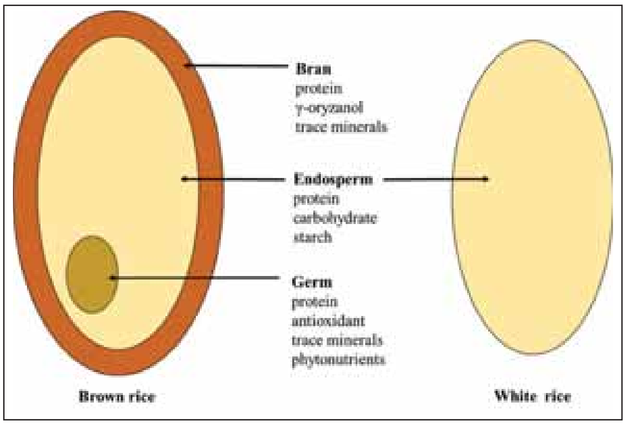

Figure 1. Hypothetical diagram of brown and white rice

Mostly, the brown rice production in Nepal is done locally in the villages using traditional rice mill called *dhiki*, a special de-husking instrument made generally of wood (**Figure 2**). After threshing, paddy is dehulled using dhiki, generally operated by one or two persons using foot (**Figure 2**). In Nepal, the commercial brown rice production has started in one industry with a total production of less than 50 tonnes (Personal Communication 2016). There is import of more than 3000 tonnes from India in 2015 (UNSD 2016). Commercially, brown rice is obtained after the de-husked grains are graded, color-sorted, and damaged or broken grains removed from the mixture. This results in considerable loss resulting in only around 65-70% recovery of the total paddy (Personal Communication, September 11, 2016). However, the recovery of brown rice depends on the quality and variety of paddy used. The brown rice recovery ranged from 78.6% in Mithila variety compared to 82.6% in Radha-4 variety (NARC 2015). Further detailed investigations are required to obtain the production and consumption data of brown rice in Nepal.

Nutritional composition of brown rice

The dehulling of paddy results in brown rice with least damage to its nutritional quality; but further milling and polishing to obtain white rice results in significant losses of vital nutrients (**Table 1**). The major key nutrient of brown rice such as fiber, antioxidants, phytoestrogens, minerals and vitamins are concentrated in bran layer which is removed during the milling process to improve the hardness and chewiness (Das et al 2008, Wang et al 2013) (**Figure 1**). Rice bran constitutes 10% of total rice grain and contains the major part of nutrients and antioxidative components such as vitamin E (tocopherols and tocotrienols), phytosterls, phytic acid, phenols, γ-oryzanols and tricin (Leardkamolkarn et al 2011). Nutritional studies have identified dietary fiber, bran oil, unsaponifiable matter, sterols and protein as rice bran's healthful components (Slavin 2004). Composition of the whole grain rice is almost similar to the whole cereal grains though it contains some unique components in unique amount (Dipti et al 2012). Milling of brown rice causes minimum loss of protein and carbohydrate, but significant losses (in the range of 60-90%) of other components like fiber, lipids, minerals, B-vitamins (USDA 2014). Brown rice, generally, contains fiber three times more than white rice (Parengam et al 2012). The insoluble dietary fiber enhances the weight of stool, prevents carcinogens actions in intestinal mucosa, easy emptying of faeces and supports normal colonic micro floral growth to produce beneficial components such as short chain fatty acids (Willet et al 1992, Daou and Zhang

2014). The dietary fibers also have potentials to reduce serum cholesterol, low density lipoprotein and blood pressure, and to improve glycaemia and insulin sensitivity (Glore et al 1994, Thebaudin et al 1997, Anderson et al 2009, Yanai et al 2014).

Table 1. Nutrient compositions of brown and white rice (per 100 g long grain, raw)

Nutrient	Unit	Brown rice	White rice	% milling loss *
Moisture	g	10.37	11.62	-
Protein	g	7.94	7.13	10
Total lipid (fat)	g	2.92	0.66	77
Carbohydrate, by difference	g	77.24	79.95	-
Fiber (total dietary)	g	3.5	1.3	63
Total sugars	g	0.85	0.12	86
Calcium, Ca	mg	23	28	-
Iron, Fe	mg	1.47	0.8	46
Magnesium, Mg	mg	143	25	83
Phosphorus, P	mg	333	115	66
Potassium, Ka	mg	223	115	49
Sodium, Na	mg	7	5	29
Zinc, Zn	mg	2.02	1.09	46
Thiamine	mg	0.401	0.07	83
Riboflavin	mg	0.093	0.049	47
Niacin	mg	5.091	1.6	69
Vitamin B6	mg	0.509	0.164	68
Folate	µg	20	8	60
Vitamin E (α-tocopherol)	mg	1.2	0.11	91
FA (total saturated)	g	0.584	0.18	69
FA (total monounsaturated)	g	1.056	0.206	80
FA (total polyunsaturated)	g	1.044	0.177	83

**Calculated on the basis of difference in brown and white rice; FA, Fatty acids*

Source: USDA National Nutrient Database for Standard Reference 2014 (Adapted).

The B-vitamins present in the brown rice may play a significant role in preventing diseases associated with vitamin deficiencies. Certain varieties of brown rice have been reported to contain more than 0.5 mg/100 g thiamine (McKevith 2004, Deepa et al 2008) which prevents from weakness, loss of sensation in the legs and cardiac failures (Adamolekun 2010). Similarly, niacin is considered important for its role as nicotinamide adenine phosphate (NAD), and important prosthetic group of several types of enzymes (Batifoulier et al 2006). Among grains and legumes, brown rice is considered good source of niacin which contains up to 5.54 mg/100 g (Lebiedzinska and Szefer 2006) (**Table 2**). The mineral content of brown rice have varying amount of iron (Fe), phosphorus (P), magnesium (Mg), potassium (K), zinc (Zn), and copper (Cu) (**Table 2**). Polished rice diets with low amount of trace minerals are thought to be reasons for anemia and Zn deficiencies disorders in certain population (Dipti et al 2012). WHO estimates that more than 30% of the world population is anemic, mainly due to Fe deficiency (WHO 2015).Brown rice contains the highest amount of Fe compared to husk, chaff and raw polished rice (Meng et al 2005). However, it should be noted that certain anti-nutritional factors like phytate present in the brown rice may reduce the bioavailability of bivalent minerals. Certain processing like soaking, germination and fermentation may reduce the phytic acid and increase the bioavailability of metals (Liang et al 2008). The rice protein is mainly found in protein bodies between starch granules, however, bran also contains considerable amount of protein (Juliano and Bechtel 1985). Furthermore, the rice protein quality has been better in comparison to wheat and corn protein quality (Cao et al 2009). The protein content of brown rice varies in the range of 4.3-18.2%, and has higher amounts of lysine, and essential amino acid, in comparison to other cereals and milled rice (Deepa et al 2008).The major carbohydrate present in the brown rice is starch, which is a homopolymer of glucose forming aglucosidic chain, called glucosan or glucan. The two main constituents of starch are amylose and amylopectin. However, rice contains lower proportion of lipid than starch and protein. The lipid is concentrated in embryo or germ of the kernel and also in aleurone layer (Juliano 1985). The rice lipid is unique source of bioactive compounds like vitamin E, y-oryzanol (Lerma-Garcia et al 2009, Yoshida et al 2011).

Table 2. B-vitamins and minerals composition of different brown rice

	Lebiedzinska and Szefer (2006)	Moongngarm and Saetung (2010)	McKevith (2004)	Deepa et al (2008)	Das et al (2008)	Dipti et al (2012)
B-vitamins						
Thiamine	0.22	0.23	0.59	0.52	0.18	-
Riboflavin	0.05	-	0.07	0.07	0.04	-
Niacin	4.36	7.66	6.8	7.32	1.48	-
Folate	-	-	0.05	0.05	-	-
Pyridoxine	0.25	0.76	-	-	1.47	-
Minerals						
Iron	-	-	1.4	1.93-3.95	-	1.16
Calcium	-	-	10	9.2-11.6	-	9.2
Sodium	-	-	-	22.6-30.9	-	-
Magnesium	-	-	110	150-216	-	148.8
Pottasium	-	-	250	248-304	-	282
Phosphorus	-	-	-	301-354	-	372
Zinc	-	-	1.8	-	-	2.38
Selenium (μg)	-	-	10	-	-	-
Copper (μg)	-	-	-	-	-	307

Physico-chemical properties of brown rice

The physicochemical properties such as dimension and appearance are regarded as the important indicators of rice properties (Deepa et al 2008, Shinde et al 2014). These indicators include kernel dimensions, and chemical properties like amylose content, gelatinization temperature, gel consistency, water uptake, solid loss of rice during hydration and sensory characteristics. All these indicators are considered while evaluating cooking quality of rice (Shinde et al 2014). Brown rice can be classified as long (>3.1 mm), medium (2.1-3 mm) and short (<2 mm) (Aluko et al 2004). Similarly, brown rice with high amylose (25-30%), intermediate (20-25%), and low (10-20%) are also found. Generally, long grains with high amylose content becomes dry, flaky and separate after cooking; the shorter and medium grains with low amylose impart moist and firm after cooking (Deepa et al 2008). More is the gelatinization temperature (>80^{o}C), higher is the resistance to water uptake and starch gelatinization (Sabularse et al 1991). Rice with higher gelatinization temperature has longer cooking time than milled rice, however, higher cooking time of brown rice is considered due to slow water absorption because of the presence of thick and intact aleurone and pericarp (Rosniyana et al 2006, Deepa et al 2008). The cooking time of brown rice can be reduced through ultrasonic treatment, albeit, there is a loss in natural morphology of the rice bran (Cui et al 2010).

Health benefits of brown rice

In some parts of the world, "to eat" literally means "to eat rice" (Babu et al 2009). This is probably due to accessibility of some variety of rice throughout the year, and the cultural practices of eating rice three times a day. Therefore, rice consumption has resulted in providing at least 50% of total calorie intake in these regions.

The milling and polishing of brown rice to white rice result in significant losses of micro nutrients (Table 1). The chemical composition of brown rice was significantly affected by the milling process (Rosniyana et al 2006). Therefore, brown rice and partially milled rice offer healthier benefits than milled rice. With high fiber content, brown rice can protect against several colonic disorders. High rice fiber intake causes changes in the microbial populations, in particular, significantly higher numbers of *Bifidobacterium adolescentis* and *Enterococcus faecalis* and significantly lower number of baceteroides, eubacteria, and clostridia (Benno et al 1989).

Several types of antioxidant phenolic compounds have been isolated from brown rice and it has been reported that these compounds more abundant in brown than white rice (Tian et al 2004). Furthermore, it has been suggested that brown rice and bran contain compound such as tricin which could be associated with the putative cancer chemo preventive properties, and that these compounds are found in higher amounts in brown rice than white rice (Hudson et al 2000). Furthermore, a clear inverse association between whole-grain, like brown rice, intake and risk of ischemic heart disease death exists, which may be due to the presence of phytochemicals, including fiber and antioxidants (Jacobs et al 1998). Moreover, epidemiological studies have indicated that individuals with higher levels of whole grain intake have a 29% lower risk for atherosclerotic cardiovascular disease (Anderson 2003). These diets tend to decrease serum LDL-cholesterol and triacylglycerol levels as well as blood pressure while increasing HDL-cholesterol levels (Anderson 2003).

Figure 2. Traditional rice mill (*dhiki*)

Substitution of whole grains, including brown rice, for white rice may lower risk of type-2 diabetes (Sun et al 2010). This could be attributed to the lower GI of brown rice (66) than white rice (72) (Jenkins et al 1981). Low GI foods have been extensively studied and association for the reduction of urinary C-peptide excretion, improvement on glycemic control of diabetic, reduction of serum lipids, enhancement of HDL-cholesterol, reduction of risk of cardiovascular diseases (Jenkins et al 1981, Wolever and Mehling 2002, Romieu et al 2012, Greenwood et al 2013). Brown rice is a more health beneficial food for diabetics and hypoglycemic individuals since it releases less amount of glucose to the blood than compared to white rice (Panlasigui et al 2006). Studies have suggested that modifying the type or rice consumed and choosing low GI snacks could have a major influence on the total meal glycaemic load of young children (Hui and Nelson 2006).

Brown rice recovery percentage in Nepal

There are several types of milling. Huller gives brown rice with higher recovery percent whereas Sheller gives white rice with lower recovery percent. The traditional technologies for rice milling are foot pounding (*dhiki*) and hand pounding (*okhal*). These, technologies are however, labor intensive and getting rare in recent years. Average price recovery of brown rice is found to be 73.15% which is higher than recovery percentage of white rice ie 66.08%. The low recovery of brown rice may be due to variety selection, low level of irrigation, unsuitable post-harvest handling, inadequate drying, unsuitable storage, unscientific mechanical milling, lack of skilled manpower for milling, and lack of advanced type of mills. The main factor hindering milling percentage was found mill type and milling skill of mill operators (Pant et al 2013).

Table 3. Recovery percentage of brown rice

SN	Varieties	Recovery percentage
1	Hardinath 1	71.00
2	Radha 4	74.00
3	Ram	73.00

SN	Varieties	Recovery percentage
4	Sabitri	75.50
5	Hybrid	71.00
6	Khumal 4	73.00
7	Sona mansuli	73.00
8	Local	74.00
9	Basmati	75.00
10	OR	72.00
Simple average percentage		73.15

Source: Pant et al 2013.

Conclusion

The nutritional composition of brown rice has several advantages over milled rice, primarily due to the presence of several phytochemicals like fiber, vitamins, minerals, mono- and poly-unsaturated fatty acids, and antioxidant phytochemicals. However, significant amount of these constituents are lost during the milling or polishing process. The evidences suggest that brown rice has disease preventing potentialities, and therefore, it is highly recommended to consume brown rice in daily dietary pattern.

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Rice Breeding and Varietal Development
(बाली प्रजनन तथा जातीय विकास)

Rice Science and Technology in Nepal (MN Paudel, DR Bhandari, MP Khanal, BK Joshi, P Acharya and KH Ghimire, eds).
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सारांश

उन्नत जातहरूले कुनै पनि बालीको उत्पादन बढाउनमा महत्वपूर्ण योगदान पुऱ्याउँछ । पछिल्लो पाँच वर्षमा धानको राष्ट्रिय उत्पादन ३.० टन/हेक्टर भन्दा माथि उक्लेको छ र कूल धान क्षेत्रफलमा उन्नत जातको क्षेत्रफल ९०% भन्दा बढी छ । सन् २०१५ सम्ममा ७५ वटा उन्नत जातहरू कृषकहरूका लागि सिफारिस भएको छ । उन्नत धान जात विकास धेरै वर्षसम्मको प्रयासबाट मात्र यो सफलता हासिल भएको हो । इ. सं. १९८० भन्दा अघि, इ. सं. १०८१-२००० सम्म र इ. सं. २००० देखि हालसम्म (२०१६ मध्य) गरी मूख्य तीन अवधिमा धानको जातीय विकासको अध्ययन गरिएको थियो। १९५० सम्म धान खेती पुराना धान जातको छनौट एवम् तिनकै खेतीमा आधारित थियो । नेपालका धानका जात विकासका लागि बाहिरबाट उन्नत जात भित्र्याउने र नेपालमा नै संकरण गरी छनौट गर्दै विकास गर्ने दुवै पद्धतिहरूको प्रयोग भइरहेको छ । सन् १९५० को सुरुमा बाहिरका जातहरू भित्र्याइएको थियो र पहाडका लागि काठमाण्डौंमा र तराईका लागि परवानीपुर, बारामा अध्ययन गर्न सुरु गरियो । सन् १९८० भन्दा पहिले १७ जातहरू कृषकहरूका लागि सिफारिस गरियो । सन् १९६० को पछिल्लो वर्षहरूमा काठमाण्डौं उपत्यकामा चार ताइवानी जातहरूले पाएको सफलताले नयाँ आयाम दिएको थियो । तराईका कृषकहरूले चैते तथा भदैया खेतीका लागि सी.एच.-४५ जातलाई रूचाए । अन्तराष्ट्रिय धान अनुसन्धान संस्था (इरी) बाट विकसित आइ. आर. -८ तथा बढी फल्ने उन्नत जातहरू कृषकहरूमाझ सिफारिस भए पनि १९७० तथा १९८० को दशकमा मसुली जात लोकप्रिय हुन पुग्यो तर यो मरूवा (ब्लास्ट) रोगप्रति संवेदनशील भयो । कुनै खास उद्देश्यका लागि पनि स्थानीय जातहरूलाई छनौट गरी कृषकहरू समक्ष व्यवसायीकरण गर्न सिफारिस गरिएन । प्रचलित जातहरू जानकी तथा सावित्री पनि १९८० भन्दा पहिलेनै सिफारिस भएका हुन् । सन् १९८१ देखि २००० सम्ममा जम्मा २७ जातहरू सिफारिस गरिए । देशभित्रकै राष्ट्रिय कार्यक्रमबाट विकसित भएका जातहरू चैते-६, राधा-७ र राधा-९ तराई तथा भित्री मधेशका लागि, खुमल-२ र खुमल-४ मध्य पहाडका लागि र पालुंग-२ तथा माछापुच्छ्रे ३ उच्च पहाडका लागि सिफारिस गरियो । स्थानीय धान छोमरोङ्लाई छनौट गरी सुधारिएको जात उच्च पहाडका लागि सिफारिस गरियो । आकाशे पानीका भरमा गरिने धान खेतीको लागि प्राथमिकतामा राखी राधा-४, राधा-७, राधा-११ र राधा-१२ जातहरू तराई तथा भित्री मधेशका असिंचित तथा अर्ध सिंचित क्षेत्रका लागि सिफारिस गरियो । धानको मरूवा रोग लाग्ने क्षेत्रका लागि मसुलीको विकल्पका रूपमा रामपुर मसुली जात सिफारिस गरियो । सन् २००० पछि पनि यो उद्देश्यका लागि अनुसन्धान कार्य जारी नै राखियो जसका फलस्वरूप मसुलीका विभिन्न गुणहरूलाई सम्बोधन गर्ने गरी विभिन्न जातहरू मिथिला, लोकतन्त्र र राधा-१३ जातहरू विभिन्न क्षेत्रका लागि सिफारिस गरियो । सन् २००१ पछि जात विकासका लागि वातावरणीय असरहरू (सुखा, बाढी) सहन सक्ने गुणहरूलाई प्राथमिकता दिइयो । सुखा सहन सक्ने वंशानुगुण भएका जातहरू सुख्खाधान-१, सुख्खाधान-२, सुख्खाधान-३, सुख्खाधान-४, सुख्खाधान-५ र सुख्खाधान-६ जातहरू सिफारिस गरिए । त्यसै गरी तराईका बाढी ग्रस्त क्षेत्रका लागि स्वर्णसब-१ र साम्बा मसुली सब-१ जातहरू सिफारिस गरियो । छिटो पाक्ने लोकप्रीय जात हर्दिनाथ-१, तराई भित्री मधेश र मध्य पहाडको वेशी क्षेत्रमा गरिने चैते धानका लागि सिफारिसले क्रमश सि.एच.-४५ लाई विस्तापित गऱ्यो । यो अवधिमा ३२ जातहरू सिफारिस गरियो । यस बाहेक वर्णशंकर धान जात विकासका साथै डि. एन. ए. प्रविधिका आधारमा धान विविधता तथा जात विकास सम्बन्धी कामको थालनी पनि यस अवधिमा भयो । प्रस्तुत लेखमा धानका यी नै विविध जातीय विकासका प्रयासका अतिरिक्त अनुशरण गरिएको धान प्रजनन् र धान जात विकासका विधि र सहभागीतात्मक जात छनौट प्रक्रिया, बाली प्रजननबारे पनि संक्षेपमा उल्लेख गरिएको छ ।

Summary

The improved varieties play significant role in increasing the crop yield. In recent five years, the national rice productivity has crossed over 3.0 t/ha and more than 90% of rice area is covered by improved rice varieties. Untill 2015, total of 75 varieties were released for the farmers of Nepal. It could be the impact of many years of research attempts for developing the high yielding improved varieties. The history of rice varietal development in Nepal was reviewed and briefed in three major periods as before 1980, 1981-2000 and 2000- till date. Up to 1950, rice cultivation was based on selection and planting of local varieties by farmers. Introduction, hybridization and selections were the major bases of varietal development in Nepal. In early fifties, exotic varieties were introduced and tested in Kathmandu for hills and Parwanipur for Tarai areas. Before 1980, seventeen exotic varieties were released for farmers. The successful cultivation of four Taiwanese varieties gave breakthrough in Kathmandu valley in late sixties. Similarly, CH-45 was accepted by the farmers in Tarai for spring as well as *Bhadaiya* rice. Besides the release of high yielding IR-8 and other IRRI varieties Masuli became the popular in late seventies to eighties but it became susceptible to blast. No attention was paid for selection and release of popular local varieties for any specific purposes too. The popular varieties, Janaki and Sabitri were also released before 1980. In 1981 to 2000, a total of 27 varieties were released. The varieties developed from national breeding program like: Chaite-6, radha-7 and Rdhakrishna-9 for subtropical Tarai and inner Tarai areas and Khumal-2 and Khumal-4 for mid hills and Palung-2 and Machhapuchhre-3 for high hills were released. Selections on local landrace Chhamroong was done and released for high altitude areas. Rainfed lowland was more emphasized and Radha-4, Radha-7, Radha-11 and Radha-12 were released for various rainfed to partially irrigated subtropical areas. Rampur Masuli was promoted as an alternate to Masuli in blast prone areas. Attempts to give an alternate to Masuli continued after 2000 too. Varieties like: Mithila, Loktantra and Radha-13 were released as substitutes to satisfy the various traits of Masuli in different rice environments. In the period since 2001 to till date, abiotic stresses were more prioritized. Drought tolerant varieties having drought tolerant QTL's were released and these were: Sukhadhan-1, Sukhdhan-2, Sukhadhan-3, Sukhadhan-4, Sukhadhan-5 and Sukhadhan-6. Similarly, Swarnasub-1 and Shambha Masulisub-1 were released for flashflood submerged subtropical areas. The popular short duration varieties Hardinath1 was released and could successfully replace the old CH-45 in Tarai, inner Tarai and foothills of mid hill districts. In this period, 32 varieties were released. Initiations were made on hybrid rice research, molecular diversity and breeding works. The general breeding methodology followed and process of varietal development including participatory varietal selection, participatory plant breeding and variety release were discussed.

Keywords: CH-45, Participatory plant breeding, Participatory varietal selection, Rice breeding, Varieties, Variety release

Introduction

Rice is the major food crop of Nepal. It is grown in 1.42 million hetares producing 4.78 million tonnes with productivity of 3.3 t/ha (MoAD 2015). The role of variety in increasing the crop yield is never underestimated. Various approaches like general breeding methods (Selection, introduction, hybridization followed by various selection schemes, heterosis breeding) and special breeding methods (mutation, polyploidy, molecular and transgenic breeding) are employed for genetic improvements of crop plants. The commonly applied methods generally fall under general methods but vary on progress of time exhibiting the noticeable history of varietal development. The improved variety coverage in rice is presently more than 90% and untill 2015 released/registered number of improved varieties is 75 including 12 denotified varieties (SQCC 2016).This outcome is the result of years of research attempts in the past and the historical achievements could be presented in different periods as given below.

Historical Achievements

Period before 1980

Before 1951, the rice varietal improvement work was limited only in selection of local varieties (Mallick 1981). The most promising local varieties in Kathmandu valley were *Tauli, Marshi* and *Thapachiniya*. The varietal improvement work had started under the leadership of Mr. Netra Bahadur Basnyat who is called the father of rice improvement in Nepal **(Annex 1)**. Since this time, attempts were made in introducing high yielding exotic germplasm. The testings were done in Singh Durbar Agronomy Farm, Kathmandu and Parwanipur Bara.

Himalayan expedition team from Japan provided few Japanese rice varieties which were tested in Singh Durbar Agronomy Farm, during 1960-1962 but did not give promising result. However, the evaluations were done in low nitrogen dose (30-40 kg N). During 1957-1959, varieties were also introduced from Philippines, India and USA and tested in Kathmandu. Azucena was introduced from Philippines in 1957 and found producing 4450 kg/ha. It was distributed among farmers of Kathmandu valley in 1958 and was popular among some farmers with the name of *Arullno*. CH (China)-13, CH-45 and N-136 were introduced from India in 1958 but were not found promising in Kathmandu. Six varieties (Zenith, Century Patna, BBT-50, Stag-521302, Nato and Fortuna) were introduced from USA in 1959 and evaluated from 1961-1965 in Kathmandu Valley. Their yield performance were not observed superior to popular local variety *Thapachiniya* (2541 kg/ha).

The revolutionary achievement was experienced after the successful contribution of Taiwanese varieties. The nine varieties were imported from Taiwan in 1964 and evaluated along with local *Thapachinya* during 1965-1967. All these varieties except *indica* type Taichung native-1 (TN-1) produced the double yield than local *Thapachinya.* Some of the promising varieties were also distributed to the farmers. During the same period, some IRRI varieties along with IR 8 were again introduced and tested in Kathmandu valley but were not found to be adoptable. So, the best adopted and promising varieties were identified as Tainan-1, Chainan-2, Taichung-176 and Chainung-242 and were released in 1967 for the general cultivation in Kathmandu valley. The average yield was around 6 t/ha (Mallick 1981).

The introduced germplasm were also tested in Parwanipur representing Tarai and inner Tarai environment. Till 1959, the varietal selection was limited to local variety. N-13, CH-13, Ptb-10 and BR-34 were introduced in 1960. CH-45 was introduced in 1959. After evaluation in Parwinpur and Kathmandu, CH-45 was released for general cultivation among farmers in 1959 for Tarai and inner Tarai condition. The introduction and testing of sixteen varieties from IRRI Philippines and 14 varieties from India identified IR-8 as high yielding variety and released in 1968 for Tarai and inner Tarai.

In 1965, the then department of Agricultural Education and Research realized the need of coordinated national rice research program and launched a coordinated rice improvement program from 1965 to 1970, under the leadership of Botany Division in collaboration with other disciplinary division and agricultural farms and stations (Shrestha 1986). A national rice research program was established in 1972 at Parwanipur, Bara and systematic research program was initiated. It was then followed by the release of other semi dwarf IRRI lines like IR-20 and IR-22 in 1972. The early duration varieties were also tested and released as Parwanipur-1 in 1973, IR-24 in in 1975 and Laxmi in 1979 for spring season planting. During this period, the other high yielding varieties were also identified and released for Tarai and inner Tarai domain. These varieties were Masuli, Jaya, Durga, Janaki and Sabitri of which Masuli was of intermediate height and all the others were of semi dwarf type. The average grain yield of these varieties ranged from 4-5 t/ha depending on management practices. Masuli was picked up by the farmers and became a very popular variety in late 1970's to 1980's to all the Tarai and inner Tarai and foot hills of Nepal. Other semi dwarf varieties including IR-8 were not received warmly by the farmers of Nepal up until early 1980's due to its coarse grain and poor straw yield. The green revolution was not realized in Nepal as it was experienced in India and other Asian Countries. It could be due to many other socioeconomic reasons besides the above factors. Local varieties were evaluated but no varieties were selected and released for commercial cultivation. Attempt for mutation breeding on local varieties was done but no remarkable results were achievement (Proceedings of coordinated rice research programme 1971). Hybridization between the local varieties and high yielding exotic germplasm were initiated both in Khumaltar and Parwanipur in early 1970's (Proceedings of coordinated rice research programme 1971) but it did not result in the development of a variety from this local crossing program till this period. However, the review of literature and the interactions among the scientists in this period reveal that a well set up coordinated rice improvement program functioned in this decade. Dr BB Shahi, the first rice coordinator and his team of scientists must be credited for the successful initiation of rice research and development program in Nepal. The leaf blight for Tarai and inner Tarai and blast on hills were identified as the major diseases in rice. Screening works were started for these two important diseases. Identification of resistant/tolerant germplasm was done against bacterial blight and blast (Upadhyay 1977, Singh and Sharma 1980, Thapa and Upadhya 1980). Similarly screening work against major insect pests like Plant hopper and stem borer (Pradhan 1980) was also established during this period for identifying the tolerant germplasm against these major pests. With the help of Integrated Cereal Project (ICP) (1975-1980) minikit program was launched for disseminating the released and promising pre-released rice varieties throughout agriculture development offices in districts that helped the rapid spread of improved varieties in the next decade. Selection of popular local varieties and their release and dissemination for the various domains and ecological niches were not done in this decade, which might be noted as the weakness of this decade as the improved varieties were not accepted by most of the farmers in the country. During this period, 17 varieties were released for the rice farmers of Nepal.

Period 1981 to 2000

IRRI originated semi dwarf varieties named Himali and Kanchan were also released in 1982 for warm temperate areas (mid-hills). But these varieties were not accepted by the farmers of mid-hill. By this time, rice scientists realized that semi dwarf high yielding varieties were not the choice of most of the farmers in Nepal especially in mid-hills. The popularity of Masuli in Tarai/inner Tarai indicated that the varieties with intermediate height, fine to medium grain size and farmers' acceptable cooking qualities were the preferred traits of farmers. Rice breeders included these objectives in their local breeding program and developed the varieties with intermediate height. These varieties were: Khumal-2 (Jarneli/KN-LD-361 DLK-2-8) and Khumal-4 (IR 28/*Pokhreli Masino*) for mid hills and Palung-2 (BG94-2/*Pokhreli Masino*) for Palung and similar climatic areas of high hills.

During this period, the popularity of Masuli was in peak but its susceptibility against blast disease declined the yield of the rice crop. In the blast susceptible areas farmers started to search the other blast resistant varieties and started to grow Sabitri in most of Tarai/inner Tarai areas. Varieties with intermediate to tall height such as Radha-7 (Janaki/Masuli), Radha Krishna-9 (IR 42/Masuli) were developed from the National Breeding Program and released for farmers in (NRRP 1997) Tarai, inner Tarai and foot hills (<900m altitude). Exotic germplasm Rampur Masuli (Lalnakanda/IR 30), a blast resistant variety with Masuli type was also released as a substitute of Masuli variety in 1999 (Khatiwada and Upereti 2008).

In these decades, the rice varietal improvement works continued with similar approaches but in addition to it, rice scientists classified the rice growing environments specifically such as: irrigated, rainfed lowland (different types) and upland, and varieties were developed similarly. In the first decade the rice research leadership was taken by Drs BB Mathema and GL Shrestha and in the later period Mr TP Pokhrel also contributed in guiding the program. In the succeeding years the responsibility of research leadership was handed over to new generations of scientists who are credited for continuing the program as per need of the time. The rice research program priority was given to rainfed lowland areas with screening of breeding populations in rainfed areas. Varieties were released targeting various environments. Bindeswari and Ghaiya-2 were released for upland areas. Makwanpur-1, Radha-4, Radha-7, Radha-11 and Radha-12 were released for rainfed lowland areas to partially irrigated environment in different years of this decade. Radha 4 was targeted to western Tarai whereas Radha-11 for central Tarai and Radh-12 for eastern Tarai. Radh-7 and Makwanpur-1 became popular in foot hill areas. Locally bred variety: Chaite-6 (NR6-5-46-50/IR28) was also released in 1991for spring season in this period which was high yielding and resistant to blast and bacterial blight.

Local variety named Chhomroong (pureline selection) was released for western high hills. It was followed by an improved variety Machhapuchhre-3 (Fuji 102/Chhamrong) for the same environment in early 1990's. For mid-hills semi dwarf exotic varieties Khumal-7 and Khumal-9 were released for mid-hills and Khumal-5 and Khumal-6 were also released for this domain which were the semi dwarf types but bred locally. A total of 27 varieties were released in this period.

Period 2001- till (mid 2016)

In 2004, Hardinath-1 a short duration variety was released for spring season which became suitable to replace CH-45, in the subtropical climate of mid-hills and Tarai/inner Tarai districts. As an alternate to Masuli, Mithila (Fortuna//Milfor6*2/Azucena) and Ramdhan (Mahsuri/IR 30) was released for irrigated and Loktantra (Mahsuri/IR4547-6-2-2) for rainfed lowland areas and Radha-13 (Mahsuri/IR38701-49-2-6) for low fertility in rainfed and partially irrigated conditions. These were mainly selected for their Masuli type grain color. In this period, the significant number of drought tolerant genotypes were released for rainfed and partially irrigated environment. These were: Sukhadhan-1, Sukhadhan-2 and Sukhadhan-3 in 2011 and Sukhadhan-4, Sukhadhan-5 and Sukhadhan-6 in 2014. Most of these have drought tolerant QTLs that are incorporated through marker aided selection. All these were of around 125-130 days maturity and suitable for shallow rainfed low areas of subtropical regions of Tarai/inner Tarai and foot hills and are resistant to bacterial blight and blast. Submergence tolerant varieties Swarnasub-1 and Samba Masuli sub 1 were also released for the flashflood zones of Tarai regions. These varieties mature in around 145-150 days and yield satisfactorily in irrigated environment without stress to excess of water. Besides these Tarhara 1 and hardinath 2 were released as an aerobic rice varieties for direct seeding for Tarai and inner Tarai areas. Similarly, aromatic rice varieties Lalka basmati (Local selection) and Sugandhidhan (exotic) were released for the farmers of Tarai and inner Tarai.

In mid-hills, Khumal-8 and Khumal-10 (Indica type) and Khumal-11 and Khumal-13 (Taichung type) were released.

In 2002, for the first time, Chandannath-1 and Chandannath-3 were released as improved varieties (exotic germplasm) for Jumla valley where Jumlamarshi was the single local variety grown by the farmers. Both these varieties were grown by the farmers for almost a decade and later more cold tolerant varieties Lekali-1(Benjaiman/Chhamrong) and Lekali-3(Yunlen5/Chhamrong) were developed with the joint venture of Agri-Botany Division and ARS, Jumla and released in 2015. The average grain yield is 3.5-4.0 t/ha in Jumla. It is one of the landmark achievements in the history of rice variety development in Nepal.

In this time period the private sector also got involved in varietal research. Varieties like, Barkhe 3004, Barkhe-2014 and Barkhe-1027 (registered) and Sunaulo Sugandha were developed in the leadership of an NGO, Local Initiatives for Bio-diversity Research and Development (LIBIRD) in collaboration with NARC (Nepal Agricultural Research Council). Pokhreli jethobudho, an aromatic rice variety for Pokhara area was developed through selection in the joint venture of NARC and LIBIRD. A total of 32 varieties were released in this period. Besides these, Initiation of hybrid rice research (Khatiwada et al 2014) and molecular diversity (Bimb et al 2010) and marker aided breeding work (Joshi et al 2010) were also initiated in these decades. Attempts are on for the development of hybrid varieties and technology for seed production. Observing the interest of farmers, 33 multinational hybrids developed in India and China have been registered for general cultivation of the farmers. *Jumli Marshi*, Khumal-4 and Masuli are the targeted varieties for molecular breeding for developing resistance against blast.

Varietal development and seed multiplication procedure in Nepal

Besides the introduction of exotic germplasm, hybridization was also followed in early seventies both in Kathmandu and Parwanipur. Adopted breeding methodology is pedigree as well as modified bulk in the segregating nurseries after the hybridization. Hybridization included the use of local land races or adopted variety and the exotic germplasm with the traits resistant/tolerant for various biotic as well as abiotic stresses with improved plant type background. Steps in varietal development are presented in the **Figure 1**. All the experimental sets are mostly managed in the research center except some of the biotic/abiotic stresses are conducted in hot spots in farmer's field as per need. FFTs (Farmers Field Trial) and FATs (Farmer's Acceptance test) are on farm trials where FFT is the researcher managed and FAT is the farmer managed trial. After years of selection in these series of experiments the suitable genotypes are proposed for release to grow for farmers for various agro climatic environments depending their performance. Agronomic studies and quality analysis are studied for selected genotypes in the advanced stage of testing as shown in the diagram. The growing of various classes of seed of the varieties is also duly considered in the process of development so that the released varieties could be commercialized timely. Existing variety development procedure in public sector in Nepal starts with the germplasm collection from different agro climatic conditions of the country. The common plant breeding strategies like pedigree selection, shuttle breeding, and bulk selection with respect to self-pollinated (rice) is adopted to develop new varieties by using base germplasm like local/land races, exotic material. For the release of the newly developed varieties, the following procedure is being practiced in Nepal.

Observation nursery: 1-2 years

The newly developed varieties/genotypes in the national program or introduced from various sources are evaluated by NARC for 1-2 years in the observation nurseries in 2-4 rows plots in 1-2 replications at 1-3 locations in the target environments. The genotypes superior over the best existing check variety with respect to various economic traits are promoted to Initial Evaluation Trial (IET) or Preliminary Yield Trial (PYT).

Preliminary yield trial/initial evaluation trial (IET/PYT): 2 years

The entries promoted from the observation nursery are evaluated in IET/PYT in 4 rows plots with 2-3 replications at 2-3 locations in target environments for 2 years. The promising and superior genotypes over the best existing check variety/hybrid are selected and promoted for Coordinated/Advanced Varietal Trials (CVT/AVT).

Coordinated/advance varietal trial (CVT/AVT): 2-3 years

The selected entries are evaluated in bigger size plots of 6-8 rows of 5 meter length in 4 replications with 1-2 best checks at 4-6 target locations. The CVT/AVT is repeated for 2-3 years and the data is recorded on agronomical performance, yield, quality traits, pest and disease resistance and suitability to cropping system. The superior entries over the best check will be considered/promoted to the Farmers' Field Trials (FFT) evaluation.

Farmers' field trial (FFT): 2 years

The top ranking 4-6 entries along with best check are evaluated in FFTs with plots size of 50-100 m^2. The trial is conducted by the farmers in the target environment. FFT yield superiority as per farmers' criteria and preference is duly considered for final decisions. FFT data for 2 years are used for determining varietal stability and making final recommendation for release. Similar to FFT, Maize Research Program has adopted Mother-Baby trials with OPVs, where along with mother trial (FFT), each test variety is also evaluated with farmers' variety under their management for comparison.

The above procedure adopted for evaluation in various stages takes about 7-9 years to generate the raw data of multi-year and multi-location evaluation including FFT.

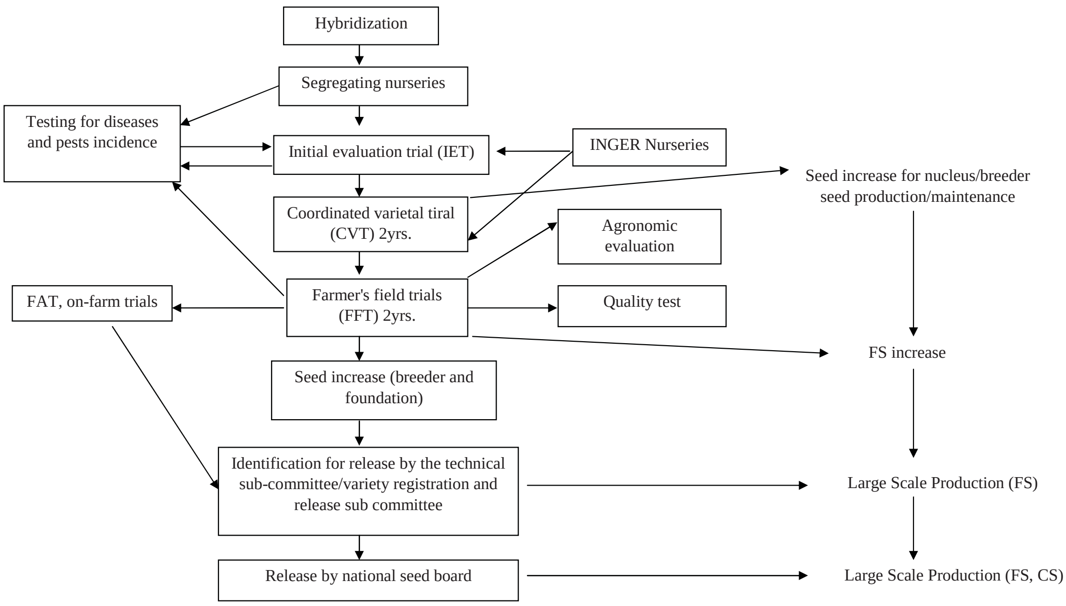

Figure 1. Steps in varietal improvement, release and seed increase system

Participatory varietal selection

The concept of participatory varietal selection was introduced in Nepal in 1990s by the scientists at Lumle Agriculture center. Sthapit et al (1996) developed Machchhapuchhre-3 rice variety for the western hills of Nepal following this concept. The segregating bulk populations were grown in the farmer's field and the selections were done with farmers' participation. The uniform best genotype was promoted, evaluated and released as variety. In the process the farmers' perceptions were duly considered, the farmers got familiarized with the variety in earlier stage and seed dissemination was faster than conventional breeding approach. The approach was later followed by the NARC system particularly for varietal selection in later stage (PVS). The promising genotypes from the co-ordinated trials were given to the farmers' field and farmers' perceptions were more specifically considered and incorporated in the selection and development of the crop variety.

Participatory plant breeding (PPB)

Participatory plant breeding is the process by which farmers are routinely involved in a plant breeding programme with opportunities to make decisions throughout. Farmers' involvement in PPB can take many forms (Figure below): defining breeding goals and priorities; selecting or providing sources of germplasm; hosting trials on their land; selecting lines for further crossing; discussing results with the scientists; planning for the following year's activities; suggesting methodological changes; and multiplying and commercializing the seed of the selected lines (Halewood et al 2007). PPB generally involves a higher and more complex degree of involvement of farmers, as they are engaged in decision-making in earlier and more fundamental stages of the variety development chain. PPB therefore has a higher empowerment effect than PVS (Witcombe 2005). PPB provides farmers with the opportunity to influence decision-making about where financial resources for research, and agricultural extension services, should be dedicated. PPB makes use of the traditional knowledge of the farmers involved. It thereby elevates the profile of that knowledge and of the holders of it, creating incentives to continue using and developing it.

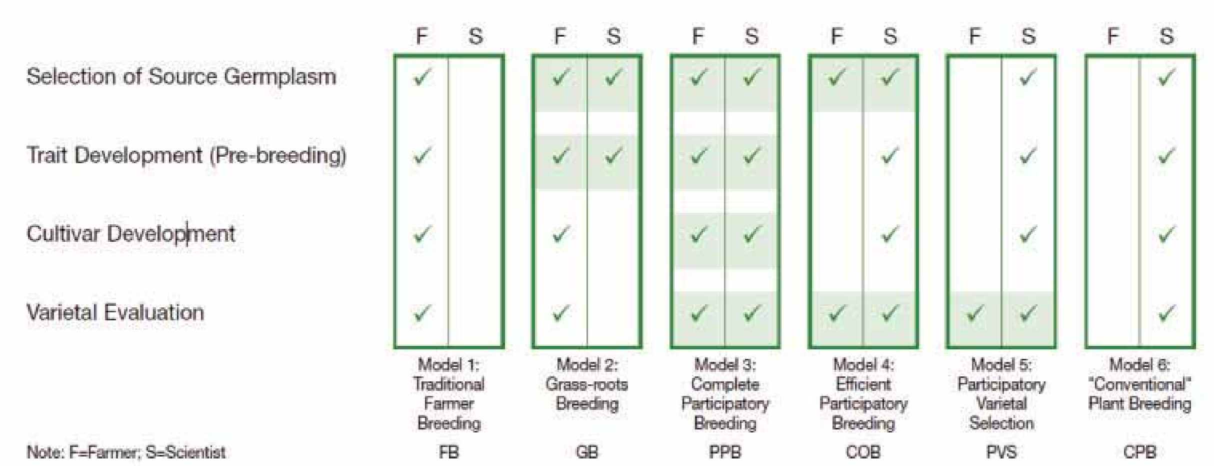

Figure 2. Participatory plant breeding

Source: Halewood 2007.

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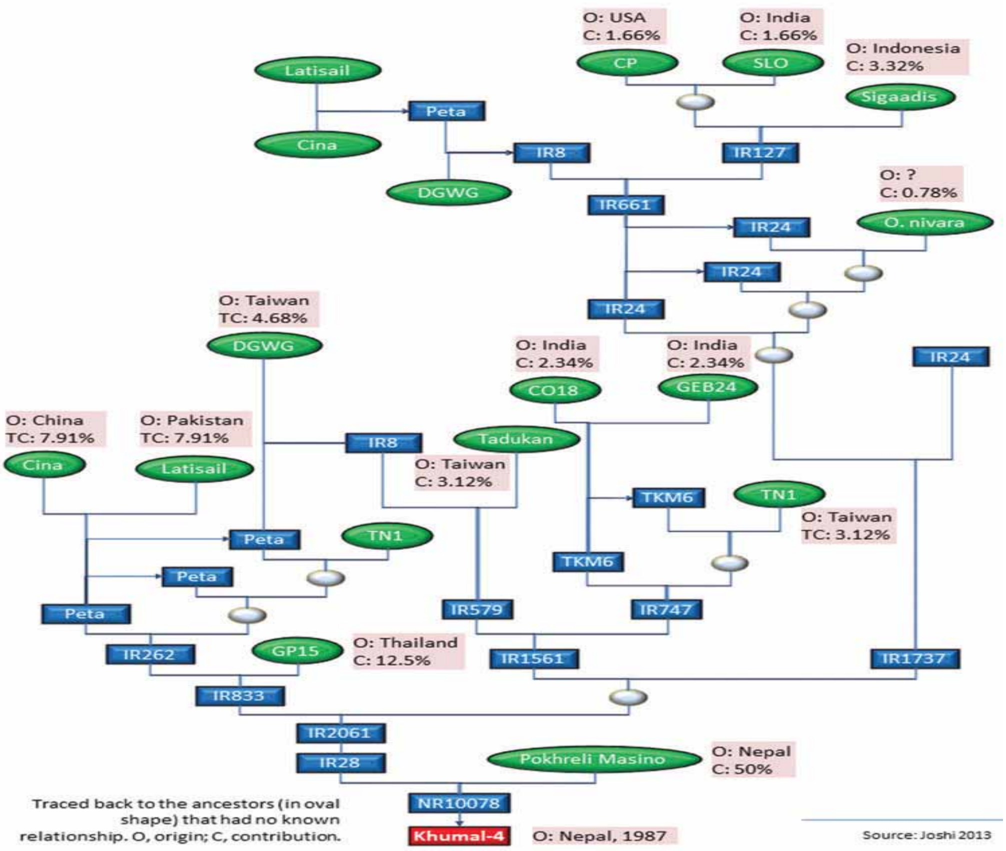
Annex 1. Historical events and activities of plant breeding and name list of pioneer breeders in Nepal

SN	Trial/method/activity	Start date	Breeder/organization	Crop
1	Introduction	1850	Rana Dynasty	Fruits
2	Plant exploration	1937	Herrlich (Germany)	Wheat, barley
3	First breeder in Nepal	1951	Netra B. Basnyat	Rice
4	Rice collection and evaluation	1951	Netra B. Basnyat	Rice
5	First introduced recommended variety and crop	1958	Netra B. Basnyat	CH-45, rice
6	Variety recommendation	1959	Parwanipur Agriculture Station	Rice (CH-45)
7	FFT	1960	Parwanipur Agriculture Station	Rice and wheat
8	First plant breeder (crossing)	1964	Gopal R. Rajbhandary	Potato
9	First university degree on plant breeding	1964	Gopal R. Rajbhandary	Brinjal
10	CVT	1966	Amresh M. Pradhananga	Rice, wheat, maize
11	First maize crossing breeder	1966	Amresh M. Pradhananga	Maize
12	IET	1966	Amresh M. Pradhananga	Rice, wheat, maize
13	Observation nursery	1966	Amresh M. Pradhananga	Rice, wheat, maize
14	Start of crop breeding	1966	ABD	Rice
15	First barley crossing breeder	1967	Shiva N. Lohani	Barley
16	First rice crossing breeder	1968	Bal B. Shahi	Rice
17	First wheat crossing breeder	1968	Badri N. Kayastha	Wheat
18	Commodity based research program	1972	NARC	Rice, wheat, maize, potato, sugarcane
19	Seed classes	1972	ABD	Rice, wheat, maize
20	Minikit	1972	NRRP, NMRP, NWRP	Rice, wheat, maize
21	Plant breeding and genetic course	1976	Krishna P. Sharma, IAAS, TU	Cereals
22	Tissue culture	1976	National Herbarium and Plant Laboratories (KATH, DPR)	Indian snakeroot (Sarpaghandha)
23	Maintenance breeding	1980	NRRP, NWRP, NMRP	Rice, wheat, maize
24	Hybrid (Commercial cultivation)	1985	Private sector	Vegetables, maize
25	Variety release	1985	ABD	Wheat (NL-297)
26	Genebank (medium term ex-situ conservation)	1986	Bharat R. Adhikary	Cereals
27	First horticulture breeder (crossing)	1988	Indra R. Pandey	Radish and cauliflower
28	Hybrid research	1988	NMRP, Rampur	Maize
29	Sand rooting	1988	Saman B. Rajbhandary	Tobacco, potato, sweet potato
30	Tissue culture (breeding perspective)	1989	NPRP	Potato
31	IRD	1990	LARC	Rice
32	PPB	1993	Bhuwon R. Sthapit	Rice
33	Community seed bank	1994	Bal K. Joshi	Cereals and vegetables
34	Department of plant breeding	1996	IAAS, TU	Cereals
35	PVS	1996	Krishna D. Joshi	Rice
36	Heterosis breeding (vegetable)	1998	Kedar P. Budathowki	Tomato
37	Isozyme technology	1998	ABD	Barley
38	Master degree in plant breeding	1998	IAAS, TU	Cereals

SN	Trial/method/activity	Start date	Breeder/organization	Crop
39	MSc in Plant Breeding	1998	IAAS, TU	Cereals
40	Heterosis breeding (CMS based)	1999	Bal K. Joshi	Rice
41	DNA marker technology (SSR)	2000	ABD	Rice
42	Anther culture (double haploid)	2001	Bal K. Joshi	Rice, wheat
43	Mother baby trial	2001	CIMMYT, Nepal	Maize
44	Wide hybridization	2001	Raj K. Niroula	Rice
45	PCR based diagnosis	2002	NAST	Citrus (HLB)
46	PhD in Plant Breeding	2002	IAAS, TU	Cereals
47	GMO testing lab	2005	SQCC	Maize
48	Mutation breeding	2006	Sabin Basu	Rice
49	Emasculation (hot water method)	2008	Bal K. Joshi	Tite buckwheat
50	Gene tagging by DNA markers	2010	Bal K. Joshi	Tomato
51	National genebank	2010	Madhusudan P. Upadhyay	Cereals
52	Protected variety and royalty system	2010	HRD	Tomato (parental lines of Srijana F1 hybrid)
53	Field genebank and community field genebank	2012	Bal K. Joshi	Taro, Ginger, Chayote, mango
54	Pre-breeding	2012	Bal K. Joshi	Rice
55	DNA bank and Tissue bank	2013	Bal K. Joshi	Potato, chayote, rice, wheat

Source: Joshi 2017.

Annex 2. Complete pedigree tree and ancestral contribution to Khumla-4 rice variety



Source: Joshi 2013.

Variety Release and Registration System in Nepal

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सारांश

नेपाल सरकारले सन् २०१६ सम्म राष्ट्रिय बीउ बिजन समिति मार्फत् ९७ धानका जातहरू उन्मोचन तथा दर्ता गरेको छ । नेपालमा विभिन्न बालीहरूको उत्पादन तथा उत्पादकत्व वृद्धि गरी खाद्य सुरक्षा कायम गर्न बीउ तथा जात प्रतिस्थापन मुख्य प्राथमिकतामा रहेको छ । उन्मोचित तथा दर्ता भएका विभिन्न बालीहरूका जातहरूको अनुसरण कृषकस्तरमा कम हुनु र समयमा कृषकले उपयुक्त जातहरू नपाउनु बीउ क्षेत्रको विकासमा चुनौतीको रूपमा रहेका छन् । तथापि, बीउ बिजन नीति २०५६, बीउ बिजनको दीर्घकालीन सोच (सन् २०१३ - २०२५), बीउ बिजन ऐन २०४५ (पहिलो संशोधन २०६५) तथा बीउ बिजन नियमावली २०६९ र यससँग सम्बन्धित तयारी अवस्थामा रहेको बीउ बिजनको अनुमोदन, उन्मोचन र दर्ता सम्बन्धी निर्देशिका जातहरूको उन्मोचन तथा दर्ताका आधार बनेका छन् । जातहरू उन्मोचन वा दर्ता (पञ्जीकरण) को बारेमा आवश्यक प्राविधिक विषयमा छलफल गर्नका लागि राष्ट्रिय बीउ बिजन समितिको सचिवालयले समितिका सदस्य सचिवको अध्यक्षतामा रहने गरी प्राविधिक उपसिमिति बनाएको छ । प्राविधिक उपसमितिले प्राप्त प्रस्ताव परिमार्जन सहित जात अनुमोदन, उन्मोचन र दर्ता उपसमितिमा पठाउने निर्णय गरेको खण्डमा छलफलमा उठेका विषयलाई समेटी प्रस्तावकले प्रस्ताव परिमार्जन गरेर समितिको सचिवालयमा पेश गर्नुपर्दछ । पुनः परिमार्जित प्रस्ताव समितिको सचिवालयले जात अनुमोदन उन्मोचन र दर्ता उपसमितिको बैठक राखी छलफल गराउँछ । बैठकले परिमार्जन सहित प्रस्तावलाई समितिमा पठाउने निर्णय गरेको खण्डमा छलफलमा उठेका विषयलाई समेटी परिमार्जन गर्ने काम प्रस्तावकले नै गर्नु पर्दछ । जात अनुमोदन, उन्मोचन र दर्ता उपसिमितिबाट जात उन्मोचन वा दर्ता (पञ्जीकरण) को सिफारिस भएका सबै प्रस्तावहरू समितिको बैठकमा पेश गरिन्छ । समितिको छलफलबाट विभिन्न भौगोलिक क्षेत्रका लागि सिफारिस गरेका जातहरू अनुमोदन गरी उन्मोचन या दर्ता गर्ने वा प्रस्ताव अस्वीकृत गर्ने निर्णय हुन्छ । समितिबाट उन्मोचन वा दर्ता गर्ने निर्णय भएका जातहरूको सूची नेपाल राजपत्रमा प्रकाशन भइसकेपछि बीउ बिजनको व्यवसायिक कारोबार गर्न पाईने व्यवस्था विद्यमान छ ।

Summary

Until 2016, Government of Nepal has released and registered 97 rice varieties. The seed and varietal replacement rate is a prime concern in increasing productivity and production to ensure food security in Nepal. The low adoption rate of new varieties and improved quality seeds is the principal challenge in agriculture sector especially in the development of seed sector. However, The Seed Act, 1988 (first amendment 2008), Seed policy, 1999, Seed Rules, 2013 and National Seed Vision 2013-2025 are the major existing seed related policies in Nepal. The Seed Rules, 2013 has explained the varietal registration and release system. The National Seed Board has formed a technical sub-committee under the chairmanship of member-secretary of National Seed Board to discuss on technical matters of a variety before its release or registration. The feedback of committee has to be incorporated and presented by proposed organization or person in variety approval, release and registration sub-committee meeting. If the proposal for release or registration is found appropriate, committee submits the proposal to the National Seed Board. After the approval of the National Seed Board, the name of that variety along with other specifications is sent for gazette notification. Seeds of the variety are then allowed for commercial transaction.

Keywords: Food Security, National Seed Board, Registration, Seed, Variety release

Introduction

Seed security is the prerequisite of food security because the use of quality seeds alone can increase the yield by 15-25%, which contributes to food security. The Seed Replacement Rate (SRR) of main cereals is about 12% and SRR is essential to increase the crop productivity and production (SQCC 2015). About

88% of the seeds are farm saved seeds and are low in quality resulting in low productivity. National Seed Board has released and registered 605 varieties of 65 different crops including cereals, legumes, oilseeds, vegetables and some grass varieties through the variety release and registration process (SQCC 2015).

History of seed registration and release of varieties in Nepal

The first rice (*Oryza sativa* L.) research in Nepal was initiated in 1951. Earlier research on rice in Nepal was confound to the Kathmandu valley. The evaluation of indigenous rice varieties was done prior to 1951, from which *Tauli, Marshi* and *Thapachiniya* were identified as the best locals. Initial introduction of American and Japanese varieties at Khumaltar as Tainan-1, Chiana-2 and Taichung -176 from Taiwan were found successful in the Kathmandu valley and were recommended in 1966 for similar temperate areas of Nepal (Sthapit 1995). There was no released variety of rice for high altitude area until 1951. The main strength of the release was its real performance under farmer's fields and continued farmers demand for the seed. The Variety Release Committee was initiated in early seventies under ministry to safeguard the qualitative and quantitative characteristics of a genotype. With the establishment of National Seed Board and Seed Act, 1988, it was renamed as "Variety Release and Registration Committee". It is one of the main technical wings of NSB. The Central Variety Releasing Sub-Committee (CVRC) was first established in 1974. Before 1974, the total of 11 varieties of rice and 5 varieties of wheat were released by the Department of Agriculture. With the establishment of NSB under Seed Act, 1988 the CVRC was reshaped as Variety Release and Registration Committee (Sthapit 1995).

Since 1960 to the end of 2015, a total of 605 varieties of 65 crops (cereals, pulses, oilseeds and other crops) have been released/registered by the National Seed Board. Until 2015, out of 95 notified rice varieties, 61 varieties are released and 34 varieties are registered. In 2016, two varieties namely Radha-14 and Sugandhit Dhan-1 were released. Thus, altogether 97 rice varieties (63 released and 34 registered) are released/registered by NSB in Nepal. Thirty hybrid varieties of rice are registered for commercial cultivation (SQCC, 2016). Hybrid variety of rice has not yet been released in Nepal.

Existing national seed legislation for variety release and registration

The existing national seed legislations for variety release and registration are: Seed Policy, 1999, Seed Act, 1988 (First amendment 2008), Seed Rules 2013 and Seed Vision 2013-2025.

The Seed Act 1988 (first amendment 2008) and Seed Rules 2013 have opened the varietal development and registration to the private sectors and the public sector. Seed policy, 1999 focuses mainly on variety development and maintenance, seed multiplication, quality control, increased involvement of private sector, seed supply, institutional strengthening and bio- technology.

Variety release and registration procedure

Application to be made for approval, release and registration of a new variety of seed to the Variety Approval, Release and Registration Sub-Committee relating to Sub-Rule (2) of the Rule (11) Section (a) in a format according to Schedule – 1 published in Nepal Gazette (Section 62) 14th of Falgun 2069 B.S. (25th February 2013) Number 48.

According to the Seeds Rules 2013 (2069 BS), a 15-member the National Seed Board, chaired by secretary of Ministry of Agricultural Development which may constitute different sub-committees as required pursuant to Section 6 of the act. National Seed Board shall be constituted to formulate and implement policies relating to the seeds and give necessary advice to government of Nepal on the matters relating to the seeds. One of the main duty and function of NSB is to approve, release and register the seeds of new variety as prescribed.

Constitution of National Seed Board

Secretary, Ministry of Agricultural Development	- Chairperson
Director General, Department of Agriculture	- Member

Executive Director, Nepal Agricultural Research Council - Member
Managing Director, Agricultural Inputs Company Ltd. - Member
General Manager, Agricultural Development Bank - Member
Managing Director, National Seed Organization Ltd. - Member
Three Scientists including woman related to Olericulture, Agronomy and Pasture nominated by Government of Nepal. - Member
Seed Expert (At least Associate professor), Institute of Agriculture and Animal Science, Tribhuvan University. - Member
Two Seed Entrepreneurs including one woman nominated by the Government of Nepal - Member
Two Seed producer and farmer including one woman nominated by the Government of Nepal - Member
Chief, Seed Quality Control Centre - Member Secretary

As per its necessity, the Board may form/constitute other sub-committees in addition to the sub-committees as mentioned in Sub-Rule (1), to regulate/manage its activities. The power, functions and duties of sub-committees so formed shall be as prescribed by the Board.

Variety Approval, Release and Registration Sub-Committee
Plan Formulation and Monitoring Sub-Committee
Quality-Standards Determination and Management Sub-Committee

Variety approval, release and registration sub-committee

Following members shall remain in the Variety Approval, Release and Registration Sub-Committee to be formed by the Board for the purpose of variety approval, release and registration of seeds pursuant to Clause (a) of Sub-Rule 1 of Rule 3 (Seed Act 1988).

Director General, Department of Agriculture – Chairperson
Director, (Crops and Horticulture), Nepal Agricultural Research Council – Member
Chief, Related Crop Research Program, Nepal Agricultural Research Council – Member
Program Director, Directorate of related subject matter, Department of Agriculture/Livestock Services – Member
Chief Soil Science Division, Nepal Agricultural Research Council – Member
Chief, Seed Science and Technology Division, Nepal Agricultural Research Council – Member
A person among the entrepreneurs representing the Seed Entrepreneurs' Association – Member
A representative nominated by the Board from among the Non-Governmental Organizations engaged in seed business – Member
Chief, Seed Quality Control Centre – Member Secretary

Functions, duties and powers of variety approval, release and registration sub-committee

The functions, duties and powers of the Variety Approval, Release and Registration Sub-Committee shall be:

- to prepare necessary prerequisites for the approval, release and registration of the developed varieties and get them approved by the board,
- to make recommendations to the board for the release and registration of seeds that have not been released,

- to identify the seeds of the released varieties and submit along with necessary details, to the board for registration thereof,
- to make arrangements for the multiplication (reproduction) of the certified and released seeds,
- to make recommendations to the board for making record of native and local variety crop seeds that have been produced within Nepal and variety of seeds to be imported from abroad,
- to recommend private sector to the board for the approval, release and registration of seeds.
- to make recommendations to the board for the deletion of varieties from the registration, if it is deemed necessary to remove any seeds of the released varieties from the registry,
- to make arrangements for the promotion and protection of seeds of the released varieties,
- to carry out other functions relating to variety approval, release and registration.

Guideline for the process of variety release

Latest three seasons' data on varietal performance would be needed for proposing a variety for release, which may be researcher designed and researcher managed replicated trials or researcher designed and farmer managed replicated trials or participatory replicated trials including agronomic, diseases, pests and soil fertility data.

- At least two seasons' data from (Farmers' Field Trials) FFTs, participatory trial or other forms of on-farm experimentation under farmers' management. Both quantitative and qualitative data should be incorporated.
- Activities in point 1 and 2 can be run simultaneously to speed up variety release process.
- Results of combined analysis over location and or seasons indicating the significance of interaction of variety with those factors would be desirable if a variety is proposed for wider adaptation.
- With respect to DUS requirement, morphological characteristics (*para 4.1*) would take care of distinctness (D), data in *para 3.1* for sufficient uniformity (U) and those in *para 2.8* for stability (S).
- Best local or outstanding recommended or widely grown variety should be used as a standard check in research design. The proposed variety should be superior or equivalent in or have at least one trait of economic importance, eg market value of yield per day compared to the recommended or widely grown variety to increase varietal diversity.
- A sample of the nominated variety will have to be submitted to the variety Approval, Release and Registration Sub-committee (VARRS). The quantity of the sample should be 50 g for small grain crops, 500 g for medium grain crops and 1 kg for large grain crops.
- The minimum quantity of Breeder Seed (BS) needed would be the quantity required to produce Foundation Seed (FS) in 5 ha area in case of food crops and 0.5 ha area for vegetables and high value crops.
- The Member Secretary will circulate completed copies of the formats/proposals to the members of the Committee at least two weeks in advance for their comments. The proposed variety will only be considered for release or approval if it meets all the requirements.
- The Variety Approval, Release and Registration Sub-committee should monitor the crop of the proposed variety in the fields as well as for post-harvest traits. The variety proposed for release should be brought to the knowledge of the committee one crop season in advance so that pre-release multiplication of FS can be done.
- The team/s and institution/s involved in the development of a variety should be duly acknowledged. The general recommendation for package of practices should be translated in Nepali. Color photo and herbarium of different growth stages should be submitted to NSB. Any incidence of recording of new diseases/insects pests should be brought to the notice of the Committee.

Guidelines for variety registration: For national developed variety

This type of variety is registered for the purpose of fast multiplication of variety and registered for pre-releasing multiplication. For the purpose of variety registration of imported seeds, the importer shall has to furnish an application in a format as set forth in clause (b) of Schedule 1, to the Variety Approval, Release and Registration Sub-Committee.

- Minimum two-season data on varietal performance from researcher designed and researcher managed replicated trials or participatory trials along with farmers and other stakeholders' preferences should be included.
- Supporting information from farmers, processors and consumers from participatory trials or other forms of on-farm experimentation under farmers' management should be included. Both quantitative and qualitative data are encouraged to be incorporated.
- Submission of data on DUS for introduced variety is necessary if NSB is not satisfied with submitted agronomic and morphological characters but can be obtained from other countries in case of landraces. Data/information on Distinctness and Stability will be sufficient and indigenous knowledge and information will be accepted to satisfy these requirements.
- A sample of the nominated variety will have to be submitted to the variety approval, release and registration subcommittee. The quantity of the sample should be 50 g for small grain crops, 500 g for medium grain crops and 1 kg for large grain crops.
- Variety developed using any biotechnological tools should also be disclosed. Color photo and herbarium of different growth stages should be submitted to NSB.

Guidelines for variety registration: For imported seeds/varieties

This type of registration is for the cultivation of imported seeds or varieties. There is absence of national varieties in Nepal for cultivation as demanded by farmers or substitute of varieties. For the purpose of variety registration of imported seeds, the importer shall have to furnish an application in a format as set forth in clause (c) of Schedule 1, to the Variety Approval, Release and Registration Sub-Committee (Seed Rules 2013).

- Minimum two-season data on varietal performance from researcher designed and researcher managed replicated trials or participatory trials along with farmers and other stakeholders' preferences should be included.
- Supporting information from farmers, processors and consumers from participatory trials or other forms of on-farm experimentation under farmers' management should be included. Both quantitative and qualitative data are encouraged to be incorporated.
- Submission of data on DUS for introduced variety is necessary if NSB is not satisfied with submitted agronomic and morphological characters but can be obtained from other countries in case of landraces. Data/information on Distinctness and Stability will be sufficient and indigenous knowledge and information will be accepted to satisfy these requirements.
- A sample of the nominated variety will have to be submitted to the variety approval, release and registration subcommittee. The quantity of the sample should be 50 g for small grain crops, 500 g for medium grain crops and 1 kg for large grain crops.
- Varieties developed using terminator gene technology will not be entertained for national crop inventory. Variety developed using any biotechnological tools should also be disclosed. Color photo and herbarium of different growth stages should be submitted to NSB.

Guidelines for variety registration: For local varieties or land races

In Nepal, there are many local germplasm or landraces of different crops but many of them are not registered. So, these local landraces or local germplasms should be protected in national documents and these seeds or varieties can be multiplied in national seed multiplication program. The use and protection of these varieties is necessary and beneficial for farmers or locals. In order to maintain the seeds of local varieties that have been in usage traditionally in the national archive and register them, an application shall have to be submitted in a format as set forth in clause (d) of the Schedule 1 to the Variety Approval, Release and Registration Sub-Committee by the local technicians or with help of scientists (Seed Rules 2013).

- Minimum two-season data on varietal performance from researcher designed and researcher managed replicated trials or participatory trials along with farmers and other stakeholders' preferences should be included.

- Supporting information from farmers, processors and consumers from participatory trials or other forms of on-farm experimentation under farmers' management should be included. Both quantitative and qualitative data are encouraged to be incorporated.
- Submission of data on DUS for variety is necessary if NSB is not satisfied with submitted agronomic and morphological characters. Data/information on distinctness and stability will be sufficient and indigenous knowledge and information will be accepted to satisfy these requirements.
- A sample of the nominated variety will have to be submitted to the variety approval, release and registration subcommittee. The quantity of the sample should be 50 g for small grain crops, 500 g for medium grain crops and 1 kg for large grain crops.
- Color photo and herbarium of different growth stages should be submitted to NSB.

Application to be filled for the registration of Seeds

- Varieties developed using terminator gene technology will not be entertained for national crop inventory. Variety developed using any biotechnological tools should also be disclosed. Color photo and herbarium of different growth stages should be submitted to NSB.
- Upon making necessary inquiry on the application being filed pursuant to Sub-Rule 1 and 2, the Variety Approval, Release and Registration Sub-Committee shall make recommendation to the Board for variety registration and notification.
- Notwithstanding anything contained elsewhere in these rules, in case of seeds of genetically modified plants and those of living modified plants are, only registered on the basis of reports or details having bio-safety analysis.
- Notwithstanding anything contained elsewhere in these rules, the registration of variety shall not be made in case of the seeds which have used terminator technology.

Conclusion

After the seeds of new varieties have been approved, released and registered, the Variety Approval, Release and Registration Sub-Committee shall maintain records of it. Variety Approval, Release and Registration Sub-Committee shall give a certificate to the concerned breeder and maintain records thereof. Inappropriate or unnecessary varieties are removed from the list of the Notified Seeds by publishing notice on Nepal gazette. Technical Sub-Committee under Variety Approval, Release and Registration Sub- Committee assesses the proposal of the variety. The Technical committee evaluates and makes the decision of acceptance or release or registration. Sub-committee makes the final decision for official release or registration. If the proposal is approved by NSB, the variety is published in Nepal Gazette for notification. Use of standard formats and guidelines is necessary before submitting the proposal to the National Seed Board and submission of specimens is also required for future reference.

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Released and Registered Varieties of Rice in Nepal and their Distribution

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सारांश

नेपालमा कृषि अनुसन्धानका लागि आधिकारिक निकाय नेपाल कृषि अनुसन्धान परिषद् हो । हाल धानको जातीय विकासमा समेत परिषद् नेतृत्वदायि भूमिकामा रहेको छ । नेपालमा औपचारिक रूपमा धानको जातीय विकासको सुरुवात सन् १९६६ मा सि. एच-४५ जातको विकाससँगै सुरु भएको हो । परिषद्बाट अनुसन्धान पश्चात् प्राप्त नतिजाहरू कृषि विभाग मार्फत् कृषकहरूमा पुर्‍याउने व्यवस्था रहेको छ । सन् २०१६ सम्ममा राष्ट्रिय बीउ बिजन समितिबाट ७५ वटा धानका जातहरू उन्मोचन तथा सिफारिस भएका छन् भने १२ वटा सूचीबाट हटाइएका छन् । हालसम्म उन्मोचन भएका जातहरूमध्ये २५ वटा जातहरू इरिबाट ल्याइएका जर्मप्लाज्मबाट विकसित गरिएका हुन् भने २१ वटा नेपालकै र १० वटा भारतबाट ल्याइएका जर्मप्लाज्मबाट विकास गरिएका हुन् । केही जातहरू चीन, ताइवान, फिलिपिन्स, वंगलादेश, श्रीलंका र इन्डोनेसियाबाट समेत ल्याइएका जर्मप्लाज्मबाट विकास गरिएका छन् । नेपालमा २०१० को दशकमा सबैभन्दा बढी १९ धानका जातहरू उन्मोचन एवम् सिफारिस भएका थिए भने त्यस पश्चात् सन १९८०, १९९०, २०००, १९७० र १९६० को दशकमा क्रमशः १४, १३, १२, ११ र ८ वटा धानका धानहरू उन्मोचन भए । नेपालमा ६१ वटा धानका जातहरू वर्षे धानका जातको रूपमा उन्मोचन भएका छन् । उन्मोचन भएका जातहरूमध्ये सि.एच-४५ सबैभन्दा छिटो पाक्ने (१०० दिनमा) र माछापुच्छ्रे-३ सबैभन्दा ढिलो पाक्ने (१९७ दिनमा) जातहरू हुन् । उन्मोचन भएमा जातहरूमा खजुरा-२ को सबैभन्दा कम उत्पादकत्व रहेको छ । सन् २०१६ सम्ममा नेपालमा जम्मा ३० वटा धानका हाइब्रिड जातहरू सूचिकृत भएका छन् जसको सम्भाव्य उत्पाकत्व ५ देखि ७ मेट. प्रति हेक्टरसम्म रहेको छ । यो उत्पादकत्व धानका पैत्रिक जातहरूको उत्पादकत्व (३.५ देखि ९ मेट. प्रति हे) भन्दा बढी हो । नेपालमा विकास भएका धानका जातहरूको उत्पत्ति, उन्मोचन तथा सूचिकृत वर्ष, उत्पादन सिजन, बाली अवधि, सिफारिस गरिएका क्षेत्र तथा सम्भाव्य उत्पादकत्व सहितको विवरण यस लेखमा प्रस्तुत गरिएको छ ।

Summary

Nepal Agricultural Research Council (NARC) has the mandate of agricultural research in Nepal. NARC is the lead organization for rice varietal improvement to date. The formal varietal development of rice in Nepal was started in 1966 with the release of CH -45 variety. The research outputs are formally disseminated among farmers through Department of Agriculture. Until 2016, National Seed Board has released and recommended 75 varieties of rice for different geographical domains. Among the released varieties, 12 of them have been denotified for their unsuitability for cultivation. Out of total rice varieties recommended and released so far in Nepal, 25 of them have been developed from the germplasm of IRRI. Similarly, rice varieties developed from germplasm of Nepal and India are 21 and 10, respectively. In addition to this, some of the rice varieties have been released/recommended by bringing the germplasm from China, Taiwan, Philippines, Bangladesh, Sri Lanka, and Indonesia. The highest number of rice varieties were released/recommended during the decade of 2010s with 19 varieties followed by decades of 1980s, 1990s, 2000s, 1970s and 1960s with 14, 13, 12, 11 and 6 rice varieties, respectively. 61 varieties of rice have been released for main season (rainy). The CH-45 has the shortest maturity period of 100 days whereas Machhapuchhre-3 has the longest maturity days of 197 days. Khajura 2 has the lowest productivity compared to other recommended/released rice varieties in Nepal. As of 2016, a total of 30 hybrid varieties were registered by National Seed Board (NSB). The registered hybrids rice in NSB have yield potentiality of 5-7 t/ha which is not so encouraging compared to inbred rice varieties having grain yield potentiality ranging from 3.5 to 9 t/ha (AICC 2016). The details of distribution of rice varieties developed and registered (in case of hybrid) in Nepal based on their origin, year of release, production season, maturity days, yield potentials and recommendation domains are given in **Table 1, 2** and **3** below.

Table 1. Parameters and number of rice varieties released

1	On the basis of origin	China	IRRI	Bangladesh	India	Nepal	Sri Lanka	Taiwan	Philippines	Indonesia	Malaysia	NA	Total
	No. of varieties released	3	25	2	10	21	3	4	2	2	1	2	75
2	On the basis of Year of Release	1960-1969	1970-1979	1980-1989	1990-1999	2000-2009	2010-2016						
	No. of varieties released	6	11	14	13	12	19						75
3	Season	*Chaite*	*Barkhe*	*Barkhe/ Chaite*	Ghaiya								
	No. of varieties released	11	61	2	1								75
4	Maturity days	100-109	110-119	120-129	130-139	140-149	150-159	160-169	>170				
	No. of varieties released	2	6	17	12	18	14	2	4				75
5	Yield Range (t/ha)	2.0-2.9	3.0-3.9	4.0-4.9	5,0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	>10			
	No. of varieties released	4	24	27	8	5	5	1	0	1			75
6	Domains	Tarai	Tarai, inner Tarai	Tarai to low Hill	Mid hill	Kathmandu Valley	Mid to high hill	High hill					
	No. of varieties released	22	24	4	12	6	6	1					75

Table 2. The name of released rice varieties with various parameters

SN	Varieties	Parentage	Origin	Released year	Production season	Maturity days	Yield potential (t/ha)	Recommended domain
	Spring Season							
1	CH-45	Selection at IRRI	China	1966	*Chaite*	110	2.8	Tarai and inner Tarai
2	Parwanipur-1	Peta/Peta 3/TN1	IRRI	1973	*Chaite*	120	4.3	Tarai
3	IR-24	IR8///centuryPatna/SLO17//sigadis	IRRI	1975	*Chaite*	120	4.3	Tarai
4	Chandina	Peta3/TN1/TKM6	Bangladesh	1977	*Chaite*	115	4.0	Tarai
5	Laxmi	IR833-6-2-1-1//IR1561-1/IR1737	IRRI	1979	*Chaite*	120	4.5	Tarai
6	Bindeswori	TN1/Co28	India	1981	*Chaite*	105	3.5	Tarai/Lower hill
7	Mallika	CP-SL02/Sigadis	Bangladesh	1982	*Chaite*	120	4.0	Tarai
8	Chaite-2	BG34-8/IR2153-159-1-4	IRRI	1987	*Chaite*	120	5.2	Tarai (Irrigated area)
9	Chaite-4	BG34-8/IR28//IR2095-625-1-252	IRRI	1987	*Chaite*	120	5.1	Tarai (Irrigated area)
10	Chaite-6	NR6-5-46-50/IR28	Nepal	1991	*Chaite*	120	3.7	Tarai, inner Tarai
11	Hardinath-1	BG951///79-3348/H4//BW288-1-3	Srilanka	2004	*Chaite*	120	4.03	Tarai, inner Tarai
	Main Season							
12	Taichung-176	Tsai-Yuan-Chung/dee-geo-woo-gen	Taiwan	1966	Summer (*Barkhe*)	145	7.0	Kathmandu valley and similar areas
13	Chainung-242	Llsin -chio-4/Taichung-150/Taipe-17/T-45	Taiwan	1966	Summer (*Barkhe*)	145	7.0	Mid hill

SN	Varieties	Parentage	Origin	Released year	Production season	Maturity days	Yield potential (t/ha)	Recommended domain
14	Tainan-1	T-Y-c/DGWG	Taiwan	1966	Summer(*Barkhe*)	132	7.0	Mid hill
15	Chainan-2	C-luamchu/shiniriAikoku/Taichung 65	Taiwan	1966	Summer (*Barkhe*)	130	6.6	Mid hill
16	IR-8	Peta/Dee-geo-woo-gen	IRRI	1966	Summer (*Barkhe*)	135	4.3	Tarai
17	IR-20	Peta 3/TN1/TKM6	IRRI	1970	Summer (*Barkhe*)	152	4.1	Tarai
18	IR-22	IR8/Tadukam	IRRI	1972	Summer (*Barkhe*)	150	3.7	Tarai
19	Masuli	Mayang Ebos 80*2/Taichung 65	Malaysia	1973	Summer (*Barkhe*)	165	4.0	Tarai and inner Tarai
20	Jaya	TN1/T141	India	1973	Summer (*Barkhe*)	130	4.3	Tarai
21	Durga	Jaya/IR8/Latisal	India	1979	Summer (*Barkhe*)	130	4.5	Tarai
22	Janaki	Peta 3/TN1/Ramadga	Srilanka	1979	Summer (*Barkhe*)	135	4.5	Tarai
23	Sabitri	IR1561-228-1/IR1737//CR94-13	IRRI	1979	Summer (*Barkhe*)	145	4.0	Tarai/Lower hill
24	Himali	CICA-4Kulu	IRRI	1982	Summer (*Barkhe*)	145	6.4	Mid hill
25	Kanchan	CR126-42-5/IR2061-213	IRRI	1982	Summer (*Barkhe*)	145	6.5	Mid hill
26	Khumal-3	China1039/IR580	India	1983	*Barkhe*/*Chaite*	100	5.6	Mid hill
27	Khumal- 2	Jarneli/kn-LD36t-DLK-2-8	Nepal	1987	Summer (*Barkhe*)	145	3.5-7.7	Kathmandu valley and similar areas with up to 3000-4500 ft. height mid hill
28	Khumal-4	IR28/*Pokhreli Masino*	Nepal	1987	Summer (*Barkhe*)	145	4.2-8.4	Kathmandu valley and similar areas with up to 3000-4500 ft. mid hill
29	Makawanpur-1	0675/IR20/H4	Sri Lanka	1987	Summer (*Barkhe*)	145	4.5	Tarai and inner Tarai
30	*Barkhe*-2	C4-63 GB/B531b-Tk39	Indonesia	1987	Summer (*Barkhe*)	135	3.6	Tarai (Irrigated area)
31	Khajura-2	RP72/Mutant 65	India	1987	Summer (*Barkhe*)	110	2.0	Mid-western Tarai, (Irrigated area)
32	Ghaiya-2	MTU/W-Kakalku	India	1987	Ghaiya	113	3.9	Tarai and inner Tarai (Rainfed area)
33	Palung-2	BG94-2/*Pokhreli Masino*	Nepal	1987	*Barkhe*/*Chaite*	158	6.4	Temperate areas similar to Palung/high hill
34	Khumal-5	*Pokhreli Masino*/KA-1B-361-BLK-2-8	IRRI	1990	Summer (*Barkhe*)	154	4.4	1000-1400 m, western midhill like Parbat, Baglung, Myagdi
35	Khumal-7	*Chaite* 1039 DEFMUT/Kn18-361-1-8-6-10	IRRI	1990	Summer (*Barkhe*)	146	4.5	1000-1400 m heighted western midhill like Parbat, Baglung, Myagdi
36	Khumal-9	K28-76-D-1/kn18-214-1-4-3/kn 18-214-1-4-3	IRRI	1990	Summer (*Barkhe*)	148	4.1	1000-1400 m heighted western mid hill like Parbat, Baglung, Myagdi

SN	Varieties	Parentage	Origin	Released year	Production season	Maturity days	Yield potential (t/ha)	Recommended domain
37	Chomrong	Selection from Ghandruk local landrace	Nepal	1991	Summer (*Barkhe*)	164	3.4	High Hills of eastern and western region (1400-2000 m), Mid hills in cold water region
38	Radha-7	Masuli/Janaki	Nepal	1991	Summer (*Barkhe*)	148	3.5	Tarai, inner Tarai (Rainfed, Lowland area)
39	Radhakrishna-9	Masuli/NR42	Nepal	1991	Summer (*Barkhe*)	148	3.8	Tarai, inner Tarai (Irrigated area)
40	Radha-4	BG 34-8/IR-2071-625-1	IRRI	1995	Summer (*Barkhe*)	121-128	3.2	Mid and far-western Tarai
41	Radha-11	Local collection(Meghadut)	India	1995	Summer (*Barkhe*)	145-150	3.5	Central-Tarai (Rainfed area)
42	Radha-12	TN1/TN41//Annapurna	India	1995	Summer (*Barkhe*)	155	4.6	Eastern Tarai (Irrigated/unirrigated low land)
43	Machhapuchre-3	Fusi102/Chhomrong Dhan	Nepal	1996	Summer (*Barkhe*)	134-197	4.9	Mid to high hills with cool climate (1300-2000 m)
44	Khumal-6	IR13146-45-2-3/IR17492-18-6-1-1-3-3	Nepal	1999	Summer (*Barkhe*)	155	7.8	Kathmandu valley and similar areas
45	Rampur masuli	Lalankanda/IR-30		1999	Summer (*Barkhe*)	135	5.7	Tarai, inner Tarai and foot hills in CDR and WDR (up to 900 m)
46	Manjushree-2	Fusi 102/NR10157	Nepal	2002	Summer (*Barkhe*)	149	10.08	Kathmandu valley
47	Khumal- 11	Akyodaka/Barkat	Nepal	2002	Summer (*Barkhe*)	144	8.5	Kathmandu valley
48	Chandannath-1	-	China	2002	Summer (*Barkhe*)	191	5.05	Jumla valley and similar high hills (2300 m)
49	Chandannath-3	-	China	2002	Summer (*Barkhe*)	192	5.3	Jumla valley and similar high hills (2300 m)
50	Loktantra	MAHASURI/IR 4547-6-2-2	Nepal	2006	Summer (*Barkhe*)	125-130	3.6	Tarai, inner Tarai, low hills and Mid hills
51	Mithila	Fortuna//Miltor 6*2/Azucena	Philippines	2006	Summer (*Barkhe*)	145-150	3.5-4.5	Tarai, inner Tarai
52	Ram	Mansuli//IR30	India	2006	Summer (*Barkhe*)	130-137	4.0-7.2	Central Tarai, siwalik valley
53	*Barkhe*-3004	KalingaIII/IR64	nepal	2006	Summer (*Barkhe*)	157	3.8	Tarai and inner Tarai
54	Pokhreli Jethobudho	Local landrace	Nepal	2006	Summer (*Barkhe*)	180-185	2.6	Pokhara Valley and surroundings (600-900 m)
55	Khumal-8	Jumli Marshi/IR36(NR10353-8-2-1	Nepal	2007	Summer (*Barkhe*)	158	7.7	Tar, Foot-hills to mid-hills
56	Sunaulo Sugandha	Selection of Pusa Basmati1 treated by ŷ raysX unknown parent		2008	Summer (*Barkhe*)	151	3.8	Tarai and inner Tarai
57	Ghaiya-1	IR 64/IR 25863-61-3-2//IR 58	IRRi	2010	Summer (*Barkhe*)	115	2.5-3.5	Tarai, inner Tarai, mid-hills
58	Lalka Basmati	Landrace(Lalka basmati)	Nepal	2010	Summer (*Barkhe*)	150	2.5-3.5	Central and eastern Tarai
59	Hardinath 2	IRTA-112/IR 50	Indonesia	2010	Summer (*Barkhe*)	125	3.1-4.2	Tarai and inner Tarai
60	Tarhara- 1	IR 70181-26-PMI2-9-1-1/IRRI 1105	IRRI	2010	Summer (*Barkhe*)	113-125	4.2	Tarai and eastern Tarai
61	Khumal-10	Khumal-5/IR 36,NR 10492-7-2-2	Nepal	2011	Summer (*Barkhe*)	107-170	4.78	Mid hills

SN	Varieties	Parentage	Origin	Released year	Production season	Maturity days	Yield potential (t/ha)	Recommended domain
62	Khumal-13	Taichung-176/Yongen-3, NR 10515-69-1	Nepal	2011	Summer (*Barkhe*)	117-183	4.17	Mid hills
63	Sukha dhan-1	IR55419*2/WAYRAREM	IRRI	2011	Summer (*Barkhe*)	123-125	3.2-4.2	Tarai, inner Tarai, river basin (up to 500 m
64	Sukha dhan-2	IR55419*2/WAYRAREM	IRRI	2011	Summer (*Barkhe*)	122-124	2.3-3.5	Tarai, inner Tarai, river basin (up to 500 m
65	Sukha dhan-3	IR55419*2/WAYRAREM	IRRI	2011	Summer (*Barkhe*)	122-125	2.5-3.6	Tarai, inner Tarai, river basin (up to 500 m)
66	*Barkhe* – 2014	Kalinga III/IR 64	Nepal	2011	Summer (*Barkhe*)	135-140	3.8	Tarai
67	Swarna Sub-1	Swarna/IR49830-7-1-2-3//2*swarna(Swarna-3/IR49830-7-1-2-3)	IRRI	2011	Summer (*Barkhe*)	150-155	4-5	Tarai, inner Tarai (up to 500 m mid hill)irrigated and swampy land
68	Samba Masuli Sub-1	Samba Mahsuri/IR49830-7-1-2-3//2*Samba Mahsuri(samba Mansuli*3IR49830-7-1-2-3)	IRRI	2011	Summer (*Barkhe*)	145-150	3.5-4	Tarai, inner Tarai, (up to 500 m mid hill) irrigated and swampy land
69	Lekali dhan-1	Banjaiman/chomrong and NR 10479-B-33-2-1-1	Nepal	2014	Summer (*Barkhe*)	158	4.07	up to 1500-2600 m high hill
70	Lekali dhan-2	Yunlen/Chomrong and NR 10482-B-10-3-2-2	Nepal	2014	Summer (*Barkhe*)	152	3.9	up to 1500-2600 m high hill
71	Sukha dhan-4	IR 77298-14-1-2-10/IR 77298-5-6-11 and IR 87077-446-B-B-B	IRRI	2014	Summer (*Barkhe*)	118-125	2.7-4	Tarai, inner Tarai unirrigated land, river basin (up to 500 m)
72	Sukha dhan-5	IR 72022-46-2-3-3-2/and IR 83388B-B108-3	IRRI	2014	Summer (*Barkhe*)	125	3.2-4.2	Tarai, inner Tarai unirrigated land, river basin (up to 500 m)
73	Sukha dhan-6	IR 72022-46-2-3-3-2/IR 57514-PMI-5-B-1-2 and IR 83383B-B-129-4	IRRI	2014	Summer (*Barkhe*)	120-125	3-4	Tarai, inner Tarai unirrigated land, river basin (up to 500 m)
74	Radha-14	IR 69020-21-3-2-2-2/IR 68068-99-1-3-3-3//BG 90-2	IRRI	2016	Summer (*Barkhe*)	132	4.4	Tarai, inner Tarai, river basine and valley irrigated land (up to 799 m)
75	Suganthit Dhan-1	Pusa Basmati/IET 12603	India	2016	Summer (*Barkhe*)	145	4.5	Tarai, inner Tarai, river basin and valley irrigated land (up to 700 m)

Note: Varities with « indicated denotified by the National Seed Board of Nepal till this date.

Source: SQCC 2016 (Available at www.sqcc.gov.np).

Table 3. The name of registered rice varieties with various parameters

SN	Variety	Year of Registration	Days of maturity	Yield (t/ha)	Recommended Domain
1	DY-18	2010	118	9.17	Tarai, inner Tarai
2	DY -28	2010	120	8.86	Tarai, inner Tarai
3	DY-69	2010	125	9.52	Tarai, inner Tarai
4	*Barkhe*-1027	2011	121	3.3	Unirrigated Tarai, Mid hill 100 m, Low hill and Unirrigated area
5	Tara	2011	116	5.1	Tarai, inner Tarai
6	Suraj	2011	123	5.77	Tarai, inner Tarai
7	Prithivi	2011	124	6.00	Tarai, inner Tarai irrigated area
8	Arise-6444	2011	122	4.43	Tarai, inner Tarai irrigated area
9	PHB-71	2011	129	5.26	Tarai/Irrigated area
10	US-312	2011	132	5.46	Sarlahi-Banke Tarai and inner Tarai
11	Champian	2011	136	5.15	Sarlahi-Banke Tarai and inner Tarai
12	Raja	2011	126	4.94	Sarlahi-Banke Tarai and inner Tarai
13	RH-257	2011	123	4.99	Tarai, inner Tarai
14	Gorakhnath-509	2011	123	4.82	Tarai, inner Tarai
15	Loknath-505	2011	129	4.79	Tarai, inner Tarai irrigated area
16	PAC-801	2011	123	4.79	Tarai, inner Tarai irrigated area
17	Reshma-786	2011	120	4.91	East Tarai, irrigated area
18	Baishali	2011	121	6.35	East Tarai, irrigated area
19	Sindhuri	2015	135-145	4-5	Tarai and inner Tarai
20	Sundaram	2015	120-125	4.4-5.3	Tarai and inner Tarai
21	Delta Rani	2015	124-128	3.9-5.0	Tarai and inner Tarai
22	Aakash	2015	120-125	6.0-6.3	Tarai and inner Tarai
23	Garima	2015	130-135	5.8-6.3	Tarai and inner Tarai
24	DRH 775	2015	125-130	5.6	Tarai and inner Tarai
25	DRH 748	2015	130-135	6.5	Tarai and inner Tarai
26	Arise 6444 gold	2015	130	5.1	Tarai and inner Tarai of eastern Banke
27	Arise Tej Gold	2015	135	5.3	Tarai and inner Tarai of eastern Banke
28	GK-5017	2015	127	5.1-5.4	Tarai and inner Tarai
29	Super-125	2015	128-133	5.3-6.3	Tarai, Irrigated and partial irrigated area of inner Tarai
30	Super-115	2015	120-125	5.0-6.0	Tarai, Irrigated and partial irrigated area of inner Tarai
31	Shanti	2015	120-130	5.0-6.0	Tarai and inner Tarai: irrigated area
32	Sudha	2015	125-130	5.0-6.0	Tarai and inner Tarai: irrigated area
33	US-323	2015	120-130	4.0-5.0	Tarai and inner Tarai: irrigated area
34	US-382	2015	120-125	5.0-6.0	Tarai and inner Tarai: irrigated area

Source : CDD 2015 and www.sqcc.gov.np 2016.

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Historical Background and Statistical Techniques in Rice Varietal Improvement in Nepal

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सारांश

नेपालमा धान सम्बन्धी अनुसन्धानका कार्य धानको सामान्य गुणस्तरीय परीक्षणदेखि विभिन्न चरणहरू पार गरी वर्तमानको व्यवस्थित संस्थागत परीक्षणसम्म आइपुगेको छ । यो समय सम्म धानको जातीय सुधार तथा धान खेतको परीक्षण गर्न विभिन्न तथ्याङ्कीय प्रविधिको प्रयोग गरिएको छ । यसै सन्दर्भमा यस लेख मार्फत धानको अनुसन्धान, गुणस्तरीय परीक्षण तथा जातीय सुधारको विभिन्न चरणमा प्रयोग भएका प्रयोगात्मक डिजाइन, क्षेत्र, फिल्ड प्लट विधि र डाटा विश्लेषण तथा तथ्याङ्क प्रविधि र गणनाको उपकरण सम्बन्धीको विषयमा जानकारी गराइएको छ ।

Summary

Research works on rice in Nepal were initiated from a very small, qualitative tests to the present day fully institutionalized systematic work in various phases. Various statistical techniques are used in rice varietal improvement research and rice field experiments. In this context, this article deals with three essential components of the statistical technique as experimental design, field plot technique and data analysis, computing devices and statistical software which are used in rice varietal improvement in Nepal in different time periods.

Keywords: Data analysis, Experimental design, Field plot technique, Qualitative tests, Research, Software, Statistical technique

Introduction

This section deals with development of rice varietal improvement research and various statistical techniques used in the rice field experiments in Nepal, with the main emphasis on statistical techniques. The topics covered deal with the three essential components of the technique: experimental design, field plot technique, and data analysis and how they were employed, as well as facilities available to carry out these tasks. Some common myths or misconceptions related to statistics are also discussed. It also attempts to offer some suggestions on improvements in the light of present day computing power and software availability.

This write-up is based mainly on the author's own experience in rice breeding and field experimentation for nearly two decades during 1970's and 80's with National Rice Improvement Program, Parwanipur and Agriculture Botany Division, Khumaltar (then Department of Agriculture, GoN, Nepal), followed by contacts with rice (as well as wheat) scientists as consultant through CIMMYT/Kathmandu, and as resource person/trainer in short term statistics trainings conducted by NARC in later periods. However, the write-up mainly is only a highlight on the subject, and by no means a comprehensive account.

Evolution of rice varietal research

Research works in rice and other crops in Nepal were initiated from a very small, qualitative tests to the present day fully institutionalized systematic work in various phases. Same can be said of development and employment of scientific/statistical methodologies. Based on these considerations the periods of rice research development are divided into four periods:

Period 1: 1954-1966 (2010-2023 BS)

Agriculture Department was established in 1954 and also various experimental farms and research sections came into being during the same period. Replicated trial was conducted in 1961 to evaluate yield potentials of some rice varieties viz Stock, Century Patna, Bluebelly, Nato, and Zenith in a testing farm in Sigh durbar premises in Kathmandu. Some Taiwanese varieties started being tested; and Taichung-176, Chinung-242, and Tainan-3 were released as per the result. From trials conducted in Parwanipur, CH-45 and BR-34 were released for Tarai areas. Apparently, they all passed through screening nurseries and replicated yield trials, but the details are not available.

Period 2: 1966-1973 (2023-2030 BS)

Department of Agriculture Education and Research was re-organized for producing mid-level agriculture technicians and doing research on cereal crops, along with four other Departments to cater other needs -horticulture, livestock, fisheries, and extension works. The First Annual Report on cereal crops mainly: rice, maize, and wheat appeared and the reports continued in the subsequent years. The varietal experiments initially handled by Agronomy Section and conducted in agronomy experimental farms throughout the country were later shared or taken over by Agriculture Botany Section. The farms were also re-designated as Agriculture Farm or Agriculture Station.

This period saw the development of systematic approach to research on rice, maize and wheat. The publication of guidebook for researchers - 'Principles of Field-Plot Technique' in 1969 was a big landmark in research development. It was published by the Department of Agriculture Education and Research and authored by Hira Bahadur Shrestha (Chief Agonomist) and Glen D Johnson (Agonomy Advisor, USAID). This handbook gave elaborate instructions on Experimental Designs, Field Plot Techniques, Data Analysis, besides other useful material (this will be referred to in later sections also).

The research projects or experiments on different problem areas – varietal testing, agronomy, soil management, entomology, and pathology were designed by respective research sections (later called 'divisions') by person designated 'in-charge' for the crop. Typically, the persons were the chiefs of the research sections or some senior scientists. The research section chiefs were responsible for development of the experiment protocols, supply of these material, and for necessary instructions to the experimental farms. They were also held responsible for training the farm scientist or the 'cooperator', monitoring the works, collection and analysis of data, and finally presentation of results at a biennial Summer Crops Workshop. A final monitoring by of the experiments in the farms was done by the 'Coordinated Team' typically consisting of the chiefs of the research sections.

A typical Coordinated Team for rice, in the late 1960's and early 1970's, before the establishment of the NRIP, comprised of the following.

Mr. Amresh Man Pradhananga	Chief, Agriculture Botany Section
Mr. Top Bahadur Basnyat	Chief, Agriculture Engineering Division
Mr. Achyut Nath Bhattarai	Chief, Agronomy Section
Mr. Prithu Narasingh Rana	Chief, Entomology Section
Mr. Bed Bahadur Khadka	Chief, Plant Pathology Division
Mr. Manik Lal Pradhan	Chief, Soil Science Section

The following represented each research discipline as active scientists and leaders in the fields.

Dr. Bal Bahadur Shahi	Agricultural Botanist (Rice Genetics/Breeding)
Mr. Puskal Prasad Regmi	Agronomist (Rice Agronomy)
Mr. Bishnu Kumar Gyawali	Entomologist (Rice Entomology)
Mr. Birendra Jung Thapa	Plant Pathologist (Rice Pathology)
Mr. Ganga Prasad Deo	Soil Scientist (Rice Soils)

Period 3: 1973-1983 (2030-2040 BS)

This period saw the dawn of a new era in research/development of the major cereals as full national programs. Parwanipur Agriculture Station was chosen as the center for National Rice Improvement Program (NRIP) with its own core group of staff. A National Rice Coordinator was designated and had permanent residence in the Parwanipur Station. NRIP coordinated rice research on the national basis - planning, supervising, compiling reports, etc from the research farms/stations in the Hills as well as in the Tarai. While Parwanipur did the maintenance and flow of breeding lines and other research material for the Tarai, Agriculture Botany Division at Khumaltar with its own resources assisted in such matters for the Hills, working practically, but unofficially, as the NRIP sub-center for the Hills.

This period, the first decade of NRIP existence, is seen as many as the 'golden age' of rice research for mainly the following reasons.

Development of interdisciplinary approach leading to more rigorous screening of breeding lines against pests and other constraints. Much emphasis was laid on mass screening especially against bacterial leaf blight using simple inexpensive method but effective methods.

Increased awareness on use of appropriate statistical techniques. Support from Integrated Cereals Project (ICP)/USAID in statistics trainings played significant role. Trainings and publications available from International Rice Research Institute (IRRI) on statistical methods became a standard practice among NRIP staff. The two such publications were: 'Statistical Methods for Agricultural Workers' by Kwanchai A. Gomez and Arturo A. Gomez and 'Techniques for Field Experimentation with Rice' by Kwanchai A. Gomez.

The young scientists began to be more active and responsible towards their works. They were handed the task not only of the field, but also of processing data and presenting the results at the annual workshops. The earlier practice of result presentation by their bosses or some assigned senior personnel virtually disappeared.

Many worked with much enthusiasm and dedication towards making rice research active and largely successful in this period. To name a few who all worked and stayed together for the decade at NRIP, Parwanipur the following selection may be justified.

Dr. Bal Bahadur Shahi	National Rice Coordinator
Mr. Gyan Lal Shrestha	Assistant Rice Breeder
Mr. Bharat Raj Adhikary	Assistant Rice Breeder
Mr. Satyendra Prasad Singh	Assistant Entomologist
Mr. Govinda Prasad Koirala	Assistant Agronomist

Dr. Bal Bahadur Shahi, DSc, an acclaimed geneticist was a great addition to the team as the leader. He was very much successful in enthusing the idea of interdisciplinary collaboration among scientists by lending full support in application of IRRI's GEU (Genetic Evaluation and Utilization) concept and practical field experimentation ideas. He was able to solicit much help from IRRI – there was ample flow of germplasm, varied assortment of experimental materials, and scientists' visits and training offers. Mr. Gyan Lal Shrestha, an untiring field worker, was responsible for developing Breeding (crossing) Block and maintenance of flow of generation lines from local materials, and maintenance of local germplasm. He was also a knowledgeable scientist on rice physiology, so liked to share his time with agronomical researches as well. Mr. Bharat Raj Adhikary emphasized the importance of genetic resistance to constraints of various sorts and worked mostly on screening nurseries, introduced mass screening against bacterial blight, and was able to put an end to the use of protection measures against pests in the varietal trials. He also contributed to improvement of statistical methods in research, working as helper and trainer on the subject. Mr. Satyendra Prasad Singh, worked as entomologist, plant pathologist, and breeder in handling large volume of IRTP nurseries as well as many varietal trial entries in making the rice breeding for pest resistance effective to the most possible extent. He successfully established rice blast nurseries in Parwanipur. Mr. Govinda Prasad Koirala handled agronomic experiments of varied types, supervised improved seed production programs and various farm operations. He was keenly involved in adaptive experiments on newly developed IRRI technologies on cropping systems, implement uses, fertilizer use efficiency, herbicides use, etc and almost single-handedly helped push forward the projects collectively, dubbed as CEU (Cultural Evaluation and Utilization).

Period 4: 1983 and later (2040 BS and later)

The later part of NRIP, which extends to the present time differ in many respects. To focus on the statistical aspect, accessibility to desktop/laptop computers and ever increasing assortment of statistical software has increased the computing power and document processing, incomparably. This combined with increased manpower with higher degrees and trainings have resulted in use of techniques that were available only in advanced textbooks. Thus, in contrast to the earlier times, these days use of sophisticated but more efficient designs and statistical analysis, like multi-location, multi-season Combined analysis, Genotype x Environment (GxE) interaction and stability tests with AMMI-Biplot Analysis, Cluster Analysis, etc, to name a few, have become common and essential features of data analysis.

Statistical techniques used and facilities available

The full recognition and systematic use of statistical techniques in rice research seem to have actually begun after the establishment of the Department of Agriculture Education and Research in 1966. This was exclusively dedicated to crop sciences (cereals and staple food plants, and cash crops). Agriculture Research Farms (called Agronomy Experimental Farms) dedicated to cereals increased throughout the country and also improved in infrastructure; so were the agriculture research sections at Khumaltar. Introduction of advanced breeding lines from IRRI was facilitated and collection and evaluation of native rice germplasm was initiated. Correspondingly, there was increasing need to systematize the field testing of these acquired materials.

The above mentioned publication of 'Principles of Field Plot Technique' by Department of Agriculture Education and Research (1969), and later of 'Techniques of Field Experiments with Rice' by IRRI (1972) along with 'Statistical Methods for Agricultural Research' by Gomez and Gomez (1972) provided good practical guidelines needed at the times.

Experimental designs

The type of design used vary with stage to which a breeding line is advanced and the objective of the evaluation. According to the stage the designs used in rice improvement are:

F2 and Early Generation Nurseries : No design

Screening Nurseries : No design.

Observation Nurseries : No design.

Initial Evaluation Trial (IET) or Preliminary Yield Trial : Yield evaluation is the objective. Usually 6x6, 7x7, or 8x8 Simple Lattice (ie Square Lattice with two replications) Design. These come in many types – Irrigated set (Early set, Normal or Late set, Rainfed set etc). Each set were tested in two locations at least.

Coordinated Varietal Trial (CVT) or Advanced Varietal Trial : Advanced yield evaluation in multiplications. Identification of varieties for FFT and possible release. Usually have 16-20.

Advanced lines. RCB Design commonly used. Like IET's come in many types – Early set, late set, Rainfed, Upland set, etc.

Rice CVT's were also designed in Split-plots with Fertilizer (NPK combinations) as main plot factor and varieties as the sub-plot factor. In these, the fertilizer had two levels ('Low' and 'High') and the varieties around 16 in number. This design for CVT's was discontinued by NRIP.

The CVT's had 4 replications. As the number of experiments increased, the replications began to be cut down. The later day CVT as well as as other trials typically begin to have 3 replications.

Varietal yield trials

Variety trials other than IET, CVT include those with special origin or nature such as IRYN's (International Rice Yield Nurseries), for some years in early NRIP years, AICRIP (All India Coordinated Rice Improvement Project) varietal trials, and others.

Usually RCB Design is used.

Farmers field trials (FFT)

The purpose of these trials is the evaluation of advanced highly promising lines that have passed through CVT or other multiyear/multisession testing's. FFT's have been integral part of varietal development and release process for any crop improvement program. FFT's are conducted in farmers field selected by District ADO (Agriculture Development Office) staff and conducted by joint cooperation of ADO's and Research Farms.

Sets of 6-7 advanced prerelease lines or varieties selected including local and standard checks have been the typical composition. About 5-6 farmers are selected in a district, only single set (ie without replication) is planted in each farmer's field. For the district, the farmers are considered for replications and the results are averaged.

Field plot techniques

Field Plot Technique (FPT), or Field Technique (FT), includes all the operations in the 'field' from the layout of the plots or experimental units to final recording of the data. Thus it includes: (1) The so called 'Local Control' measure is often considered one of the three essential elements of 'Design' to reduce experimental error. (2) 'Sampling' or 'Observation' methods that will reduce bias and/or error, and capture the attribute values as it should.

Selection of experimental site and plot

Little choice is seen in the selection of experimental plot. The choice is dictated largely by availability of land. Most often, the experiment is repeated in the same plots used in the previous years. New randomization and planting of uniform crop in the intervening season (for example, wheat crop in winter in rice experimental plots) are thought to be helpful.

Consideration of soil heterogeneity

Soil heterogeneity and its gradient are visually estimated. However, this is poorly understood

Shape and orientation of blocks and plots

This is related to the soil heterogeneity and a result of guesswork

Competition between adjacent plots and removal of border rows

Two border rows, at least one in case of small sized plots are known to be routinely removed. The exception are with heterogeneous crop stands with sparse populations (eg with some upland trials) where the whole plot is harvested.

Missing hills

Missing hills are counted and adjustments to yield are done.

Statistical analysis

The single factor RCB Design, and in case of two-factors, Split-plots Design took their roots with the very beginning of field experimentation in the 1960s. Statistical textbooks and, especially, the publications mentioned above amply demonstrated the computations needed. These designs and computations served virtually all the needs of the time. With widening research goals and sophisticated objectives, more elaborate methods have been sought and applied. Use of Incomplete Blocks Designs (Lattices and

Alphas) especially by breeders, and multifactor families of Split-plot Designs (Strip-plots, Split-Split-plots, Strip-split-plots, etc).

Analysis of data routinely followed ANOVA-LSD pattern in almost every situation. These are fine as long as the treatments are categories (like varieties in variety trials) and the responses are numerical (like yield). In other situations, depending upon the treatment and response other methods of analysis, viz. regressions, chi squared analyses; logit/probit, nonparametric tests, Bivariate/multivariate etc are unknown to most. The probit analyses were used by entomologists on occasions using laborious manual methods. For some other situations, data transformations are done to facilitate mean comparisons in the traditional manner.

There have been gradual shift to methods other than the ANOVA with the changing computing scenario. Regressions have become more common. Multivariate methods, mainly cluster analysis, biplots are increasingly being known. However, the changes seem to be coming from personal enthusiasms of some new generation scientists rather than from any planned policy or systematic backup from the concerned institutions.

Computing devices

Looking back, the computing tools available were manually operated mechanical calculators capable only of addition, subtraction, multiplication, and division. Square root was calculated with the use of printed table, or with pencil and paper. All the keying in of data and calculations were performed twice (if lucky) or more to ensure accuracy. The computations were done mostly for RCB Design and Split-plot Design. Lattice Designs, used in case of Initial Evaluation Trials (usually with 7 x 7 treatments, 2 replications) were also analysed as RCB Design.

The statistical software used varied with availability and depending on personal preferences. The most popular have been:

IRRISTAT : Developed by IRRI. Available initially in DOS version, and later in Windows version. Freely available. Feature rich for agriculture data analysis. But problems were reported for some operating systems

MSTATC : Developed at Michigan State University. Available only in DOS version. Fast and bug free. Brought by CIMMYT trainees from wheat program, considered free. This is still taught in IAAS and AFU, Rampur.

GENSTAT : Promoted by Rothamsted Agriculture Station, UK. This is powerful, major software. Commercial, expensive. Initially sponsored by ODA through Pakhribas and Lumle Agriculture Centres, now collecting dust due to lack of renewals.

CROPSTAT : Developed by IRRI with CIMMYT collaboration. Freely available. Powerful and feature rich, considered advanced version of IRRISTAT.

R : Very powerful and feature rich (especially through its add-in packages) and also, because of its open source and free nature, becoming a leading statistical software worldwide. It is being introduced in the NARC training programs in recent years and is being warmly received.

Besides the above list, Statistics, Minitab, Systat, SPSS were available through CIMMYT/Kathmandu in the 1990's and early 2000's,thanks to the unfaltering enthusiasm and support of Dr. Peter Hobbs. Systat and SPSS were said to have been purchased in several copies by NARC in the early 90's but apparently were not renewed or maintained. These and some others Statistica, SAS, etc are used unofficially by some researcher.

Statistical manpower

The department did not have any section or unit or any persons exclusively assigned to look after statistical matters. The scientists looked after the matter themselves with the help of some guide books or some senior or better informed individual. This is true as of today, although at present most of those handling research projects independently seem to have developed enough understanding or capability of handling the research tools. Attempts had been made to establish a biometrics 'Unit' in the NARC premises and the issue was raised several times. In the early NARC years two full time statisticians were indeed recruited and stationed at Khumaltar. They resigned and have not been replaced. A Biometrics Unit then has come into existence in NARC. However, due to inability to find appropriate personnel to fill the post, the unit is said to be practically functionless.

Suggestions for improving the capabilities

NARC handbook

Although myriads of books and tutorials/manuals on statistical topics are available, many of them freely down loadable from reputed institutions, an official 'Handbook' produced by NARC may really be handy and a more helpful companion. Such handbook should be readily understandable and applicable in solving most problems of the user.

NARC official statistics software

Various statistical software are in use, as discussed earlier. An 'official' software should have the advantages of being a common link among the scientists, being a base material for training as well as handbook/guidelines preparation, etc.

For several reasons the statistical software R may be suggested as the official statistics software for the NARC scientists.

- It is Open source and free of cost. Everyone can download a free copy and upgrade later freely
- Very powerful and feature rich, can be applied to almost any problem area
- The language of R has close resemblance to standard statistical modeling language
- Fast growing in popularity, and adopted by many universities, business organizations
- Large maintenance and support worldwide
- Large document base; freely available books and manuals using R

Training

NARC has issued some guidelines on statistical requirements in project submissions and result presentations by its scientists. Meanwhile, it has made its policy of providing introductory training to new entrants and in-service trainings to regular staff. Specific trainings are also organized by research Divisions to cater their specific needs. However, these need to be more systematized.

Origin, Taxonomy and Morpho-Physiological Description of Rice

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सारांश

प्रस्तुत लेखमा एसियन धान र अफ्रिकन धानको उत्पत्तिबारे वर्णन एवम् वैदिक कालपूर्व नेपालमा पाइने धानका विभिन्न प्रजाति साथसाथै धानका केही जंगली तथा रैथाने प्रजातिको बारेमा संक्षिप्त जानकारी दिने प्रयत्न गरिएको छ । धान नेपालमा वैदिक कालदेखिनै खेती गर्न थालिएको र हिन्दुहरूको पवित्र धर्मग्रन्थ वेदमा समेत धान सम्बन्धी उल्लेख भएको, साथै इ.पू. २८०० अगाडिका दस्तावेजहरूमा समेत नेपालमा धान खेती गरिएको चर्चा समेत भएका आदि तथ्यहरूबाट हिमालयको दक्षिणी काख नेपाल धानको उद्‌गम स्थान मध्ये एक स्थान हुन सक्ने सम्भावनालाई प्रस्ट्याउँछ । धानको वैज्ञानिक वर्गीकरण अनुसार पोयसी परिवारमा पर्ने यो बाली उम्रेदेखि परिपक्वतासम्म पुग्ने अवधिसम्ममा विभिन्न अवस्थाहरू पार गर्ने गर्दछ भने उत्पादनलाई स्पाइकलेट संख्या, १००० दाना तौल, भरिएका स्पाइकलेट आदिले असर गर्ने गर्दछ । धान सि$_३$ समूहमा पर्ने बाली भएकोले शक्ति संचय/निर्माण केल्भिन साइकलको प्रक्रियाबाट गर्ने गर्दछ ।

Summary

This paper highlights the origin of Asian rice (*Oryza sativa* L.) and African rice (*O. glaberrima* Steud) and different species of rice in Vedic period and availability of wild species and relatives of rice in Nepal. In Nepal, availability of different cultivated species and wild species of rice are mentioned even in the pre-Vedic period in various literatures. Rice cultivation in Nepal has also been mentioned in the ancient literatures of 2800 BC. It indicates that Nepal could be one of the probable places of origin of rice in southern slopes of the Himalaya as indicated in the literatures of pre-Vedic periods. Rice falls under the poaceae family as per botanical description and passes through different growth stages. Productivity of rice generally depends on spikelet number, 1000 grain weight and filled spikelet numbers. Rice being C3 plant assimilates energy through Calvin cycle/C_3 cycle.

Keywords: Botanical description, C_3, Origin, Poaceae

Origin

There are contrasting ideas as to where rice; Asian rice (*Oryza sativa* L. and African rice (*Oryza glaberrima* Steud.) actually originated. One can go for volumes of literatures about origin of rice and rice based civilization in general and particular to Asia and Africa. Two important cultivated species have already indicated that these originated from Asia and Africa. Scientists are not in full consensus about the particular point of the origin of rice in Asia but African rice originated from the inland delta of the Niger River (www.africanrice.org/publications/) is broadly agreed and thereby it spread to other parts of the continent. Controversy lies over the exact place of origin of Asian rice. However, Fuller (2011) reported that early rice cultivation followed two pathways towards domestication in India and China. Evidence of modern genetics, ecology and archaeology combined to reenact the domestication and diversification of rice was believed that the protracted domestication process finished around 6,500–6,000 years ago in China and about two millennia later in India. These expansions can be linked to language family dispersal models along with the migration of rice farming population mixing with preexisting population of the Sino-Tibetan and Austronesian languages group in South Asia and Indo-Aryan and Dravidian speakers adopted rice from speakers of lost languages of northern India (Fuller 2011). Lost languages of northern India were for more than 2,000 years, several volumes of classical South Asian texts remained locked away in languages that have either died, have a dwindling number of speakers or no one bothered to translate these stories for a global audience (http://www.pbs.org/newshour/rundown/murty-library-aims-revive-2-millennias-worth-indic-literature).

It is believed that *O. sativa* L. has been originated in the southern slope of the Himalaya and Nepal is one of the probable locations of its origin. Availability of many wild species and relatives of rice are prevailed in Nepal and a wide adaptation from 60 to 3050 masl, Chhunchour of Jumla, the highest point in the world where rice is cultivated in Nepal (Paudel 2011) as well. Mallick (1981) mentioned that rice cultivation in Nepal started since before the Vedic period and description of rice in the *Veda* has been written 1500 BC. This has been cited in many literatures written in Nepal. According to *Rig Veda*, rice has been divided into five subdivisions; *Sali Dhanya, Brihi Dhanya, Simi Dhanya*, and *Chudra Dhanya,* nevertheless, rice cultivation in Nepal has been mentioned in the ancient literatures of 2800 BC and this justifies that why rice is so associated with Nepalese culture encompassing southern slope of the Himalaya. From these regions rice was taken to Europe, USA and other parts of the word by Alexander the Great (Mallick 1981). There is availability of many locally adopted indigenous rice genotypes of *O. sativa* var. *indica* and O. *sativa* var. *japonica* in Nepal coupled with some wild relatives of rice too. These findings also support the theory that Nepal could be one of the origin sites of *O. sativa* L. because of availability of many wild rice species from swampy low land to sloppy high hills of the country.

General description of rice

Rice is an annual grass that belongs to the genus *Oryza*. Of the recorded species of rice, only two species have been known for their commercial value being used for cultivation. These two species are *Oryza sativa* L. (Asian rice) and *Oryza glaberrima* Steud, (African rice). Presently, *Oryza sativa* is the most commonly grown species throughout the world whereas the *Oryza glaberrima* is grown only in South Africa. Among these *Oryza sativa* is by far the more widely utilized and is a complex group composed of two forms endemic to Africa but not cultivated. A third form, *Oryza rufipogon,* having distinctive partitions spread into South Asian countries, China, New Guinean, Australian, and America. In Asia, *Oryza sativa* is differentiated into three sub-species based on geographical locations such as *indica*, *japonica* and *javanica*. The variety *indica* refers to the tropical and sub-tropical varieties grown throughout South and South-East Asia and Southern China. The variety *japonica* is grown in temperate areas of Japan, China, Korea and Nepal while *javanica* varieties are grown alongside of *indica*s in Indonesia in general and particular to Java region.

Taxonomical classification of rice

Kingdom: Plantae – Plants
Subkingdom: Tracheobionta – Vascular plants
Super division: Spermatophyta – Seed plants
Division: Magnoliophyta – Flowering plants
Class: Liliopsida – Monocotyledons
Subclass: Commelinidae
Order: Cyperales
Family: Poaceae – Grass family
Genus: *Oryza* L. – rice
Chromosome number: x= 12, 2n= 24

Nepal is blessed with rich diversity in cereals, grain legumes, vegetables, fruits and other crops (Paudel et al 2016, Bhatta et al 2014). There are records of at least four species of wild rice in the country and these include *Oryza nivara, O. rufipogon, O. granulata* and *O. officinalis* and two wild relatives of rice *Hygroryza aristata* and *Lersia hexandra* and several types of weedy rice such as *O. sativa* f. *spontanea* exist in Nepal (Bhatta et al 2014). Probability of getting still more species of rice and other food crops are still there in Nepal (Paudel et al 2016, Joshi 2005). Many indigenous rice landraces like *Anadi, Tauli* and *Thapachiniya* are vanishing from general cultivation. Overall diversity of major crops is in decreasing trend and genetic erosion of crops including rice is apparently visible (Joshi et al 2008, Bhatta et al 2014).

Morpho-physiological description

Rice, being under the *Poaceae* family, is a self-pollinated crop. It is semi-aquatic plant and consists of *arenchymatic* tissues. The presence of *arenchymatic* cells on leaf, culm and roots can diffuse oxygen from aerial parts downward to roots. As a result this plant can carry out normal physiological activities under submerged/water logged condition as well. Therefore, rice is called a unique plant which can thrive well in water logged, submerged, upland and aerobic conditions. The plants are about 1m tall but certain deep water varieties can elongate up to 5 meter with the rise in water level. There are some local land races in Nepal which are about 2 meter tall *japonica* type (*Anandi, Jumli Marshi*) and *indica* type (*Kalo Masino, Jhunuwa, kagkire*). Straw/culm of these local land races are used for making local straw mats and other local products used in traditional villages in Nepal (Paudel et al 2016).

Root system

The root system is fibrous. Soon after sowing, rice seed gives out seminal roots out of the radical. These are temporary in nature. The real functional roots are secondary adventitious roots that are produced from the lower nodes of the culm.

Shoot system

The rice stem known as culm is hollow and is made up of nodes and internodes. Each node bears a leaf and bud, which may grow into a shoot or tiller. Primary tillers grow out of the main culm. Tillering continues in rice up to vegetative phase. Some tillers die during the reproductive phase due to competition for light, water and nutrients. Panicles bearing tillers are known as fertile or productive tillers.

Leaf

Each node of the culm bears a leaf. Each leaf consists of the following parts.

Leaf sheath: It originates from the node of culm and many a times encloses it and sometimes it encloses even the next upper node and a part of the leaf sheath of the upper leaf.

Leaf blade: It is the upper expanded part of the leaf and begins at the node, where it is joined with leaf sheath. At the joint there is a thick collar.

Auricles: These are hairy appendages at the base of the leaf blade.

Ligules: It is a thin papery structure just above the auricles. Different parts of leaf are of importance in identifying the varieties.

Flag leaf: It is the uppermost leaf just below the panicle. It is generally shorter in length and remains erect at an angle. Flag leaf contributes most assimilates in the grain.

Panicle: The inflorescence of rice plant is born on terminal shoot and is known as panicle. It is determinate type and at maturity it is droopy in nature. Panicle bears the spikelets.

Spikelet: A spikelet is the floral unit and consists of two sterile lemmas, a lemma, a palea and the flower.

Lemma: It is a five nerved hardened bract with a filiform extension known as awn. Rice varieties may or may not have an awn.

Palea: It is a three nerved bract slightly narrower than lemma.

Flower: It consists of 6 stamens with two-celled anthers and a pistle with one ovary and two stigmas. The pistil consists of one ovule.

Grain

Rice grain is the ripened ovary with lemma and palea firmly adhered to it. The lemma and palea with other smaller components from the hull are removed in shelling rice for consumption. The rice fruit is a caryopsis in which single seed is fused with the wall of the ovary (pericarp). The seed consists of endosperm and an embryo. The embryo is very small and is found on the ventral side of the caryopsis. It contains plumule (embryonic leaves) and radicle (root).On submergence in water or on sowing the radicle grows as root and plumule grows as shoot.

Photoperiodism

Plants set seed at appropriate seasons. One major mechanism responsible for this adaptation involves photoperiodic flowering. Most plants are classified as either long-day plants or short day plants, which flower under a longer photoperiod, or under a shorter photoperiod (Izawa 2007). It has been understood that photoperiodic flowering in rice revealed unique, evolutionarily conserved pathways involved in photoperiodic flowering at the molecular level. Furthermore, the conserved pathways promote flowering under short-day conditions and suppress flowering under long-day conditions in rice (Izwa 2007). Rice, a short-day plant is sensitive to photoperiod-long-day treatments can prevent or considerably delay its flowering. Rice cultivars exhibit a wide range of variation in their degree of sensitivity to photoperiod (Enomoto 1935, Liang et al 1983, Morinaga and Kuriyama 1954, Yoshi 1926). Rice has also been classified into photoperiod-sensitive and photoperiod-insensitive types, the latter showing a low response or a slight delay in flowering with an increase in photoperiod. These days the tendency of rice scientists is to select photoperiod-insensitive cultivars so that most of the cultivated rice may eventually become photoperiod-insensitive. Present day rice being short stature, improved, and early maturing cultivars could fit into the multiple cropping systems of progressive agriculture (Vergara and Tang 1985) under varying environments. On the basis of selection and development of photoperiod-insensitive cultivars, rice productivity could be enhanced so that these can complete their life cycle based on short duration growth period of 90-120 days.

Growth phases of rice

Broadly speaking there are four major growth phases/stages of rice. Within these major growth phases other sub growth phases/stages are mentioned by physiologists working on rice. These stages are: germination, vegetative, reproductive and ripening. However, some consider germination and vegetative stages as one stage of vegetative stage (Yoshida 1981). From seeding to harvesting (seed to seed), rice passes through different growth stages. The growth stages of three species of *O. sativa* var; *indica, japonica* and *javanica* differ markedly due to their difference in growing environments. It differs from photo sensitiveness and non-photo sensitiveness variety as well. Photo sensitive varieties are mostly local land races and these complete their life cycle only after fulfilling their particular day length requirement irrespective of crop duration. While photo non-sensitive modern rice varieties mature according to their crop duration which differs among these three varieties of var. *indica, japonica* and *javanica*. Brief description of these important growth phases of rice has been described herewith.

Germination phase

It is the first phase of growth when rice seed imbibes water in a proper media once it is exposed to adequate temperature. In germination, first shoot and roots start to emerge from the seed and the rice plant begins to grow. To germinate, rice seeds need to imbibe certain amount of water and need to expose to the favorable temperature range of 10–40 °C by breaking dormancy stage of the seed. Under flooded soil condition, the shoot is the first to emerge from the seed thereby develops roots when the first shoot has reached the air while under upland soil condition the root is the first to emerge from the seed and shoot follows to emerge thereafter.

Vegetative phase

The vegetative phase is characterized by the development of tillers and more leaves, and a gradual increase in plant height. The number of days the vegetative stage takes varies depending on the variety of rice, but is typically between 55 and 85 days after sowing. The early vegetative phase begins as soon as the seed germinates into a seedling and completes this phase at tillering stage which differs from variety to variety mostly during 30-50 days after germination. The seedling stage starts right after the first root and shoot emerge, and lasts until just before the first tiller appears. During this stage, seminal roots and up to five leaves develop. As the seedling continues to grow, two more leaves develop. Leaves continue to develop at the rate of one every 3–4 days during the early stage. The late vegetative phase starts when tillering begins, which extends from the appearance of the first tiller until the maximum number of tillers is reached. This typically happens 40-50 days after sowing. The stem/culm begins to increase height late in the tillering stage and stops growing in height just before panicles initiate about 50-60 days after sowing. This is called the end of vegetative phase and initiation of reproductive phase of the rice.

Reproductive phase

Booting stage is followed by a bulging of the leaf in the stem that conceals the developing panicle which signals the reproductive stage of rice. The tip of the developing panicle emerges from the stem and continues to grow. Panicle when fully visible is called heading stage, the perfect visible reproductive phase. Flowering/anthesis begins when the panicle is fully visible. Flowering begins a day after heading has completed. As the flowers open they shed their pollen on each other so that pollination can occur. Flowering can continue up to 7 days of the first initiation of flowering.

Ripening phase

The ripening phase starts at flowering and ends when the grains mature and is ready to harvest. This stage usually takes 30 days after flowering. Rainy days or low temperatures may lengthen the ripening phase, while sunny and warm days may hasten ripening phase. Germination, vegetative and reproductive phases of growth make up the ripening phase of rice. Ripening follows fertilization and can be subdivided into milky, dough, yellow, ripe, and maturity stages. These terms are primarily based on the texture and color of the growing grains. The length of ripening varies among varieties from about 15 to 40 days. Ripening is also affected by temperature, with a range from about 30 days in the tropics to 65 days in cool temperate regions. A typical growth stage of photo non-sensitive rice variety grown in the tropics has been shown in the **Figure 1**.

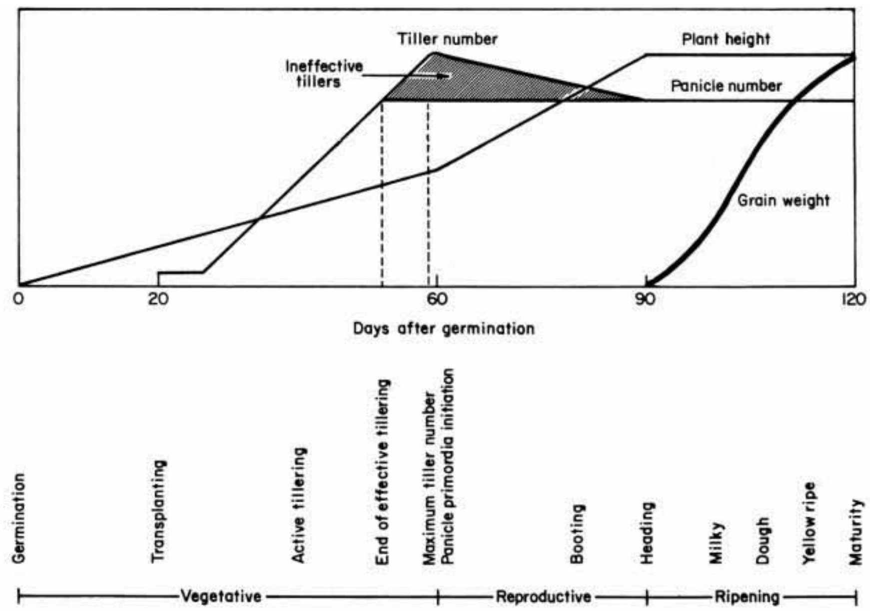

Figure 1. Growth stages of a 120-day rice variety grown in the tropics under the transplanting cultivation

Source: Yoshida 1981.

Yield components of rice

Grain yield of rice is a function of the number of spikelet per unit area, 1000 grain weight and percentage of filled spikelets. Relationship of grain yield and yield components of rice could be explained in the following equation (Yoshida 1981).

$Y = N \times W \times F \times 10^{-5}$

Where Y = grain yield (t/ha),

N = spikelet number/m 2 ,

W = 1,000-grain weight (g), and

F = filled spikelets (%).

Each of the yield components not only differ its contribution to grain yield but in time when it is determined. Yoshida and Parao (1976) for computing total contribution of yield components for rice yield was 81%. Of this contribution, 60% alone was by the number of spikelet per square meter and filled spikelet percentages and grain weight together accounted for 21% total variation in yield (**Table 1**). This explicitly explains that the number of spikelet per square meter is the most important yield component limiting yield.

Table 1. Contribution of each yield component to grain yield

Variable [a]	Contribution to total variation in yield (%)
N	60.2
F and W	21.2
N and F	75.7
N and W	78.5
N and F and W	81.4

[a] N = spikelet number per square meter, F = filled-spikelet percentage, and W = 1,000-grain wt.

Source: Yoshida and Parao 1976.

Calvin cycle and C_3 plant

Rice is a C_3 plant which uses Calvin cycle for photosynthesis, the major pathway of energy assimilation from light. Those plants that utilize just the Calvin cycle for carbon fixation are known as C_3 plants. Carbon dioxide diffuses into the stroma of chloroplasts and combines with a five-carbon sugar, ribulose1,5-biphosphate (RuBP). The enzyme that catalyzes this reaction is referred to as RuBisCo, a large molecule that may be the most abundant organic molecule on the Earth. This catalyzed reaction produces a 6-carbon intermediate which decays almost immediately to form two molecules of the 3-carbon compound 3-phosphoglyceric acid (3PGA), 3-carbon molecule is the first stable product of photosynthesis calling this cycle the C_3 cycle. About 85% of plant species are C_3 plants. C_3 plants have the disadvantage that in hot dry conditions their photosynthetic efficiency suffers because of a process called photo-respiration which refers to the metabolism of oxygen and the release of carbon dioxide. In cellular respiration it is a positive term, a process vital to life. But photorespiration is an entirely negative term because it represents a severe loss to the process of using light energy in photosynthetic organisms to fix carbon for subsequent carbohydrate synthesis. Photorespiration happens in C_3 plants when the CO_2 concentration drops to about 50 ppm. The key enzyme that accomplishes the fixing of carbon is rubisco, and at low concentrations of CO_2 it begins to fix oxygen instead. This is highly wasteful of the energy that has been collected from the light, and causes the rubisco to operate at perhaps a quarter of its maximal rate (http://hyperphysics.phy-astr.gsu.edu/hbase/biology/calvin.html#c1)

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Distribution Patterns of Rice Landraces in Different Agro-ecological Zones of Nepal

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सारांश

धान बालीको उत्पत्ति स्थलहरू मध्ये नेपाल पनि एक हो । नेपालको भौगोलिक विविधता अनुसार यहाँ तराईको समथर जमिन करिब ६० मिटर उचाईदेखि संसारकै उच्च स्थान जुम्लाको छुमचौर (३०५० मिटर) सम्म धान खेती गरिन्छ । त्यसैले यहाँ पाइने धानका रैथाने जातहरूमा समेत धेरै विविधता पाइन्छ । हाम्रा अग्रजहरूले आ-आफ्ना क्षेत्रमा पाइने विविधतायुक्त जातहरूलाई प्राथमिकताको आधारमा लगाउदै आएको पाइन्छ । तर बढ्दो जनसंख्या, विकास निर्माणका गतिविधिहरू, औधागिकीकरण तथा जलवायुमा देखिएका परिवर्तन आदिले गर्दा थोरै जग्गाबाट धेरै फल्ने, छिटो पाक्ने, नढल्ने, रोग किरा सहन सक्ने जस्ता जातहरूका साथै वर्णशंकर जातहरूको प्रयोगमा आएका बढोत्तरीले गर्दा रैथाने धानका जातहरू क्रमशः लोप हुँदै जाने अवस्थको सृजना भइरहेको छ । त्यसैले विभिन्न दातृ राष्ट्रहरू तथा धान बालीसँग सम्बन्धित संघ-संस्थाहरूको सक्रिय सहभागितामा समय-समयमा नेपालका विभिन्न क्षेत्रहरूबाट यस्ता रैथाने जातहरूको संकलन, प्रशोधन, पुनरोत्पादन गरी सोको अभिलेख सहित राष्ट्रिय कृषि आनुवंशिक स्रोत केन्द्र (जिन बैंक) मा संकलित बीउको मात्रा र अवस्था अनुसार लामो (५० वा १०० वर्ष) तथा छोटो (५ वर्ष) अवधिसम्म संरक्षित भण्डारण हुँदै आएको छ । हाल चलन चल्तीमा रहेका उन्नत जातहरूमा यस्ता रैथाने जातहरूको कुनै न कुनै रूपमा प्रयोग हुँदै आएको छ । प्रतिकूल मौसमको अनुकूलका धानका जातहरू विकास गर्न भविष्यमा यी रैथाने जातहरूको उपयोगिता अझ बढी रहन्छ । त्यसैले यस्ता जातहरूको संकलन, संरक्षण सम्वर्द्धन जस्ता कृषि कार्यमा संलग्न हरेक व्यक्ति, संस्था, निकायको आ-आफ्नो क्षेत्रबाट सक्दो प्रयास हुन आवश्यक छ ।

Summary

Nepal is considered as one of the centers of origin of rice. Nepal has a wide diversity of rice landraces as it is grown in all rice-growing areas from 60 masl in the Tarai to 3050 masl in Chhumchaur, Jumla, and the highest place of growing rice in the world. These landraces have evolved in response to wide variations in local conditions, combined with the careful seed selection and management practices of farmers as per their need, priorities and importance. Modern developmental activities and increased human population pressure along with changing climatic context necessitate the introduction and/or development of modern rice cultivars which ultimately contribute to the loss of rice landraces. Therefore, exploration, collection, characterization and conservation were started with the help of many national and international rice related organizations from different parts of the country at different time periods. The collected germplasm of rice have been preserved in National Agriculture Genetic Resource Centre (Genebank) after its establishment for short term to long term as per the quantity and status of the seed. All modern varieties can be traced back to landraces. Rice landraces combine well with modern high yielding varieties and can produce better adapted elite materials with enhanced yield potential, which can meet the demand of growing population. Therefore, joint effort by researcher, conservationist and N/GO's is vital for collection and conservation of these valuable rice genetic resources for future use.

Keywords: Diversity, Germplasm, Researcher, Rice, Varieties

Introduction

Nepal is considered as one of the origin of centers of rice. Nepal has a wide diversity of rice landraces in all rice-growing areas from low to high altitude. In Nepal, farmers have maintained around 2000 rice landraces including their wild and weedy relatives (Shrestha and Vaughan 1989). These landraces have evolved in response to wide variations in local conditions, combined with careful seed selection and management practices followed by farmers. Rice landraces and their related wild species contain several desirable traits to be used in breeding program. Landraces are well known for their adaptive genes, resistance to pests and diseases and quality traits (Joshi 2005). Further, landraces combine well with modern high yielding varieties and produce elite materials with enhanced yield potential.

These valuable genetic resources of rice are being replaced by improved varieties and human activities. Conservation of these genetic resources is essential to plant breeders for current and future crop improvement and to farmers to meet their immediate livelihood needs. In addition, Nepalese rice germplasm possesses a great diversity both in qualitative and quantitative traits. It is necessary to identify and document those traits through collection, conservation, characterization and utilization. The main source of diversity for development of modern varieties is the traditional varieties that have been grown and selected for generations by rice farmers. All modern varieties can be traced back to landraces.

Exploration, collection and characterization of landraces

Many national and international biologists, naturalists, adventurers, travelers and plant hunters explored and collected germplasm from different parts of Nepal at different time periods. The introduction, collection, evaluation and utilization of plant genetic resources including rice started in 1940. Characterization is mainly concentrated on morphogenetic and agronomic characters and classified as per the variation in different traits. However, due emphasis was given to exploration, collection, characterization and conservation activities after establishment of Plant Genetic Resources (PGR) section in 1984 in Agriculture Botany division (ABD). The PGR section of ABD has collected 2987 accessions of rice landraces from 72 districts of the country. The highest number of rice accessions was collected from Kaski (4.65% of total accessions) followed by Sunsari (3.85%), Jhapa (3.35%), Parsa (2.85%), Bara (2.81%) and Siraha (2.48%). Thus, these districts may be the focal area for rice landraces diversity. Collection sites of 197 accessions were unknown. The collected germplasm of rice was preserved in a genetic seed house and later handed over to National Agriculture Genetic Resources Centre (Genebank) in 2010. National Agriculture Genetic Resources Center currently holds 2284 rice accessions and the rest are still in the process of regeneration and characterization.

Local landraces distribution pattern

The rice land in Nepal has the largest variations in altitude in the world. Rice is grown in four distinct major agro-ecological zones, which are Tarai and inner Tarai (60-300 masl), foot hills and river basin (300-900 masl), midhills (900-1500 masl) and high hills (>1500 masl). Rice production systems in Nepal are winter rice, spring rice, normal rice, deep water rice, up-land rice, warm temperate rice and cool temperate rice. Rice landraces have been adapted from the low tropical areas of Tarai to the cool temperate areas of Nepal.

Fine and aromatic landraces and their distribution pattern

Landraces are of different types and valued differently under different situations because of their better adaptation and other economic and cultural values. Conservation of landraces which do not have value to farmers is rather worthless (Gauchan 2004). Several landraces in Nepal have been conserved because they possess socially preferred traits. Aromatic rice landraces, such as Lalka Basmati, *Kariyakamod, Kanakjira* in Bara, *Kalonuniya* in Jhapa, *Jethobudho, Jhinuwa* and *Pahenle* in Kaski, *Gudgudo* in Gulmi and *Gude* (*Kalo* and *Seto*) in Dailekh are conserved in cultivation because of their higher cultural and social values. Several fine and aromatic rice landraces are distributed from 60 to 1400 m altitude (**Table 1**).

Table 1. Distribution of aromatic rice landraces in Nepal

SN	Rice cultivar	Districts	Altitude, m
1	*Achhame masino*	Chitwan, Jhapa, Makawanpur, Morang	200-800
2	*Andi/A. dhan*	Arghakhanchi, Kailali, Rupandehi, Siraha,	60-300
3	*Bagadi auns*	Dhanusha, Siraha	60-300
4	*Bagari*	Chitawan, Siraha	60-300
5	*Baharni*	Bara, Parsa, Saptari, Siraha,	<500

SN	Rice cultivar	Districts	Altitude, m
6	*Basmati*	Bara, Bajura, Dadeldhura, Darchula, Dhanusha, Doti, Humla, Jhapa, Kapilvastu, Kanchanpur, Kathmandu, Lalitpur, Mahottari, Morang, Parsa, Pyuthan, Ramechhap Rautahat, Rupandehi, Sarlahi, Siraha, Sindhupalchok, Taplejung, Udayapur,	200-1000
7	*Basmati anadi*	Bara	<300
8	*Basmati anpjhutte*	Dolakha	<800
9	*Belguthi*	Jhapa, Morang, Sunsari, Sankhuwasabha, Panchthar, Ilam, Jhapa, Terhathum.	<800
10	*Biramphool*	Dhading, Jhapa, Kathmandu, Kaski, Lamjung, Morang, Parbat, Siraha, Sunsari, Udayapur	400-800
11	*Chengul*	Bara, Parsa, Sunsari	<500
12	*Chhoti basmati*	Jhapa, Morang, Sunsari	<300
13	*Chirankhe*	Bhojpur, Dhankuta, Illam, Okhaldhunga, Panchthar, Terhathum,	<1800
14	*Chulthe*	Jhapa, Sunsari	60-300
15	*Danda basmati*	Dadeldhura	1530
16	*Ekle*	Gorkha, Kaski, Lamjung, Parbat	700-1300
17	*Gauria*	Arghakhanchi, Baglung, Kapilvastu, Lamjung, Myagdi, Nawalparasi, Ramechhap, Rupandehi, Sankhuwasabha, Sunsari, Terhathum	300-1400
18	*Ghyukumar/i*	Bara, Parsa, Sarlahi, Sindhuli	<500
19	*Gola basmati*	Sunsari	<500
20	*Gude (seto, kalo)*	Dailekh	<1100
21	*Gudgudo*	Gulmi	<1100
22	*Hansraj/H. dhan*	Bajhang, Baitadi, Darchula, Dadeldhura, Jhapa, Kanchanpur, Morang, Palpa, Pyuthan, Salyan, Sunsari, Surkhet, Syangja	60-1100
23	*Hapsa*	Jhapa	<300
24	*Hapsa rato*	Jhapa	60-300
25	*Indrabeli*	Dhading, Dhankuta, Gorkha, Lamjung	800-1400
26	*Jaran dhan (kalo)*	Arghakhanchi, Bajhang, Dang, Gulmi, Jajarkot, Kaski, Parbat, Rukum, Salyan and Surkhet.	800-1400
27	*Jaswa*	Dhanusha, Mahottari, Morang, Rautahat, Saptari, Siraha, Sunsari	60-300
28	*Jethobudho*	Kaski, Myagdi, Parbat, Sunsari, Syagnja, Tanahun	600-1250
29	*Jhinuwa*	Baglung, Doti, Gorkha, Kailali, Kanchanpur, Kaski, Kathmandu, Lamjung, Myagdi, Nuwakot, Parbat, Shankhuwasaba, Sindhupalchok, Sunsari, Syangja, Tanahun,	300-1300
30	*Jirasari*	Jhapa, Morang, Panchthar, Ramechhap, Sunsari,	<600
31	*Jogini*	Chitwan, Ramechhap	500
32	*Jorayal basmati*	Doti	<800
33	*Jorpal basmati*	Jhapa, Morang, Sunsari	<1200
34	*Kalo basmati*	Dhankuta, Jhapa, Kathmandu, Morang, Sunsari,	<1200
35	*Kalo nuniya*	Jhapa, Morang, Sunsari	60-300
36	*Kalo nuniya thulo*	Jhapa, Morang, Sunsari	60-300
37	*Kalo/Kala nimak*	Bardiya, Chitwan, Nawalparasi, Rupandehi,	100-400
38	*Kalotunde basmati*	Jhapa, Morang, Sunsari	<300
39	*Kanak jira*	Bara, Bardiya, Chitawan, Jhapa, Kailali, Kanchanpur, Kapilbastu, Morang, Salyan, Sunsari, Syanja.	<600
40	*Kanakjir basmati*	Jhapa, Morang, Sunsari	<300
41	*Kariya kamod*	Dhanusa, Morang, Saptari, Siraha	200-400

SN	Rice cultivar	Districts	Altitude, m
42	*Kasturi*	Bara, Kailali, Parsa.	<500
43	*Krishnabhog*	Achham, Dhankuta, Kanchanpur, Ramechhap.	<1400
44	*Krishnacharcha*	Bajura	<1400
45	*Lalbachchhi*	Jhapa, Morang, Sunsari	60-300
46	Lalka Basmati	Bara, Dhanusha, Parsa, Rautahat,	60-300
47	*Lanjhi*	Bara, Parsa	<500
48	*Mahabhog*	Kailali, Dhading, Rasuwa, Bara, Parsa	200-600
49	*Mahajogini*	Bara, Parsa	<300
50	*Masino basmati*	Dhading, Khotang	<900
51	*Motisar*	Bara, Parsa	<300
52	*Pahade basmati*	Ilam	<1000
53	*Pahenle*	Bajhang, Bardiya, Gorkha, Ilam, Kaski, Lamjung, Myagdi, Palpa, Parbat, Sinduplanchok, Syanja	600-800
54	*Pran Peuli*	Sallyan, Surkhet	1200-1400
55	*Rajbhog*	Dhading, Kailali, Kanchanpur	<600
56	*Ram Tulsi*	Panchthar, Terhathum	800-1100
57	*Ramjawain*	Bara, Parsa	<600
58	*Rato basmati*	Jhapa, Morang, Sunsari	60-300
59	*Rato basmati sano*	Bara, Jhapa, Mahottari, Morang, Parsa, Siraha, Sunsari	<300
60	*Ratotunde basmati*	Jhapa, Morang, Sunsari	<300
61	*Sali dhan*	Baitadi, Dadeldhura, Gorkha	<1200
62	*Samundrabakhi phim*	Dhading, Nuwakot	<600
63	*Samundraphinj*	Dhading, Kaski, Makawanpur, Nuwakot	200-600
64	*Seto basmati*	Bara, Jhapa, Morang, Parsa, Sunsari	60-300
65	*Shyamjira*	Banke, Doti, Jhapa, Kailali, Kanchanpur, Morang, Sunsari,	60-300
66	*Thapachini*	Achham, Bajhang, Bajura, Dadeldhura, Kailali, Lamjung, Terhathum	200- 1400
67	*Tulsiprasad*	Nawalparasi, Parsa, Dhanusa	200-1400
68	*Tulsiful/Tulsiphool*	Dhanusha, Jhapa, Mahottari, Morang, Saptari, Sindhuli, Siraha, Sunsari, Udayapur,	60-300
69	*Ujarka basmati*	Bara, Parsa, Rautahat	60-300

Source: Upadhyay and Joshi 2003, Joshi et al 2013, Joshi 2004, Joshi 2005, Joshi et al 2014a.

Specific peculiarities of rice landraces

A broad spectrum of resistance to various diseases and insects has been observed in collected rice samples (**Table 2**). *Sathi* and *Gamadhiare* conserved for worshipping the goddess during Chhath festival. Similarly, *Anadi*, a local rice variety, is especially demanded for preparation of snacks, such as *Latte* (sweetened rice) and *Khatte* (puffed rice) for household and community food traditions and household local medicinal purposes in Kaski (Rijal et al 1998). The challenge is to use these valuable traits in crop improvement programme to increase yield potential and disease/insect resistance.

Table 2. Some of the unique rice genetic resources in Nepal

SN	Genotype	Uniqueness
1	*Amaghauj*	Multiple spikelet per node
2	*Anati or Anadi*	Festival rice/sticky rice/medicinal value
3	*Amaghauj, Budiya dain, Bhati, Jalmardan, Silhat, Lajhi, Karma.*	Deep water rice, water logged and swampy land

SN	Genotype	Uniqueness
4	*Chhommrong dhan, Jumli Marshi, Darmali*	Cold tolerance rice
5	*Ekle rice*	Zn deficiency tolerance
6	*Gamadhi/Sathi*	Enclosed panicle within flag leaf sheath
7	*Ghaiya*	Upland rice
8	*Kalanamak, Lalka basmati, Kariyakamod*	Photo period sensitive
9	*Laila Majnu or Jodi dhan*	Two grain in a lemma and palea.
10	*Anga, Gurdi, Mansara, Mutmur, Nakhisaro, Thapachiniya*	Rainfed upland condition, poor/low fertility
11	*Naltumme*	Shade tolerant rice
12	*Nakhisaro, Sathi, Laltengar*	Pest resistant
13	*Patle/P. dhan*	Good for pregnant and delivery women
14	*Rango/R. dhan*	Lodging resistant (strong stem)
15	*Samundaphinj*	Swampy land rice
16	*Sikichan, Tilki, Jirasari*	Small grain soft rice
17	*Sokan dhan, Bageri*	Resistant to BB and GLH
18	*Sotwa, Gajargaul*	Medicinal value (fever)
19	Wild rice	Festival rice/perenniality gene

Source: Upadhyay and Joshi 2003, Joshi 2004, 2005, Joshi et al 2005, Joshi et al 2014b, Joshi 2015.

Utilization of rice landraces in breeding program

Utilization of local landraces should be the first priority to conserve them in addition to increasing yield. Rice landraces combine well with modern high yielding varieties and produce better adapted elite materials with enhanced yield potential, which can meet the demand of the growing population. Some of the landraces are comparable to the improved cultivars. A total of seventy six rice varieties with full package of cultivation practices have been released in Nepal. Among them 10 varieties were developed through the use of landraces (**Table 3**) and three were released for general cultivation from pure line selection (**Table 4**). Several elite lines have been developed and some of them will be released in near future for general cultivation. The trend of using local landraces in research is increasing. This would certainly help to identify and develop better genotypes with respect to yield and yield attributing traits. However, large numbers of rice landraces are still left untouched.

Table 3. List of rice varieties developed using landraces in Nepal

SN	Varieties/Lines	Parents	Grain type	Recommended domain
1	Khumal-2	Jameli/Ku-16-361-BLK-2-8	Fine	Warm temperate
2	Khumal-4	IR 28/*Pokhreli Masino*	Fine	Warm temperate
3	Palung-2	BG 94-2/*Pokhreli Masino*	Fine	Cool temperate
4	Khumal-5	*Pokhreli Masino*/Ku-IB-361-BLR-2-6)	Medium	Warm temperate
5	Machhapuchhre-3	Chhomrong/Fuji 102	Coarse	Cool temperate
6	Manjushree-2	Fuji 102/NR10157 (Jumli Marshi/IR 9129-159-3//kn-lb-361-1-8-6-3)	Fine	Kathmandu valley
7	Khumal-8	Jumli Marshi/IR-36	Fine	Warm temperate
8	Khumal-10	IR 36/Khumal-5 (*Pokhreli Masino*/Ku-IB-361-BLR-2-6)	Fine	Warm temperate
9	Lekali Dhan-1	Banjaiman/Chhomrong	Coarse	Cool temperate
10	Lekali Dhan-3	Yunlen 5/Chhomrong	Coarse	Cool temperate

Table 4. List of rice varieties selected from landraces as pure line varieties in Nepal.

SN	Varieties/Lines	Parents	Grain type	Recommended domain
1	Chhomrong	Selection of Chhomrong from Ghandruk area of Kaski	Coarse	Cool temperate
2	Pokhareli Jethobudho	Selection of Jethobhudho from Pokhara valley	Fine and aromatic	Pokhara valley and its surroundings
3	Lalka basmati	Selection from eastern Tarai Lalka Basmati	Fine and aromatic	Irrigated eastern and central Tarai.

Conclusion

Modern developmental activities and increased human population pressure necessitate the introduction and/or development of modern rice cultivars which ultimately contribute to the loss of rice landraces. Many rice landraces like Achhame Masino, Anadi, Tauli, Thapachini and Thapachiniya are vanishing from general cultivation and many of them are under threat. Rice landraces are rich in phenological and agro-morphological diversity. It is necessary to estimate the extent and magnitude of rice diversity and the important and useful traits should be used in rice breeding program. Therefore, joint effort by researcher, extensionist, conservationist and NGO's is vital for collection and conservation of these valuable rice genetic resources for future use.

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Local Germplasm of Rice in Nepal: Diversity, Characters and Uses

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सारांश

नेपालमा करिब २५०० स्थानीय धानको जातहरू पाईन्छ र ७५ जिल्लामध्ये ७३ वटा जिल्लामा धानको खेती गरिन्छ । कास्की, लम्जुङ्, तनहुँ, बारा र सुनसरी जिल्लाहरूमा बढी स्थानीय जातहरू पाइन्छ । विभिन्न राष्ट्रिय तथा अन्तराष्ट्रिय जिन बैंकमा करिब नेपालको ८३८९ धानको संकलन गरी संरक्षण गरिएको छ । छ वटा स्थानीय जातहरू बाली प्रजनन कार्यमा प्रयोग भएको पाईन्छ । स्थानीय जातहरू लाई १४ आधारहरू बनाएर विभिन्न समूहमा राख्न सकिन्छ । खेती गरिने जग्गाको आधारमा आकाशे भरको उच्च जग्गा, आकाशे भरको गहिरो जग्गा, सिंचित क्षेत्र र ढाव तथा डुबान क्षेत्रमा विभाजन गर्न सकिन्छ । त्यसै गरी खेती गरिने समय अनुसार धानलाई हिउँदे, चैते, भदैया अथवा घैया र वर्षेमा विभाजन गर्न सकिन्छ । केही स्थानीय जातहरू विशेष ठाउँ सुहाउँदा छन् भने केही रोग, किरा, सुख्खा तथा डुबान सहने खालका छन् । केही स्थानीय जातहरूको गुण निश्चित ठाउसँग मात्र सम्बन्धित भएको पाईन्छ । अनदी, साठी, भाटी, साली, अमगौज आदि विशेष प्रकारका केही जातहरू हुन् । स्थानीय जातको खेती करिब १०% क्षेत्रमा मात्र गरिन्छ र विकासे जातहरूको खेतीसँगै थुप्रै स्थानीय जातहरू लोप भएका छन् । धानको स्थानीय जातहरू संरक्षण गर्न सबैको संयुक्त प्रयास हुनु पर्दछ ।

Summary

About 2500 rice landraces are reported from Nepal, distributed in 73 out of 75 districts of the country. Centers of diversity are Kaski, Lamjung, Tanahu, Bara, Sunsari. A total of 8389 rice accessions from Nepal are conserved in different national and international Genebanks. Six landraces were used in breeding as parents. Landraces can be grouped under different categories on the basis of 14 different criteria. Major categories are rainfed upland, rainfed low land, irrigated and deep water rice on the basis of rice growing environments and *Chaite* (Spring rice), *Badhaiya* (*Ghaiya* rice), *Barkhe* (Normal/Main Season rice) and *Hiunde* (Boro/Winter rice) rice on the basis of planting season. Some landraces have adoptive and tolerant to specific biotic and abiotic traits and some can be considered as geographical indicators. Some of unique landraces are *Anadi, Sathi, Bhati, Sali, Amaguaj,* etc. Landraces occupied about 10% of total rice areas. Due to expansion of improved varieties, many landraces have been replaced and they are not available locally. Collaborative conservation initiatives have contributed significantly to conserve many landraces in the country.

Keywords: Conservation, Diversity, Rice landraces, Unique landraces, Utilization

Introduction

Nepal is one of the centers known for the diversity for rice. There are 2500 types of landraces including about 50 aromatic landraces, 73 improved varieties, 34 registered varieties, more than 1000 introduced genotypes and 4 wild species of rice (CDD 2015, Mallick 1981, Upadhyay and Joshi 2003, Joshi 2004b, Joshi 2005, Gupta et al 2000, Genebank and AFACI 2013). In the past there were very limited studies on local landraces. Lack of studies and preemptive measures resulted in the loss of many landraces mainly due to not considering in breeding, access to improved varieties, their low yield, sensitivity to diseases and pests, and their late maturity (Joshi and Bauer 2007, Joshi et al 2005b). In addition, large numbers of rice landraces are grown by only a few farmers in small plots. The adoption of improved varieties is based on higher yield potential, better market demand, better pricing and reduced lodging compared with local landraces (Chaudhary et al 2004). Recently, research and conservation efforts are focused on local landraces (**Annex 1, 2 and 3**).

CDD (2015) listed 157 landraces currently growing in the country. Landraces occupied about 10% of total rice areas (CDD 2015) and there are 9% of upland type rice landraces. More than 1000 genotypes are introduced annually from IRRI for evaluation (Joshi 2014). There are many landraces with specific traits useful for breeding and have potential yield greater than improved one. After the establishment of

National Genebank, now many landraces are conserved for long term storage. Their utilization is very poor and therefore, extensive research using DNA markers are necessary on these landraces so that country can become independent on rice genetic resources for research and development.

Local landraces and diversity

About 2500 different landraces of rice are reported from Nepal (CDD 2015, Mallick 1981/82, Gupta et al 2000, Joshi 2004b, Joshi 2005, Upadhyay and Joshi 2003, NRRP 1997). Site specific landraces are developed and maintained by farmers across the country. Unique landraces are evolved mainly because of diverse agro-climate and ethnic groups.

Landraces can be grouped on the basis of 14 different criteria (**Table 1**). The center of landrace diversity are Kaski, Lamjung, Tanahu, Sunsari and Bara. Different factors play role to maintain and develop diversity between and within landraces. Mid hill region is relatively more diverse in terms of types of landraces (Gyawali et al 2005a). Households having large area for rice cultivation maintained a large number of rice landraces (Joshi et al 2012). The landraces were found different significantly for many traits (Sharma et al 2007, Bajracharya et al 2007, and Khatiwada et al 2003). Seven types of *Jhinuwa* rice landraces can be found in Kaski district (Tripathi et al 2013). However, Jumla landrace population has a narrow genetic base (Bajracharya et al 2010).

Table 1. Grouping of Nepalese rice landraces based on different criteria

SN	Basis	Type	Meaning	Example
1	Farmer's given name (base on the morpho type, name of donor or source, taste, adaptation)	*Ghaiya*	Upland, broadcast in unbund land	*Sali Dhan, Ghaiya-2, Suki Ghaiya*
		Basaune Dhan	Scented rice	Lalka Basmati, *Manbhog, Kariya Kamod*
		Masino Dhan	Small size grain rice	*Bayarni, Sikichan*
		Mota Dhan	Large size grain rice	*Tauli, Sal Dhan, Lalka Jesriya*
2	Planting season	*Chaite Dhan*	Spring rice, transplanting in Chaitra (March-April)	*Tauli, Jamara, Jaulo,* Chaite-4*,* Hardhinath-1*, Dalle,*
		Bhadayia Dhan	Early type	*Sathia,* Ghaiya-2*, Chinaboro, Phillip*
		Barkhe or Agahani Dhan	Normal rice	Basmati*, Kasturi, Masuli,* Radha-7*, Belguti, Ate, Timure, Marsi, Jhinuwa*
		Hiunde Dhan	Winter or boro rice	*Pakhe Masino,* Radha-4*, Taichung, Lahure Sahila, Gori Sahila, Makar Kandhu*
3	Ecotype or subspecies	*Indica* rice	Non sticky, long grained, adapted to sub-tropical and tropical region	Masuli*, Karmuli, Naka Dhan*
		Japonica rice	Glutinous, waxy, sticky, opaque grain, short grained, adapted to temperate region	Taichung-176*, Bhatela, Chiure, Karange*
		Tropical *Japonica* rice	Sticky, medium grained, adapted to sub-tropical region	Khumal-2*, Sukirato*

SN	Basis	Type	Meaning	Example
4	Maturity	Early rice	Early maturity	*Thima, Sinjali, Dudhisaro, Santha Kalo*
		Medium rice	Medium maturity	*Jarneli, Jharlaji, Anjani*
		Late rice	Late maturity	*Gurdi, Thakaali, Mansara, Kohili Jathaniya*
5	Quality (size and scent)	Fine and aromatic rice	Small size grain with aroma	*Jethobudho, Pahenle, Anpjhutte, Basmait, Motisar*
		Fine and non-aromatic rice	Small size grain without aroma	*Mutmur, Anjani*
		Medium and aromatic rice	Medium size grain with aroma	*Laji, Mahajogani*
		Medium and non-aromatic rice	Medium size grain without aroma	*Anjana, Kohile Jadhaniya*
		Coarse and aromatic	Large size grain with aroma	*Sali Dhan, Anadi Basnadhar*
		Coarse and non-aromatic rice	Large size grain without aroma	*Tauli, Mutmur, Jarneli*
6	Ecosystem (production environment)	Rainfed upland rice	Unbunded condition	*Seto Ghaiya, Lalchanda, Suwawat*
		Rainfed lowland rice	Bunded condition	*Dulaniya, Ratanpuri, Mansara*
		Irrigated rice	Bunded condition	*Tilki, Hathijumar, Ramdulari*
		Deep water rice	Floating rice	*Jalmardan, Bhati, Bhandsar, Jagarnathiya*
7	Use	Staple food type rice	For daily uses	*Achami Masino, Remunna, Karmuli*
		Special type rice:	Occasional uses	
		Chiura	Beaten rice	Taichung-176*, Sajani, Chiure*
		Siramla	Chewing rice, eat as raw	*Jarneli, Anadi*
		Latte	Special dish with ghee and sugar	*Jarneli, Anadi*
		Khatte	Pop rice	*Parewa Pawkh*
		Khir	Milk soaking rice	Basmati*, Jhinuwa, Bayerni*
		Sel Roti	Round bread with hollow at central	*Seto Ghaiya, Jarneli*
		Sacred	Required to worship Goddess	*Sathi, Khera*
8	Temperature adaptation	Temperate rice	Cold tolerant rice	*Jumli Marshi, Pakhe, Boyo Dhan*
		Sub-tropical rice	High temperature rice	*Sathi, Kasturi, Motisar, Khera*
9	Cultivation	Domesticated rice	Under cultivation	
		Introduced	From abroad	Chandina, IR-8, Taichung-176
		Improved	Developed by breeder	Khumal-4, Lalka Basmati
		Landrace	Maintained, developed by farmers	*Jumli Marshi, Bhageri, Atte*
		Wild rice	In wild form	*Nabo, Sitarani, Bhan Dhan, Thima*
10	Morphotype	Tall rice	Tall height	*Gurdi, Jerneli, Atta, Rate Dhan*
		Medium rice	Medium height	*Hamsaraj, Sanga Marshi, Thapachiniya*
		Dwarf rice	Short height	*Tulsi Kathey, Santha Kalo*

SN	Basis	Type	Meaning	Example
11	Spikelet per node	Multiple spikes	Many number of spikelets in a node of panicle	*Amaghauj*
		Single spike	One spikelet per node of panicle	*Biramphool, Dharmali, Bhurni*
12	Grain color	White rice	Grain with white husk	*Sotwa, Jarlaji, Dudhisaro*
		Black rice	Grain with black husk	*Bagari, Shyam Jira*
		Red rice	Grain with red husk	*Anadi, Jumli Marshi,*
		Straw rice	Grain with straw color	*Biramphool, Jarneli*
		Gold rice	Grain with gold husk	*Mutmur, Pahenle*
13	Photoperiod response	*Aus (Saro, Gaddar or Ghaiya)* rice	Landraces mature within a certain period, photoperiod non sensitive	*Laxmi, Ghiu Puri, Bhel Saro, Sath Kalo*
		Aman (Agahani or Sarihan) rice	Landraces mature at particular time, photo period sensitive	*Kalanamak, Rahimunma, Tilki*
14	Awn	Awn less rice	Grain without awn	*Pokhreli Masino, Mansara*
		Short awn rice	Grain with very short awn	*Sahimunuwa, Anadi*
		Long awn rice	Grain with long awn	*Sothiyari, Sukha Pankhi, Anga*

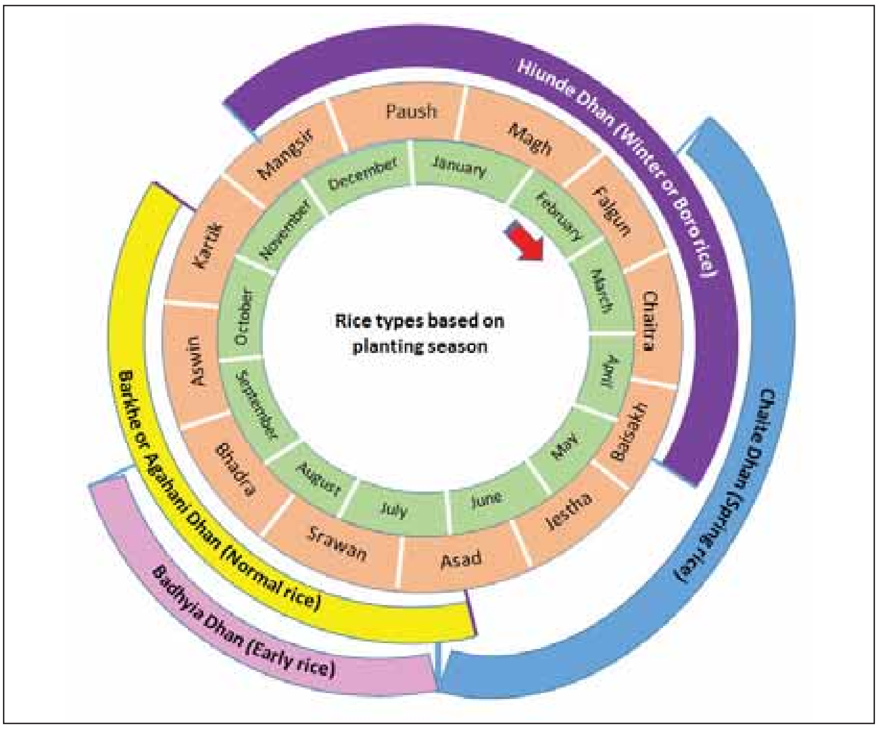


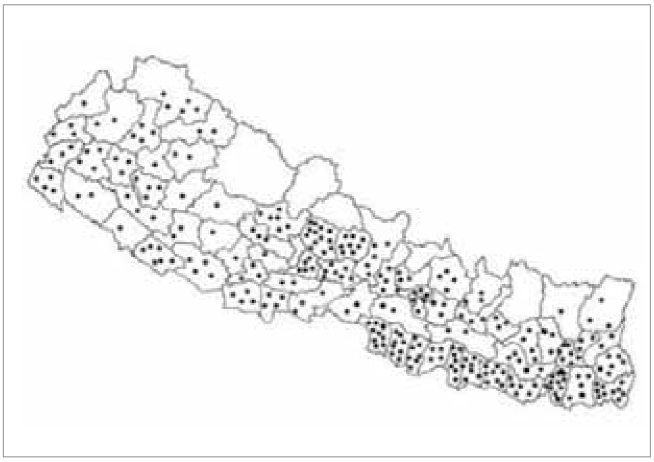
Figure 1. Types of rice based on planting seasons

Source: CDD 2015, Joshi 2004a, Gauchan et al 1997, Mallick 1982.

Distribution

Landraces are found in 73 districts out of 75 of Nepal (CDD 2015, Genebank and AFACI 2013, Mallick 1981/82, Joshi 2004b, Joshi 2005, Gupta et al 2000). Its cultivation ranges from 60 to 3050 masl altitude (Mallick 1981), indicating the existence of both temperate and tropical rice. Three subspecies, namely indica in Tarai and mid hill regions, *japonica* in high hill and tropical japonica mostly in mid hill are found.

Considering the name of landraces, Kaski, Lamjung, Tanahu, Bara and Sunsari are richer in rice diversity (**Figure 2**). They are adopted to poor soil to high fertile, drought to deep water, and to different planting season (**Table 4**).



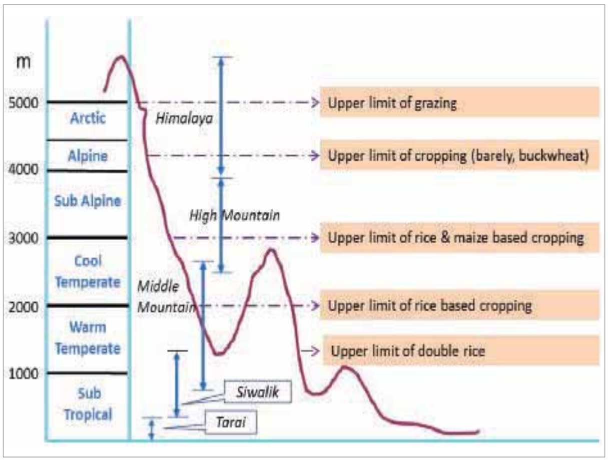


Figure 2a. Distribution of rice diversity (more the number of dots more the diversity)

Figure 2b. Zonation of rice cultivation in Nepal

Unique, rare and endangered landraces

Name of landraces have been listed by Joshi et al (2014b), Genebank and AFACI (2013), Rijal et al (1998), Poudyal et al (1998), Sherchan et al (1998), Gupta et al (2000), Joshi (2004b, 2005), Joshi et al 2005, CDD (2015), Adhikari et al (1995), Joshi et al (2014c). Unique rice landraces are listed in **Table 2** (Mallick 1981/82, NRRP 1997, Rijal 1998, Upadhyay and Joshi 2000, Sthapit et al 2015). Rare and endangered rice landraces are compiled in **Table 3** (Upadhyay 1995, Rijal et al 1998, Joshi et al 1998, Sherchan et al 1998, Rana et al 2000a, 2000b, 2000c, Joshi et al 2004). Major criteria for identification of unique landraces and for classifying under rare/endangered landraces are as depicted in **Figure 3** and **4** (Joshi et al 2004, Joshi et al 2013b).

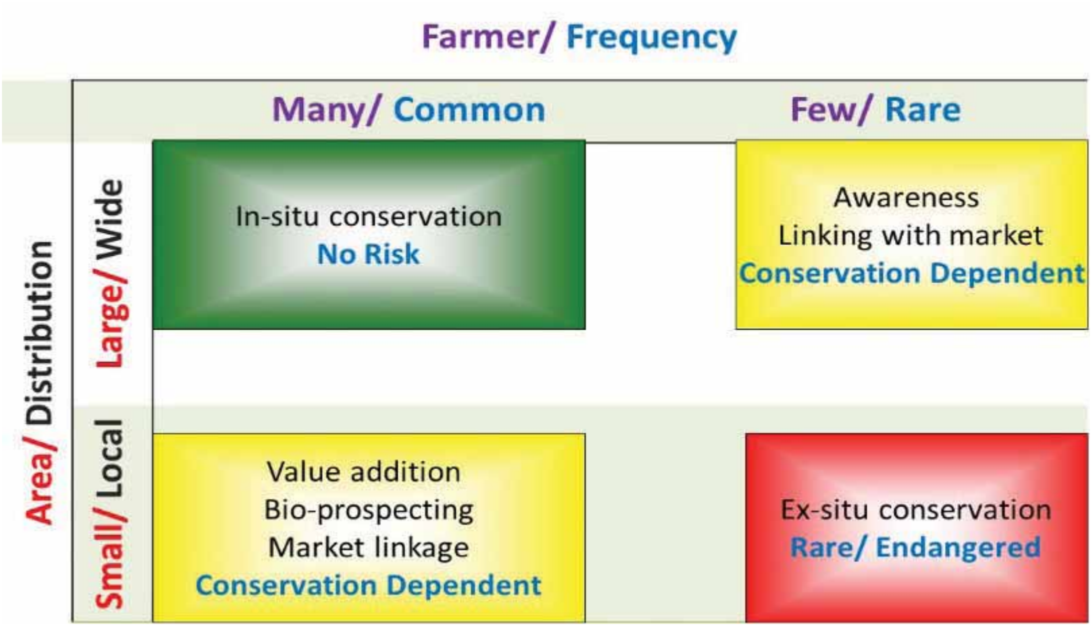


Figure 3. Method to categorize the landraces into rare and endangered list

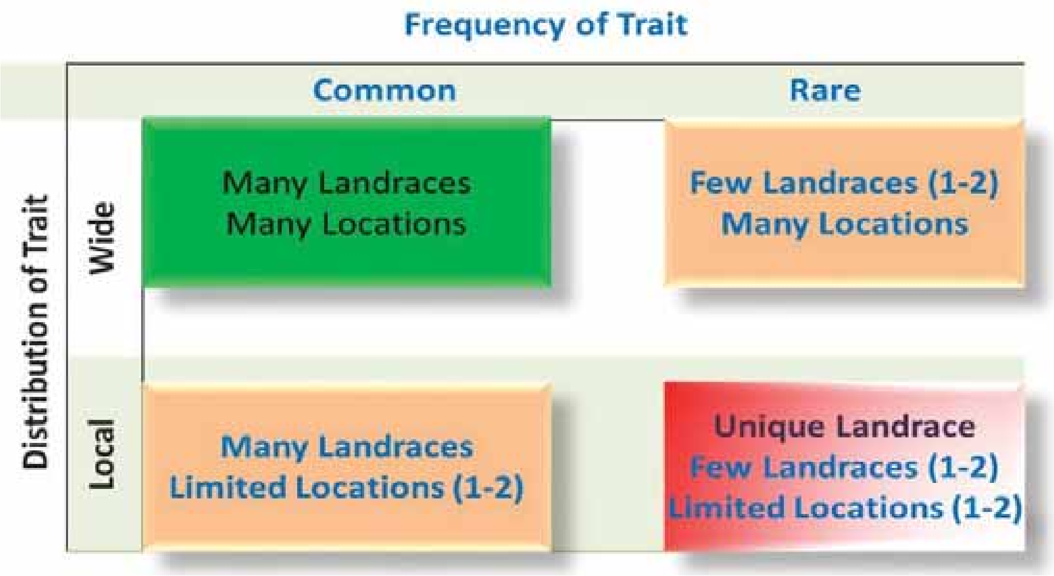


Figure 4. Identifying unique landrace based on trait distribution analysis

Table 2. Some of the unique rice genetic resources cultivated in Tarai, inner Tarai, mid and high hills of Nepal

SN	Genotype	Uniqueness
1	*Amaghauj*	Multiple spikelets per node
2	*Anati Or anadi*	Festival rice/sticky rice/medicinal value
3	*Bhati, Silhat*	Deep water rice
4	Chhomrong *dhan*, Jumli Marshi	Cold tolerance rice, *andilo*
5	*Ekle* Rice	Zn deficiency tolerance
6	*Gamadi, Sathi*	Panicle matured within flag leaf, early rice
7	*Ghayia*	Upland rice
8	*Gurdi*	Lodging susceptible
9	*Jarneli, Kathe gurdi*	Drought tolerance, secure grain yielder
10	*Jhinuwa*	Good eating quality
11	*Kalanimak*	Photo period sensitive
12	*Khera*	God preferred landrace
13	*Laila Majnu Or Jhodi Dhan*	Two grains in a lemma and palea
14	Lalka basmati	Important for party
15	*Mansara, Mutmur, Anga*	Adopted to very marginalized land
16	*Nal Tumme*	Shade loving rice
17	*Nakhisaro, Sathi, Laltenger*	Pest resistance
18	*Pahenle*	Vitamin A content landrace
19	*Pakhe masino*, Radha-4, Taichung, *Lahure sahila*, *Gori sahila*, *Makar kandhu*	*Hiunde* (winter) rice
20	Parwanipur-1	Ratoon rice
21	*Patle Dhan*	Good for pregnant women
22	*Samundaphinj*	Swampy land rice
23	*Sokan dhan, Bageri*	Resistance to bacterial leaf blight and green leaf hopper
24	Wild rice	Virgin rice/perenniality type

Hiunde rice (seeding at December and harvesting at May) has been cultivated since 35 years ago at Taruwa VDC, Nawalparasi. This rice was extensively cultivated after 2042 BS (1984) in these areas. Farmer of this area, Khadka Narayan Mahato has more knowledge on *Hiunde* rice.

Table 3. Endangered/rare and lost rice landraces in Tarai, inner Tarai, mid and high hills of Nepal†

Endangered (48)	Lost (105)
Tauli, Thapachinia, Marsi, Mansara, Siraunla, Masind, Nathani, Khalte Kolo, Biramphool, Samundaphinj, Jhinuwa, Bayarni, Ramani, Pahenle Ghaiya, Bichare, Basmati, Dudhe Marange, Pakhe Masino, Sindhuli, Pakhe Sali, Jabaka, Charinangre, Pakhe Jhinuwa, Basaune Jhinuwa, Pahenle, Jhinuwa, Gudura, Bardari, Battisara, Pokhreli Jhinuwa, Pagate Jhinuwa, Phente Silange, Lalka Basmati, Soka, Sarho, Satraj, Lajhi, Rango, Gajargul, Ratrani, Katuash, Latongad, Masura, Dudhisaro, Lalka Kartik, Ghuthani, Anadi, Khera, Mansari And Anga	*Lahure Sahila, Gori Sahila, Makar Kandhu, Timaha, Darmali, Germani, Koili, Budho Thakale, Ghote, Salidhan, Jhauri, Bhamger, Lalka Pharam, Lajhi, Lohasaran, Parewa Pankha, Handiphul, Karma, Golabachhi, Dudhi Kariya, Bachhi, Devsar, Dudhraj, Sikhichanda, Galphuli Dutha, Rjana, Madhukari, Habsa, Ratin, Bansbarcli, Kanakjira, Ramjamai, Ratan, Tulasiprasad, Mahajogi, Ramini Katika, Sankharika, Sokan, Baramphusi, Ghiukumari, Anandi, Manshara, Satraj, Barkhabahadur, Pokhraj, Sankharika, Gondan, Maturi, Bhulani, Kuriya, Surkamiti, Satraj, Najhi, Golarato, Rajala, Megadoot, Dudhraj, Maturi, Parweapankhe, Kariyakamod, Gaddar, Kanajira, Babadudhi, Bhulani, Barkha Bahadur, Nakhi, Karma, Rati, Horinlduri, Gokulchanda, Maturi, Jhali, Gangaur, Dhudi, Katausi, Tulsi Prasad, Kanakjira, Gokulchan, Sukhichand, Pakhar, Bansnareli, Karma, Silan, Akhidudhi, Jhabri, Jajagaur, Satawa, Bangaluwa, Dudhisaro, Borch Bahadur, Mutari, Amaghaur, Barbasaru, Jhali, Mashura, Gokhul, Handa, Kudiya, Ramjamai, Kasturi, Dudha Kariya, Satariya, Changol, Golabati, Madhusar, Manshari*

† Not exhaustive. This information is mostly from western development region.

Descriptors and characters

Descriptors for local landraces have been developed by NAGRC along with passport data format for collection, characterization and evaluation. Standard abbreviations and coding system was developed for rice research. Any research materials can be conserved now for many years in National Genebank. In the past many important characters were identified in many landraces, however these characterized landraces were not available for further research due to lack of conservation facility in the country.

More than 2000 accessions have been characterized by agro-morphological traits, biochemical and DNA markers. Some of landraces with their traits are given in **Table 4** and additional landraces can be found in the respective paper. Population structure in some landraces of Kaski district were studied (Tiwari et al 2003) and agro-morphological diversity was assessed in landraces of Bara district (Yadaw et al 2003). Sthapit and Witcombe (1997) studied the heritability of chilling tolerance in Chhomrong and Raksali rice landraces. Landraces were evaluated in system of rice intensification by Khadka et al (2014). Outcrossing was studied by Amgai et al (2004, 2005). Bajracharya and Rajbhandary (1984) evaluated *Pokhreli Masino*. Heterosis was studied in some landraces by Joshi et al (2003c) and Joshi (2003a, 2003b, 2003c). Biochemical and morphological markers were used in *Pokhreli Masino* (Bajracharya 1997) and isozyme variation was studied in *Rato Basmati, Pahenle, Jethobudho* (Bimb et al 2004). Sharma et al (2001) characterized using molecular markers. Joshi et al (2014a) have reviewed the DNA markers based blast breeding. 313 rice accessions were screened for flood tolerant genes, 96 rice accessions were screened for bacterial leaf blight by SSR markers, 92 accessions for blast resistance (Bhatta and Amgai 2012). DNA finger prints of local landraces have been developed in NAGRC.

Table 4. Some name list of rice landraces, their distribution and characters

SN	Landrace	Distribution	Characters	References	Remarks
1	*Anadi*	Kaski	Good for *Siraula, Latte, Khatte* and *Puwa*	Rana et al 2000b	Many landraces are described

SN	Landrace	Distribution	Characters	References	Remarks
2	*Bageri, Sokan dhan,*		Resistant to bacterial leaf blight and green leaf hopper	Mallick 1981/82	Many landraces are described
3	*Darime*	Jumla	Drought tolerant and shade loving	Bajracharya et al 2010	Many landraces are listed
4	*Gauriya*	Kaski	Suitable in swamps and wet land	Regmi et al 2009	Lost
5	*Ghiupuri*	Mid Western Tarai	Very tasty, scented	Amatya 2012	Many landraces are described
6	*Jarneli*	Lamjung	Drought tolerance	Mallick 1981/82	Many landraces are described
7	*Jaswa*		Good even in low fertility and drought conditions, field resistance to blast and bacterial leaf blight	NRRP 1997	Many landraces are described
8	*Kalo Marshi*	Jumla	Tasty, easy milling, *Andilo*	Rana et al 2000a	Many landraces are described
9	*Kalonuniya*	Jhapa	Aromatic rice	Shrestha and Sthapit 2014	
10	*Mansara*	Kaski	Adapted to low-fertility rainfed marginal environments	Rana et al 2009	Many landraces are described
11	*Mutmur*	Bara	Grow in poor, rainfed soils	Gauchan et al 2005, Gauchan and Smale 2003	Many landraces are described
12	*Nakhisaro*	Bara	Less insect and disease, respond well in low fertility	Rana et al 2000c	Many landraces are described
13	*Naltumme, Tunde*	Kaski	Drought tolerant and shade loving	Bajracharya et al 2010, Rijal and Synnevag 2005	Many landraces are listed
14	*Pakhe jhinuwa*	Lamjung	Earliness, high straw yield, higher yield under low inputs	Subedi et al 2011	
15	*Sali dhan*		Bold grain, scented upland rice	Joshi et al 2013	Elite line
16	*Samundraphinj*	Kaski	Suitable in swampy land	Rijal et al 1998	Many landraces are described
17	*Sotwa*	Bara	Medicinal property	Shrestha et al 2006	Many landraces are described
18	*Sukirato*		Early maturity, red grain, good in low fertility	Saud 2010	Many landraces are described
19	*Tilki*	Dang	Aromatic rice	Shrestha and Sthapit 2014	

Landraces as geographical indicators

There are many site specific landraces of rice whose quality is associated with geographical condition. Landrace that produces their certain quality in only specific location can be used as geographical indicator and this helps to farming community of such geo-location to get benefited from such landraces. For example, Pokhreli Jetodbudho is a landrace from Pokhara, Kaski. Jumli Marshi and Tilki are considered as geographical indicator for Jumla and Dang respectively. Detail study is necessary on this aspect.

Uses

Among the 73 released rice varieties, only 12 varieties were developed using six local landraces (**Table 5**). *Pokhreli Masino* is used frequently in crossing as parent. Khumal-4, one of the most popular variety has about 50% genic portion of *Pokhreli Masino* landrace. Some landraces have been used in Master Thesis in

IAAS, Rampur (Joshi 2000, Niroula et al 2002). Three varieties, Lalka Basmati, Pokhreli Jethobudho and Chhomrong were developed simply by selecting landraces. Because of high intra-landrace diversity (Sharma et al 2007, Tripathi et al 2013), there are many landraces that can be improved though pure line selection.

Most of the landraces are used as staple food and some during festival and for certain cultural events like Sathi to worship Goddess and considered as *chokho dhan* (pure paddy), Anadi for making *latte, khatte,siraula*, *Jarneli* for *chiura* (bitten rice) etc. Popular recipes from landraces are *sel roti, khir, pulau*, etc. Some landraces have adaptive trait for drought, poor soil and deep water conditions.

Table 5. Improved rice varieties developed from local landraces in Nepal

SN	Variety	Parent	Method	Released date
1	Khumal-2	Jarneli/KN-1B-361-BLK-2-8	Landrace/exotic genotype cross	1987
2	Khumal-4	IR-28/*Pokhreli Masino*	Landrace/exotic genotype cross	1987
3	Palung-2	BG94-2/*Pokhreli Masino*	Landrace/exotic genotype cross	1987
4	Khumal-5	*Pokhreli Masino*/KN-1B-361-BLK-2-6	Landrace/exotic genotype cross	1990
5	Khumal –5	*Pokhreli Masino*/KN-1B-361-BLK-2-8	Landrace/exotic genotype cross	1990
6	Chhommrong	Ghandruk local	Selection on landrace	1991
7	Machhapuchhre-3	Fuji-102/Chhomrong	Landrace/exotic genotype cross	1996
8	Pokhreli Jethobudho	Jethodbudho landraces	Selection on landrace	2006
9	Khumal-8	Jumli Marshi/IR-36	Landrace/exotic genotype cross	2006
10	Lalka Basmati	Local Lalka Basmati	Selection on landrace	2010
11	Lekali Dhan-3	Yunlen-5/Chhomrong	Landrace/exotic genotype cross	2014
12	Lekali Dhan-1	Banjaiman/Chhomrong	Landrace/exotic genotype cross	2014

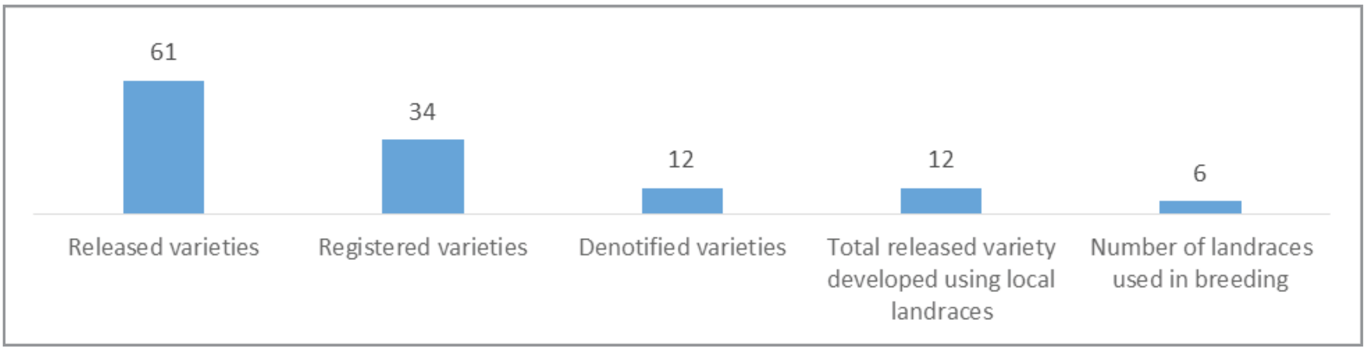


Figure 5. Number of total released and registered rice varieties and use of landraces in breeding

Landrace enhancement and mixture

There are many landraces that can be genetically improved by simply giving selection pressure mainly because of variation within landrace (Ghimire et al 2014, Joshi et al 2013). However very limited works have been done on this aspect (Upadhyay and Joshi 2003, NRRP 1997, SQCC 2015). Landrace enhancement and conservation (LEC) program was initiated in 1992 (Joshi 2013). Chhomrong is the first variety developed through selection of landrace. Pokhreli Jethobudho is another variety that was enhanced genetically by selecting suitable line from among the population of Jethobudho landrace (SQCC 2015, Gyawali et al 2005b). NAGRC has identified many elite landraces that can be used either in breeding or directly for production (Joshi et al 2013, Ghimire et al 2014). PVS is an effective tool for landrace enhancement (Gyawali et al 2008).

Landraces mixture in rice is not common however, some farmers in Humla, Jumla, Lamjung, Gorkha and Kaski cultivate rice by mixing different landraces and varieties. Mallick (1981) has also reported mixing cultivation of *Gurdi* with *Mansara*, *Pahenle* with *Mansara* and *Guduraa* with *Mansara* rice landraces. Farmers in Meramche, Dikkur Pokhari, Kaski mix *Kalo Patle* landrace with Chhommrong, Machhapuchre-3 and other landraces. *Kalo Patle* is black in color, tall (lodging problem), low production and tasty. The advantages of mixing this landrace with others are non-lodging of: *Kalo Patle*, low diseases, more production, tasty and do not have problem from monkey. In Sorpani, Gorkha, farmers mix *Jarneli* with *Sobhara* rice landraces. *Jarneli* lodges, produces low grain yield but has good taste and *Sobhara* does not lodge, produces more and is not tasty. Mixing such landraces with contrast characters make rice production more sustainable. Competition of rice landraces in mixture with wild rice was studied by Joshi et al (2001).

Conservation

Exploration and collection mission of germplasm in Nepal was started since 1938. First rice collection mission was held in 1971 in collaboration with IRRI (Upadhyay and Joshi 2003). In recent year (from 2014) trait specific rice collection missions (eg cold tolerant, drought tolerant etc) are also organized by NAGRC. Main organizations involved in rice exploration and collection are NAGRC, Community Seed Bank, IRRI, DADO, LIBIRD, RARS and ARS of NARC, NRRP, IAAS, AFU, ABD. Rice accessions have been collected almost from all rice growing districts of Nepal and a total of 8,389 accessions are conserved in six different genebanks. Most of these accessions are accessible through Genesys, NIAS, IRRI, USDA. In some cases, farmers say landraces even to improved varieties, create difficulty on identifying and collecting landraces. Many CSBs have also initiated conservation of rice landraces (Shrestha et al 2013). Existing supplementary mechanisms and options for conserving rice biodiversity in Nepal are: i. Ritual practices of Hindu ii. Culturally protected areas (temple and other religious places) for wild rice, iii. Protected areas (National parks, Conservation areas, Wildlife reserves, hunting reserve) for wild rice, iv. World heritage sites for wild rice, v. Ramsar sites for wild rice, vi. Leasehold, community and private forests for wild rice, vii. Farmers seed network system, viii. Protection of some plant species, ix. Seed bank, x. DNA bank, xi. Field Genebank for wild rice, xii. Household Genebank, xiii. Community Genebank, xiv. Svalbard Global Seed Vault, xv. World Seed Vault, xvi. CGIAR Genebanks, xvii. Botanical gardens/parks for wild rice and xviii. Himalayan seed bank and xix. Landrace enhancement (Joshi 2016, Joshi et al 2013a).

Acknowledgements

I am thankful to KH Ghimire, D Gauchan, UK Kushuwa and RB Yadav for providing with technical information on local landraces of rice.

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Annex 1. Rice landraces of mid and high hills of Nepal

District	Landraces	District	Landraces	District	Landraces
Achham	*Salaujo*	Dhading	*Anadi Masino*	Dolkha	*Banghe Masino*
Baglung	*Pyuthari Seto*		*Asrange*		*Basmati Anpjhutte*
Baitadi	*Bhure Dhan*		*Banghe Dudhe*		*Charikote Marsi*
Bajura	*Lanmanya*		*Chherlinge Shiwuwa*		*Chotangre Marsi*
	Manhara		*Cholikathe*		*Dande Marsi*
	Phale		*Chowa*		*Dolkhe Marsi*
Bhaktapur	*Agacha*		*Dudhe Mansaro*		*Gudure Marsi*
	Biganpa		*Edle Masino*		*Jeena Masino*
	Gunte		*Garue Ghaiya*		*Jeph Masino*
	Gunte Tauli		*Hathi Chhera*		*Kayachha*
	Pokhareli Sathiya		*Himadi Dhan*		*Lahare Marsi*
	Rato Masino		*Jini Bengani*		*Likhole Marsi*
	Sathiya		*Juneli*		*Sapinge Marsi*
	Swanwa		*Kalo Kathe*	Gorkha	*Akele Masino*
	Togawa		*Kalokals Dhan*		*Larey*
	Ulaka		*Kanjira Pahenlo*		*Maju Rato*
Bhojpur	*Aau*		*Krishnabeli*		*Panthi*
	Bate		*Lahare Ghaiya*		*Sano Chobo*
	Chari Dhan		*Lidi Ghaiya*		*Sovan/Sal Dhan*
	Sulsiane Masino		*Manahari*	Gorkha	*Thathar*
Dailekh	*Dailekhe*		*Manasara*		*Thathar Bagari*
	Dhaya		*Masino Basmati*	Gulmi	*Chaureli*
	Gade		*Pahenlo Anpjhuppa*		*Madesi Chhote*
	Goode		*Pakhe Sale*		*Sete Jaran*
	Gude Dhan		*Palpali*	Jajarkot	*Dotiyali Dhan*
	Gure		*Rajbhog Masino*		*Jhyali Dhan*
	Kaili Jado		*Salyan Dudhe*	Jumla	*Jadan Marsi*
	Kalo Seto Gude		*Sano Begani Chhiya*		*Kalo Maheli*
Darchula	*Rado Dhan*		*Silly*		*Meheli*
	Rajmati		*Sirwa*	Kabhre	*Bagha Tauli*
	Temase Dhan		*Tauli Ghaiya*		*Bolakhe*
Okhaldhunga	*Ahe*		*Thade Masino*		*Buddhabir*
	Bhatti		*Thosar Ghaiya*		*Chhote Marsi*
	Bhuimali		*Thule*		*Chuplunge*
	Dudhe Marsi	Kaski	*Batisi*		*Dolkhe Masino*
	Laldob		*Bayarni Jhinuwa*		*Ramali Chhote*
	Sovara		*Jhawi*	Sindhupalchok	*Himali*
Taplejung	*Bhote Tauli*		*Jhimse*		*Karkali Jukari*
	Chhitange	Myagdi	*Bikase*		*Nepali Thapachiniya*
	Eyeder		*Masino Gauriya*		*Pahenlo Jharakathe*
	Gadbade		*Sano Gauriya*		*Sano Chhotte*
Khotang	*Setharo*	Rasuwa	*Khareli*	Taplejung	*Khoranse Seto*
	Suvana				*Kobhangi*
					Namsule

District	Landraces	District	Landraces	District	Landraces
Kathmandu	*Bigin*	Lalitpur	*Bighadewa*	Nuwakot	*Boudha Massi*
	Tauli Marshi		*Pokhreli*		*Jhinuwa Agahani*
	Thapachiniya		*Aaghani*		*Jira Sarange*
	Chhote Gunte		*Chhote Marshi*		*Kalaykathi*
	Chhote Pahenlo		*Sano Marshi*		*Kali Kathe*
	Chiniya Marsi		*Banse*		*Limbutare Masino*
	Chiniya Seto		*Pahale Marshi*		*Narjali Gole*
	Dansi		*Gudgude*		*Samundrbakhi Phim*
	Duraj		*Purano Masino*	Panchthar	*Barkhe Tauli*
	Hakuwa		*Rato Aga*		*Choirakha*
	Hariyo Marsi		*Thankote Marsi*		*Dhanasiri*
	Jire Asarange	Lamjung	*Akali*		*Dhoosar*
	Kalo Basmati		*Dale*		*Kanti Masino*
	Kathe Marsi		*Gardi*	Parbat	*Archoty Zrura*
	Lamo Pahenlo		*Gudule*		*Bhasey Grura*
	Nepali Puwa		*Jhapka*		*Lumlati Kalo*
	Puwa		*Jhuli*		*Masara*
	Tayasiva		*Jodi*		*Thulo Pahenlo*
Khotang	*Atte Pahele*		*Madeso*		*Toli Anadi*
	Bage Tauli		*Manamuri*		*Zerman*
	Bhotange		*Manbo*		*Zola*
	Dumsi		*Manusara*	Rukum	*Sagun*
	Jodi Chand		*Thodo Chobo*		*Big*
	Kumale Marsi		*Thulo Gudrabeli*		*Simjira*
	Lathi Jhavar	Terhathum	*Bango Masino*		*Ghaiya*
	Motange Pahenlo		*Chiruakha*		*Basmati*
	Okhaldhunge		*Hukpa*		*Dalsing*
	Ramsali Katka		*Kaduwa*		*Marse*
Sankhuwa	*Tauli*		*Karele*		*Jyali*
saba	*Manipure*		*Khyamti*	Ramechhap	*Basmati Masino*
	Tulsi		*Manksula*		*Bhotange Marsi*
	Dalbir		*Masino Bhangere*		*Gauriya Masino*
	Masino		*Yaksen*		*Jira Sari Masino*
	Halpude				*Jogini Masino*
	Masri				*Kalo Jumli*
	Juwa				*Katikasali*
	Aanapasi				*Katuwa Kumale*
	Neuli				*Phode Jagannathiya*
	Budhe				*Purano Jagar*
					Rakshe
					Saro Mumale

Annex 2. Rice landraces in districts lies in both Tarai and hill regions

District	Landraces	District	Landraces	District	Landraces
Arghakhanchi	*Chhotki Asram*	Makwanpur	*Achhame Masino*	Ilam	*Baidai*
	Dedi		*Baglunge*		*Bairani*
	Deori		*Chhoti Marsi*		*Bhumi Dhan*
	Estmali		*Gazali Ghaiya*		*Champasari*
	Hawa		*Gola Ghaiya*		*Chimasari*
	Jedia		*Jute Masino*		*Chimase*
	Lame Jadan		*Motisari*		*Chyanse Dhan*
	Laure		*Phalame*		*Dashara Dhan*
	Lave		*Purbiya/Kalamsar*		*Dudhuwa*
	Silame		*Seti Ghaiya*		*Kakhauri*
	Sunmune		*Seto Ghaiya*		*Makhmali Dhan*
Dandeldhura	*Modora Dhan*		*Thulo Marsi*		*Mangsuli*
	Syamjiro	Sallyan	*Chinne*		*Nangere*
Dhankuta	*Bhain Marse*		*Desi Dhanahawa*		*Nania*
	Bhutan Dhan		*Guraura*		*Niranphul*
	Dude Masino		*Pubde Jhinuwa*		*Pahade Basmati*
	Ghomota		*Rimali Jarahan*		*Pakha Tauli*
	Jire Mansara		*Sano Marsi*		*Phaudal*
	Juwa		*Seto Jarahan*		*Phodel*
	Katak Marse		*Seto Jhanuwa*		*Ruduwa*
	Rangeli Dhan	Sindhuli	*Bhat Kanya*		*Sindhu Marsi*
	Saraj		*Darjilinge*		*Takmaru*
	Takmare Rato		*Dhuse*		*Tapre*
	Tauli Masino		*Gahume Masino*		*Thandre*
Doti	*Bharadya*		*Ghiew Kumari*		*Thangre Masino*
	Chucheri		*Jarneli Masino*	Syangja	*Badhari*
	Gazi		*Karme Masino*		*Bhaisegola*
	Gurthonglo		*Kharpali*		*Chaite Dhan*
	Hapali		*Kharpali Masino*		*Chove*
	Jhunjhunya		*Kumale*		*Gazali*
	Jore		*Mobhanga*		*Jarpari*
	Lalgadi Dhan		*Morange*		*Makuwa*
Doti	*Nawn Goulndoo*		*Rambeli*		*Sejali*
	Mari				
	Nimdi		*Santara*		*Thema*
Palpa	*Madi*		*Seto Masino*		*Zaruda*
	Masino Zolo		*Sobara*		
	Pauata	Surkhet	*Hansa*		
	Seto Kathe		*Nimai*		
Pyuthan	*Bombay Jarhan*		*Sothari*		
	Jarneli Chaureli	Tanahun	*Badbade*		
	Suga Pankhi		*Masino Madesi*		
Sallyan	*Ath Hageri Jarahan*				
	Bagari Jarahan				

District	Landraces	District	Landraces	District	Landraces
Location unknown	*Bangali*	Location unknown		Location unknown	
	Bartalo Dhan		*Kalo Timure Masino*		*Pakistani*
	Bharai		*Kamuli*		*Pameli*
	Chanaphor		*Karauli*		*Raimanowa*
	Chyangula		*Khoile*		*Saothari Dhan*
	Deukhoria Dhan		*Kholasin*		*Sauthari Dhan*
	Goguwa Dhan		*Kirmala*		*Seto Atte*
	Gokul Dhan		*Lale*		*Sidali*
	Gorhna Dhan		*Lamani*		*Sohabat*
	Gorra Dhan		*Madhuwa Karaiya*		*Suhawat*
	Gundrikbhog		*Makhmal Mehi*		*Takle*
	Jalmani		*Matkan*		*Thakali*
	Jaunthari		*Matkut Dhan*		*Thuli Begano China*
	Jernali		*Pahenlo Phalame*		*Tinasari*
	Zungali		*Zenna Masino*		*Yangkhuke*

Annex 3. Rice landraces of Tarai and inner Tarai districts of Nepal

District	Landraces	District	Landraces	District	Landraces
Banke	*Bahami*	Bara	*Kundwa Saphed*	Chitwan	*Dudhraj Satari*
	Baruna		*Lalki Saro*		*Gauradi*
	Burma Dhan		*Langhi*		*Jogini*
	Deharadun Basmati		*Lanjhi*		*Sathi Bagari*
	Didwa Dhan		*Loha Singh*	Dang	*Andi Rato*
	Jirabatisi		*Madhukar*		*Araret*
	Ketaki		*Marchaia*		*Badka Agani*
	Mehi		*Mehinya Saro*		*Bahari*
	Nibaria Dhan		*Motaka Asahani*		*Chhotka Agani*
	Suwapankha		*Mothi*		*Geruwa*
Bara	*Amaghauj*		*Muturi*		*Girdi*
	Banguluwa		*Naiharwa*		*Golwa*
	Barccha Bahadur		*Nan Kajali*		*Kalipare*
	Basmati Nokhi		*Nokhi*		*Lalka Bajante*
	Chitmaniya		*Rato Gadar*		*Lateri*
	Dhusara		*Sautinia*		*Moti Gauri*
	Gadar		*Seto Godar*		*Piyale Pahenle*
	Galphooli		*Thalery*		*Rai Manule*
	Jangar		*Thali*		*Reshmi Andi*
	Jhakhia		*Ujarka Basmati*		*Simtharo*
	Kalo Kundwa		*Ujarka Gadar*		*Sunkasara*
	Kariya				*Tillaki*
	Kataura				*Ujarka Bijeta*
	Katunjhar				

District	Landraces	District	Landraces	District	Landraces
Jhapa	*Palsa/Lalkamal*	Dhanusha	*Muarliya*	Kailali	*Kali Gurdi*
	Panidhan		*Sanjira*		*Kasturi Basmati*
	Panikalam		*Shahmardan*		*Mahesiya*
	Panikalam Dhan	Bardiya	*Athabise*		*Nimue*
	Pankhiraj		*Behue*		*Rahimaduwa*
	Patalshree		*Karhangi*		*Sarju-52*
	Radini		*Lalka Mehi*		*Sehawat*
	Rashdhan		*Mehi Khanjer*		*Sethyari*
	Sapio Marsi		*Sapwaraow*		*Sothiyari*
	Satho Ahu		*Satha Bhadai*	Kanchanpur	*Anjor*
	Seto Nunia	Dhanusha	*Ans Harinkar*		*Bherani*
	Tamtulsi		*Kalami*		*Dhunmuniya*
	Uhtahla Dhan		*Karma Seto*		*Dhunmuria*
	Zamara		*Kasauth*		*Gojuwa*
	Zirasari	Jhapa	*Halpani*		*Goral*
	Zoowa		*Haritor*		*Indrasan*
	Zuli		*Jhute Masino*		*Karmuli*
Jhapa	*Achhame Bachchi*		*Kalojuniya Dhan*		*Khajuwa*
	Ahu		*Kalomuriya Dhan*		*Lawangi*
	Aruna		*Kalonunia/Kamod*		*Nebuwe*
	Auns Dalle Dhan		*Kamti*		*Palpal*
	Auns Masuli		*Kanji Matsaro*		*Rajbhog*
	Bachri Dhan		*Kartiksali*		*Ramania*
	Badasal		*Kathkalam Dhan*		*Rudani*
	Balam		*Katiksali*		*Sintaro*
	Balamachi		*Kukurjali*		*Siudi*
	Bange Chulthe		*Kukurjali Dhan*		*Sunchari Dhan*
	Banse Dhan		*Lal Bachhi*		*Tilak*
	Barkote		*Lal Dhan*		*Vari Dhan*
	Bena		*Lalkalam Dhan*	Kapilvastu	*Dharia*
	Champa		*Lalmungar Dhan*		*Kalakanth*
	Chiewre		*Mainagiri Dhan*		*Kaniya*
	Chule Dhan		*Misin Phoora*		*Matmuri*
	Chulthe		*Moonor*		*Parani*
	Chuwan Dhan		*Munger*		*Phoolbaneh*
	Dalekaso Bachhi		*Najir*		*Ramkajara*
	Dalle Kalam		*Nooha Jange*	Rupandehi	*Bajar Bhang*
	Dhankute		*Pahade Champe*		*Bhathi*
	Dhukar Bachhi				*Motichur*
	Dhusuni				*Parni*
	Dosaro				*Sethre*
	Dumsikalam				*Sotharcha*
	Dungibaruwa				
	Gudrikbhog				
	Habsa				

District	Landraces	District	Landraces	District	Landraces
Rautahat	*Gokue Sah*	Siraha	*Aeszni*	Sunsari	*Lakhi*
	Gokulpati		*Dudhiya Auns*		*Laliguras*
	Jirajewaen		*Dumhakher*		*Lohagadh*
	Lohaban		*Haragola*		*Mardathula*
	Lohabi		*Kalam Kathi*		*Nagir*
	Malsi		*Kalo Anadi*		*Oha, Lailamajanu*
	Mosingi		*Kushum Katki*		*Pahariya*
	Murla		*Ladbhadi*		*Pahariya Asami*
	Phoolosari		*Lathi Jhari*		*Panjhali*
	Ratagola	Siraha	*Nandha Dudhraj*		*Pharma*
	Sapeta		*Samdhi Dhulari*		*Rato Bhadaiya*
	Sikichan		*Satariya Jhar*		*Rato Marsi*
	Than Tar		*Satariya Masino*		*Roopkala*
Sarlahi	*Baramphool*		*Sumaha*		*Roopkamal*
	Dhanushban	Sunsari	*Aath Number*		*Samdauli*
	Gajpate		*American*		*Sarmana*
	Ghiew Kuar		*Ans Bhadaiya*		*Saya*
	Guthare		*Asami*		*Shreekuti Kalo*
	Jasariya		*Barabate*		*Sinalipatre*
	Jhar Lanjhi		*Bengsar*		*Tally*
	Khera		*Bera*		*Tara*
	Lal Tengar		*Bhadhri*		*Tulsishar*
	Loha Sagar		*Bhediya*	Mahottary	*Balan*
	Madhuri		*Chapanj*		*Bhadaiya Harikar*
	Maturi		*Chengbul Masino*		*Bhadaiya Thelaiya*
	Muslim		*Chultha Masino*		*Gamlari*
	Payanwa		*Dale Maid*		*Ghaiya Ansu*
	Saro		*Datuje Dhan*		*Gokulsair*
	Sotawa		*Dudh Karma*		*Gola Rata*
Udaypur	*Anpaki*		*Dudhi Kalam*		*Gukulsar*
	Assame Rato		*Dusari*		*Harin Dolan*
	Assame Seto		*Farmi Marsi*		*Jasa Ariashu*
	Au		*Gaduma*		*Kala Kamod*
	Balamsari		*Gangasar*		*Kankhi*
	Balamser		*Gatima*		*Katiki Dhan*
	Barehhi		*Gola Basmati*		*Madhusar Masino*
	Bhadaiya Naki		*Gorura Dhan*		*Madhusar Moti*
	Bikase Auns		*Halida*		*Majeer Dhan*
	Devrani		*Hardawati*		*Murali*
	Haribar		*Jira Shah*		*Phoolkumari*
	Hariphore		*Kal Kamod*		*Ram Jewaen*
	Katike Auns		*Kalchi Bhadai*		*Sabo Ansu*
	Khunjee		*Kalosar*		*Sahmardan*
	Lathighabar		*Kalseni, Kunji*		*Sajira*
	Marsi Pahelo		*Katakipanja*		*Sarlari Dolan*
	Sajani		*Kathinumal*		*Thakur Prasad*
	Seto Harda		*Kumbal*		

District	Landraces	District	Landraces	District	Landraces
Morang	*Achhamiya*	Nawalparasi	*Asame Masino*	Parsa	*Anadi Pankha*
	Aginsar Dhan		*Baburam*		*Aneria*
	Asamiya Basmati		*Bachhi*		*Babuniya*
	Balsa		*Banshaor*		*Babuniya Saro*
	Chuhan		*Bhutahi Laldeya*		*Baccha Bahadur*
	Dashariya		*Farambvagadi*		*Balesari*
	Gehuna Jungali		*Joohi*		*Bangla*
	Jamira		*Kanjira*		*Belaur*
	Jeera Dhan	Rautahat	*Adarat*		*Berwasaro*
	Jhappar Dhan		*Anthawan*		*Bhalami*
	Madhuva		*Balausar*		*Bhalani*
	Madhuwa Kariya		*Bansbareli*		*Bholani*
	Malbhog Dhan		*Bansphool*		*Bhondwa Anadi*
	Maldahiya Dhan		*Begani*		*Bhulni*
	Nagin Dhan		*Chhobo*		*Chanrauti*
	Palsa Dhan		*Choro*		*Chengaul*
	Palsa Masino		*Dudhiya Dyne*		*Dewsar*
	Palsa Moto		*Gajkeshar*		*Dudhi Gadar*
	Rathkumal		*Ghaiya Bijari*		*Dudhi Saro*
	Rato Dudhraj	Saptari	*Bachchhi Harda*		*Gadur*
	Rupkalam Dhan		*Bakni*		*Hararemuwaso*
	Rupmati Dhan		*Dhumasi*		*Harkher*
	Sataraj		*Dudha Bakai*		*Hatti Jhoolan*
	Sehamani Dhan		*Gahuae*		*Jagar*
	Sehwani		*Lalighawar*		*Jengar*
Parsa	*Lohajir*		*Luhabi*		*Jholhi*
	Manesari		*Motiya*		*Kataujhar*
	Murlakhera		*Sahmena*		*Katika Rato*
	Naukhi		*Satariya Moto*		*Khalanga*
	Parewa Pankha		*Surajmukhi*		*Kunjiyauji Yala*
	Ratin				*Lalkagudar*
	Risal				*Sathisaro*
	Sankharika				*Satlari*
	Seto Basmati				*Sita, Sokan*

Annex 4. Wild rice and wild relatives of rice found in different districts of Nepal

SN	Wild /relative	Local name	Districts
1	*Oryza nivara* Sharma et Shastry	-	Banke, Kapilbastu, Lumbini, Bardiya, Kailali, Kanchanpur, Kaski, Dang, Rupandehi
2	*O. rufipogon* Griff. (*O. perennis* Moench.)	*Nabo ghans, Anga, Salidhan*	Banke, Kapilbastu, Kailali, Kanchanpur, Surkhet, Kaski, Palpa, Rupendehi, Dang
3	*O. granulata* Nees et Arn. ex Watt.	*Ban dhan, Jangali dhan, Sitarani dhan*	Chitwan, Jhapa, Ilam, Makawanpur
4	*O. officinalis* Wall ex Watt.	-	Kancahnpur, Bara, Janakpur
5	*O. sativa f.* spontanea (weedy rice)	*Navo, Thima, Jara*	All rice growing districts, Rupandehi, Kapilbastu, Banke, Bardiya, Kanchanpur, Lamjung
6	*Hygroryza aristata*	-	Kaski, Kailali, Kathmandu
7	*Leersia hexandra*	-	Kaski, Lamjung

Source: Gupta et al 2000, Joshi 2004, 2004, 2015, Mallick 1982, NRRP 1997, Shrestha and Vaughan 1989 , Shrestha and Upadhyay 1919.

Rice Science and Technology in Nepal (MN Paudel, DR Bhandari, MP Khanal, BK Joshi, P Acharya and KH Ghimire, eds).
Crop Development Directorate (CDD), Hariharbhawan and Agronomy Society of Nepal (ASoN), Khumaltar.

A Brief Review of Cold Tolerant Rice in Nepal

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सारांश

धान एक विविधतायुक्त बाली हो । यो बाली नेपालको तराईदेखि मध्य एवम् उच्च पहाडमा खेती हुन्छ र विविध वातावरणीय प्रतिकूलताका बावजुद उत्पादन हुने गरेको छ । मध्य एवम् उच्च पहाडका केही क्षेत्रहरूमा चिसो हावापानी र उच्च तथा न्यूनतम तापक्रमले धान बालीको वृद्धि र उत्पादनमा असर पारेको हुन्छ । यी क्षेत्रहरूमा उत्पादन हुने प्रायजसो उन्नत एवम् स्थानीय जातहरूमा चिसो हावापानी खप्ने क्षमता रहेको हुन्छ जसले गर्दा चिसोबाट हुने क्षतिलाई न्यून गर्छ । जुम्लीमार्सी एक स्थानीय जात हो जसमा चिसोपना खप्ने क्षमता रहेको पाइएको छ । स्थानीयस्तरमा छनौट प्रक्रियाबाट विकसित पोखेली मसिनो, छोमरोङ र माछापुच्छ्रे-३ का जातहरूमा पनि चिसो हावापानी सहने क्षमताको पहिचान भएको छ । विभिन्न देशबाट आयातित अनुसन्धानको क्रममा रहेका केही धानका प्रजनन् लाइनहरूमा चिसोपन खप्ने क्षमताको पहिचान भएको छ । यी उन्नत एवम् स्थानीय जातहरू नेपालको खेती तौरतरिका र आनुवंशिक विविधताको हिसाबले महत्वपूर्ण छन् र उच्च पहाडका क्षेत्रहरूको लागि जातीय अनुसन्धान कार्यमा यी जातहरू महत्वपूर्ण आनुवंशिक स्रोतको रूपमा हुन सक्छन् ।

Summary

Rice is one of the most diversified crop species. It is grown across the agro-ecosystems from foot-hills to high-hills. It is adapted to wide range of environments with some sorts of yield even in adverse climatic conditions. Low temperatures and the higher elevations are the crucial factors in the region that occur at critical reproductive stages of rice that adversely affect grain quality and also cause yield reductions in many parts of mid- and high-hill ecosystems of Nepal. Improved and local rice varieties of these region possess the attributes of cold tolerance and thus the yield loss due to extreme cold is minimized. *Jumli Marshi* is high-altitude cold tolerant local rice grown very commonly in Jumla. *Pokhreli Mashino*, Chhommrong and Machhapuchrre-3 are also the local selections identified as cold tolerant rice varieties. Fewer exotic breeding lines have been identified for cold tolerance. These local and improved varieties are important from genetic diversity perspectives and can be used as genetic resources for varietal research in Nepal.

Keywords: Cold tolerance, Environment, Local and improved varieties, Research, Rice

Introduction

Rice is one of the most diversified crop species, enabling it to adapt to a wider range of environments and the resulting stresses (Chang 1976). Cold stress is the environmental factor due to low chilling (0 to 15°C) and freezing (<0°C) temperatures during growing life cycle of a plant (Zhu et al 2007). As a result it limits the growth, productivity, and geographical distribution of the crop species and varieties. It is one of the major environmental stresses in mountain agricultural system in Nepal. Low temperatures and the higher elevations are the crucial factors in the region that occur at critical reproductive stages of rice which adversely affect grain quality and also cause yield reductions in many parts of mid and high-hill ecosystems of Nepal. Cold tolerance in rice in mountain agriculture is an important but complex trait which responds to the cold stress and tries to reduce the physiological and physical damages in rice plant. It has been obviously evaluated among rice varieties and landraces grown in mountain environments. Here, we try to review briefly the rice varieties and landraces under production in Nepal with different degree of mild to strong cold tolerance at different growth stages.

Distribution of rice varieties

The cultivation and diversity of rice in Nepal is unique, being grown across the agro-ecosystems from foot-hills to high-hills. It is here in the Nepalese Himalayas where unique high elevation traditional rice varieties are grown at the world's highest elevations, at 3050 masl (Paudel 2011), containing cold tolerance traits that are recognized globally (Shahi and Heu 1979). Besides, the co-existence of 4 wild rice species (*O. nivara* Sharma and Shastry; *O. rufipogon* Griffith*; O.granulata* Nees et AM ex Watt, and *O. officinalis* wall ex Watt) and wild relatives (*Hydrorhiza aristata* Nees and *Leersia hexandra* L.) and cultivation of tremendous traditional varieties on-farm in the form of landraces states, existence of a high degree of genetic diversity in rice constitutes an important gene pool for rice research integration (Shrestha and Vaughan 1989, Upadhyay 1995). Except Manag and Mustang, rice cultivation is practiced in all 73 districts of Nepal. In the mountain districts, rice has been under cultivation with a time series increase in area coverage of 61620 hectares (4.14% of the total rices area) with the production of 149,569 tonnes (2.96% of the total rice production) and productivity of 2,427 kg/ha (**Table 1**) (MoAD 2013, 2014). Rice is therefore the number one stable food crops of Nepal and is equally considered important with presitigious value in high mountain agroecosystem of the country. Extent and distribution of these landraces with the potential adaptive traits under the farmers' management has been described in several earlier studies (Bajracharya 2003, Zhang et al 2009, Kumar et al 2010, 2011, Pandey et al 2011).

Table 1. Area, production and yield of rice grown in the mountain agroecosystem over last few years

Mountain	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14
Area (ha)	62263	64145	64915	62175	66713	69051	61908	61620
Production (tonnes)	120172	125541	129105	114555	137674	154459	129156	149565
Yield (kg/ha)	1930	1957	1989	1842	2063	2269	2086	2427

Source: MoAD 2013 and 2014.

Cold tolerant rice varieties, local land races genotypes and exotic genotypes

A fascinating diversity of rice growing environments is prevalent in Nepalese agriculture. Five major rice growing environments exist based on source of irrigation. These are spring rice with assured irrigation, main rice with partial or full irrigation, high altitude rice with rainfed or partial irrigation, upland rice with total rainfed and submerged deep water rice. High altitude and upland rice are stress tolerant genotypes genetically structured to suit the location specific stress for water and chilling weather in mountains. In high altitude rice cultivation, chilling temperature, cool water, and blast disease are the principle limiting factors. Pioneering research works on rice in high hill regions has developed the region specific and stress specific improved rice varieties with further added preferred traits (**Table 2**). *Jumli Marshi* is a high-altitude cold tolerant local rice grown very commonly in Jumla (2240-3050 m), most popular for grain quality and accounts 85% of total rice land in Jumla. *Pokhreli Mashino*, Chhommrong and Machhapuchrre-3 are also the local selections for rice area in Lumle (Sthapit 1989). Likewise, *Raksali, Silange, Sinjali, Seto Takmare, Kalo Patle, Rato Deurali, Kalo Patle, Juwari, Himali Dhan, Himali Marshi, Nani Ghaiya, Gulmi Marshi* and China-1039 were few local and exotic rice varieties that were reported cold tolerant at different growth stages from seedlings to anthesis (**Table 3** and **4**). These germplasm with cold tolerance have been used in crossing for developing the varieties to hill environments.

Table 2. Cold tolerant rice varieties and germplasm maintained by Rice Research Programme for mid- and high-hill regions in Agriculture Botany Division, NARC, Khumaltar Nepal

Variety	Origin	Released year	Maturity (days)	Plant ht cm)	Yield (t/ha)	Remarks
Palung-2	Nepal	2044 BS	172	143	6.1	Fine grain, can be grown up to 1800 meter
Chhomrong	Nepal	2048 BS	164	153	4.2	Mild cold tolerant and grown up to 2000 m.

Variety	Origin	Released year	Maturity (days)	Plant ht cm)	Yield (t/ha)	Remarks
Machhapuchre-3	Nepal	2053 BS	174	154	5.0	Mild cold tolerant and grown up to 2000 m.
Chandan Nath-1	China	2058 BS	191	92	6.0	Highly cold tolerant, black grain but hard to thresh
Chandan Nath-3	China	2058 BS	192	101	5.7	Highly cold tolerant, bold grain
NR- 10482	Nepal	Pipe line	185-190	105	5.5	Highly cold tolerant, bold grain
NR- 10479	Nepal	Pipe line	185-190	105	5.4	Highly cold tolerant, bold grain
K39-96	IRRI	Pipe line	180-185	100	5.6	Highly cold tolerant, Medium grain

Jumla (2240-3050 masl) is one of the remotest mountainous districts of Nepal. It represents high-altitude agro-ecosystem and a detailed study on genetic diversity of rice landraces has been undertaken using various approaches and tools (Bajracharya et al 2006, 2007, 2010). A number of rice landraces with different names, phenotypes and values are under cultivation in Jumla and they are well adapted to local extreme high altitude and cold environments, cultural regimes to suit the diverse traditional farming systems, agro-ecological niches, socio-cultural settings and economic standards of the farmers. *Seto Marshi, Rato Marshi, Kalo Marshi, Mehele, Darime, Palte Dhan, Rato Dhan, Seto Dhan, Jumli Rato Marshi* and just *Dhan* are the group of rice landraces identified and named by the farmers based on their agro-morphological phenotypes and adaptation to respective agro-environments. *Dhan* is the name of local rice variety in Jumla with literal meaning for small grains. Likewise, *Marshi* is the group of landraces named for bold and glutinous rice. The morphological traits especially of qualitative trait with major gene control such as colour traits are informative and farmers have used them in the ethno-botanic classification of these landraces examples: *Rato Marshi, Kalo Marshi* and *Seto Marshi* with colored to clear glumes and pericarp.

Table 3. Local rice landrace genotypes surveyed with cold tolerant gene and maintained in Agriculture Botany Division, NARC, Khumaltar, Nepal

Landraces	Preferred traits	Non-preferred trait
Jumli Marshi	Cold tolerant, Feeling full stomach for long time after eating (Aadilo)	Blast susceptible
Patle	Mild cold tolerant, Medicinal value (use for food of delivery woman as it tighten the body)	Blast susceptible
Kalo Patle	Cold tolerant, bold grain	Blast susceptible
Nani Ghaiya	Mild cold tolerant, drought tolerant	Blast susceptible, lax panicle
Raksali	Mild cold tolerant	
Pokhreli Masino	Mild cold tolerant, good fine grain	Tall
Chhommrong	Mild cold tolerant, bold grain	MR to blast
Gulmi Marshi	Mild cold and drought tolerant,	Lax panicle
Himali Marshi	Mild cold tolerant, Medium grain	Blast susceptible
Himali Dhan	Mild cold tolerant	Blast susceptible

Table 4. Exotic rice genotypes with cold tolerance used in crosses for developing the varieties for mid and high hill environments

Lines/varieties	Source	Preferred traits	Non-preferred traits
Akiyudaka	IRRI (Japan)	Cold tolerant, dense grain panicle	Dwarf
Barkat	IRRI (India)	Cold tolerant,	Lax panicle
Yunlen-1	IRRI (China)	Cold tolerant, bold grain	
Yunlen-5	IRRI (China)	Cold tolerant, bold grain	
Yunlen-9	IRRI (China)	Cold tolerant, bold grain	
Fuji-102	IRRI (Japan)	Mild cold tolerant, drought tolerant	Dwarf

Lines/varieties	Source	Preferred traits	Non-preferred traits
Bainjaiman	IRRI (USA)	Mild cold tolerant	
China 1039	IRRI (China)	Cold tolerant, medium grain	
Hexi-30	IRRI (USA)	Mild cold and blast tolerant,	
HR 17512	IRRI	Blast resistant and cold tolerant	
K39-96	IRRI	Blast resistant and cold tolerant	
SKUAT-27	IRRI	Blast resistant and cold tolerant	Dwarf
Laguna	IRRI	Blast resistant and cold tolerant	Dwarf
Gumei-2	Korea (China)	Blast resistant and cold tolerant	Dwarf
Hanereumbyeo	Korea	Mild cold tolerant and high yield	Dwarf
Milyang 223	Korea	Mild cold tolerant and high yield	Dwarf
Dasanbyeo	Korea	Mild cold tolerant and high yield	Dwarf
Suweon-526	Korea	More no. grain/panicle and mild cold tolerant	
Suweon-519	Korea	More no. grain/panicle and mild cold tolerant	
Suweon-525	Korea	More no. grain/panicle and mild cold tolerant	

Source: Rice Improvement Programme, ABD, Khumaltar

The basic information on genetic structure of these high altitude rice landraces based to socio-physical, agro-morphological and genetic traits indicate comparatively a narrow genetic base (Bajracharya et al 2006, 2010). *Jumli Marshi* is the only variety with genetic integrity in Jumla (Rana et al 2000) and possesses evolutionary potential together with cold tolerance. The morphological variations in landraces could have been developed through continuous cultivation over time and space as a process of evolution or as a result of farmers' management and selection practices for better adaptation.

Knowledge, access and use of diversity available in cultivated and wild relatives are essential for broadening the genetic base of cultivars to continue the improvement and breeding of the elite more productive and improved cultivars to suit to the harsh environments and modern cultivation techniques. Present study reviews the diversity structure of group of the rice varieties with cold tolerance in contexts to their adaptation and distribution in Nepalese mountain agricultural system. Majority of these rice varieties are under cultivation and production system in the form of landraces and also have developed improved cultivars through breeding research on cold tolerance in rice. It is an extremely valuable trait in rice with tolerance to chilling temperature in difficult mountain regions and they are of primary importance from diversity and adaptation point of views in the region. Group of rice varieties as landraces are valuable gene pool with cold tolerance however, at present they are less utilized and less prioritized in national research system, and are poorly represented. This information could be used to develop rice varieties suitable to cold tolerant regions of Nepal.

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Black Rice: A New Entry in Nepal

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सारांश

कालो धान नेपाली कृषि प्रणालीको लागि नयाँ हो । अनुसन्धानबाट यस धानको प्रयोगले मानव स्वास्थ्यमा नकारात्मक असर पर्ने घातक रोगको लागि फाइदाजनक नतिजा देखिएकोले यसप्रति उपभोक्ताहरूको आकर्षण बढ्दै गएको देखिन्छ । एन्थोसाइनिन र गामा ओराजनोल जस्ता यौगिकहरूको उपलब्धता बढी भएको कारण कालो धानको सेवनले प्राण घातक रोगबाट मान्छेलाई बचाउन सहयोग गर्दछ भन्ने धारणा विद्यमान रहिआएको छ । छोटो समयमा पाक्ने, होचो र बढी गाँज हाल्ने यो धानको उत्पादकत्व कम भए पनि उच्च बजार मूल्य र बढी मागको कारण आन्तरिक र वाह्य बजारीकरण गरी यसको खेतीबाट नेपाली कृषकले प्रशस्त आर्थिक मुनाफा लिन सक्ने देखिन्छ । यद्यपि, व्यवसायिक खेतीका लागि सिफारिस गर्नु पूर्व धानका जातीय अनुकूलनमा स्थान विशेषको अनुसन्धान जरूरी देखिन्छ ।

Summary

Black rice has multiplier benefit in human health although there are little information in Nepalese farming system on this type of rice. Black rice can be grown from Tarai to mid hill environment of Nepal. Research works have proved that it contains much higher amount of anthocyanin and gamma oryzanol which are beneficial for improving the plasma lipid profile, reducing total plasma cholesterol, increasing high-density lipoprotein (HDL) cholesterol levels and inhibiting platelet aggregation in human physiology. The cultivation of this rice has been started in Nepal by innovative farmers for the past few years. These rice varieties have extra early maturity period, they are non-sensitive to fertilizers, dwarf and high tillering. Black rice has the potentiality for export market and may have high economic returns to the farmers due to its higher market price. However, more researches focusing on yield, diseases and quality parameters should be considered before recommending the commercial cultivation of this rice in certain domains in Nepal.

Keywords: Agro-morphological, Anthocyanin, Black rice, Black rice variety

Background

High diversity in rice determines the consumers' preference on demand and price. The aromatic fine grain rice varieties have generally high price than coarse and non aromatic rice. The rice gene pool contains some special rice landraces which have high medicinal value. Black rice (*Oryza sativa* L. *indica*), a special cultivar of rice which contains a much higher content of anthocyanins in the aleurone layer than other rice (white and red rice), has been regarded as a food and widely consumed as a health-promoting food in China and other Eastern Asian countries for thousands of years. The purple pigment (anthocyanin: cyaniding-3-glucoside) in the husk (hull) and pericarp and gamma oryzanol from rice bran oil are advantageous antioxidants (Xu et al 2001, Juliano et al 2005, Vorarat et al 2010, Pitija et al 2013). Black rice contain two to three times the amount of anthocyanin and gamma oryzanol higher than did white rice (Ryu et al 1998 and Boonsit et al 2010). For gamma oryzanol, it is a mixture of phytosterylferulate esters in the rice bran oil (Bergman and Xu 2003, Boonsit et al 2010) with properties that are beneficial to health including improving the plasma lipid profile, reducing total plasma cholesterol, increasing high-density lipoprotein (HDL) cholesterol levels and inhibiting platelet aggregation (Cicero and Gaddi 2001). It is believed that the supplementation of black rice pigment fraction markedly reduced oxidative stress and inflammation, improved plasma lipid level and alleviates atherosclerotic lesions (Xia et al 2003, Ling et al 2002, Ling et al 2001). Black rice pigment fraction can reduce some cardiovascular risk factors in patients. Similarly black rice anthocyanin have both antioxidant and anti-inflammatory properties in human (Qing et al 2007).

In Thailand, black glutinous rice has been increasingly attractive as a high value-added crop and it has become a key driving force in economic development. It is grown under rainfed condition in both upland and lowland environments. Farmers mostly grow local genotypes of black glutinous rice with low yield (Saenjum et al 2012, Somsana et al 2013). In the context of Nepal it is a new crop and some of farmers in mid hills across Kathmandu periphery are trying this crop. Genebank in Khumaltar has collected some accessions of black rice. It is sometime misinformation that black rice is actually black in appearance but it is not the case and black rice is the dehulled aleurone layer of rice not the hull which farmers generally consider. Peculiar curiosity among growers, entrepreneurs and consumers about this new rice variety in Nepal is increasing mainly because of its medicinal value as claimed by the researchers of Indo China including China, Japan and Korea. The present paper was reviewed to settle some common myth and curiosity about black rice in Nepal.

Origin of black rice

Clear history about the origin of black rice is still unknown**.** Black rice was used in ancient China before Chinese dynastic times (Newman 2004) and was sometimes called emperor's rice or forbidden rice since it was used as a tribute food and prized for its rarity in ancient China. It is completely unknown how this aesthetic trait arose and has been maintained for such a long time. The genome analysis of rice landraces showed that black rice emerged in tropical japonica and its subsequent and spread to the *indica* subspecies. It can be attributed to the causal alleles of Kala 4. The relatively small size of genomic fragments of tropical japonica origin in some *indica* varieties indicates that refined introgression must have occurred by natural crossbreeding in the course of evolution of the black trait in rice (Oikawa et al 2015). The black (or purple) grain color has not been observed in any accessions of *O. rufipogon* (http://www.gramene.org). Thus, the black rice trait is most likely newly acquired, incorporated either during or after rice domestication. Compared with the broad distribution of white rice cultivars, black rice cultivars are sporadically distributed throughout Asia.

Introduction of black rice in Nepal

There is no any recorded history about the introduction of black rice in Nepal. But Prof. G.R. Tripathi of Tribhuvan University claims that it was introduced in Nepal in 2005 from China (personal communication). However, for the first time the black rice was cultivated in Rukum district of Nepal on the initiative of District Agriculture Development Office, Rukum (Kul Prasad Adhikar 2016, Personnel communication). According to Adhikari the black rice seed was introduced in 2010 by a local political leader who received it from abroad for testing. The first commercial production of black rice started at Bhukunde Besi of Kabre in 2013/014 by a politician turned farmer. There are some commercial farms producing and packaging the black rice in small pouch available at local market of Nepal that can be seen in some of the supermarkets in Kathmandu that is fetching handsome price. The consumers of black rice are urban elites who are suffering from physical anomalies including obesity and cardiovascular problems.

Cousins of black rice

Reports showed that the black rice could not be digested if it is consumed solely. It should be mixed with other types of rice and beans as is the practice in Indo-Chinese nations. The general recommendation is 15 gram per person per day. Reports suggest that the black rice is suitable for making porridge, dessert, cake, bread and noodles. It is usually consumed by mixing with other rice (Kushuhuwa 2016). The grain of black rice has similar amount of fiber to brown rice. Due to unusual color, this rice is used as condiment, dressing or as a decoration for different types of deserts in many countries in the world. The unique color makes it very popular for dessert decoration. In China and Taiwan the black rice is traditionally used in sweet or savory dish in mixed with plain rice.

Phyto-chemical profile of black rice

Black rice contents higher amount of health benefiting compounds than white polished rice. The report of Caro et al (2013) showed that black rice contents anthocyanins (3.5 mg/g), with cyanidin 3-Oglucoside and peonidin 3-O-glucoside predominating, followed by flavones and flavonols (0.5 mg/g) and flavan-3-ols (0.3 mg/g), which comprised monomeric and oligomeric constituents. Significant quantities of γ-oryzanols, including 24-methylenecycloartenol, campesterol, cycloartenol, and β-sitosterol ferulates, were also detected by them along with lower levels of carotenoids (6.5 μg/g).

Importance and salient features of black rice

Black rice varieties contain higher amount of fiber than those of white rice. Therefore, black rice is slowly digested. This rice contains an antioxidant, the anthocyanins due to which it is darker in color than other rice. Anthocyanins are linked with better heart health, cancer prevention, relieving inflammation, and increasing memory. One tablespoon of black rice contains the same or more anthocyanins than the same amount of blueberries. This makes it a stellar addition to the diet in place of other rice. This rice is naturally high in iron that causes the dense purple color, and it is high in fiber, since the bran is left on the rice. A research on physicochemical properties of black rice and white rice varieties were investigated; black rice varieties showed a higher amount of minerals, faster hydrolysis rate, and lower blue value than the ordinary white rice. This study illustrated the wide variation in the physicochemical properties of the black rice varieties analyzed (Kang et al 2011). Frank et al (2012) reported that black rice exhibited, in particular, higher levels of fatty acid methyl esters, free fatty acids, organic acids and amino acids compared to non-colored and red rice. American Health Association, the American Cancer Society and the 2005 Dietary Guidelines for Americans recommended an increase in the consumption of black rice to prevent heart disease and certain kinds of cancers (USA Rice Federation 2008). Moreover, the US Food and Drug Administration have recognized black rice as a healthy whole grain capable of reducing the risk of certain diseases. The health benefits of black glutinous rice have recently been reported by several investigators. A recent report showed that anthocyanin supplementation in humans improves LDL and HDL levels (Qin et al 2009) and can delay cancer development in rodents models of carcinogenesis (Thomasset et al 2009). Black rice may have antiatherogenic activity and may improve certain metabolic pathways associated with diets high in fructose (Guo et al 2007). Unfortunately, it is not well received by many people since it is difficult to cook and because of its distinct off taste, dark appearance and hard cooked rice texture.

Agro-morphological characters of black rice

Black rice varieties are generally dwarf types. A field trial at RARS, Khajur during 2014 showed that the average plant height ranged from 50.33 – 52.073 cm (Khadka 2016). Similarly, the length of panicle was similar with normal rice it was found to be ranged between 18 to 20 cm. Number of grain per panicle was ranged from 59 to 72. The seed was found to be bold sized. The thousand grain weight ranged from 24 to 25 gram. The black rice has higher tillering capacity than the normal rice. The Khajura experimentation showed the effective tiller per square meter was ranged from 432 to 516. The most peculiar character with black rice is the extra early maturity period. The black rice variety can be harvested between 80 to 90 days in Tarai region while it may be 100 days in mid hill area. The yield is considered to be one of the most important factors for accepting the variety as a commercial; allied with quality. The tested black rice variety was not found to be high yielding. The yield ranged from 2.1 - 2.5 t/ha which is far lower than the prevailed rice varieties. But due to the many health benefiting qualities the variety could be considered for commercial productions (Khadka 2016).

Conclusion

The quality and yield of rice is obviously determined by local micro climate and varieties. Therefore, other popular high yielding varieties of black rice should be introduced from abroad for research. The focus on yield, diseases and quality parameters should be considered before recommending for commercial cultivation in Nepal. However, this rice has higher potentiality for export as well as local market because of increasing elite consumers in the urban areas. This rice could be a good source of income for rural people and could meet the demand of rich and wealthy people of urban areas. Because consumers' awareness for quality rice is increasing in Nepalese society there may be high demand for these peculiar rice varieties in areas where living standard of people is surging rapidly, especially in city areas. The high market price and extra early maturity period can compensate the low yield with high economic return from black rice cultivation.

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Biotechnology, Genomics, GIS and CAT in Rice Research and Development

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सारांश

नेपालमा २०५७ सालबाट धानमा जैविक प्रविधि सुरु भएको हो । जैविक प्रविधि अन्तर्गतको आइसोजाइम मार्कर कृषि वनस्पति महाशाखाले प्रथम पटक धानको आनुवंशिक विविधता अध्ययन गर्न प्रयोग गरेको थियो । विभिन्न जातीय वर्णशंकर निकाल्न परागकण तथा इम्ब्रियो (भ्रुण) को उद्धार मार्फत् गरिएको थियो । धानलाई गामा किरणद्वारा उपचार गरी म्यूटेन्ट निकालिएको छ । हाल आएर डि.एन.ए. प्रविधि विभिन्न आनुवंशिक विविधता अध्ययन, निश्चित गुण भएको जात छनौट, फिङ्गर प्रिन्टिङ, डि.एन.ए. बैंकमा संरक्षण गर्न, जिन बैंकमा संकलनको व्यवस्था गर्न, जातीय गुण सुधार तथा मार्कर सहयोगी छनौट कार्य गर्न प्रयोग भएको छ । अन्तर्राष्ट्रिय धान अनुसन्धान केन्द्रबाट मार्कर सहयोगी छनौटबाट विकसित गरिएको धानका जातहरू धान बाली अनुसन्धान कार्यक्रम, हर्दिनाथमा हरेक वर्ष परीक्षण गरिन्छ । यो प्रविधिबाट विकसित गरिएको तीन वटा धानका जातहरू नेपालमा उन्मोचन गरिएको छ । धानको जैविक विविधता व्यवस्थापन गर्न भौगोलिक सूचना प्रणाली र जलवायु एनालग औजारको प्रयोग भैरहेको छ । यस्ता विकसित प्रविधिहरू बृहत् रूपमा प्रयोग गर्न सके धानमा दिगो तथा बढी उत्पादन लिन सकिन्छ ।

Summary

Rice biotechnology was started in Nepal since 2000. The first biotech tool was isozyme markers for estimating rice genetic diversity used by Agriculture Botany Division. Anther culture and embryo rescue were applied for producing double haploid and interspecific F_1 hybrids rice. Gamma ray irradiated rice mutants have been developed. DNA markers technology is now increasingly used for diversity assessment, screening for specific traits, finger printing, conservation (as DNA bank), duplicates management, genetic enhancement of landraces and marker assisted selection. Marker assisted selection (MAS) based rice genotypes introduced from IRRI have been evaluated annually in Hardinath. Three rice varieties, developed through MAS in IRRI have been released in Nepal. Geographical information system (GIS) and climate analog tool (CAT) have been applied basically to manage rice genetic resources. These modern tools need to be used extensively in rice research and development for sustainable rice production and management.

Keywords: Anther culture, DNA markers, Geographical information system, Landraces, Rice biotechnology

Introduction

Major advances in rice research are use of biotechnology, genomics, geographical information system (GIS) and climate analog tool (CAT). Their contributions are well documented in rice research and development. However, very limited study has been done in Nepal using these technologies (Abstract of 7th National Conference on Science and Technology 2016, organized by NAST; Abstract of National Biotechnology Conference 2011, organized by NARC; Abstract of National Conference on Biotechnology 2014, organized by Nepal Biotechnology Association; Proceedings of the National Seminar on Present Status and Future Prospects of Biotechnology Development in Nepal 2007, published by NARC; Joshi et al 2009, Upadhyaya 1996). Biotechnology has the potential to address problems not solved by conventional agricultural research. In addition, biotechnology may speed up research processes and increase research precision. Owing to the development of biotechnology in global scenario and richness of diversity in rice genetic resources in Nepal, there is great potentiality of biotechnology as tools for increasing rice production and promoting sustainable rice culture.

Major areas under biotechnology are marker technology, tissue culture and genetic engineering. Molecular markers are particularly useful for accelerating the breeding works with desirable traits. Diversity assessing, construction of linkage maps, gene tagging and QTL mapping using DNA markers are the very important preliminary works for marker assisted selection and gene pyramiding. Markers linked to the gene can be used to select plants possessing the desired trait and markers throughout the genome can be used to select plants that are genetically similar to the recurrent parent (Hospital et al 1992). This approach is thought to be promising in crops like rice because a number of rice cultivars are widely grown for their adaptation, stable performance and desirable grain quality. Chen et al (2000) used such an approach to transfer the bacterial blight resistance gene *Xa21* into Minghui 63, a widely used parent for hybrid rice production in China. Ahmadi et al (2001) used a similar approach to introgress two quantitative trait loci (QTL) controlling resistance to rice yellow mottle virus into the cultivar IR-64.

Tissue culture is adopted to produce double haploid lines through the anther culture reducing breeding cycles of cultivars and to overcome incompatibility barriers and to produce interspecific and inter generic hybrids through embryo culture.

Rice biotechnology

Biotechnological tools have been in use since early 1990s to improve the research works, particularly to improve the efficiency and precision of breeding works in different divisions and stations scattered across the country (Joshi et al 2009). Major institutes working in rice biotechnology are Biotechnology Division, National Agriculture Genetic Resources Centre, Seed Science and Technology Division, National Rice Research Program and Regional Agricultural Research Station, Lumle of NARC; Nepal Academy of Science and Technology, and Department of Plant Breeding of Institute of Agriculture and Animal Sciences. Biotechnology Division of NARC was established in 1998. More than 10 scientists have received training on rice biotechnology.

The first biotechnology tool used in rice research is isozyme markers, started from 2000 for diversity assessment and finger printing (Joshi and Bimb 2004, 2006, Joshi 2007). Isozymes survey was conducted both in rice landraces and wild rice species (Bimb et al 2004, Rai and Bimb 2004). Agriculture Botany Division initiated rice biotechnology since 2000 by creating facility for isozyme study and anther culture. This division gradually integrated DNA marker technology in rice breeding. NARC established Biotechnology Unit (now upgraded to Division) in 1998 under Agriculture Botany Division to look after the biotechnological works. Biotechnological tools that are used in Nepal for rice research are: anther culture, embryo rescue, isozyme and DNA markers and mutation breeding. Joshi et al (2009) has summarized the use of biotechnological tools and its achievements in rice research. Other potential tools are: genetic engineering, bioinformatics, protoplast fusion, SNP markers that can be applied in rice research and development.

Tissue culture

Callus induction from mature seeds and anther culture in rice was initiated since 2002 for double haploid production (Joshi and Bimb 2003, Sah and Bimb 2004, Niroula and Bimb 2009). Two doubled haploid lines from wide hybridization (*O. sativa* cv. Himali x *O. rufipogon*) were developed (Sah and Niroula 2007). Embryo rescue was also used in interspecific rice hybrids (*O. officinalis* with indica) (Niroula et al 2002). Tissue culture is also applied for developing submergence tolerant variety in rice by Biotechnology Division (Resham Amgai, personal communication). NRRP has also started evaluating anther culture derived rice lines received from IRRI mainly focusing on management of phosphorus uptake (Rambaran Yadav, personal communication).

DNA markers technology

Genetic diversity of many rice landraces and improved varieties have been assessed using RAPD and SSR markers (Bajracharya et al 2005a, 2005b, 2006, 2003, Sharma et al 2001, 2003, Joshi et al 2012). Results from the diversity analysis are not generally used further eg in breeding. DNA finger prints have been developed using SSR markers (Bajracharya and Singh 2011). Three Hundred and thirteen Nepalese rice accessions are screened for the presence of submergence tolerance characters using SSR markers (Tamang et al 2011). SSR based screening was also done to identify blast and bacterial leaf blight resistant (Joshi et al 2014a, Bhatta and Amgai 2012, Amgai et al 2015) and drought tolerant genotypes of rice. Anther culture lines were screened by SSR markers for determining the variants. Jumli Marshi was enhanced for blast resistance by transferring *Pi33* gene from IR-64 using SSR markers. Ninety two rice lines were screened for the presence of blast resistance genes *Pi-54, Pi-y2(t), Pi-d(t)1,Pi-z, pi-a, Pi-k, Pi-y1(t), Pi-44, pi-b, Pi-g(t), Pi-29, Pi-11, Pi-ta, Pi20(t).* In collaboration with Australian research institutes, KASP markers are applied for incorporating blast and bacterial leaf blight resistance genes in four rice varieties namely Khumal-4, Sunaulo Sugandha, Sugandha-1 and Anmol Mansuli. SSR markers were applied for evaluating Jethobudho rice landrace and for detecting parental contribution to their progenies on rice genotypes derived through participatory plant breeding (Bajracharya et al 2005c, 2005d).

Since 2012, NRRP has started evaluating DNA markers based selected rice genotypes developed by IRRI. These lines are tolerant to drought, submergence and resistance to blast. Some of QTLs were incorporated on these lines which are found very promising in NRRP. NARC has developed three varieties (namely Swarna Sub-1, Sambha Masuli Sub-1 and Sukhadhan-4) which were improved through MAS. These varieties were released from National Seed Board. In 2016, NRRP has proposed two varieties with multi traits eg blast and bacterial leaf blight resistance, drought and submergence tolerance rice developed through MAS in IRRI for release.

Genetic engineering

Genetic engineering can be applied in rice in Nepal (Bhandari et al 2013) however, it has not been initiated yet. Many discussions were done on testing Golden rice which is the product of genetic engineering enriched with pro-vitamin A. The potential area is the use of this Golden rice as a parent in rice breeding.

Conservation rice biotechnology

National Agriculture Genetic Resources Center (National Genebank) has applied biotechnological tools (especially tissue culture and molecular marker technology) for effectively and efficiently conserving and sustainably utilizing agricultural plant genetic resources (APGR) including rice genetic resources. Under the molecular marker technology, currently RAPD and SSR markers have been used for developing DNA profiles, identifying duplicates in the collections, assessing genetic diversity and screening accessions against economic traits. DNA bank has also been created for storing DNA of indigenous crops including rice (Joshi et al 2014c, Joshi 2016) and these DNA can be accessed for research and study.

Mutation breeding

Mutagens eg radioactive substances, x-rays, ultraviolet radiation, and certain chemicals cause changes in DNA structure, resulting with different genotypes in the mutant. Mutation breeding is widely used to create variation including genotypes tolerant to specific biotic as well abiotic stresses. One of the students of IAAS, TU has conducted Master Thesis on gamma ray based mutation breeding in rice. Biotechnology Division, NARC has started mutation breeding in rice (BU 2016) and gamma-ray irradiated seeds of Jumli Marshi and Khumal-4, Sabitri and Radha-4 were developed.

Rice genomics

Rice genomics is a part of rice genetics that applies recombinant DNA, DNA sequencing and bioinformatics to sequence, assemble and analyze the function and structure of genomes (the complete set of DNA within a single cell of an organism). Complete DNA sequences of rice is now publically available (http://irri.org/news/media-releases/3-000-rice-genome-sequences-made-publicly-available-on-world-hunger-day,http://shigen.nig.

ac.jp/rice/oryzabase). Sequencing and DNA profiling facilities are available in NARC and NAST however, there is no study on and use of genomics in Nepal. Information on genomics of Nepalese rice is not available.

Application of GIS and CAT

National Agriculture Genetic Resources Center (NAGRC), Soil Science Division of NARC and MoAD are using geographical information system (GIS) since 2003. Training on GIS application in agriculture research was organized by NARC in 2003 however there are very limited use of GIS particularly in rice research. NAGRC have applied GIS for wild rice management (Joshi et al 2008), gap analysis and to develop collection map of rice (Joshi 2013, Joshi et al 2014b). Analogue sites for introduction of rice landraces and adaptation trials were identified using both GIS and climate analog tool (CAT) (www.ccafs-analogues.org/tool) (Joshi 2014, Chaudhary et al 2016). Rice landraces conserved in NAGRC and accessible through GeneSys (www.genesys-pgr.org) were identified for different districts of Nepal based on the analog sites. Rice yield was estimated using GIS in 2004 (Kamal Sah, personal communication). Mapping and GIS capacity of Nepalese rice agriculturists were strengthened by conducting an international training workshop in 2013 in Kathmandu (IRRI 2013). Rice varietal mapping following conventional system were developed (CDD 2015) for which the use of GIS could enhance the result and interpretation.

GIS are designed to facilitate the integration and analysis of geographically referenced data (Mallawaarachchi et al 1996). It has a wide application and need to integrate in rice research and development. Climate analogues tool is basically useful in finding tomorrows' climate adaptation solutions today. These tools can be very effective for identifying trials sites, variety recommendation domains, and agricultural plant genetic resources management and in identifying suitable genotypes, etc.

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Hybrid Rice: A Paradigm Shift from Inbred Rice

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सारांश

विश्वमा सन् १९७३ मा सर्वप्रथम चीनका वैज्ञानिक युएन लंगपिंगले वर्णशंकर धानको विकास गरेका हुन् । यो उपलब्धी वर्णशंकर धानको विकासमा कोषेढुंगा हो । वर्णशंकर धान विकास गर्न धेरै जटिल प्रविधि समावेश हुन्छन् । ती प्रविधिमा साइटोप्लामिक पुंकेषर नपुंसकता, २–लाइन र ३–लाइन तरिका र रिस्टोरर लाइनको सफलतापूर्वक विकास गर्नुपर्छ । अन्तर्राष्ट्रिय धान अनुसन्धान संस्थाले उक्त संस्थासँग सम्बन्ध भएका देशहरूलाई यी माथिका प्रविधिहरू उपलब्ध गराई वर्णशंकर धान विकासमा सहयोग पुऱ्याउँदै आएको छ । साथै चीनबाट पनि धेरै देशलाई वर्णशंकर धान उत्पादनमा उसँग सम्बन्ध भएका देशहरूलाई यस कार्यमा सहयोग भै राखेको छ । नेपालमा वर्णशंकर धान सम्बन्धी अनुसन्धान विभिन्न धानबारे अनुसन्धान गर्ने संस्थाहरूसँगको सहकार्यमा सञ्चालन भइरहेका छन् । संसारका धेरै देशहरूले वर्णशंकर धान प्रयोग गरी धान उत्पादनमा २०–३०% बढोत्तरी गरेका छन् । नेपालले हालसम्म आफैंले वर्णशंकर धान विकास गरेको छैन तथापि छिमेकी देशहरूबाट निजी बीउ व्यवसायीहरूले केही वर्णशंकर धानका जातहरू भित्र्याएका छन् । नेपालमा वर्णशंकर जातहरू ल्याउँदा नेपालको बीउ बिजन ऐन र नियमावलीले निर्दिष्ट गरेका नियमको पालना गरी आयात गर्ने प्रावधान रहेको छ । वि.सं. २०७२ सम्म नेपालमा उच्च पहाड, मध्य पहाड र तराई गरी कूल धान उत्पादनको क्षेत्र मध्ये ७.४% क्षेत्रफलमा वर्णशंकर धानको खेती गरिएको तथ्यांक छ ।

Summary

For the first time in the world, development of hybrid rice started from Chine in 1973 by the Chinese scientist Yuan Longping. It was a milestone break through to enhance rice yield for the important crop of the world. To develop hybrid rice a complex technical consideration is involved exploiting heterosis, maintaining cytoplasmic male sterility following 2-line and 3-line procedure and restorer line for successful development of hybrid rice varieties. IRRI has developed scientific methodology for breeding inbred rice line to be supplied to collaborating countries. Many countries of the world have initiated hybrid rice cultivation and increased rice grain yield ranging from 20-30% from the inbred lines received from the IRRI and following hybrid rice production methodology developed by China and IRRI. Up to these days, Nepal has not developed hybrid rice; however, some of the hybrids have been introduced from neighboring countries by private seed traders in the country. Research works for hybrid rice in Nepal have been conducted in Nepal in coordination with various rice research institutions. In Nepal, share of area with hybrid rice varieties was 7.4% in 2015 out of total cultivated area of the country encompassing, mountains, hills and Tarai. Nepal has further clarified the import of crop varieties notification to be done through registration process and for this purpose the proponent of the seed importer should submit the proposal to the National Seed Board (NSB) as per standard rules envisaged therein.

Keywords: CMS-line, Heterosis, Hybrid vigor, Maintainer-line, Restorer-line

History of hybrid rice development

Rice is one of the most widely grown crops in the world that provides food for half of the world's population. In all of Asia, rice is the staple food grain accounting for approximately 30% of daily calorie intake, and in several countries in South and Southeast Asia, the calorie intake derived from rice is more than 50% (FAO 2014). Further, more than 140 million rice-farming households rely on rice as their primary source of livelihood (FAO 2014). Therefore, it is imperative to look for ways to enhance rice production in a limited area with limited inputs the world is ever facing. Development of hybrid rice in this regard could address the burning issues of rice production to feed the ever multiplying population of the 21st century.

Rice is a self-pollinated crop and naturally there is no development of hybrid in rice. Hybrid rice was developed in China and spread in the world. Yuan Longping, a Chinese agriculturalist, born in Qianyang, Hunan Province, China in 1930, is called the father of hybrid rice (https://en.wikipedia.org/wiki/Yuan_Longping). Professor Longping made remarkable achievements in developing first hybrid rice in the world. The achievements of Yuan Longping greatly solved the food shortage, and provided as a solution of the worldwide starvation. This achievement of developing hybrid rice in China is regarded as the fifth invention after China's Four Major Inventions, and is acclaimed as the Second Green Revolution. Yuan Longping started the research of indica hybrid in 1964. At the beginning, he discovered male-sterile rice. Yuan Longping made breakthrough in 1973 as the first person who developed indica hybrid rice. The new technology was tested in many areas of South China in 1974 and 1975, and then extended to other areas. China became the first country that is capable of producing hybrid rice. This acclaimed Yuan Longping of the first scientist who successfully altered the self-pollinating characteristic of rice and realized large-scale farming of hybrid rice. This earned him the title "Father of Hybrid Rice" (https://en.wikipedia.org/wiki/Yuan_Longping).

In the winter of 1970, a break-through for hybrid rice was streamlined on the island of Hainan when a student working under professor Yuan Longping discovered a wild rice plant that was naturally male sterile, known as a Wild Abortive (WA). This finding is considered a break-through because much of the Cytoplasmic-genetic Male Sterile (CMS) lines today have some relation to this wild abortive plant. Much of the work on hybrid rice is based on the principal of WA and CMS as a result first hybrid rice was developed by Longping in 1973 (Yuan et al 2003).

The pioneering work of Longping in hybrid rice breeding and production techniques has revolutionized rice cultivation in China, establishing China's world leading position in hybrid rice research. From 1976 to 1987, the total cultivated area of the hybrid rice developed by Yuan reached 1.1 billion mu (15 mu=1 hectares), and increased rice yield by 100 billion kg. In 1979, the hybrid rice was transferred as China's first agro-technology patent to the United States. At present, the hybrid rice developed by Yuan is planted on the farmlands all over China, which played an important role in increasing China's grain production. It made possible the feeding of 22% of the world population on only 7% of the world's total arable land (Yuan et al 2003).

China's achievements in hybrid rice R&D

China is the first country to produce hybrid rice commercially. Hybrid rice has about a 30% yield advantage over conventional pure line varieties and hybrid rice technology has helped China to increase rice production by nearly 300 million tonnes (www.fao.org/docrep/003/w8595t/w8595t02.htm). A well-established package of the technology for hybrid rice seed production would greatly boost the expansion of hybrid rice. The technology has been well developed in China to give an average seed yield of 2.3 t/ha nationwide. The first batch of rice hybrid varieties was released commercially in 1976. Since then the area under hybrid rice has been increasing year after year. It has been proved on a large scale for 20 years that hybrid rice has about a 30% yield advantage over conventional pure line varieties. China in 2015 produced hybrid rice seed of estimated 239,000 tonnes which was similar to production in 2014(USDA Foreign Agriculture Service 2015). In 2015/016 total supply of seed was estimated at 339,000 tonnes, including 100,000 tonnes in carry-in stocks. Further MoAD estimates in 2015/16 hybrid rice seed demand including domestic usage and exports at 250,000 tonnes, causing stocks to decrease to 89,000 tonnes (ibid). This implies that China is one of the lead countries in production hybrid rice seed in the world.

IRRI and hybrid rice

After China's successful development of hybrid rice technology, IRRI in 1979 started to explore the prospects and problems of using hybrid rice to increase yields. In 1989, two commercially usable CMS lines, IR58025A and IR62829A with a "WA" cytoplasm, were bred at IRRI and shared with national programs worldwide (Virmani et al 1996). Inbred line IR58025A was a stable in sterility in tropical countries while the inbred IR62829A was found having good combining ability. However, sterility of IR62829A was not stable enough for hybrid seed production under higher temperature conditions. In recent years, IRRI's capacity to breed genetically diverse CMS lines have increased and enough inbred are being developed successfully to develop hybrids. As a result, participating countries with IRRI are getting sufficient number of inbred to develop hybrids rice across the world in general and developing countries in particular.

Hybrid seed technology for the tropics has been developed at IRRI in collaboration with national programs, and the institute's technology packages can now result in a hybrid seed yield of up to 2 t/ha in the tropics. FAO considers hybrid rice technology a key approach for increasing global rice production to help meet the world's growing food requirements. It is expected that hybrid rice could play an important role in fighting world hunger in the near future. In this regard, projections of demand of rice and population increase are shown in the **Figure 1**. This again compels planners and agriculture scientists to think seriously about increase of rice production by implementing new tools which boot rice productivity to meet its demand in the foreseeable future.

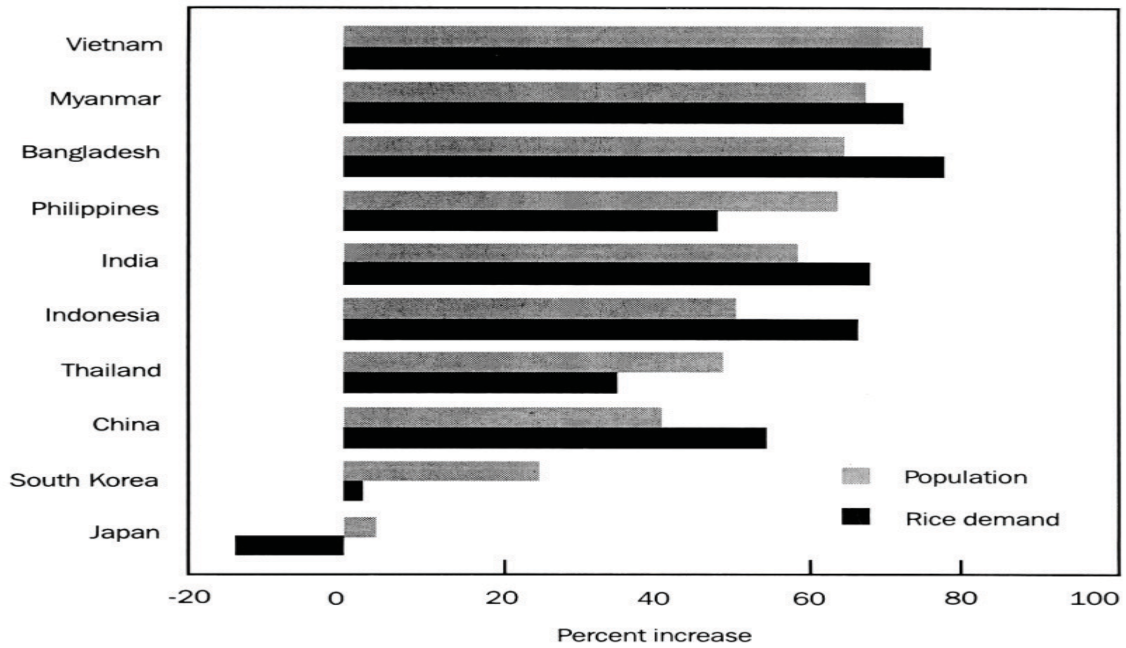

Figure 1. Projection of population growth and demand for rice 1990-2025

Source: Hybrid Rice Production Manual, IRRI 1997.

Procedure of hybrid rice development

Heterosis and hybrid vigor

Hybrid Rice Manual of the IRRI (1997) defined hybrid rice as the commercial rice crop grown from F1 seeds of a cross between two genetically dissimilar parents. Hybrids have the potentiality of yielding 15-20% more than the best inbred variety grown under similar conditions. It further explains that hybrid rice farmers have to buy fresh seeds of hybrid rice every cropping season aiding burden to farmers. Given the yield level plateau of semi dwarf varieties, there is the need to produce more rice in a limited land using less inputs. Also demand for rice is ever increasing due to burgeoning population in the rice eating zones, hybrid could perform better under adverse condition of rice production. Ultimately, to address these scenarios hybrid rice could be one of the best options.

Hybrids are produced by crossing two inbred varieties of a particular crop. Plant breeders select a number of crop lines which have desired characteristics and breeders want to introgress them in new hybrids. Selected lines are self-pollinated for several generations to create inbred “pure lines” which are homozygous and produce their exact clones. The theory behind this is that from the cross between two distinct inbred pure-line parents, the offspring will be "superior", particularly in terms of yield. This is called the "heterosis effect" or hybrid vigor, however, the heterosis effect disappears after the first generation, so it is pointless for farmers to save seeds produced from a hybrid crop (Grain et al 2000). This makes it very profitable for seed companies, since farmers need to purchase new seeds every season to get the heterosis effect each time.

Heterosis is expressed in three ways, depending on the reference which is used to compare the performance of a hybrid. Types of heterosis are: a. **Mid-parent heterosis**; the increase or decrease in the performance of the hybrid in comparison with the mid-parental value. b. **Heterobeltiosis**; the increase or decrease in the performance level of the hybrid in comparison with the better parent of the cross combination; and c. **Standard heterosis;** the increase or decrease in the performance of a hybrid in comparison with the standard check variety of the region. From the practical point of view, standard heterosis is the most important because breeders are trying to develop hybrids which are better than the existing high yielding varieties grown commercially by farmers.

Experiences of China, Vietnam and India have shown that hybrid rice offers an economically viable alternative to increase yield of rice to feed ever burgeoning population of these countries cultivar yield (Joshi et al 2003). The usual method for raising hybrids is to establish many inbred lines, perform inter-crosses and determine which hybrids are most productive in a given locality. These inbred lines should be locally adapted and perform well in hybrid combinations. The basic requisites for successful hybrid rice production are development of male sterile lines (A), maintainers (B) and restorers of fertility (R).

Cytoplasmic male sterility

As outlines in the Hybrid Rice Production Manual (1997) the use of male sterility for developing hybrid is a must which connotes "the use of a male sterility system is a prerequisite for commercial exploitation of heterosis in rice. Though several male sterility systems are known to occur in rice, cytoplasmic-genetic male sterility has been widely used for developing rice hybrids. Recent discovery of a genetic male sterility mechanism influenced by environmental factors is getting serious attention from hybrid rice breeders. To a limited extent, chemical gametocides have also been used to induce male sterility in rice".

The schematic male sterility is explained in the **Figure 2**. There are different male sterility systems which are genetic and non-genetic. Up to now both genetic and non-genetic male sterility systems are known for developing rice hybrids. These include; Cytoplasmic-genetic male sterility, environment-sensitive genetic male sterility, and chemically-induced male sterility. Chemically induced cytoplasmic male sterility system is caused by an interaction between genetic factor(s) present in cytoplasm and the nucleus. In developing rice hybrids, absence of a sterility inducing factor either in the cytoplasm or in the nucleus makes a line male fertile. Presence of certain dominant restorer gene(s) in the nucleus makes a line capable of restoring fertility in the hybrid derived from it and a CMS line.

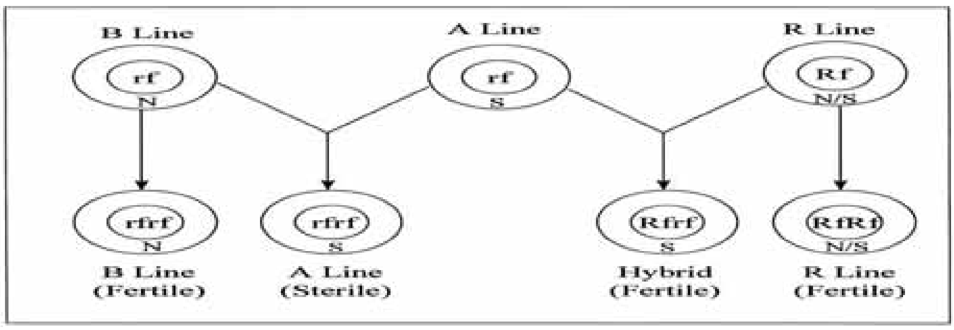

Figure 2. Schematic description of cytoplasmic genetic male sterility system

Source: Hybrid rice production manual, IRRI 1997.

The procedures outlined in this paper are entirely based on the principals given by Yuan et al (2003), Yuan et al (1995) and http://www.riceweb.org/research/Res_issyield.htm. These days, hybrid rice development in the world is mostly founded on two line and three-line explanation theories which are briefly delineated below.

Three-line and two-line explanation

As for now, there are only two ways to successfully produce hybrid rice. These two are three-line and two-line hybridization. Other methods such as a genetic switch method are still in the research and development phase.

Three-line method

The first and oldest of the two methods of producing F_1 hybrid rice is the CMS (cytoplasmic-genetic male sterility) method. This genetic code is used to produce a special sterile line of rice, referred to as CMS line or A line. The A line is male sterile chiefly because many of the CMS lines have abnormal flowering developments such as irregular anther or pollen formation. Genetically, the interaction between the cytoplasm, which is sterile, and the nucleus, which contains male sterile genes, cause the sterility. A line is the first of three lines of rice in the CMS method or three-line method. B line or the maintainer line is the second of the three lines. The only duty the maintainer line has is to multiply the A line. To do this and have offspring and still be genetically male sterile, the B and A line must be almost identical. The main difference between CMS line and B line deals with flowering. Flowering time should be the same but the maintainer line should have male fertile pollen and the abnormalities associated with the A line in the flowering process and development should be reversed.

The third line is called the restorer line (R line). The purpose for the restorer line is as a pollinator variety for pollinating the CMS line to produce F1hybrids that become normal in fertility and thus can produce seeds by selfing. The R line has some desirable characteristics that the breeder wishes to have in her/his hybrid population. It is essential for the restorer line to have strong restoring ability ie, the seed set of its F1 hybrids should be equivalent to that of a normal variety. The restorer line should also have venerable combining ability and agronomic characteristics, along with a well-developed flowering system to ensure successful transfer of pollen from R line to A line. One of the downfalls of CMS line hybrids is the amount of time and effort it takes to make a successful hybrid rice variety this way. Much of this time goes into the breeding of the hybrid seeds.

Steps in three-line hybrid rice breeding: In the source nursery, each line is grown isolated from each other and any other outside plants as to avoid accidental cross pollination until the right time. The restorer and maintainer lines are selfed there along with CMS line maintaining. After the correct number of A line and R line, seeds are made, the test-cross and re-test cross phases are next. The testcross nursery is used to test the fertility of F1 hybrids along with screening the R and B lines. Since, it is simply a test; just twenty plants are needed from each line (on average) for the testcross nursery. To identify the restoring ability of the male parent again, in the re-test cross nursery about 100 plants are grown for each combination. The re-test nursery is also used to show that F1 hybrids have normal seed set. The varieties must show normal seed setting rate so the combinations can pass on to the next stage. In addition, this is the first stage where F1 heterosis can be seen and recorded. The fourth stage, called the backcross nursery, lasts an average four to six rice generations. The reason for such a long time is to make the CMS lines and maintainer lines more similar and, also to fortify the male sterility in the CMS line. The next stage is where the evaluation of heterosis starts. The Nursery for Evaluating Combining Ability is used to test and select the best CMS and R line combination. The sixth and seventh stages differ only in size.

Replicated yield trial uses the promising selections from the Nursery for Evaluating Combining Ability to see how each combination does when put up against one another. The plot size is normally larger than 1.3 hectares. The Trial is held over a one- to two- year period, and performance is based on agronomic characteristics, visual observations, and other qualities deemed necessary for combinations to be passed on to the advanced yield trials (next stage).

The advanced yield trials determine how the new varieties will perform in different environments. These trials are held in farmers' fields from specific ecological and geographical locations. The trial along with the locations should be carried out according to the standard regulations of the area and commercial industry. After the trials, those combinations deemed worthy are officially named, marked, and put into production according to amount of interest in each combination. Also any of the steps can be by passed if an outstanding combination is found.

Steps in two line hybrid rice breeding

The second method for producing hybrid rice uses a plant type that has an abnormality in the section of gene that dictates whether the plant is male fertile or sterile depending on day- and/or temperature-length. This type of plant is known as **Photo or Thermal-sensitive Genetic Male Sterile variety (P[T]GMS)**. Because the plant's male sterility can easily be controlled with variations in natural conditions a restorer line is no longer needed. This fact significantly cuts down the time it takes to produce new hybrid varieties because breeders no longer have to make restorer lines and check them every generation for the restoring ability. Although it is easier to control male sterility both temperature and day length must be factored in for P (T) GMS line breeding. Those temperatures that drastically affect the plant's sterility, so much that day-length has little effect on sterility are normally hard to achieve. Because of the degree of difficulty most breeders must factor in length of daylight at the plots they use.

Although pure PGMS lines have not yet been found, mostly TGMS lines have been bred. The key point for practical usable P(T)GMS lines is for the sterile parent to have very low critical male sterility-inducing temperatures. These lines are more useful in place of high temperature regions of tropics and subtropics climate around the equator. As the alternative name for P(T)GMS method are only two lines in P(T)GMS type breeding. One is the P(T)GMS variety, which is switched to sterility before flowering. The second is the pollen parent or male parent. This parent is compatible with the particular P(T)GMS variety chosen and it contains feature and/or heterocyst that the breeders wish to add. When producing hybrids with the two-line method there are only two primary steps; step one is the growing of plants in the source nursery. This, like that of the CMS line breeding, is used to produce seeds for the next step. Both P(T)GMS plants and male parents are produced. The second step is the test cross-nursery, where the two types of plants are crossed. From this nursery, pollen parents who's F_1 hybrids show strong heterosis or desirable traits and high seed setting rate are chosen for further evaluation before becoming a registered restorer line for that particular P(T)GMS line.

Comparison between P(T)CMS lines and CMS lines for hybrid rice production

Benefit of P(T)GMS line breeding of hybrid rice system over CMS line for producing hybrid rice might be evident that P(T)GMS line breeding has a rather large advantage over CMS line. The amount of time it takes to make a P(T)GMS hybrid from start to finish, on the average, is shorter than that of CMS line breeding. However, CMS line breeding has its strengths. The main benefit that breeders and producers have when they use CMS line for hybrids is the fact that three-line system sterility is usually very stable. Only very extreme stresses can force a change to fertility, and usually these stresses kill or greatly harm the plant. However, the restorer gene is a very specific and strong gene and because of this only five percent of the germplasms (source varieties) can naturally restore the fertility. This restorer gene is also hard to maintain because of its specificity. So to make sure each generation of restorer line has the restorer gene, a test-cross has to be performed on each generation after multiplication. The P(T)GMS is opposite of three- line in pros and cons. The largest obstacle when producing a successful hybrid line through this method is the fact that P(T)GMS genes are greatly affected by temperature fluctuations. One way scientists think they can solve this problem is by making or finding a complete Photo Genetic Male Sterile (PGMS) plant variety. If varieties were only PGMS then only light control would be used. This premise cannot be put into use until a pure PGMS line is found. Until then scientists must make a region specific hybrid, because temperature flux from lab to field conditions is major problem.

This problem of how P(T)GMS gains and losses it fertility is also the main positive point for two line system. Because of how two-line sterility works within the cell, more than 95% of germplasm (source verities) can be used to restore the sterility of P(T)GMS. This allows a much larger gene pool to be tapped into, thus increasing the genetic variation within hybrid rice.

Transfer of CMS source into an elite line

By now it has been explained about the process of hybrid rice development. It is worthy to note that CMS line should be transferred to an elite line for producing hybrid rice. Hybrid rice breeding manual (1997) has outlined procedure of transfer of CMS source into an elite line (**Figure 3**). According to the manual elite lines are first testcrossed with the CMS line of a desired cyto-sterility source to test their maintaining ability. Those elite lines which are identified as maintainers are repeatedly backcrossed up to six generations for complete transfer of cyto sterility source (**Figure 3**).

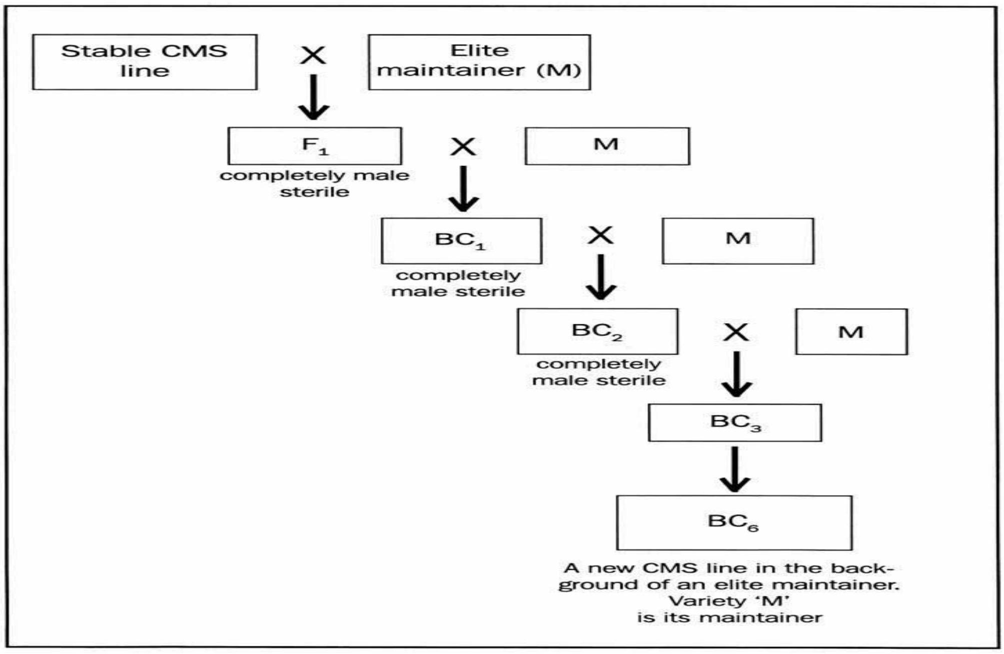

Figure 3. Identification of new CMS sources in inter-specific crosses

Source: Hybrid Rice Production Manual, IRRI 1997.

Hybrid rice breeding manual (1997) delineates some of the characteristics of a commercially usable CMS line should be: an ideal CMS line should have stable male sterility over environments; adaptability to target environment for which rice hybrids have to be developed; easy restorability so that many elite lines can be used as male parents; good out crossing ability to result in higher seed yield; good combining ability; and good grain quality so that rice hybrids can be developed with acceptable grain quality.

Situation of hybrid rice cultivation in Nepal

The hybrid rice is reported to be introduced unofficially in Nepal since early 2000 through India Nepal boarder. Most of the hybrid varieties of rice are introduced by private seed traders in the country. Hybrid seeds are mostly imported either from India or China. Farmers are using hybrid varieties of rice for their higher yield potentiality. However, cases of not setting of seeds in hybrid varieties have been noticed in some parts of the country. The latest example of such incidence was noticed in Bhaktapur district in 2014, where farmers used non recommended hybrid rice variety (DY-69). As a result, no seeds were set due to neck blast. Nepal has not become able to develop own hybrid rice variety within domestic territory. We are completely dependent on exotic hybrid rice seeds for paddy production. The official process of registration of imported hybrid rice seeds in Nepal started in 2010. The hybrid varieties: DY 18, DY 28 and DY 69 were the registered for the first time in Nepal by National Seed Board (NSB). As of 2016, a total of 30 hybrid rice varieties were registered by National Seed Board (NSB) (CDD 2015 and www.sqcc.gov.np 2016) The registered hybrids rice in NSB have yield potentiality of 5-7 t/ha which is not so encouraging compared to inbred rice varieties having grain yield potentiality ranging from 3.5 to 9 t/ha (AICC 2016).

It has been reported that the share of area with hybrid rice varieties was 7.4% in 2015 out of total cultivated rice area in Nepal. Western Tarai region has the highest share of area (55.04%) followed by mid-western Tarai (18.10%) and the central hills (8.09%). In totality, hybrid rice coverage in Nepal is reported for Tarai 83.00% followed by hills 16.79% and mountains 0.22% of the total hybrid rice area in the country. Hybrid varieties have been cultivated in 39 districts of the 75 districts in Nepal for which 3 districts fall under mountain, 19 under hills and 17 under Tarai of Nepal (CDD 2015). **Table 1** below shows percentile area under hubrid rice cultivation under different agro-ecological domains of Nepal.

Table1. Percentile area under hybrid rice varieties coverage in different agro-ecological domains in Nepal

Development region	Ecology							
	Mountain		Hill		Tarai		Overall	
	Area	%	Area	%	Tarai	%	Area	%
Eastern	0	0	296	0.26	2891	2.54	3187	2.80
Central	149	0.13	9209	8.09	7138.87	6.27	16497	14.48
Western	0	0	6520	5.73	62690	55.04	69210	60.77
Mid-Western	0	0	3096	2.72	20618.08	18.10	23714	20.82
Far-Western	102	0.09	0	0	1180	1.04	1282	1.13
Total	251	0.22	19121	16.79	94525.94	83	113890	100

Source: CDD 2015.

Present research status of hybrid rice under NARC

Nepal Agricultural Research Council (NARC) is the formal institution to carry out agricultural research works for technology generation in Nepal. Hybrid rice technology is new to the country and is dependent on neighboring countries and the international institutions. NARC conducts research in hybrid rice in cooperation with various research institutions within and outside the country. The cooperation and the source of germplasm for hybrid rice research in Nepal can be explained in the following ways.

Germplasm from International Rice Research Institute (IRRI)

National Rice Research Program (NRRP) started hybrid rice research since 2002 receiving the germplasm through INGER network of IRRI. It was continued up to 2005 and it was interrupted as IRRI's policy was changed and it started to give the hybrid germplasm to only the countries who are the members of hybrid rice research consortium. Nepal received the membership in 2011 and again continued receiving the germplasm. In 2012, a total of 25 hybrids were

Figure 4. Seed increasement of parental line of hybrid rice at NRIP at Hardinath 2016

brought from IRRI and studied at NRRP, Hardinath. Result of the study of hybrid rice in 2004, 2005 and 2012, identification of the best hybrids that gave 30-40% higher yield than popular inbred variety Sabitri (Khatiwada et al 2014). The parental lines of rice hybrids are called A (male sterile line), B (maintainer line) and R (Restorer lines). The A, B, R lines of 24 hybrids along with the best identified hybrids were brought from IRRI again in 2014. The practice of seed production and maintenance of eight hybrid varieties were started in 2014 and continued after 2014 up to now (2016) at NRRP, Hardinath. The result of the study is encouraging and in coming 2-3 years it is expected that at least one hybrid could be identified and registered for general cultivation to the farmers in Nepal.

Hybrids from seed companies of India and China

Hybrid rice evaluation from seed companies of India and China was started since 2009. Hybrids from mostly India and few from China (DY Series) were studied in NARC research stations and under farmers' field. Evaluations were done mostly for two years for grain yield, agronomic traits and tolerance to major diseases. The best hybrids giving significantly higher yield than popular inbred variety or old hybrid varieties were started to be registered by the National Seed Board, Nepal. The grain yields of those hybrids were found 10-30% higher in general than the best inbred varieties. Hybrids introduced from various private seed companies are studied each year in four locations of Tarai (Tarahara, Hardinath, Parwanipur and Nepalgunj). In 2016, a total of 90 hybrids are under evaluation in these locations and 10 hybrids introduced from Indian and Chinese seed companies are also under evaluations in four locations of mid hill region (Khumaltar, Pakhribas, Kavre and Dailekh).

Collaboration with Yuan Longping High Tech Agriculture Company Limited in China.

China-Nepal Technical co-operation project has been launched between NARC and LPHT (Yuan Long Ping High Tech Agriculture Company limited) China for three years starting from February 2016. The project includes the research in hybrid rice and maize with major emphasis on rice. The project has included two activities in rice as below.

Evaluation of 45 rice hybrids in Khumaltar, Lamjung and Hardinath representing mid hill, river basin and Tarai respectively. Experiments are being conducted in three replications in randomized block design in barkhe rice season (June/July/October/November) 2016.

Identification of restorer lines

The research activities mentioned above have been undertaken at the Agriculture Botany division, Khumaltar, Lalitpur. Both the 50 male and four female parents (male sterile lines) were planted in three different dates starting on 25th May. Crosses were performed on four female and selected 25 male lines to identify the best restorer lines. Studies are going on to identify the suitable restorer lines. LPHT has also assigned five Chinese experts to work at the Agriculture Botany Division Khumaltar for implementing the project smoothly. These activities would assist to develop the suitable hybrid rice varieties in the coming years.

Implications of hybrid rice in Nepal

The self-sufficiency in rice has become a burning social and political issues in Nepal at present. Several voices of people demanding the bumper production of rice are heard in every streets of country. Heavy imports of rice sometimes becomes the headlines of national newspapers. There is no doubt to say that hybrid rice seeds increase the productivity of rice. Rice productivity growth is critical to improving the livelihoods of households in Nepal. Higher yields increase on-farm incomes and ensure supplies of rice that reduce or stabilize prices for both urban and rural food-insecure households. In such circumstances, some people argue to promote the hybrid rice production in Nepal. However, the promotion of hybrid rice in Nepal has always become the matter of discussion in Nepal. The promotion of hybrid rice technology has created the floor for serious discussion in the existing situation. Some of the people including technicians argue that hybrid rice is a means of reinvigorating stagnant yield growth in rice, boosting rural incomes, and stimulating private investment in rice improvement, while some other people believe that introduction of hybrid rice technology in the existing technical and infrastructural arrangements is not sufficient for the country and the Nepalese farmers. Some of the implications of promotion of hybrid rice technology in Nepal are discussed below.

Farmers are unable to manage existing available recommended production technology to harness the potential yield of even for inbred rice varieties which has become the major constraint to increase the production and productivity of rice in Nepal. In this situation, rice system cannot be made sustainable through hybrid rice technology which requires careful and sensitive management. The annual purchase of hybrid seeds of rice are too costly for many resource poor small scale farmers, they need to buy hybrid rice seed every year. So, the purchasing power of Nepalese farmers may not support to use such and expensive hybrid seeds. As the production cost for hybrid seeds is expensive, the price of seeds will also be higher. Similarly, at he same time, the use of hybrid rice seeds in paddy field increases the uptake of fertilizers and waters. The fertilizer consumption will be increased three times compared to present consumption status. This supply is based on import. The existing service delivery system has not been able to provide appropriate production technologies to harness the yield potentiality of inbred varieties of self-pollinated crop like rice and open pollinated varieties of cross pollinated crop like maize. In Nepal, it has been noticed that the hybrid rice seed business are generally run by private seed traders. The transaction of hybrid rice seeds are generally based on profit motives. The existing marketing practices show that the hybrid rice seeds cost around NRs 150-250 per kg which is 4 to 5 times higher than the price of inbred rice varieties. This raises the issues that how farmers can afford such expensive hybrid rice seeds every year.

Hybrid rice production is a labor intensive technology. In recent years, it has been reported that the commercial farmers of China have started giving priorities to the seed production of inbred rice varieties due to higher seed cost of hybrid rice. Hybrid rice producing mega seed companies of China are concentrating seed production activities to Vietnam, Burma, Philippines where the labor wage rate is cheaper.

However, there is no argument that hybrid rice technology is an emerging technology in the world generated to increase the production and productivity of rice. In order to promote the hybrid rice technology in Nepal, the capacity should be developed in producing F1 seeds by developing Nepalese inbred lines and distribute them to Nepalese farmers. National Seed Vision (2013-2025) has envisioned to develop a total of 13 hybrid rice varieties till 2025 (NARC- 8 and Private sector- 5 varieties). NRIP, Hardinath has started to test hybrid rice varieties made available from China and IRRI. The government should give emphasis on high investment, high technical manpower development and high management for hybrid rice variety development, seed production and their maintenance in the country. Hybrid rice provides the technology platform on which both private-sector scientists and entrepreneurs can make profitable and socially beneficial enterprises.

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Quantitative Trait Loci Mapping and Marker Assisted Selection in Rice

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सारांश

विभिन्न महत्वपूर्ण गुणहरूसँग सम्बन्धित आणविक चिन्हहरूको आविष्कार पश्चात् अन्य बालीहरूमा जस्तै धान बालीको प्रजनन् र आनुवंशिकी अनुसन्धानमा धेरै प्रगति भएको छ । उत्पादकत्व लगायत अधिकांश आर्थिक दृष्टिले महत्वपूर्ण गुणहरू कम असरयुक्त धेरै अनुवंश (जीन) हरूले निर्धारण गरेका हुन्छन् जसलाई मात्रात्मक गुणहरू भनिन्छ र यीनै मात्रात्मक गुणहरू निर्धारण गर्ने केन्द्रिका रेशा (क्रोमोजोम) को क्षेत्रलाई मात्रात्मक गुण क्षेत्र (क्यूटियल) भनिन्छ । विभिन्न आणविक चिन्हहरूको सहायताबाट क्रोमोजोमको कुन भागमा कुन क्यूटियल छ भनेर अंकित गर्ने कार्यलाई क्यूटियल म्यापिङ्ग भनिन्छ । हालैका केही वर्षमा नेपालका प्रचलित जातहरू सावित्री, स्वर्ण र आई.आर.६४ बाट विकसित लाइनहरूमा पनि सुख्खा सहने गुणयुक्त क्यूटियल म्यापिङ्ग भएका छन् । विविध आनुवंशिक पृष्ठभूमिमा लगातार एकै खाले असर देखाएका त्यस्ता क्यूटियलहरूलाई आणविक चिन्हहरूको सहायताबाट पश्चसंकरण (ब्याक क्रसिङ्ग) गरी प्रचलित जातहरूमा सार्न अति आवश्यक भएको छ । आणविक चिन्हहरूको सहायताले दोस्रो पुस्तापछिको हजारौं बोटहरूबाट आवश्यकता अनुसारका बोटहरूको छनौट गर्ने र प्रजनन् चक्र छोट्याउने कार्यलाई आणविक चिन्हसहयोगी छनौट (मास) भनिन्छ, जसले धान लगायत विभिन्न बालीहरूको प्रजनन् र सुधारमा क्रान्तिकारी परिवर्तन ल्याएको छ । नेपालमा हालसालै सिफारिस गरिएका सुख्खा धान-१ देखि सुख्खा धान-६ सम्मका सुख्खा सहने जातहरू तथा स्वर्ण सब-१, साँवा मसुली सब-१ र सिहेराङ्ग सब-१ जस्ता डुवान सहने जातहरू मास प्रविधिबाट विकास गरिएका जातहरू हुन् । सुख्खा र डुवान सहने गुणका अलावा विश्वमा धान बालीका धेरै गुणहरू (धेरै फल्ने, रोगहरू नलाग्ने, चिसो, तातो र लवण सहने, खान मीठो, बासनादार आदि) निर्धारण गर्ने क्युटियलहरू पत्ता लागेका छन्, जसको यथोचित प्रयोगबाट हाम्रा प्रचलित जातहरूको सुधार गर्नु आजको आवश्यकता भएको छ ।

Summary

Like in other crops, many advances have been made in rice breeding and genetics after the discovery of molecular markers associated with various functional traits. Most of the economically important traits including grain yield are controlled by several genes with smaller individual effects known as quantitative traits and the genetic region in the chromosome responsible for expression of quantitative traits is called Quantitative Traits Locus (QTL). Detecting and locating such loci in the chromosome with the help of various DNA markers is termed as QTL mapping. In recent years, Nepalese scientists have also mapped some of the QTLs responsible of grain yield under drought condition on the history of popular varieties: Sabitri, Swarna and IR-64. Those QTLs with large and consistent effects in multiple genetic backgrounds need to be transferred to the popular varieties through marker assisted backcrossing (MAB). Selection of desired individuals from segregating populations with the help of molecular markers in order to accelerate breeding cycle is known as Marker Assisted Selection (MAS) which has revolutionized the crop improvement process including rice breeding. Some recently released drought tolerant varieties: Sukhkha Dhan-1 to Sukhkha Dhan-6 as well as submergence tolerance varieties: Swarna Sub-1, Samba Masuli Sub-1, Ciherang Sub-1 are rice varieties developed through MAS. Globally, in addition to drought and submergence tolerance, several QTLs responsible for different traits (higher yield, diseases resistance, cold, heat and salinity tolerance, taste, aroma, etc) have been identified and such QTLs need to be utilized to improve popular rice varieties of Nepal through MAB.

Keywords: Backcrossing, Markers assisted selection, Molecular markers, Quantitative trait loci

Background

Just as the human individuals plants also have their heritable characters to be distinguished from others such as morphological, physiological and biochemical characters. Those characters are of two types: qualitative (governed by one or few genes like color, shape, etc) and quantitative (governed by many genes like yield and yield attributing traits). Characters that can be easily identified are known as markers. Markers are of different types: morphological (can be seen by external morphology), biochemical (distinguished by variation in proteins and enzymes), cytological (different in chromosomal shape and size) and molecular or DNA markers (distinguished by a DNA fragment) (Joshi 2017a). Molecular markers have been used for evolutionary study and genetic diversity assessment, gene mapping and genotypes selection. After the development of different DNA markers, crop breeding has been revolutionized with their uses in selection process.

QTL mapping

Most of the economically important traits including grain yield are inherited quantitatively presumed to be controlled by large number of genes and highly dependent on the environment. The exact number, mode of action and location of these genes is difficult to be ascertained through Mendelian analysis. The individual effect of polygenes is too small to be detected separately and these are expected to be located on several chromosomes. This makes the study for these quantitative traits more difficult. The chromosomal region or locus where the genes responsible for the expression of quantitative traits are located is called quantitative trait locus (QTL). The identification and location of such QTLs with the help of molecular markers is called QTL mapping. QTL mapping requires densely saturated molecular marker map to identify each and every segment of the genome and suitable mapping population segregating for QTLs. The process undergoes with three main steps: 1) phenotypic evaluation of a relatively large number of plants from a segregating population, 2) genotyping of whole population with polymorphic genetic markers and 3) statistical analyses to identify the loci that are affecting the trait(s) of interest. Such mapping studies are performed to detect the tight linkage of a molecular marker to a gene of interest. Large numbers of SSR markers distributed on the entire genome of rice have been developed (McCouch et al 1997). Molecular marker technology has facilitated dissecting the complex nature of these traits (Wang et al 2001).

Principle of QTL analysis

Identifying a gene or QTL within a plant genome is like finding the proverbial needle in a haystack. However, QTL analysis can be used to divide the haystack in manageable piles and systematically search them (Collard et al 2005). In simple terms, QTL analysis is based on the principle of detecting an association between phenotype and the genotype of markers. Markers are used to partition the mapping population into different genotypic groups based on the presence or absence of a particular marker locus and to determine whether significant differences exist between groups with respect to the trait being measured. A significant difference between phenotypic means of the groups, depending on the marker system and type of population, indicates that the marker locus being used to partition the mapping population is linked to a QTL controlling the trait.

Bulk Segregant Analysis (BSA)

QTL analysis is usually carried by genotyping mapping population consisting of individual progenies. Each of the progenies has to be genotyped with all the markers selected to cover the genome. Whole genome scanning of all individuals in a large recombinant inbred line (RIL) population to identify the donors of alleles or QTLs with large effects on grain yield under stress for conventional QTL analysis requires high cost. Bulk Segregant Analysis (BSA) is an efficient form of selective genotyping where in DNA samples of extreme individuals from each tail of a phenotypic distribution for a given trait are pooled and the two resultant bulks are genotyped (Michelmore et al 1991). Markers linked to a QTL affecting the trait are expected to be present at different frequencies in the contrasting tails, resulting in polymorphic expression of genotype signals (eg bands on an electrophoresis gel) between the two bulks. BSA has been reported to detect large-effect QTLs for grain yield of rice under stress cheaply and quickly.

Importance of QTL mapping for crop improvement

The identification of genes and QTLs and DNA markers that are linked to them is accomplished via QTL mapping. QTL mapping thus represents the foundation of the development of markers for MAS in crop improvement. Previously, it was generally assumed that markers could be directly used in MAS. However, there are many factors that influence the accuracy of QTL mapping such as population size and type, level of replication of phenotypic data, environmental effects and genotyping errors. These factors are particularly important for more complex quantitative traits with many QTLs each with relatively small effects (eg drought tolerance, yield). The major problem associated with QTL analysis is that the individual QTL effects are small. The efficiency of QTL may also be reduced when the interaction of environment and genes affect largely the final phenotypic trait.

QTL Mapping of rice in Nepal

QTL mapping of rice has not yet been started in Nepal in lack of well-equipped laboratories. However, Nepalese scientists studied different mapping populations in the background of popular varieties of Nepal for drought tolerance at International Rice Research Institute (IRRI). Bulk Segregate Analysis (BSA) approach was applied to identify QTLs showing a consistent effect in the background of two popular high-yielding varieties, Swarna and IR64, grown on millions of hectares in South and Southeast Asia including Nepal. RIL populations were developed from crosses involving traditional drought-tolerant donor Dhagaddeshi as a male parent and Swarna and IR64 as female parents. The first QTL $qDTY_{1.1}$ was reported in the chromosome 1 to show a consistent effect in both IR64 and Swarna backgrounds as a suitable candidate for use in marker-assisted breeding to improve modern high-yielding but drought-susceptible varieties and to help farmers in obtaining sustainable yield under drought stress (Ghimire et al 2012).

Similar approach was also used to detect QTL in the background of popular Nepalese variety Sabitri. Mapping population developed from the cross IR77298-5-6-18/2*Sabitri was tested under severe reproductive-stage drought at IRRI and under naturally occurring drought and non-stress conditions at NRRP, Hardinath (target environment). A large-effect QTL ($qDTY_{3.2}$) explaining 23.4% of the phenotypic variance under severe lowland drought was detected on chromosome 3 and introgression of this QTL for the rapid improvement of the drought tolerance of popular variety Sabitri is undergoing (Yadaw et al 2013). Likewise, backcross inbred line (BIL) population developed from the cross of IR74371-46-1-1 (Sukhkha Dhan-1) and Sabitri was studied in IRRI and RARS, Nepalgunj. IR74371-46-1-1 is a backcross-derived line from Way Rarem (Way Rarem/2*IR55419-04). Way Rarem is upland adapted variety from Indonesia. A major grain yield QTL under drought ($qDTY_{12.1}$) was detected on chromosome 12 with a high and consistent effect (AE-23%) across two environments: Los Banos, Philippines, and Nepalgunj, Nepal (Mishra et al 2013). Sabitri is also used for QTLs analysis in China (Joshi et al 2017).

Marker Assisted Selection (MAS)

The development of molecular markers has irreversibly changed the disciplines of plant genetics and plant breeding. While there are several applications of DNA markers in breeding (Joshi 2017a), the most promising for cultivar development is called marker assisted selection (MAS). Phenotypic selection is difficult for quantitative characters with low heritability for which MAS approach is very effective. Plant breeders typically work with hundreds of populations, which often contain large number of individuals.

MAS (also ‘marker-assisted breeding’ or ‘marker-aided selection’) may greatly increase the efficiency and effectiveness in plant breeding compared to conventional breeding methods. Once markers that are tightly linked to genes of interest are identified, prior to field evaluation of large numbers of plants, breeders may use specific DNA marker alleles as a diagnostic tool to identify plants carrying the genes. MAS approach has following advantages.

- Time saving from the substitution of complex field trials with molecular tests,
- Elimination of unreliable phenotypic evaluation associated with environmental effects,
- Selection of genotypes at seedling stage,
- Gene pyramiding or combining multiple genes simultaneously,
- Avoidance of the transfer of undesirable or deleterious genes (linkage drag, this is of particular relevance when the introgression of genes from wild or distant relatives is involved) and
- Selection of traits with low heritability.

Marker-assisted backcrossing

Backcrossing is subsequent crossing between progeny with the recurrent or recipient parent. The use of DNA markers in backcrossing greatly increases the efficiency of selection. As in other marker assisted breeding schemes, markers may be used for selection of the target gene or QTLs. However, MAB may differ from other marker assisted breeding schemes because additional markers may be used for purposes other than target locus selection, in order to minimize linkage drag and accelerate the recovery of the recurrent parent. Therefore, if tightly-linked markers, flanking QTLs and evenly spaced markers from other chromosomes (ie unlinked to QTLs) of the recurrent parent are used for selection, the introgression of QTLs and recovery of the recurrent parent may be accelerated. This process is called marker-assisted backcrossing. Therefore, considerable time saving can be done by using markers compared to conventional backcrossing which is also known as early generation selection (**Figure 1**). Although the initial cost of marker-assisted backcrossing would be more expensive compared to conventional breeding in the short term, the time saving could result in economic benefits. This is an important consideration for plant breeders because the accelerated release of an improved variety may translate into more rapid profits by the release of new cultivars in the medium to long-term (Morris et al 2003).

Marker assisted pyramiding

Pyramiding is the process of simultaneously combining multiple genes/QTLs together into a single genotype. Genes controlling different agronomic traits can be pyramided together to ensure that a variety may simultaneously acquire several traits, such as: drought resistance, blast resistance, suitable amylose content, etc. DNA markers may facilitate selection because DNA marker assays are non-destructive and markers for multiple specific genes/QTLs can be tested using a single DNA sample without phenotyping. The most widespread application for pyramiding has been for combining multiple disease resistance genes in order to develop durable disease resistance. One of the most intuitive stages to use markers to select plants is at an early generation (especially F_2 or F_3). The main advantage is that many plants with unwanted gene combinations, especially those that lack essential disease resistance traits and plant height, can be simply discarded. This has important consequences in the later stages of the breeding program because the evaluation for other traits can be more efficiently and cheaply designed for fewer breeding lines.

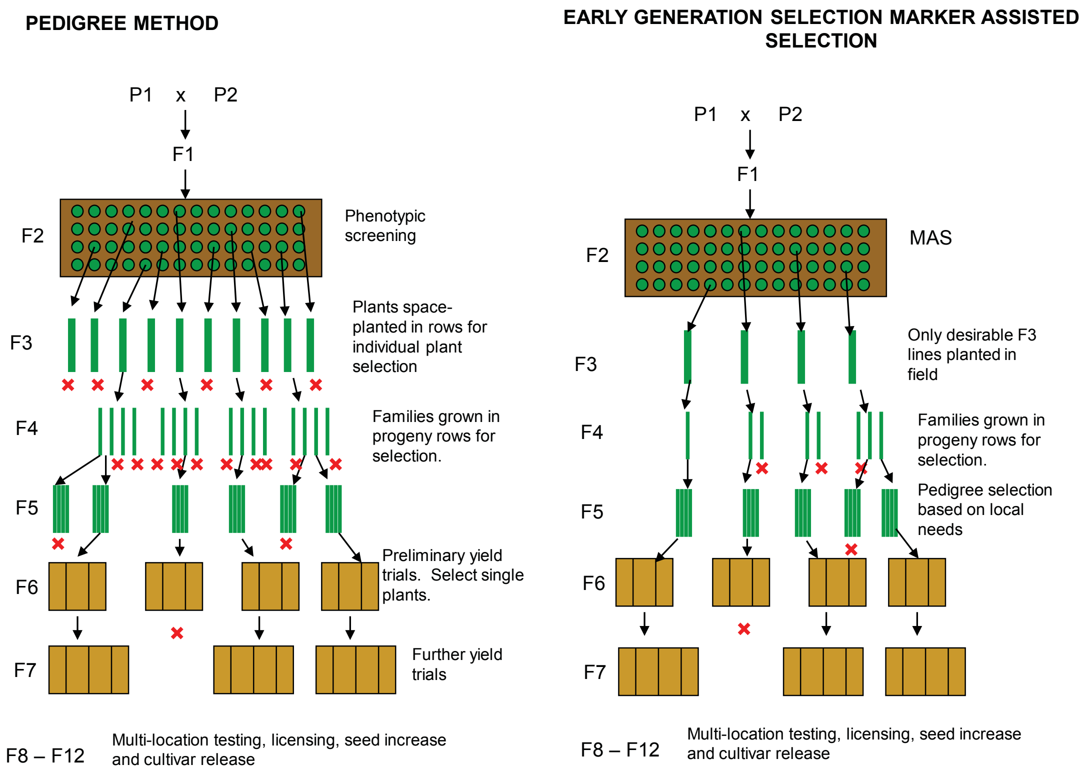

Figure 1. Early generation selection scheme

Source: Proposed by Ribaut and Betran 1999.

MAS for rice breeding in Nepal

In recent years, many research stations in Nepal have started using DNA technology especially in crop breeding program. Major focus in the past was on genetic diversity assessment (Bajracharya et al 2006, Joshi et al 2009, Joshi et al 2012) and now MAS is being practiced in major crops. MAS has been applied to identify blast and bacterial leaf blight resistance plants in rice. Some of the released varieties like Swarna Sub-1, Samba Masuli Sub-1 and Siherang Sub-1 for submergence tolerance as well as Sukha Dhan-1, 2, 3, 4, 5 and Sukhkha Dhan-6 for drought tolerance in Nepal are the contribution of MAS technology.

SSR based screening was also done to identify blast and bacterial leaf blight resistant (Joshi et al 2014a, Bhatta and Amgai 2012, Amgai et al 2015) and drought tolerant genotypes of rice. KASP markers are applied for incorporating blast and bacterial leaf blight resistance genes in four rice varieties (Joshi 2017b). SSR markers were applied for evaluating Jethobudho rice landrace and for detecting parental contribution to their progenies on rice genotypes derived through participatory plant breeding (Bajracharya et al 2005a). Aroma in local rice landrace was also study by SSR marker (Bajracharya et al 2005b).

Way forward

The horizon of rice breeding has broadened drastically after the advancement in genomics. The unconventional approaches ie QTLs and MAS tools to breeding create new possibilities which were otherwise impossible to achieve through conventional methods. Several factors will greatly affect the efficiency and effectiveness of QTL mapping and MAS research in the future such as: new developments and improvements in marker technology, the integration of functional genomics with QTL mapping, and the availability of high-density maps. It is anticipated that in the future, novel applications and technology improvements will result in a reduction in the cost of markers, which will subsequently lead to a greater adoption of markers in plant breeding. These unconventional approaches in rice breeding tends to receive more attention from funding agencies than the conventional approach in developed countries, partly because of their novelty and advertised potential, as well as the glamour of the technologies involved which can easily attract the younger generation. Laboratory facilities/networks for marker genotyping need to be established and/or strengthened within the country especially in NARC system so that these tools could widely be applied in crop improvement including rice breeding in Nepal.

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Recent Advances in Genetically Modified Rice: Implications to Rice Farming System in Nepal

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सारांश

धान संसारमा दोस्रो र नेपालमा पहिलो खाद्यान्न बाली हो । विगत तीन दशक यता धान बालीको अनुवंश परिवर्तन प्रणालीमा व्यापक विकास भई यसको माध्यमबाट उत्पादित अनुवंश परिवर्तित धानका बिरुवाहरूमा जैविक र अजैविक प्रतिरोधी क्षमतामा वृद्धि, गुणस्तर, पौष्टिकतत्वमा सुधार र औषधी तथा औद्योगिक प्रयोजनको लागि थप उपलब्धी हासिल भएका छन् । अधिकांश यी उपलब्धीहरू परम्परागत प्रजनन् प्रविधिहरूबाट प्राय सम्भव थिएन । तसर्थ, धान बालीमा विभिन्न आनुवंशिक परिवर्तित इभेण्टहरूको विकासको लागि आनुवंशिक परिवर्तन प्रणालीको प्रयोग हुँदै आएको छ । जिई/एम विकास प्रक्रियाको समयमा यसका सार्वजनिक सम्भावित लाभ तथा यसका जोखिमहरू आकंलन सम्बन्धी चिन्ता पनि न्यूनिकरण गरिन्छ । यसले गर्दा यो मानिसको भोजन, पशुको दाना र व्यवसायिक खेती स्वीकृतिका लागि एक उत्प्रेरकको रूपमा काम गरेको छ । जिई/एम धानको जिनोम अनुक्रमण पूरा भइसकेको र जिई/एम धानमा भएको विकासले सार्वजनिक वस्तुको साथै व्यवसायिक उपलब्धीको लागि विशिष्ट जैविक समस्याहरू समाधान गर्ने एक राम्रो अवसर खुला गरेको छ । तसर्थ, नीति निर्माताले बायोटेक्नोलोजीको प्रयोगको सम्भावना, बौद्धिक सम्पत्तिको अधिकारमाथि पहुँच प्रदान गर्ने, स्रोत साधनमा गरिब किसानका लागि बौद्धिक सम्पदा निःशुल्क उपलब्ध बनाउनेबारेमा गहिरिएर विचार गर्नुपर्दछ । यो अध्ययनबाट प्राप्त जानकारी अनुसार नेपालमा धान तथा अन्य बालीको खेती प्रणालीको लागि यो प्रविधि एक राम्रो स्रोत बन्न सक्दछ । नेपालसँग जिई/एमको लागि कमजोर पूर्वाधार, योग्य मानव संसाधनको अभाव, कमजोर नीति, नियम, निर्देशन तथा नियमावलीहरू, कमजोर गुणस्तर नियन्त्रण तथा व्यवस्थापन, अध्ययन, अनुसन्धानको अभाव भएको हुँदा यी आधारभूत आवश्यकताहरू पूरा नगरी यो प्रणाली अपनाउने कार्य गरिनु धेरै छिटो हुन जान्छ । जिई/एम प्रविधिले संसारमा व्यापकता पाए तापनि सिस्जेनिक प्रणालीसँग जीन पाईरामिडिङ्को प्रयोग गरी धान बालीका जातहरू विकास गर्न सके नेपालको लागि लाभप्रद हुनेछ । साथै, क्रिस्पर र टालेन प्रविधिहरू पनि अन्य विकल्पहरू हुन सक्छन् ।

Summary

Over the past three decades, genetic engineering of rice has made rapid advances in rice GE system to produce rice plants that withstand several abiotic and biotic stresses; quality/nutritional improvement, and add pharmaceutical and industrial values. Rice transgenic system has been used to develop different GE/M events. During the process of GE/M development, public concerns relating to potential benefits and risk assessments of transgenic technology were also alleviated. This would act as a catalyst for greater acceptance of GE/M rice for food, feed and commercial cultivation. The completion of the rice genome sequencing and advances in GE/M rice has opened up a plethora of opportunities to solve specific biological problems for public goods as well as commercial gain. Therefore, policy makers should look into the potential use of biotechnology, provide access to intellectual property rights (IPR), make improved rice seeds available free of IPR for resource-poor farmers. Nepal has weak infrastructure; lack of qualified human resources, and lack of policies, rules, regulations and directives/guidelines in GE/M, it is too early to adopt this system without fulfilling these basic requirements for research and study, and its quality control and management. Although GM technology is getting popularized in the world, the adoption of genes pyramiding with cisgenic system would be more advantageous in rice variety development in Nepal.

Keywords: Agronomic improvement, Genetic engineering, Nutritional, Pharmaceutical, Risk assessment

Introduction

The morphology, physiology, agronomy, genetics and biochemistry of *O. sativa* have been intensively studied over a long period (Food Standard 2008). So far, advances in genetic modification of rice have kept pace with the growing demand, despite losses, suffered as a result of various biotic and abiotic factors.

However, due to increasing global population, ie expecting to reach 9 billion by 2050, there will be a gap between rice demand and supply. Therefore, to meet the challenges of food supply over the next 50 years, conventional breeding methods need to be supplemented with recent development in rice biotechnology or genetic engineering such as insect resistant, herbicide tolerance, quality improvement, nutrition improvement, etc (Kathuria et al 2007). During the journey of rice genetic modification, it has taken rapid strides since the first transgenic rice plant was produced 27 years ago. Using different transgenic technologies, a number of genetically modified rice events were developed for insect resistant, herbicide tolerance, quality improvement, and nutritional improvement (Dawe and Unnevehr 2007 and James 2014). Rice has become the first crop plant to have its genome sequenced. Because of small genome size, enriched genetic map and relatively easy transformation (Kathuria et al 2007); rice is considered as a model monocotyledon system, similar to the use of *Arabidopsis* as model for dicotyledon.

This paper highlights the advances on rice genetic modification technology with particular emphasis on rice variety development systems through selection, conventional breeding and genetic engineering; global status of genetically engineered crops; status of GE crops in Nepal; advances in genetically engineered (modified) rice crop, including biotic/abiotic stress tolerance, nutritional quality improvement, rice pharmaceutical properties and potential benefits and risks of GE rice. It also highlights some implications of GE/M rice to rice farming system in Nepal.

Varietal development systems of rice

Globally, plant variety development systems have been adopted with sedentary agriculture and particularly domestication of agricultural plants. Then, classical plant breeding and modern plant breeding systems, ie genetic engineering systems were developed and applied for developing new superior varieties of any crops, including rice.

Genetic engineering of plant is achieved by adding a specific gene(s) to a plant, which is faster than traditional breeding system. If genetic material from another species is added to the host, the resulting organism is called Transgenic; whereas if genetic material from the same species or a species that naturally breed with the host is used the resulting organism is called Cisgenic (Schouten et al 2006, Jacobsen and Schouten 2008). Genetic engineering can also be used to remove genetic material by knocking down a gene with RNAi, to produce a desirable phenotype (Capecchi 2001).Transgenic plants are called as genetically engineered/modified (GE/M). The term transgenic is favored by scientists but GM has been adopted most widely by non-specialists.

There are some specific aims where genetically engineered food crops include resistance to certain insect-pests (Karthikeyan et al 2012), diseases (Zhang et al 2009, Singh et al 2012), stressful environmental conditions (Kathuria et al 2007, Farooq et al 2009), resistance to chemical treatments (eg resistance to herbicide) (Carpenter and Gianessi 1999), reduction of spoilage (Nowogrodzki 2015) to improving the nutrient profiling of the crops (Ye et al 2000). In addition, the non-food crops include production of pharmaceutical agents (Lean, 2004, Spok and Karner 2008), biofuels (Damien 2012) and other industrial value as well as bioremediation (Bonder 2008).

There are four main goals of genetically engineering crops: i) to protect from environmental threats by developing cold tolerance, insect resistant, disease resistant and herbicide tolerance varieties; ii) to improve the nutritional quality such as Golden Rice for Vitamin A, blue colored rose; iii) to develop 'molecular pharming' for producing pharmaceuticals and industrial chemicals, ie vaccines and drug intermediates, is a rather radical new area of plant breeding, and iv) to improve yield by accelerating growth or making the organism more hardy. The majority of commercially released transgenic plants are currently limited to plants that have introduced resistance to insect pests and herbicides. Over the years, several methods of genetic transformation of rice have been developed (Kathuria et al 2007).

Status of GM crops in Nepal

Nepal is in at embryonic and/or infant stage in GE/M crops research and development, and its quality control and management system. Therefore, there is no any varietal development work for GE/M in Nepal (NARC 2010). However, GMO was tested first time on some maize seed samples of Nepal in Taiwan in 2008 using multiplex PCR system developed by the Author (Shrestha et al 2010). The result showed that there was no any indication of GMO presence in all tested Nepalese maize seed samples. Similarly, the Annual Progress Reports of Seed Quality Control Centre, Hariharbhawan has also showed that there was no GMO in samples of imported maize and soybean seed (SQCC 2067/68 to 2071/72). Due to lack of human resources and GMO testing facilities with Food Laboratory in Nepal, GMO was not tested on any food and feed sample. However, we cannot assure that Nepal is GMO free country. It was because; some Nepalese people have been doing GM cotton field performance trials in Nepal for a couple of years (SEAN 2012).

Due to lack of qualified human resources, use of few PCR primers, lacking of proper storage facility for chemicals, weak implementation of quality control system, few samples tested and lacking of sufficient budget with SQCC; the test results are not reliable to assure the absence of GMOs in Nepal. Based on these evidences, it is concluded that Nepal cannot regulate GMO unless and until improves the existing situation. In addition, majority of the imported seeds were found to be smuggled due to open border system between Nepal and India. Some of the illegally imported seed were found to be developed from GM developing companies. Therefore, there is a great possibility of importing GM soybean, canola, rape seed, brinjal, maize, paddy, cauliflower, flower and fruit in Nepal (SEAN 2012).

To measure the level of GMO understanding with seed producers, distributors and traders (importers/exporters/retailers), a small survey was carried out by the author in a training program of SEAN in Hetauda and Nepalgunj from 3-7 April 2016. Altogether, there were 53 respondents from 38 districts from the Eastern to Far-Western regions. Based on their responses, only 34% participants were aware about GMO and rest 40 and 26% were unaware and not responded respectively. In 2012, similar result was observed with seed traders, ie out of 58 respondents only 36% was aware about GMO (SEAN 2012). Therefore, there is urgent need of improving the level of awareness among Nepalese people. Otherwise, in this situation, there might be higher possibilities of importing GMO illegally or unknowingly in Nepal, which is required to be regulated by the concerned authority soon. India is going to approve vitamin A containing GM rice (Golden Rice)and other GM crops in the near future.

Potential benefits and risks of GM rice

After the World War II, there have been lots of improvements in the development of rice varieties through using conventional as well as genetic engineering technology for supplying food to the world population. Recent advances in genetic modification have opened up a good avenue for the development of GE/M rice, where some countries have already developed and approved some GE/M rice events for food, feed and/or commercial cultivation. At the same time, complexity of economical, environmental and health issues was also associated with it. Therefore, both the schools of thoughts, ie potential benefits (pros) and its risks (cons) related to GM rice need to understand.

Potential benefits of GM rice

Several GM lines have been developed for biotic stress such as insect, bacteria, fungus and viral resistance and herbicide tolerance, and abiotic stress such as high temperature, chilling, freezing, drought, salinity, high light intensity and flooding/submergence tolerance, and bioremediation such as exposure to ozone/heavy metal contamination.

Improved grain quality such as nutritional enhancement, vitamin A, iron, protein and calcium, starch contents (6-11%), which reduces micronutrient malnutrition (Steura et al 2013), and improved other industrial value in GM rice. The other benefits of GM rice are:

- Increased yield in GM rice, ie from 17-30%.
- Improved pharmaceutical value in GM rice such as anti-allergy, anti-biotic resistance.
- Reduces the cost of cultivation, which will increase the farm income and improve the environmental situation.

Risk of GM rice

Some environmental reactionary or advocacy forces, including Greenpeace, Friends of the Earth, Food First and some other individuals have already engaged in raising issues on GM rice **(**Dawe and Unnevehr 2007). Some of the key issues are:

- GM foods, including golden rice are inherently unsafe to the environment and human health particularly risks to the kids. Therefore, they have suggested focusing on sustainable nutritional intervention through backyard or community gardens.
- Non-target affects either directly or indirectly on living organisms in or around the GM field. However, Li et al (2015), Zhang et al (2015), Song et al (2015) and Zou et al (2015) have demonstrated that there was no any significant effect of GM rice on non-target species.
- Gene flow is a natural process, where its frequency in cross-pollinated crops is higher than self-pollinated crop, including rice (Gewin 2003, Bellon and Berthaud 2004).Therefore, rice transgenes are expected to disperse to nearby weedy and wild relatives through pollen-mediated gene flow(Lu and Snow 2005, and Merotto et al 2016). Therefore, Cleistogamy technology would be an efficient strategy for protecting gene flow from GM crops, where Superwoman1-clestogamy (*spw1-cls)* mutant can plays a great role in it (Yoshida et al 2007).
- Insect resistance to *Bacillus thuringensis (Bt)* could increase resistance to *Bt* toxin very quickly by insect-pests (Greenpeace 2003, TWN 2005). Therefore, it will lead to damage the natural ecosystems and sufferer will be the general grower and organic rice producers (Shrestha 2010).
- Allergenicity is another food safety issue of GM crops. However, in some GM cases, gene products that are not allergenic normally will not suddenly become allergenic (Goto et al 1999).
- Increased invasiveness and volunteerism of transgenic crops. In the case of crops such as alfalfa (*Medicago sativa*), canola (*Brassica napus and Brassica rapa*) sunflower (*Helianthus annuus*), and rice (*Oryza sativa L.*) that have some "weed-like" characteristics become weedy and invasiveness (Raybould and Gray 1993, Regal 1994, Kumar et al 2008).
- GM pharmaceutical rice developed for helping third-world children to overcome chronic diarrhea could cause more disease such as exacerbate certain infections or cause dangerous allergic or immune system reactions (Huff 2012). In some cases, human genes are incorporated into GM rice for pharmaceutical production as well as resistance to herbicide (Huff 2012), which are heavily opposed by the communities (Weiss 2007).
- Monopoly market: GM rice developed with patenting and sterile seed will block the ability of poor farmers to save and use seed by themselves. Therefore, they have to depend on multi-national companies for purchasing new seed, which destroy their traditional farming practices, invest huge amount of money for buying seed, resources and expertise and reduces the employment opportunities (Skerrit 2000, Lele 2003, ISS 2004).

Risk assessment (Environment and health biosafety)

Risk assessment of agricultural and food technologies is not a new concept (Swetward et al 2000). Each innovation in food production has come with its own set of potential risks. Adverse effects of GMOs, including rice or products thereof may occur at any stage of GMO activities such as developing GMOs, testing, releasing, marketing and use (MoFSC 2006). Therefore, environmental and health risks should be assessed on a case by case, step-by-step or tire basis at the national or regional level (Dutton et al 2003, ISS 2004, MoFSC 2006,, Sherstha 2010). Pilot testing, field trials, release in the market and use of GMOs will be allowed only after the research or testing of the GMOs in contained demonstrates that there is no risk, or the associated risks are manageable. At the time of assessing the risks, it is required to look at the potential socio-economic impacts also. In addition to the consideration of the impact on traditional culture, values and norms of the nation in the risk assessment report it is equally necessary to address the potential adverse effects on the biological diversity, which in turn affects to local communities' income. Currently, MoFSC (2006) has classified the following four levels of the risks of GMOs or products thereof for the Nepalese context.

Level 1: No risk to human health, biological diversity and environment.
Level 2: Low risks to human health, biological diversity and environment.
Level 3: Medium risk to human health, biological diversity and environment and
Level 4: High risk to human health, biological diversity and environment.

Implications of GE/M to rice farming system in Nepal

Based on study and experiences, followings are the possible implications of genetically engineering system to the Nepalese rice farming system.

- Due to climate change, the incidence of all forms of biotic (insect-pest, disease, weed infestation) and abiotic (drought, flooding, chilling/freezing temperature, high temperature) stresses in rice farming systems are the critical issues to be addressed in rice variety development system through the combination of conventional and genetic engineering systems.
- Quality improvement (vitamin, protein, oil, texture) for food consumption and rice bio-farming for medical purpose are other important aspects of rice research in Nepal.
- We have to identify gene(s) as per our national interest, and select target Nepalese rice varieties for developing GE lines. In addition, it is also urgently necessary to isolate and identify some genes responsible for droughts, nitrogen/water use efficiency, flooding, chilling/freezing and high temperature and so on from our local land races, such as Ghaiya for identifying drought resistance gene and *Jumli Marshi* for chilling/freezing tolerance.
- Among different transformation systems, *Agrobacterium* method is commonly and efficiently used in different crops, including rice. Therefore, we can use *Agrobacterium*-mediated gene transformation system.
- Genes pyramiding or multigene engineering system involved in various agronomic traits is a powerful approach to obtain superior rice varieties. This approach has already been used to confirm resistance against a broad range of different rice pests and pathogens using genes like *cry, Xa, chitinase* and *GNA*, which can be used for rice.
- Cisgenic technology is one of the useful genetic engineering systems where genetic material from the same species or a species that naturally breed with the host is used to develop new rice lines (Schouten et al 2006, Jacobsen and Schouten 2008, Prins and Kok 2010). Cisgenic engineering technology of rice should be in a priority. In addition, as rice is a self-pollinated and most important crop for food security in Nepal, GE technology with different gene(s) of interest can be used in developing GE/M rice.
- The cleistogamy would be an efficient strategy for protecting gene flow from GE crops, where Superwoman1-clestogamy (*spw1-cls)*mutant can plays a great role on it (Yoshida et al 2007).

Conclusion

Over the last 25 years, rice has been transformed with many new genes of agronomic, nutritional, pharmaceutical and other industrial attributes. The recent completion of the sequencing of rice genome and advances in GE/M rice should provide a wide scope for the application of genetic engineering system across ecosystems and crop barriers. Therefore, countries like Australia China, Canada, Columbia, Hondurus, Iran, Japan, Mexico, the Newzealands, Phillipines, Russian Federation, South Africa, and USA have already approved GM rice and initiated field trials and regulatory studies for safety release of transgenic rice crops. In the future, it is desirable to create superior transgenic rice plants using already known genes and discovery of new genes utilizing the advances in rice structural and functional genomics that can grow in compromised environment and have higher yield with decreasing arable land availability. The development of nutritionally enriched rice would initially be available for consumers of developing countries within next few years and adopted quickly, where India has already committed to forward this technology. Indeed, current rice genetic engineering gives benefits and safety to all people in the world, including Nepal.

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Nepalese Rice Around the World

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सारांश

नेपालमा पहिलो पटक धानको खोजी तथा संकलन २०२८ सालमा अन्तर्राष्ट्रिय धान अनुसन्धान संस्था (ईरी) सँग मिलेर भएको थियो । नौ वटा विभिन्न जिन बैंकहरू (नेपाल, फिलिपिन्स, जापान, भारत, कोरिया, भुटान, अमेरिका, रसिया र बेनिन) मा ८३८९ वटा नेपाली धानको संकलन संरक्षित गरिएको छ । ईरी ले ६० वटा देशहरूलाई जम्मा ७३५३ पटक नेपाली धानको संकलन अनुसन्धानको लागि वितरण गरेको छ । उक्त वितरण कार्य मिति २०३२ सालबाट सुरु भएको देखिन्छ । बढी अध्ययन गरिएको जातहरूमा चिसो सहने गुणको लागि जुम्ली मार्सी, चिसो र डडुवा सहने गुणको लागि छोम्रोंग र किरा नलाग्ने गुणको लागि जंगली धान पर्दछ । केही नेपालमा उन्मोचन गरिएको धानका जातहरू भुटान, भारत र मदागास्कारमा सिधै उत्पादनको लागि खेती गरेको देखिन्छ । नेपाली धानमा अरू थुप्रै राम्रा गुणहरू हुन सक्छन, जसलाई अध्ययन अनुसन्धान गरी अन्तर्राष्ट्रिय स्तरमा बजारीकरण गर्न सकिन्छ ।

Summary

First rice collection mission in Nepal was held in 1971 in collaboration with IRRI. A total of 8389 rice accessions collected from Nepal are conserved in nine different genebanks (NAGRC, Nepal; IRRI, the Philippines; NIAS, Japan; NBPGR, India; NAC, Korea; NBC, Bhutan; USDA, USA; Vavilov Institute, Russia and ARC, Benin). Sixties countries have received Nepalese rice accessions from IRRI for research and production. IRRI distributed 7353 times rice accessions collected from Nepal to these countries starting from 1975. Most commonly studied landraces were Jumli Marshi for cold tolerance, Chhomrong *Dhan* for cold tolerance and blast resistance, *O. nivara* for brown plant hopper. Some released varieties were also used directly for grain production in Bhutan, India and Madagascar. There are many rice landraces that have global potential (aromatic, drought tolerance, diseases and insect pest resistance, etc) and that needs to be explored to be utilizated at commercial scale.

Keywords: Conservation, Distribution, Nepalese rice, Utilization

Introduction

Nepal is one the centers of diversity for rice (Mallick 1981, Shrestha and Upadhyay 1999, Upadhyay and Joshi 2003, Joshi 2004, 2005). Aromatic rice (called *Basmati Dhan* in Nepali) and beaten (flattened) rice prepared from special landrace called Anadi Dhan are popular around the world. About 2,500 different rice landraces are reported in Nepal. Rice is grown from 60 to 3050 m altitude in Nepal, the latter being the highest altitude in the world (Mallick 1981). *O. rufipogon*, one of the natural parents of the present day cultivated rice is reported to be found in the northern most limits and the highest altitude in Nepal in the world (Shrestha and Upadhyay 1999). However, foreign germplasm is commonly used as the parents in rice breeding programs and Nepal is about 95% dependent on foreign rice germplasm for varietal development (Joshi et al 2016). Most commonly used ancestors in rice breeding mainly in Nepalese modern varieties were Century Patna (CP) originated in USA, Cina from China, Latisail from Pakistan, Sigadis from Indonesia, Taichung Native-1 (TN1) from Taiwan, Dee-Geo-Woo-Gen (DGWG) from Taiwan and SLO from India (Joshi 2006). There are other many success cases of using particular country based originated genes in many modern varieties. Chaudhary (1996) has listed many best rice varieties resistance against biotic and abiotic stresses, eg Tetep from Vietnam for blast resistance, Cisadane from Indonesia for bacterial blight resistance, Utri Rajapan from Indonesia for Tungro resistance, Rathu Heenati from Sri Lanka for white backed plant hopper resistance, Mudgo from India for brown plant hopper resistance, RD9 from Thailand for gall midge resistance, TKM6 from India for stem borer (dead heart) resistance, Taichung sen 10 from Taiwan for stem borer (white head) resistance, Fuji-102 from Japan for cold tolerance, Carijo from Brazil for drought tolerance and Pokkali from India for alkalinity and salinity tolerance.

The semi dwarfing gene in rice (*sd-1*) is one of the most important genes deployed in modern rice breeding. The *sd-1* gene was first identified in the Chinese variety Dee-geo-woo-gen (DGWG), and was crossed in the early 1960s with Peta (tall) to develop the semi dwarf cultivar IR8 (IRRI 1967). A wild rice (*O. nivara*) growing in Uttar Pradesh, India was found to have a gene for resistane to the grassy stunt virus (RGSV). This gene is now routinely incorporated in many new varieteis of rice (Khush and Ling 1974). Success in fine mapping of Submergence-1 (Sub-1), a robust quantitative trait locus from the submergence tolerant Indian FR13A landrace, has enabled marker-assisted breeding of high-yielding rice capable of enduring transient complete submergence (Bailey-Serres et al 2010). DRO1, drought tolerance gene identified in Indian deep-rooting landrace Kinandang Patong has been widely used (Uga et al 2013).

The trend toward using local landraces in breeding programs is increasing in Nepal, and it is assumed that the diverse landraces being cultivated in diverse climates may have potential genes for higher rice production (Joshi et al 2014, Joshi 2015). There is very limited information on use of Nepalese rice landraces in foreign countries.

Exploration and collection

Due to the great variation at genetic, species and ecosystem levels many national and international biologists, naturalists, adventuress travelers and plant hunters explored and collected germplasm from different parts of Nepal at different time periods (**Table 1**). Collection of Nepalese specimens began in 1802 by Buchanan Hamilton and was continued by N. Wallich during 1820-21.

Exploration and collection mission of germplasm in Nepal had been started since 1938. First rice collection mission was held in 1971 in collaboration with IRRI (Upadhyay and Joshi 2003). In recent year (from 2014) trait specific rice collection missions (eg cold tolerant, drought tolerant, etc) are also organized by National Agriculture Genetic Resources Center (NAGRC) in collaboration with international institutes. Main organizations involved in rice exploration and collection are International Board for Plant Genetic Resources (IBPGR), National Bureau of Plant Genetic Resources (NBPGR), National Institute of Agrobiological Sciences (NIAS), International Rice Research Institute (IRRI), etc. Rice accessions have been collected almost from all rice growing districts of Nepal (**Figure 1**).

Table 1. Rice exploration and collection missions undertaken by international organizations

SN	Collection year	Organizer	Team	Area explored	Primary purpose	Sample collected
1	1950	Prof. Kihara, Japan	X	Nepal	Multicrop	X
2	1971	NRRP/IRRI	X	Nepal	Rice	X

SN	Collection year	Organizer	Team	Area explored	Primary purpose	Sample collected
3	1980	IRRI, Philippines	X	Nepal	Rice	X
4	1984	IBPGR	M Izuka, RC Lamb, A Ujihara, BK Baniya, HK Sainju, H. Serigawa, M Nakagahara, I Kajiura, H Yamazaki & CB Shrestha	EW Nepal	Multicrop	2,052
5	1985	IBPGR/Nepal	M Izuka, RC lAMB, A Ujihara, BK Baniya, H Serigawa, M Nakagahara, HK Sainju, BR Adhikary & CB Shrestha	CFW Nepal	Multicrop	2,800
6	1985-1987	IBPGR	S Yangihara	Nepal	Multicrop	72
7	1986	Japan/Nepal	X	Nepal	Multicrop	X
8	1987	Shinshu University, Japan	A Ujihara & M Minami	Nepal	Multicrop	1,752
9	1988	IRRI, Philippines	DA Naughan, GL Shrestha & PP Regmi	EW Nepal	Rice and wild rice	29
10	1988	IRRI/Nepal	X	Nepal	Wild rice	X
11	1993	Japan	X	Nepal	Multicrop	X
12	1998	IRRI, Philippines	BR Lu, MP Upadhyay & SR Gupta	WMFW Nepal	Rice and wild rice	75
13	1998	IRRI/Nepal	X	Nepal	Wild rice	X
14	1999	Marburg University, Germany	BR Hurek, SR Gupta & RC Prasad	Kaski & Rupandehi	Rice and wild rice	10
15	1999	Marburg University, Germany	T. Hurek & SR Gupta	Rupandehi & Kapilvastu	Wild rice	5
16	1999	Germany/Nepal	X	Nepal	Wild rice	X
17	1999	IRRI/Nepal	X	Nepal	Wild rice	X
18	1999	IRRI, Philippines	BR Lu, MP Upadhyay & SR Gupta	CE Nepal	Rice and wild rice	53
19	2004	University of Birmingham, UK	S Decombel and BK Joshi	Western Nepal	Wild rice and rice (leaf sample)	150

X: Not known. Source: Upadhyay and Joshi 2003.

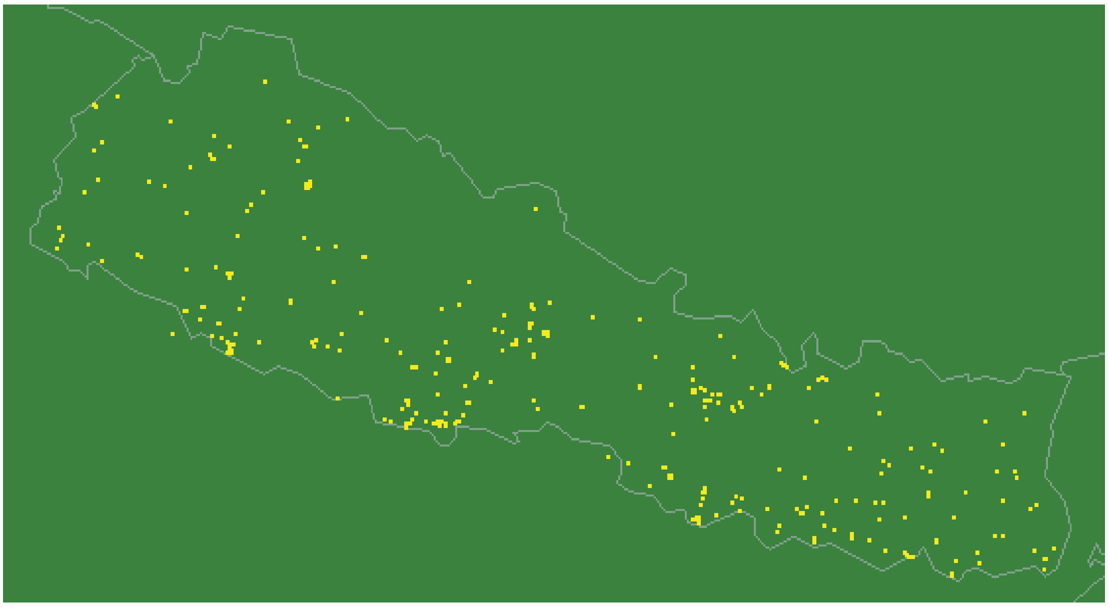

Figure 1. Collection maps of Nepalese rice accessions conserved in different foreign genebanks

Conservation status

A total of 8389 rice accessions collected from Nepal are conserved in nine different genebanks (**Figure 2**) (NAGRC, Nepal; IRRI, Philippines; NIAS, Japan; NBPGR, India; National Agro-biodiversity Center, NAC, Korea; National Biodiversity Center, NBC, Bhutan; USDA, USA and ARC, Benin). Most of these accessions are accessible through Genesys (https://www.genesys-pgr.org), NIAS (http://www.gene.affrc.go.jp/index_en.php), IRRI (http://www.irgcis.irri.org:81/grc/irgcishome.html), US Department of Agriculture (USDA) (http://www.ars-grin.gov/npgs/index.html). These collections include both wild and cultivated rice species.

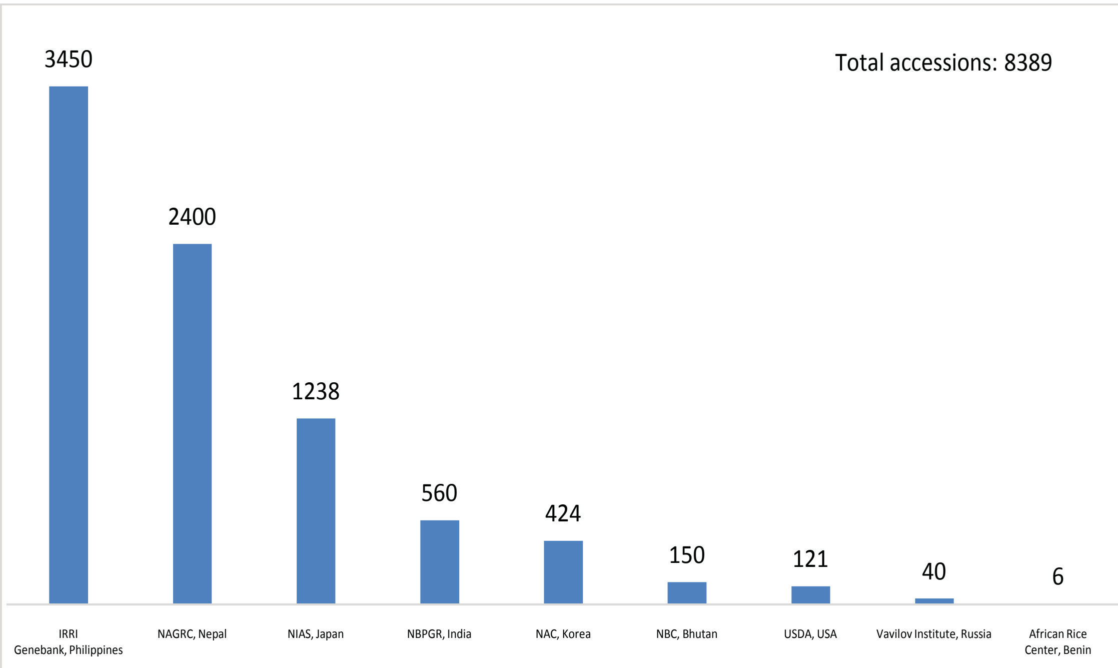

Figure 2. Rice accessions collected from Nepal and stored in different genebanks (Holding institutes in x-axis)

Research and utilization

Sixties countries have received Nepalese rice accessions from IRRI (**Table 2**). IRRI distributed 7353 times rice accessions collected from Nepal to these countries starting from 1975 (**Figure 3**). NAC, Korea has also distributed 140 accessions of Nepalese rice for research purposes (N Youngwang and S Lee 2016, email communication). Details findings and uses of these Nepalese rice accessions are not available.

Table 2. Nepalese rice accessions and times distributed to different countries from IRRI Genebank

SN	Country	Times distributed	Distributed accession name/number
1	Argentina	22	ASAMIYA BASMATI, BASMATI, BASMATI ANPJHUTTE, BASMATI DHAN, BASMATI GOLA, BASMATI LAMO, BASMATI MASINO, BASMATI MASINO(PURPLE TIP), BASMATI NOKHI, BASMATI PAHADE, BASMATI RED, BASMATI UZARKA, BASMATI WHITE, DHERA DUN BASMATI, KANJIRE, MASINO, MASINO BASMATI, RAKSALI, RATO BASMATI
2	Australia	35	BAGETAULI, BAGETAULI::IRGC 61909-1, BASMATI LAMO::IRGC 58881-1, CHHOTE DHAN::IRGC 58930-1, DAINY, DAINY::IRGC 58943-1, DARMALI, DUDHI SAROO, DUDHI SAROO::IRGC 16261-1, DUMSIKALAM::IRGC 58968-1, GAJPATI::IRGC 58981-1, GHAMRI, GOPAL::IRGC 61953-1, JENGAR::IRGC 59027-C1, JUMALI::IRGC 9542-C1, JUMULA 2, JUMULA 2::IRGC 13375-1, KAKANI 2::IRGC 13373-C1, KALO PHALAME, MANA MURI::IRGC 23973-1, NAULO DHAN A, NEP-98-034, PAHELO PHALAME, PATLE, PATLE::IRGC 27635-1, PURBIA (KALANSAR)::IRGC 59189-1, TARA::IRGC 59244-1, THANKOTE MARSI, THAPACHINIYA::IRGC 16234-1, THULO MARSI,
3	Bangladesh	32	ARUNA, BANSPHUL, BASMATI LAMO, CHAIA ANASER, CHHOTE DHAN, DARMALI, DHARIA, FARAM BAJARI, GOKHUE SAIER, JUMULA 2, KARMULI, KASHI PRASAD, KATUYHAR DHAN, LATIGHAWAR, NAKHI, NEMAI, OIRI, SABITRI, TARA
4	Belgium	5	063/88/27, BANDHAN, DARMALI, IR-44595, LAL AHU
5	Belize	1	RAM KAJARA
6	Benin	10	DARMALI, GAJPATI::IRGC 58981-1, GOPAL::IRGC 61953-1, IR-44595, JUMALI, KAKANI 2, MARANGI GHAIYA, PURBIA (KALANSAR)::IRGC 59189-1, HAPACHINIYA::IRGC 16234-1
7	Bolivia	28	ADARA DHAN, AURI(JHAR DHAN), BANDHAN, CHHOMRONG DHAN, DHAN, JHAR DHAN, JHARANG DHAN, JHARANGA DHAN, JHARNADHAN, JUMLI MARSHI, KALO MARSHI, OIRI, PALTI DHAN, RAMDHAN, RATO DHAN, RATO MARSHI, SETO DHAN, SETO MARSHI
8	Brazil	27	063/88/41, AURI(JHAR DHAN), BAGAR THIMAHA, BAGETAULI::IRGC 61909-1, BANDHAN, BASMATI LAMO::IRGC 58881-1, CHHOTE DHAN::IRGC 58930-1, DAINY::IRGC 58943-1, DARMALI, DUDHI SAROO::IRGC 16261-1, DUMSIKALAM::IRGC 58968-1, GAJPATI::IRGC 58981-1, GOPAL::IRGC 61953-1, IR-44595, JUMALI, JUMALI::IRGC 9542-C1, JUMULA 2::IRGC 13375-1, MANA MURI::IRGC 23973-1, NEP-98-065, *O. nivara, O. rufipogon*, PATLE::IRGC 27635-1, PURBIA (KALANSAR)::IRGC 59189-1, TARA::IRGC 59244-1, THAPACHINIYA::IRGC 16234-1, TUMBA
9	Canada	9	063/88/19, BANDHAN, CHHOMRONG DHAN, JUMULA 2, KALI MARSI, KALO MARSI, OIRANGE MARSI, SUNAULA DHAN
10	China	540	4, 063/88/19, 063/88/21, 063/88/23, 063/88/27, 063/88/41, 063/88/42, AANGA, AAP JHOOTE, AAPGHUTTE, ACHHAME MASINO, ADALAT, ANADI, ANADI WHITE::IRGC 61897-1, ANANDI, ANGA, ANJANA, ANJANA DHAN, APA JHUTE, ASAMIYA BASMATI, ATH HAGARI JARAHAN PADDY::IRGC 23796-1, AURI(JHAR DHAN), AUS HARINKER, BADA GAUNLE, BAGERI, BAGETA ULI::IRGC 61909-1, BAHARANI, BAIRANI, BAKAI, BALAMACHI, BANDAR KUHI, BANDHAN, BANGALUWA, BANGLA::IRGC 58876-1, BANGULIA, BANSPHUL, BARCHHA BAHADUR, BARKHE TAULI::IRGC 16116-1, BASMATI, BASMATI DHAN, BASMATI LAMO, BASMATI LAMO::IRGC 58881-1, BASMATI MASINO(PURPLE TIP), BASMATI NOKHI, BHADAIYA, BHAT KHANYA, BHATTE JARAN, BIJULI BATI::IRGC 58917-1, CHABO GHAIYA, CHAIA ANASER, CHENGULA, CHHITA, CHHOTE DHAN, CHHOTE DHAN::IRGC 58930-1, CHHOTEA, CHHOTI MASHINO, CHINIYA, CHOBO::IRGC 61930-1, CHULTHE, CO ANADI, DAILEKH(LOCAL), DAINY, DAINY::IRGC 58943-1, DALE KASO BACHHI, DALE MAID, DARJILINGE, DARMALI, DASHRIYA, DEHRADUNE DHAN, DERAWA::IRGC 64106-1, DEVARASI::IRGC 16173-1, DHANKUTE, DHARIA, DUDHI SAROO, DUDHI SAROO::IRGC 16261-1, DUDHRAJ SATARI, DUMSIKALAM::IRGC 58968-1, DURAJ, EARLY 1(KATHMANDU VALLEY), ENDRA BALEE, FARAM BAGADE, GAIYA DHAN, GAJPATI::IRGC 58981-1, GAMADEE, GAMADI, GAMLARI, GARURA, GARURA::IRGC 64111-1, GAURE DHAN, GHAIYA,

SN	Country	Times distributed	Distributed accession name/number
10	China	540	GHAIYA::IRGC 16286-1, GOLA BACHI, GOPAL::IRGC 61953-1, GUDURA::IRGC 61955-1, HALIDA::IRGC 59005-1, HANSA, HANSA RAJ, HAPALI, HIMALI, HIMALI DHAN, I 41::IRGC 75927-1, I 41::IRGC 75927-1, I 814::IRGC 76028-1, I 814::IRGC 76028-1, IR-44595, J 2, J 9, JADO::IRGC 61966-1, JALMANI, JAMRA, JARNERI, JASHA ANASU, JHALI, JHALI B, JHAR, JHAR DHAN, JHARA, JHARANGA, JHARANGA DHAN, JHARNADHAN, JHINUWA DHAN::IRGC 88545-1, JHOOPE MASHINO, JHYALI DHAN, JINUWA, JIRASHARI, JUMALI, JUMALI::IRGC 9542-C1, JUMULA 2, JUMULA 2::IRGC 13375-1, JUNGEMARSI::IRGC 76901-1, JUNGLE DAN, KAILE DHAN, KAKANI 2::IRGC 13373-C1, KALA NAMAK, KALA NIMAK, KALO BASMATI, KALO JHINUWA, KALO METHA DHAN, KALO PHALAME, KALOMASINO DHAN, KAMOD, KAMULI::IRGC 23928-1, KANCHAN, KARISHNABELI::IRGC 61979-1, KARMA, KARUEL::IRGC 83792-1, KATHE JHINUWA DHAN, KATUYHAR DHAN, KHERA, KUNDWA SAPHED, KUSUM KATIKI::IRGC 59099-1, LAHARE GHAIYA, LAL AHU, LAL DHOF, LAL SAR, LAL SAR::IRGC 16185-1, LALSAR, LATIGHAWAR, LATIJHABAR::IRGC 61991-1, LIKHOLE MARSI, MADHESA, MADHUWA KARIA::IRGC 16138-2, MAKHMAL MEHI, MALINGE, MANA MURI, MANA MURI::IRGC 23973-1, MANSARA, MANSARA DHAN::IRGC 86940-1, MARINAKER ANASE, MARSHI, MASINO, MASINO BASMATI, MOTANGE PAHELLO LAULE::IRGC 16160-1, MOTHI, NABO, NAGINA 22, NAKHI, NAULO DHAN A, NAULO DHAN B, NAURO, NAURO, NEP-98-007, NEP-98-020, NEP-98-022, NEP-98-025, NEP-98-027, NEP-98-029, NEP-98-030, NEP-98-034, NEP-98-034, NEP-98-057, NEP-98-061, NEP-98-063, NEP-98-064, NEP-98-066, NEP-98-068, NEP-W-010, NEP-W-021, NEP-W-022, NEP-W-034, NEP-W-042, NYAULI, NYAULI::IRGC 88628-1, *O. nivara, O. rufipogon, O. sativa*, OHA, OIRI, PAHELO PHALAME, PATLE, PATLE::IRGC 27635-1, PEALEA, POHHERLIMASION::IRGC 62025-1, POKHARA MASINO, POKHARELI MASINO, PURBIA (KALANSAR)::IRGC 59189-1, RAI MANULA::IRGC 64138-1, RAJ BHOG, RAM JHOKE, RAM SALEE DHAN, RAM SALEE KATAKA::IRGC 24014-1, RAMDULARI, RATHE DHAN, RATO AHU, RATO BASMATI::IRGC 59205-1, RATO MARSI, RERM BILASH::IRGC 16273-2, ROTODHAN B, SANO BEGANY CHIYA, SATHI, SATHI BAGARI, SATHI SARO, SATHIYA, SATHIYA::IRGC 59225-1, SATRIYAJHAR, SETO ANADI, SETO GADDAR, SETO JHINUWA::IRGC 62043-1, SETYA::IRGC 88654-1, SETYA::IRGC 88654-1, SHANSAR, SIDALI::IRGC 9567-1, SIKICHAN(EARLY), SILANGE, SIMTARO DHAN, SIMTHARO, SINGRA DHAN, SITA, SOKAN, SOKAN DHAN, SUGA PANKHA::IRGC 24054-1, TAKHU DHAN, TALLY, TARA::IRGC 59244-1, TAULI, THANKOTE MARSI, THAOLAE, THAPACHINI DHAN, THAPACHINIYA::IRGC 16234-1, THULO MARSI, TINNA, TINNI, TULSIPHOOL, VII 77, YANGKHUKE, ZANELI, ZARUDA
11	Colombia	127	32, 33, 063/88/23, 063/88/41, 063/88/42, BAGERI, BANGALUWA, BANGLA, BANSPHUL, CHHOTE DHAN, CHHOTE DHAN::IRGC 58930-1, DERAWA::IRGC 64106-1, DEVARASI, DEVARASI::IRGC 16173-1, DUDHI, DURGA, EARLY 1(KATHMANDU VALLEY), FARAM BAGADE, GAJPATI::IRGC 58981-1, GHAIYA::IRGC 16286-1, GOKHUE SAIER, GOPAL::IRGC 61953-1, GORA(LOCAL), HIMALIMARSI(DHAN), J 25, J 26, J 4, J 7, JADO::IRGC 61966-1, JANAKI, JARNERI, JHINUWA, JIRA BATISHI, JUMALI, JUMALI::IRGC 9542-C1, JUMLI MARSHI, JUMULA 2, JUNGEMARSI::IRGC 76901-1, KAKANI 2::IRGC 13373-C1, KALO, KAMULI::IRGC 23928-1, KARISHNABELI::IRGC 61979-1, KATUYHAR DHAN, LAL AHU, LAL SAR, LAL SAR::IRGC 16185-1, LALAKA GADUR, LATIGHAWAR, LAXAMI, MAKHMAL MEHI, MANSARA DHAN::IRGC 86940-1, MATURY, NAKHI, *O. rufipogon*, PAKHI, PHOOL KUMARI, PHOOL KUWAR, PHOOLOSARI, POKHARA MASINO, POKHARELO MASINO, POKHRELI, PURANO JAGAR, PURBIA (KALANSAR)::IRGC 59189-1, PURBIA (KALANSAR)::IRGC 59189-1, PURBIA(KALANSAR), PUTUJE, RAI MANULA::IRGC 64138-1, RAJBIRAJ, RAKHSHE, RAM JHOKE, RAMNI, RANGELI DHAN, RATANI, RATE BHADAIYA, RATIN, RATO BASMATI, RERM BILASH, RERM BILASH::IRGC 16273-2, ROOP KAMAL, SABITRI, SAHMARDAN, SAJANI, SAJANI GHAIYA, SANKHARIKA, SARAJ, SARLARI DOLAN, SATARIA, SAYA, SETI GHAIYA, SETYA::IRGC 88654-1, SIDALI::IRGC 9567-1, SIKICHAN(EARLY), SITA, SITA MATA, SOKAN DHAN, SUGA PANKHA::IRGC 24054-1, SUNAULI, TALLY, TANKI, TARA, TARNELI, TAULI, THAKUR PRASAD, THANKOTE MARSI, THAPACHINI, THAPACHINIYA::IRGC 16234-1, THINUWA, THULO MARSI, TIMURE MASINO KALO(BLACK), ULAKA, USHI, ZANELI, ZOOWA
12	Cuba	2	SATHI, SATHI SARO
13	Czech Republic	2	063/88/41, RAM JHOKE
14	Denmark	3	ANDI WHITE, NABO, SUGA PANKHI

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15	Dominican Republic	1	BASMATI
16	Egypt	3	*O. nivara*, WHITE ATTE, YANGKHUKE
17	Ethiopia	1	MASULI
18	France	52	8800323, 00059626, ANADI, ANATI, BASMATI DHAN, BASMATI MIXED 1, BATE, BONA, CHHOMRONG DHAN, DANDA BASMATI, DARMALI, DHERA DUN BASMATI, DUMSIKALAM, FARAM BAGADE, GAJPATI, GHAIYA DHAN, GHANDRUK, GOPAL, HIMALI, JALMANI, JAWLYA DHAN, JENGAR, JUMALI, JUMLI DHAN, JUMLI MARSHI, JUMULA 2, KAKANI 2, KALA NAMAK, KALA NAMAK DHAN, KALA NIMAK, KALO MAHELI, KALO MARSHI, KURIYA, MASINU AROMA, NAIHARWA, NYAULI, PASHNI, PHALAME, PURBIA(KALANSAR), SETHARO, SETO ANADI, TANKI, TAULI, THAKUR PRASAD, THAPACHINIYA, ZANELI
19	Germany	16	063/88/41, AU, BASMATI PAHADE, CHHOTI MASHINO, DARMALI, DEHRADUNE, DHERA DUN BASMATI, IR-44595, JARNERI, JHARA, MANSARA DHAN::IRGC 86940-1, NEP-98-040, POHHERLIMASION::IRGC 62025-1, SUGA PANKHA::IRGC 24054-1, TINNA
20	Ghana	1	BASMATI
21	Guinea	2	BASMATI RED, DARMALI
22	Hong Kong	2	063/88/23, BANDHAN
23	India	302	063/88/19, 063/88/21, 063/88/23, 063/88/27, 063/88/41, 063/88/42, ACHHAMIYA, AMAGHAUD, AMERICAN, ANANDI PANKH, ANGA, ANJANAWA, ARCHOTY ZRURA, ASAMIYA BASMATI, AURI(JHAR DHAN), BACCHIHARDA, BADSAR, BAGERI, BAGETAULI, BAGETAULI::IRGC 61909-1, BAKAI, BAKE, BANDHAN, BANSPHUL, BASMATI, BASMATI DHAN, BASMATI GOLA, BASMATI LAMO, BASMATI LAMO::IRGC 58881-1, BASMATI NOKHI, BASMATI PAHADE, BASMATI RED, BASMATI UZARKA, BASMATI WHITE, BHOTANGE, BIRUMPHOOT, CHAIA ANASER, CHANANCHUR, CHANDAN CHOON, CHHITA, CHHOTE DHAN, CHHOTE DHAN::IRGC 58930-1, DAINY, DAINY::IRGC 58943-1, DARMALI, DHUMASI, DUDH BAKAI, DUDHI, DUDHI SAROO, DUDHI SAROO::IRGC 16261-1, DUMAHA KHERA, DUMSIKALAM, DUMSIKALAM::IRGC 58968-1, GAHUAE, GAJPATI, GAJPATI::IRGC 58981-1, GAMADI, GARURA, GHAIYA, GOKHUE SAIER, GOLA, GOPAL, GOPAL::IRGC 61953-1, GORA(LOCAL), HANSARAJ DHAN, HYANG NASWA, IR-44595, JENGAR, JHALI, JHAR, JHAR DHAN, JHARA, JHARAN, JHARANGA, JHARNADHAN, JHINUWA, JINI DHAN, JUMALI, JUMALI::IRGC 9542-C1, JUMULA 2, JUMULA 2::IRGC 13375-1, KAKANI 2, KALA NIMAK, KALO JHINUWA, KARIA KAMODH, KARIA KUMATHI, KATUYHAR DHAN, KHEMATI, KRISHNA BHOG, KUSHUM KATKI, LADBHADI, LAL AHU, LAL SAR, LAME, LANJHI, LATIGHAWAR, MAKHMAL MEHI, MALABHOG, MALLIKA, MANA MURI, MANA MURI::IRGC 23973-1, MASINO, MASINO BASMATI, MURLA, NABO, NAGINA 22, NAKHI, NAN KIRWI, NANDHADUDHRAJ, NANIA, NAURO, NEMAI, NEP-98-020, NEP-98-025, NEP-98-027, NEP-98-028, NEP-98-030, NEP-98-033, NEP-98-034, NEP-98-057, NEP-98-061, NEP-98-064, NEP-98-068, NEP-W-022, NEP-W-042, O. nivara, O. rufipogon, OHA, OIRI, PALSA MASINO, PALSA MOTO, PANJHALI, PATLE, PATLE::IRGC 27635-1, PHOKALERI, PHOOLPATO, PURBIA (KALANSAR)::IRGC 59189-1, PURBIA(KALANSAR), RAJ BHOG, RAJMANUWA, RAM DULARI, RAM KAJARA, RANGI, RERM BILASH, SABITRI, SAMDHI DULARI, SANO BEGANY CHIYA, SATARIYA MASINO, SATARIYA MOTO, SATHIYA, SATRIYAJHAR, SETHARO, SETO HARDA, SHELI GHAIYA, SHYAMJIRA, SITA MATA, SOKAN, SOKAN DHAN, SUGA PANKHI, TAKHU DHAN, TALLY, TARA, TARA::IRGC 59244-1, THAPACHINIYA, THAPACHINIYA::IRGC 16234-1, TINNA, TINNI
24	Indonesia	32	BANSPHUL, BASMATI PAHADE, BHATTE, BHUIN DHAN, CHHOMRONG DHAN, DANGSING DARMALI, DARMALI, FARAM BAGADE, GHAMRI, JHALI(EARLY), JHINUWA, JUMALI, JUMULA 2, KALCHI BHADAI, LATIGHAWAR, NAKHI, NEP-98-027, O. nivara, PHALAME, PURAMI MARSHI, RATO DARMALI, RATO TAKMARE, SILANGE, TANKI, THANDRE
25	Iran	8	BARSHE-TAULI, BHADIYA DHAN, BHADIYA DHAN, DARMALI, IR-44595, JUMALI, TAULI, THULI DHAN
26	IRRI	4337	063/88/19, 063/88/21, 063/88/23, 063/88/27, 063/88/41, 063/88/42, 32, 34, 8800196, 00080218, 8800200, 00080219, 8800201, 00080220, 8800202, 00080221, 8800206, 00059593, 8800208, 00080222, 8800211, 00080224, 8800212, 00080225, 8800213, 00080226, 8800214, 00059594, 8800215, 00080227, 8800216, 00080228, 8800217, 00080229, 8800218, 00059595, 8800219, 00059596, 8800221, 00080230, 8800222, 00059597, 8800223, 00059598, 8800225, 00080231,

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			8800226, 00080232, 8800247, 00080249, 8800254, 00080255, 8800255, 00080256, 8800290, 00080264, 8800298, 00059611, 8800314, 00059618, 8800317, 00059620, 8800318, 00059621, 8800323, 00059626, 8900158-1, 8900158-2, 9000410, 9000417, 00077151, 9000444, 00077154, 9000492, 9000542, 9000557, 9000559, 9000601, 9000616, 9000716, 9000717, 9100017-1, 9100053, AAMJHUTTE, AANGA, AAP JHOOTE, AASRANGE, AATTE, ABJUTE DHAN, ACHAME, ACHHAME, ACHHAME MASINO, ACHHAMEBACHHI, ACHKAME, ADALAT, ADARA DHAN, AGA DHAN, AGAN, AHE(LOCAL), AIRET DHAN, AKALI, AKELEY MASINO, AMAGHAUD, AMERICAN, AMJHUTTE, AMP JHOTE DHAN, AMP JHUTE DHAN, AMPJHUPE, ANAD DHAN, ANADEE, ANADI, ANADI DHAN, ANADI WHITE, ANADI WHITE::IRGC, ANADY, ANANDE DHAN, ANANDI, ANANDI MASINO, ANANDI PANKH, ANAPACHHI, ANATI, ANDA, ANDDI DHAN, ANDI, ANDI WHITE, ANGA, ANJAN DHAN, ANJANA, ANJANA DHAN, ANJANA RICE(DHAN), ANJANAWA, ANJYANA DHAN, ANP JHOOTE, ANPJHUTTE, ANTHAWAN, ANTI (ANADI-DHAN), ANYA, APA JHUTE, APTHUTTE, ARA DHAN, ARCHOTY ZRURA, ARUNA, ASAME, ASAME MASINO, ASAMI RATO, ASAMIYA BASMATI, ASARE DHAN, ATBISE DHAN, ATH HAGARI JARAHA, ATH HAGARI JARAHA, ATTE, ATTE MARSI, ATTE PAHELE, ATTE PHEDI, ATTE(LOCAL), ATTYA DHAN, AUDAN, AUNDRE DHAN, AUNRI DHAN, AURI(JHAR DHAN), AUS HARINKER, AVARBAS, BABHANI, BABUNIYA SAROO, BABURAM, BACCHIHARDA, BADA GAUNLE, BADAIYA, BADARI DHAN, BADASAL, BADHIYA NAKI, BADSAR, BAGAR, BAGAR DHAM, BAGAR THIMAHA, BAGARI, BAGERI, BAGETAULI, BAGETAULI::IRGC 6, BAGHE RUDWA, BAHARANI, BAHERIA, BAJAR BHANG DHAN, BAKAI, BALAM SARI, BALAM SER, BALAMACHI, BALAMSAR, BALAUSAR, BALESARI, BALMSAR DHAN, BANDAR KUHI, BANDHAN, BANGALUWA, BANGARI JARHAN, BANGE DUDHE, BANGLA, BANGLA::IRGC 5887, BANSBARELI, BANSPHOOL, BANSPHUL, BANYARE, BARAGAULE DHAN, BARAGAUNLE DHAN, BARAM KARTIKA, BARCHHA BAHADUR, BARDANA, BARHAM BHOOSI, BARKAASAN DHAN, BARKHE TAULI, BARKHE TAULI::IRG, BARMA BHOOSI, BARMA DHAN, BARTALO DHAN, BARWA SARO, BASMATI, BASMATI ANPJHUTTE, BASMATI DHAN, BASMATI GOLA, BASMATI LAMO, BASMATI LAMO::IRG, BASMATI MASINO, BASMATI MASINO(PU, BASMATI MIXED 1, BASMATI MIXED 2, BASMATI MUTANT, BASMATI NOKHI, BASMATI PAHADE, BASMATI RED, BASMATI UZARKA, BASMATI WHITE, BATESURA, BATISI, BATIYA, BATTAI DHAN, BATTAL DHAN, BATTISARE JARAN, BAUTE, BAYARNI, BAYARNI DHAN, BAYARNI THINUNA, BEBUE, BEGAMI, BELAUR, BELGUDI, BENGSAR, BERUGUTI DHAN, BHADAIYA BA, BHADAIYA HARINKER, BHADAIYA THELAIYA, BHADIYA DHAN, BHADRI, BHAGHAIYA, BHAI SALOT DHAN, BHALU, BHALU TAULI, BHANGENE, BHANRADYA, BHASEY GRURA, BHAT KHANYA, BHATTE, BHATTE DHAN, BHATTE MARSI DHAN, BHOLANEE, BHONDWA ANANDI, BHOOLANI, BHOTANGA, BHOTANGE, BHOTBACHHI, BHUA DHAN, BHUI DHAN, BHUI MALI DHAN, BHUIN DHAN, BHURSHALE DHAN, BHUTAHI LAL DEYA, BHUWA DHAN, BIGIN, BIJULI BATI, BIJULI BATI::IRGC, BINANAM DHAN, BIRAM PHOOL, BIRIMPHUL, BOHORA, BOKATI DHAN, BOOMBOLI GHAIYA, BORE DHAN, BOTE DHAN, BOTE TAULI, BOYA DHAN, BRINGPHUL, BRUNI, BUNGARI JARUN, BUWA DHAN, CHABO GHAIYA, CHAIA ANASER, CHAMPA, CHAMPASARY, CHANACHUR DHAN, CHANANCHUR, CHATKE DHAN, CHENGAUL, CHENGUL, CHENGUL MASINO, CHHATANGE DHAN, CHHERLINGE SHIWUW, CHHERLUNGE, CHHERLUNGE PAHERO, CHHITA, Chhomromg, CHHOMRONG DHAN, CHHOTE, CHHOTE DHAN, CHHOTE DHAN::IRGC, CHHOTI MASHINO, CHIEWRE, CHIKUWA KHOLA LOC, CHIMALE DHAN, CHIMASARI, CHIMATHE DHAN, CHINA 4, CHINA BURO, CHINA(EARLY), CHINAMURI DHAN, CHINATOR DHAN, CHINDI, CHINIYA DHAN, CHINNE DHAN, CHIRAKHE, CHIRAKHE ATTE, CHIRANKE DHAN, CHIRUAKHU, CHIULI DHAN, CHIUNDE DHAN, CHIVAKHA, CHIVAKHE, CHIVANKHE, CHOBE, CHOBHA GHAIYA, CHOBO, CHOBO::IRGC 61930, CHOOCHEU, CHOTE MARSI, CHOTEMARSI, CHOTTI, CHOVE, CHOWA, CHURE, CHURENO DHAN, COLORED ATTE, DAILEKH(LOCAL), DAINY, DAINY::IRGC 58943, DALE MASINO(KASHA, DALLE DHAN, DALLE KALAM, DALLE MASINO, DALMARI, DALSHINGE DHAN, DAMARI DHAN, DANALE NAKA, DANDA BASMATI, DANGE MARUWA, DANGSING DARMALI, DANKI LOCAL, DARAMALI, DARAS, DARAS (PICHAR), DARIN MASINO, DARMALI, DARMALI DHAN, DARMALI LOCAL, DARMARI, DARMARI DHAN, DARUMARI, DAULI DHAN, DAWADI GHAIYA DHA, DEDHWA DHAN, DEDI DHAN, DEHRADUNE DHAN, DELAIYA, DELUA DHAN, DENDI, DERAWA, DERAWA::IRGC 6410, DERUWA, DESHI THANAHWA, DESI THARUWA, DEVARASI, DEVARASI::IRGC 16, DEWSAR, DHAN, DHAN LOCAL, DHANGALI, DHANICE, DHANUSH BAN, DHATULO, DHAUDO, DHEDSARA SARIYAN, DHEDUWA DHAN, DHERA DUN BASMATI, DHOKRO DHAN, DHUDHE DHAN, DHUDUKALAM,

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			DHUM KARA, DHUMASI, DHUMMKHORA, DHUNGE DHAN, DHUNGE DOKRO DHAN, DHUNMURIA, DHUSARA, DHUSE, DHUSUNI, DIRAWA DHAN, DIRWA, DJARANGA, DOGRO DHAN, DOKORO, DOLAN, DORMALI, DOSARA DHAN, DOSARO, DUDE, DUDE DHAN, DUDENEULI, DUDHA RAJ,DUDHE, DUDHEL BHATIA, DUDHI, DUDHI SAROO, DUDHI SAROO::IRGC, DUDHIA DYNE, DUDHURAJ, DUDY MASHINU, DUMSI, DUMSIKALAM, DUMSIKALAM::IRGC, DUNGHE DHAN, DUNGI BARUWA, DURGA, DUSARI, EARLY 1(KATHMANDU), EARLY 2(KATHMANDU), EARLY MID-SEASON, EKRLE MASINO, FALE, FARAM BAGADE, FARM 45, FARM BAGARI, FARMA, FULBIRENG, GADAR, GADAR UZARKA, GADDER 2, GADE, GAHUAE, GAHUM, GAHUME MASINO, GAIA, GAIJALE GHAIYA, GAIYA DHAN, GAJ GAUR, Gajale, GAJALEE GHAIYA, GAJALI DHAN, GAJI, GAJKESHAR, GAJPATI, GAJPATI::IRGC 589, GAJPATI::IRGC 589, GAMADI, GAMLARI, GARBHADHAN, GARDI, GARESI MARSI, GARJI DHAN,GARURA, GARURA::IRGC 6411, GAURADI, GAURE DHAN, GAURI DHAN, GAURIA, GAYA DHAN, GAZALI, GHADEWA, GHAIYA, GHAIYA DHAN, GHAIYA LOCAL, GHAIYA::IRGC 1628, GHAMRI, GHANDRUK, GHAR, GHARA, GHERAI, GHIEW KUAR, GHIEW KUMARI, GHILE, GHIU KUMARI, GHOCHI TAULIA, GHODE BACHHI, GHURIA, GHYALE DHAN, GIHOTE DHAN, GILASPURI DHAN, GITA CHOURE DHAN, GOGI DHAN, GOJAWA, GOJI DHAN, GOJI PAKHE DHAN, GOKHUE SAIER, GOKUL PATI, GOKUL SAH, GOLA, GOLA BACHHI, GOLA BACHI, GOLAI, GOLAI TAULI, GOPAL, GOPAL DHAN, GOPAL::IRGC 61953, GOPALE DHAN, GORA(LOCAL), GORURA, GORUWA, GUD GUDE, GUDE DHAN, GUDGUDE DHAN, GUDULE, GUDURA, GUDURA MANSARA, GUDURA::IRGC 6195, GUNDRIKBHOG, GUNTE DHAN, GURANRA DHAN, GURDI, GURDI DHAN, HAKUWA, HALIDA, HALIDA::IRGC 5900, HALPURA, HANDI PHOOL, HANSA, HANSA RAJ, HANSARAJ DHAN, HANSRAJ, HANSRAJ DHAN, HAPALI, HARA GOLA, HARDA THOOLA, HARIBHAKTE DHAN, HARINA DOLAN, HARINCARE, HARINKER, HATAKIA DHAN, HAUSE DHAN, HAUSRAJ DHAN, HAUSRAJ ZARAN, HAVANEMUWA SARO,HAWA, HILE MARSHI, HIMALI DHAN, HIMALIMARSI(DHAN), HYANG NASWA, I 126, I 200, I 210, I 230, I 262, I 3, I 319, I 364, I 371, I 406, I 41, I 41::IRGC 75927-, I 45, I 463, I 466, I 483, I 51, I 523, I 536, I 614, I 650, I 667, I 695, I 814, 814::IRGC 76028, II 25, III 194, III 214, III 37A, III 60, III 66, III 77, IMPROVED SHEN, INDRA BACHHI, IR-20(IMP), IR-44595, IRET DHAN, J 2, JADAN, JADAN DHAN, JADAN MARSHI, JADAN POKHARELI, JADO, JADO::IRGC 1966-, JAGAR, JAGGIWAN DHAN, JAGONATI, JALMANI, JALWADALI DHAN, JAMADI, JAMRA, JANAKI, JAPANI DHAN, JAPO DHAN, JARA DHAN, JARAN, JARAN DHAN, JARAN SETO DHAN, JARHAN DHAN, JARMANI, JARNELI, JARNELI DHAN, JARNELI JARAN, JARNELI ZARAN, JARNERI, JARO, JASARIA, JASAWA, JASWA, JAULE DHAN, JAULE LOCAL, JAULEA, JAULI, JAULI DHAN, JAWARO DHAN, JAWLE DHAN, JAWLYA DHAN, JENGAR, JENGAR::IRGC 5902, JEPH MARSI, JERNELY, JETHO BUDHO, JETHO BUDO, JHABARI SARO, JHALI, JHALI B, JHALI DHAN, JHALI(EARLY), JHAR, JHAR DHAN, JHAR LANJHI, JHARA, JHARAN, JHARANG, JHARANG DHAN, JHARANGA, JHARANGA DHAN, JHARNADHAN, JHARUWA, JHARUWA DHAN, JHAYALE GHAIYA, JHAYLE DHAN, JHILINGI DHAN, JHILLI DHAN, JHIMMA, JHINUWA, JHINUWA DHAN, JHINUWA DHAN::IRG, JHINUWA KALO, JHINUWA MASINO, JHIRI, JHIRI DHAN, JHOOPE MASHINO, JHOOPO MAXSINO, JHUNMUNYA, JHUPPE MASINO, JHUSE DHAN, JHYALI DHAN, JILI DHAN, JINI DHAN, JINUWA, JIRA BATISHI, JIRASHARI, JIRASHORI, JIRE ASRANGE, JIRE MANSARA, JIRE SARANGE, JOGI, JOGINI MASINO, JUGA DHAN, JUHARI DHAN, JULEARI MARSI, JUMALI, JUMALI::IRGC 9542, JUMALI::IRGC 9542, JUMLI DHAN, JUMLI MARSHI, JUMULA 2, JUMULA 2::IRGC 13, JUMURI ZALO, JUNGE MARSI, JUNGE TAULI, JUNGEMARSI, JUNGEMARSI::IRGC, JURA DHAN, JUWA, JUWA DHAN, JUWADI, JUWARI, JUWARI DHAN, JUWARO DHAN, JWARI, JYALI DHAN, JYAMIRE, JYANAGI DHAN, KABHNACHARCHA DHA, KAHARE DHAN, KAILE DHAN, KAIRE DHAN, KAIYA, KAKANI 2, KAKANI 2::IRGC 13, KAKANI 3 A, KAL KAMOD, KALA KAMOD, KALA NAMAK, KALA NAMAK DHAN, KALA NIMAK, KALAM KATHI, KALAM KHOR, KALAMHOR, KALCHI BHADAI, KALI MARSHI, KALIKATE DHAN, KALNATE, KALNATHE DHAN, KALO, KALO BACHI, KALO BASMATI, KALO DHAN, KALO GAIYA, KALO GUDE DHAN, KALO GUNDE DHAN, KALO JARAN DHAN, KALO JHINUWA, KALO KHARSYA DHAN, KALO MAHELI, KALO MANSARO, KALO MANSARO MUTA, KALO MARSHI, KALO MARSI, KALO MARSO, KALO METHA DHAN, KALO NAMAK, KALO NUNIYA, KALO PARAME, KALO PATALE, KALO PATALE DHAN, KALO PHALAME, KALO ROOMA, KALO THINUWA, KALOKATTE, KALOMASINO DHAN, KALOPUCHHRE, KALOSAR, KALOTOULI, KALPANA, KAMOD, KAMODH, KAMRI, KAMULI, KAMULI::IRGC 2392, KANAK JIRA, KANAKGIR, KANAKGIRA, KANCHAN, KANEGIRA, KANGRES DHAN, KANGRESHI DHAN, KANGRESSI, KANHKI, KANJEERA PAHENLOO, KANJHAR, KANJI MATSARO, KANJIRA, KANJIRE, KANTI MASINO, KARANGA,

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			KARANGE, KARANGI, KARANGI DHAN, KARI KAMAR, KARIA KAMAT, KARIA KAMODH, KARIA KUMATHI, KARISHNABELI, KARISHNABELI::IRG, KARIYA KAMAT, KARIYA KAMUR, KARMA, KARMA SETO, KARME MASINO, KARMULEE DHAN, KARMULI, KARNGI, KARTIK SALI, KARUEL, KARUEL::IRGC 8379, KASANTH, KATAKA, KATAURA, KATE DHAN, KATH KUMAL, KATHAKAMAL, KATHE, KATHE DHAN, KATHE JHINUWA, KATHE JHINUWA DHA, KATHE MASINO, KATIK SALI, KATIKIAUNS, KATKAMAL, KATKI PANJA(RED P), KATURE DHAN, KATUWA KUMALE, KATUYHAR DHAN, KAYACHHA DHAN, KETAKI, KHACHCHA DHAN, KHACHYA DHOKRO, KHALUJYALE DHAN, KHARELI, KHASARI DHAN, KHASRE, KHEMATI, KHERA, KHERHA, KHETALA DHAN, KHETARA DHAN, KHOACHHA PATI, KHOILE, KHYANTY, KIUDE, KOELI, KONJIRA, KOYALEE MASINO, KRISHNA BELI, KRISHNA BHOG, KRISHNA DHAN, KT31-1, KT31-4, KT32-2, KUMALE, KUMMAT, KUNDIA UJALA, KUNDWA SAPHED, KUSUM KATIKI, KUSUM KATIKI::IRG, KUTYULIA DHAN, LADBHADI, LADEKOLI DHAN, LADMADE, LAHARE DHAN, LAHARE PAKHE DHAN, LAHARI DHAN, LAILA MAJNU, LAL AHU, LAL DHAN, LAL DHOF, LAL SAR, LAL SAR::IRGC 161, LALAKA GADUR, LALDHOJE, LALKA EJANTA, LALSAR, LALTAR, LAMANI, LAME DHAN, LAME JARAN AND RU, LAME JARANA, LAME MANSARO, LAMJOAM, LAMJUNYE, LAMLARI DHAN, LAMO PAHENLO, LAREY, LASMORO, LATHAMATHYA DHAN, LATIGHAWAR, LATIJHABAR, LATIJHABAR::IRGC, LAUBILI, LAXAMI, LAXHMI, LESPAR B, LOHA SINGH, LOHABAN, LOHJIR, LOKIME DHAN, LOTAN SERAU, LUHAGRU, MACHE GHAIYA, MACHHE DHAN, MADHU SARMASINO, MADHUSAR MOTI, MADHUWA KARIA, MADHUWA KARIA::IR, MADI, MADISHE, AHAJOGIN, MAHARA DHAN, MAINA POKHARI, MAINE POKHRELI, MAK MASINU, MAKHMAL MEHI, MAKUWA, MAL BHOG, MAL MARSO, MALBHOG MASINO, MALIDA, MALINGE, MALSI, MAN SULI DHAN, MANA MURI, MANA MURI::IRGC 2, MANABOGA, MANAHARA, MANAMURI, MANASARA, MANBHOG, MANEPURI, MANESARI, MANIPURE, MANSAR, MANSARA, MANSARA DHAN, MANSARA DHAN::IRG, MANSARI, MANSARO, MARANGI GHAIYA, MARSEY PAHELO, MARSHI, MARSHI DHAN, MARSHO DHAN, MARSI, MARSI AND JUMLI, MARSI DHAN, MARSI SUN, MARSIPAHELO, MARSO, MAS INO ZARUN DHA, MASARI, MASHINO DHAN, MASHINO MADESHE, MASINO BASMATI, MASINO GAURIA, MASINO ZOLO, MASINU AROMA, MASNSARA GHAIYA, MASSU, MASULI, MATIA, MATIYA, MATURI, MATURY, MEHELI, MEHIKHANJAR, MEPE MARSI, MIMBAI DHAN, MISHIN BORA, MISIN PHOORA, MIXED DHAN, MODORA DHAN, MONAPURI, MOONOR, MORANGE, MORONIGIYA, MOTAKA ASAHANI, MOTANGE PAHELLO L, MOTANGE PAHELLO L, MOTISAR, MOTISARI, MOTY CHUR, MURALA, MURALIA, MURLA, MURLA KHERA, MURLIA, MURSI DHAN, MUSLIM, MUSURI DHAN, MUTURI, MUTURI (EARLY), NABO, NAGBELI, NAGBERI, NAGINA 22, NAGIR, NAIHARWA, NAJEER, NAJHIR, NAJIR, NAKA DHAN, NAKHI, NAKHINE DHAN, NAMERO DHAN, NAN DHAN, NANI DHAN, NANI GHAIYA, NANIA, NANIYA DHAN, NANKI, NASWA MASINU, NAULI DHAN, NAULO DHAN, NAURO, NAWN GAWN DOOMARI, NEEMAI DHAN, NEP-98-007, NEP-98-020, NEP-98-022, NEP-98-025, NEP-98-026, NEP-98-027, NEP-98-028, NEP-98-029, NEP-98-030, NEP-98-031, NEP-98-033, NEP-98-034, NEP-98-035, NEP-98-037, NEP-98-038, NEP-98-040, NEP-98-057, NEP-98-061, NEP-98-063, NEP-98-064, NEP-98-065, NEP-98-066, NEP-98-068, NEP-98-070, NEP-W-001, NEP-W-002, NEP-W-003, NEP-W-004, NEP-W-010, NEP-W-012, NEP-W-014, NEP-W-017, NEP-W-019, NEP-W-021, NEP-W-022, NEP-W-034, NEP-W-042, NEP-W-045, NEP-W-046, NEP-W-052, NEPALE DHAN, NEPALE JARAN, NEPALSE THAPACHIN, NGRC 1657, NGRC 1658, NGRC 1659, NGRC 1660, NGRC 1661, NGRC 1662, NGRC 1663, NGRC 1665, NGRC 1666, NGRC 1668, NGRC 1669, NGRC 1670, NGRC 1671, NGRC 1672, GRC 1673, NGRC 1674, NGRC 1675, NGRC 1677, NGRC 1678, NGRC 1679, NGRC 1681, NGRC 1683, NGRC 684, NGRC 1685, NGRC 1686, NGRC 1687, NGRC 1688, NGRC 1689, NGRC 1690, NGRC 1691, NGRC 1692, NGRC 1693, NGRC 1694, NGRC 1695, NGRC 1696, NGRC 1697, NGRC 1698, NGRC 1699, NGRC 1701, NGRC 1702, NGRC 1703, NGRC 1704, NGRC 1705, NGRC 1706, NGRC 1707, NGRC 1708, NGRC 1709, NGRC 1710, NGRC 1711, NGRC 1712, NGRC 1713, NGRC 1714, NGRC 1715, NGRC 1716, NGRC 1717, NGRC 1718, NGRC 1721, NGRC 1722, NGRC 1723, NGRC 1724, NGRC 1725, NGRC 1726, NGRC 1727, NGRC 1728, NGRC 1729, NGRC 1730, NGRC 1731, NGRC 1732, NGRC 1733, NGRC 1735, NGRC 1736, NGRC 1737, NGRC 1738, NGRC 1739, NGRC 1740, NGRC 1741, NGRC 1742, NGRC 1743, NGRC 1744, NGRC 1745, NGRC 1746, NGRC 1747, NGRC 1748, NGRC 1749, NGRC 1750, NGRC 1751, NGRC 1752, NGRC 1753, NGRC 1754, NGRC 1755, NGRC 1756, NGRC 1757, NGRC 1758, NGRC 1759, NGRC 1760, NGRC 1761, NGRC 1762, NGRC 1763, NGRC 1764, NGRC 1766, NGRC 1767, NGRC 1768, NGRC 1769, NGRC 1770, NGRC 1771, NGRC 1772, NGRC 1773, NGRC 1774, NGRC 1775, NGRC 1777, NGRC 1778, NGRC 1779, NGRC 1780, NGRC 1781, NGRC 1782, NGRC 1783, NGRC 1785, NGRC 1786, NGRC 1787, NGRC 1788, NGRC 1789,

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			NGRC 1790, NGRC 1791, NGRC 1792, NGRC 1793, NGRC 1794, NGRC 1795, NGRC 1796, NGRC 1797, NGRC 1798, NGRC 1799, NGRC 1800, NGRC 1801, NGRC 1802, NGRC 1803, NGRC 1804, NGRC 1805, NGRC 1806, NGRC 1807, NGRC 1808, NGRC 1809, NGRC 1810, NGRC 1811, NGRC 1812, NGRC 1813, NGRC 1814, NGRC 1815, NGRC 1816, NGRC 1817, NGRC 1818, NGRC 1819, NGRC 1820, NGRC 1821, NGRC 1822, NGRC 1823, NGRC 1824, NGRC 1826, NGRC 1827, NGRC 1828, NGRC 1829, NGRC 1830, NGRC 1831, NGRC 1832, NGRC 1833, NGRC 1834, NGRC 1835, NGRC 1836, NGRC 1837, NGRC 1838, NGRC 1839, NGRC 1840, NGRC 1841, NGRC 1842, NGRC 1843, NGRC 1844, NGRC 1845, NGRC 1846, NGRC 1847, NGRC 1848, NGRC 1849, NGRC 1850, NGRC 1851, NGRC 1852, NGRC 1853, NGRC 1854, NGRC 1856, NGRC 1857, NGRC 1858, NGRC 1859, NGRC 1860, NGRC 1861, NGRC 1862, NGRC 1863, NGRC 1864, NGRC 1865, NGRC 1866, NGRC 1867, NGRC 1868, NGRC 1869, NGRC 1870, NGRC 1871, NGRC 1872, NGRC 1873, NGRC 1874, NGRC 1875, NGRC 1876, NGRC 1878, NGRC 1879, NGRC 1880, NGRC 1882, NGRC 1884, NGRC 1885, NGRC 1886, NGRC 1887, NGRC 1888, NGRC 1889, NGRC 1890, NGRC 1891, NGRC 1892, NGRC 1893, NGRC 1894, NGRC 1896, NGRC 1897, NGRC 1898, NGRC 1899, NGRC 1900, NGRC 1901, NGRC 1902, NGRC 1903, NGRC 1904, NGRC 1905, NGRC 1906, NGRC 1907, NGRC 1908, NGRC 1909, NGRC 1910, NGRC 1911, NGRC 1912, NGRC 1913, NGRC 1914, NGRC 1915, NGRC 1916, NGRC 1917, NGRC 1918, NGRC 1919, NGRC 1920, NGRC 1921, NGRC 1922, NGRC 1923, NGRC 1924, NGRC 1925, NGRC 1926, NGRC 1927, NGRC 1928, NGRC 1929, NGRC 1930, NGRC 1931, NGRC 1932, NGRC 1933, NGRC 1934, NGRC 1935, NGRC 1936, NGRC 1938, NGRC 1939, NGRC 1940, NGRC 1941, NGRC 1942, NGRC 1943, NGRC 1944, NGRC 1945, NGRC 1946, NGRC 1947, NGRC 1948, NGRC 1949, NGRC 1950, NGRC 1951, NGRC 1952, NGRC 1953, NGRC 1954, NGRC 1955, NGRC 1956, NGRC 1957, NGRC 1958, NGRC 1960, NGRC 1961, NGRC 1962, NGRC 1963, NGRC 1964, NGRC 1965, NGRC 1966, NGRC 1967, NGRC 1968, NGRC 1969, NGRC 1970, NGRC 1971, NGRC 1972, NGRC 1973, NGRC 1974, NGRC 1975, NGRC 1976, NGRC 1978, NGRC 1979, NGRC 1980, NGRC 1981, NGRC 1982, NGRC 1984, NGRC 1985, NGRC 1986, NGRC 1987, NGRC 1988, NGRC 1989, NGRC 1990, NGRC 1991, NGRC 1992, NGRC 1993, NGRC 1994, NGRC 1996, NGRC 1998, NGRC 1999, NGRC 2000, NGRC 2001, NGRC 2002, NGRC 2003, NGRC 2004, NGRC 2005, NGRC 2006, NGRC 2007, NGRC 2008, NGRC 2009, NGRC 2010, NGRC 2011, NGRC 2012, NGRC 2013, NGRC 2014, NGRC 2015, NGRC 2016, NGRC 2017, NGRC 2018, NGRC 2020, NGRC 2021, NGRC 2022, NGRC 2023, NGRC 2024, NGRC 2025, NGRC 2026, NGRC 2027, NGRC 2028, NGRC 2029, NGRC 2030, NGRC 2031, NGRC 2032, NGRC 2033, NGRC 2034, NGRC 2035, NGRC 2036, NGRC 2037, NGRC 2038, NGRC 2039, NGRC 2040, NGRC 2041, NGRC 2042, NGRC 2045, NGRC 2046, NGRC 2047, NGRC 2048, NGRC 2049, NGRC 2050, NGRC 2051, NGRC 2052, NGRC 2053, NGRC 2054, NGRC 2055, NGRC 2056, NGRC 2057, NGRC 2058, NGRC 2059, NGRC 2060, NGRC 2061, NGRC 2062, NGRC 2063, NGRC 2064, NGRC 2065, NGRC 2066, NGRC 2067, NGRC 2068, NGRC 2069, NGRC 2070, NGRC 2071, NGRC 2073, NGRC 2075, NGRC 2076, NGRC 2077, NGRC 2078, NGRC 2079, NGRC 2080, NGRC 2081, NGRC 2082, NGRC 2083, NGRC 2085, NGRC 2086, NGRC 2087, NGRC 2090, NGRC 2091, NGRC 2092, NGRC 2093, NGRC 2094, NGRC 2095, NGRC 2096, NGRC 2097, NGRC 2098, NGRC 2099, NGRC 2100, NGRC 2101, NGRC 2102, NGRC 2103, NGRC 2104, NGRC 2105, NGRC 2106, NGRC 2107, NGRC 2108, NGRC 2109, NGRC 2110, NGRC 2111, NGRC 2112, NGRC 2113, NGRC 2114, NGRC 2115, NGRC 2116, NGRC 2117, NGRC 2118, NGRC 2119, NGRC 2120, NGRC 2121, NGRC 2122, NGRC 2123, NGRC 2124, NGRC 2125, NGRC 2126, NGRC 2127, NGRC 2128, NGRC 2129, NGRC 2130, NGRC 2131, NGRC 2132, NGRC 2133, NGRC 2134, NGRC 2135, NGRC 2136, NGRC 2137, NGRC 2138, NGRC 2139, NGRC 2140, NGRC 2141, NGRC 2142, NGRC 2143, NGRC 2144, NGRC 2145, NGRC 2146, NGRC 2147, NGRC 2148, NGRC 2149, NGRC 2150, NGRC 2151, NGRC 2152, NGRC 2153, NGRC 2154, NIBAI DHAN, NIMACE, NIMUE, NOKHI, NYAULI, NYAULI::IRGC 8862, O. nivara, O. rufipogon, OHA, OIRANGE DHAN, OIRANGE MARSI, OIRI, OSAN DHAN, PACLENI DHAN, PADHANEE, PADMA, PAHALWAN BARCHHA, PAHELE, PAHELE RAJMELE, PAHELI, PAHELO, PAHELO JARAN, PAHELO MARSI, PAHELO MASINO, PAHELO PHALAME, PAHELO THARAKATHE, PAHENLE, PAHENLEY, PAHENLI, PAHENLOO APPGHUPP, PAKHA ZERMANI, PAKHE DHAN, PAKHE GHAIYYA, PAKHE JARAN DHAN, PAKHOLAHARI DHAN, PALE, PALIJA, PALSA, PALSA MASINO, PALSA(LAL KAMAL), PALTI DHAN, Palung 2, PANERI, PANGALI DHAN, PANI KALAM, PANIDHAN, PANIKALAM, PARAMI, PARAN PIULI DHAN, PARAN PRALI, PARANPAULI, PAREWA PANKH, PARNI, PARWAL, PARWANIPUB, PASHNI, PATAL SHREE, PATLE, PATLE MARSI, PATLE::IRGC 27635, PATTE (AULALI) DHAN, PAYANAWA, PEALEA, PELE DHAN, PHALAM, PHANKHIRAJ, PHARMA, PHAUDAR MASINO, PHAUDEL, PHELE DHAN, PHODE JAGANATHIYA, PHODEL, PHOKALERI, PHOOL KUMARI, PHOOL KUWAR, PHOOLOSARI, PHOOLPATO, PHULPATA, PHULPATA DHAN, PHURUCHYOTI, PIPAL MARSHI, PIYALE PAHELO, POHHERLIMASION, POHHERLIMASION::I, POKARILO MASINO, POKEJUA, POKEJUA MIXED, POKHARA

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			MASINO, POKHAREL DHAN, POKHARELI, POKHARELI MASINO, POKHARELO MASINO, POKHRELI, POTALE DHAN, POUJE, PULPATO, PUOBE JHINUWA, PURAMI MARSHI, PURANO JAGAR, PURBERI JINUWA DH, PURBIA (KALANSAR), PURBIA(KALANSAR), PUTUJE, PYALE JARAN DHAN, PYUTHAN DHAN, PYUTHANE DHAN, PYUTHARI SETO, RAHAMANUWA, RAI MANULA, RAI MANULA::IRGC, RAJ BHOG, RAJKUMAR DHAN, RAJMANUWA, RAKHSHE, RAKSALI, RAM BHAG, RAM DULARI, RAM JAMAI, RAM JAWAN, RAM KAJARA, RAM SALEE KATAKA, RAM SALEE KATAKA, RAM SALI, RAMANI, RAMANUWA JARAN, RAMDHAN, AMDULARI, RAMJEWAEN, RAMLAHARI DHAN, RAMMILI CHOTE, RANGELI DHAN, RANGI, RANGO, RANGWA, RANKHE DHAN, RASH DHAN, RATANPUR DHAN, RATE DHAN, RATE GHAIYA DHAN, RATHE DHAN, RATIN, RATO AHU, RATO ANADI DHAN, RATO BASMATI, RATO BASMATI::IRG, RATO DARMALI, RATO DHAN, RATO GAIYA, RATO GHAIYA, RATO GHAIYA DHAN, RATO GOLA, RATO KATANYA, RATO MARSHI, RATO MASINO, RATO PIDIYA DHAN, RATO TAKMARE, RATOHATIKE DHAN, RATOKATHE, RATOMANSARA, RAWDUWALI, RED BASMATI, RERM BILASH, RERM BILASH::IRGC, RESALI, RIMALI JARHAN, ROOP KAMAL, ROSANEE DHAN, ROTANPUR DHAN, RUDWA, RUMSERO DHAN, SABITRI, SAHMANA, SAHMARDAN, SAJANI, SAJANI GHAIYA, SALI, SALO DHAN, SALYAN DUDHE, SAMDHI DULARI, SAMUNDRA-PHENEE, SAMUNDRA PHINJ, SAN JIRA, SANKHARIKA, SANO CHOTE, SANO DHAN, SANO DHUDE, SANO GUDE DHAN, SANO GUNDE, SANO JARAN DHAN, SANO KALO GUNDE D, SANO MARSI, SANTARA, SAPRADI, SAPRALI, SARAIYA DHAN, SARI DHAN, SARJU 49, SARLARI DOLAN, SARO, SAROMUMALE, SAT RAJ, SATARA, SATARA(DHUMKHERA), SATARIA, SATHA, SATHA BHADAI, SATHA DHAN, SATHI, SATHI BAGARI, SATHI SARO, SATHIA, SATHIYA, SATHIYA::IRGC 592, SATI, SATIKE DHAN, SATLARI, SATNAJ, SATRA, SATRAJ, SATRIYAJHAR, SAUTINIA, SETE, SETE BASMATI, SETE DHAN, SETE JHANUA, SETHARO, SETHRE, SETI KUMALE, SETO ANADI, SETO AND KAULO DH, SETO BACHHI, SETO BASMATI, SETO CHAIYA DHAN, SETO DHAN, SETO GHAIYA, SETO GUNDE DHAN, SETO HARDA, SETO JHINUWA, SETO JHINUWA::IRG, SETO JINUWA, SETO MARSI, SETO MARSO MUTANT, SETO MASINO, SETO PHAN, SETO SHYAMJEERA, SETOHATIKE DHAN, SETYA, SETYA::IRGC 88654, SHAYAN JIRO, SHELI GHAIYA, SHEPA CHALIS, SHETE KUALAMA, SHIMTARO, SHINALIPATRE, SHINTARO, SHOGAN DHAN, SHYAM ZIRO, SHYAMJEERO, SHYAMJIRA, SHYAMJIRO DHAN, SHYANO KALAN, SIDALI, SIDALI::IRGC 9567, SILAME ZARAN, SILANGE, SIM JIRA, SIM THADO, SIMGIRA, SIMTARA, SIMTARO DHAN, SIMTHARO, SIMTMARO DHAN, SINGRA DHAN, SIST, SITA, SITA MATA, SITALI DHAN, SIUANTHARI DHAN, SOBARA, SODHUWA, SOHAWAT, SOKAN, SOKAN DHAN, SOMALE DHAN, SONKHAS CHA, SOTAWA(EARLY), SOTHARI, SUGA PANKHA, SUGA PANKHA::IRGC, SUGA PANKHI, SUGA PANKHI DHAN, SUHAWAT, SULSIDANE MASINO, SUNALO DHAN, SUNAULA DHAN, SUNAULI, SUNAULO, SUNAULO DHAN, SUNAWHO, SUNKHARI, SUNKHARI DHAN, SUTWARY DHAN, SUVANA, SUWA, TAGMARO DHAN, TAICHAN DHAN, TAICHUN, TAICHUNG GHAIYA, TAICHUNG(IMP), TAKHU DHAN, TAKMARE, TAKMARE DHAN, TAKMARO, TALAPHOLI DHAN, TALLY, TANGLEKOT DARMALI, TANGMARO DHAN, TANKI, TAPACHINNE, TAPATINI, TARA, TARA::IRGC 59244-, TARAHORE ZARUN DH, TARALE GHAIYA, TARMARE DHAN, TAULEE, TAULEE GHAIYA, TAULI, TAULI DHAN, TAULI GHAIYA, TAULIGA, TAURE DHAN, TAURI, TAURI DHAN, TEBA, TEKLE, THADA DHAN, THAKUR PRASAD, THALIE, THAMKOTE DHAN, THANDRE, THANKOTE, THANKOTE MARSI, THANTER GHAIYA, THANUWA, THAOLAE, THAPA CHINIA DHAN, THAPA CHINIYA, THAPACHHINI, THAPACHINE, THAPACHINE DHAN, THAPACHINI, THAPACHINI DHAN, THAPACHINIA, THAPACHINIA DHAN, THAPACHINIYA, THAPACHINIYA DHAN, THAPACHINIYA::IRG, THAPCHINIA DHAN, THARACHINI DHAN, THARRA DHAN, THATHAR BAGARI, THAURI DHAN, THEMA, THEPA CHINE DHAN, THIMSE, THINUWA, THINUWA DHAN, THINUWA GHAIYA, THOSARE, THUDE GUDE DHAN, THUL DHAN, THULI, THULI DHAN, THULO ACHHAME, THULO GNDRABELI, THULO GUDE DHAN, THULO GUNDE, THULO KALO DHAN, THULO MARSI, THULO SETO, THULOLAHARI DHAN, TILANJAN DHAN, TILIKE DHAN, TILK, TILKE DHAN, TILKI DHAN, TIMURE, TIMURE MASINO KAL, TINA SARY, TINNA, TINNI, TMIMA, TOLLI 27-8, TOLO PAHELO, TSAMATE DHAN, SAMPASARI, TSUAMADA, TSYANAPHOL, TUDHE DHAN, TULSHI PRASAD, TULSIPHOOL, TUMBA, TUMMA, TUNDE, TUNDE DHAN, ULAKA, UZARKA BEJETA, V 12, V 141, V 166, V 178, V 2, V 57, V 79, VII 142, VII 178, VII 193, VII 25, VII 266, VII 270, VII 344, VII 71, VII 77, VII 95, VII 97, VIII 122, VIII 124, VIII 125, VIII 163, VIII 31, VIII 58, VIII 71, VIII 73, VIII 77, VIII 78, VIII 79, W-WA TOLI 26-8, W1244, WANPAKI, YANGKHUKE, Zacaodao 13, ZANELI, ZARMANI DHAN, ZARUDA, ZAULE DHAN, ZEENA MASINO, ZERMAN, ZERNELI, ZINUWA DHAN, ZOOWA, ZUNZALO

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27	Italy	59	AAU BHADAIYA, ANDI, ANDI KALO, ANGHA, ARARET, ARUNA, ASAMI RATO, ATHABISE, BADDADE, BAGAR THIMAHA, BAHAMI, BANSPHUL, BHADAYA, BOYA, DAILEKH(LOCAL), DASHRIYA, GAMADEE, GAMLARI, GARDAR A, GHAIYA LOCAL, GHAMRI, HAKUWA, HANSA, HIMALI, III 13, III 37A, JADO, JALWADALI DHAN, JAMADI, JAMADI, JAMRA, JHAR, JHAR DHAN, KALI MARSHI, KHERA, KUNDIA UJALA, KURIYA, LAREY, LAXAMI, MADHUWA KARIA, MASINU AROMA, MEHELI, MEHILALKA, NABO, NEP-98-040, OIRI, PADMA, PHALAME, SATHA, SATHI SARO, SETO MARSHI, SITA, TARA, TAULI MASINO, THAOLAE, TINNA, TINNI, USHI, VII 198
28	Ivory Coast	2	*O. rufipogon*
29	Japan	118	063/88/19, 063/88/21, 063/88/23, 063/88/27, 063/88/27, AURI(JHAR DHAN), BAKAI, BANDHAN, BASMATI, BASMATI LAMO, CHALISE, CHHOTE DHAN, CO ANADI, DAINY, DALLE KALAM, DARMALI, FARAM BAGADE, GADUR, GAMADI, GHAIYA, GHANDRUK, GHARA, GOLA BACHI, HIMALI, IR-44595, JHINUWA, JUMALI, JUMLI MARSHI, JUMULA 2, KAKANI 2, KALA NIMAK, KALO MASINO, KALOSAR, LUMLE, MAKHMAL MEHI, MANA MURI, MASINO, MASULI, MATKAN, NABO, NAGIR, NAULO DHAN A, NEP-98-027, NEP-98-028, NEP-W-022, NEP-W-042, O. nivara, O. rufipogon, OIRI, PAHELO PHALAME, PHALAME, RATO MARSI, TAKMARE, THANKOTE MARSI, THULO MARSI, TINNA, TINNI
30	Kenya	5	ASAMIYA BASMATI, BASMATI,BASMATI ANPJHUTTE, BASMATI WHITE, MASINO BASMATI
31	Madagascar	39	ANADI WHITE::IRGC 61897-1, ATH HAGARI JARAHAN PADDY::IRGC 23796-1, BANGLA::IRGC 58876-1, BARKHE TAULI::IRGC 16116-1, BIJULI BATI::IRGC 58917-1, CHHOTE DHAN::IRGC 58930-1, CHOBO::IRGC 61930-1, DERAWA::IRGC 64106-1, DEVARASI::IRGC 16173-1, GARURA::IRGC 64111-1, GHAIYA::IRGC 16286-1, GUDURA::IRGC 61955-1, HALIDA::IRGC 59005-1, I 41::IRGC 75927-1, I 814::IRGC 76028-1, JADO::IRGC 61966-1, JHINUWA DHAN::IRGC 88545-1, JUNGEMARSI::IRGC 76901-1, KAKANI 2::IRGC 13373-C1, KAMULI::IRGC 23928-1, KARISHNABELI::IRGC 61979-1, KARUEL::IRGC 83792-1, KUSUM KATIKI::IRGC 59099-1, LAL SAR::IRGC 16185-1, LATIJHABAR::IRGC 61991-1, MADHUWA KARIA::IRGC 16138-2, MANSARA DHAN::IRGC 86940-1, MOTANGE PAHELLO LAULE::IRGC 16160-1, NYAULI::IRGC 88628-1, POHHERLIMASION::IRGC 62025-1, RAI MANULA::IRGC 64138-1, RAM SALEE KATAKA::IRGC 24014-1, RATO BASMATI::IRGC 59205-1,RERM BILASH::IRGC 16273-2, SATHIYA::IRGC 59225-1, SETO JHINUWA::IRGC 62043-1, SETYA::IRGC 88654-1, SIDALI::IRGC 9567-1, SUGA PANKHA::IRGC 24054-1
32	Malaysia	32	BAKAI, BUWA DHAN, DANDA BASMATI, DHUNGE DHAN, DOGRO DHAN, GHAIYA, GHAIYA DHAN, JAULE DHAN, JAWLYA DHAN, JETHO BUDHO, JHAYALE GHAIYA, JHUSE DHAN, JIRASARI MASINO, JUMULA 2, LALKI SARO, NAKHI, OHA, PAHENLE, PAKHE DHAN, PELE DHAN, RANGELI DHAN, RATO BASMATI, RATO DHAN, SHOGAN DHAN, SUNKHARI, TAKMARE, THALIE, YANGKHUKE
33	Mali	10	ANADI WHITE::IRGC 61897-1, ATH HAGARI JARAHAN PADDY::IRGC 23796-1, BANGLA::IRGC 58876-1, BARKHE TAULI::IRGC 16116-1, BASMATI, DERAWA::IRGC 64106-1, I 41::IRGC 75927-1, I 814::IRGC 76028-1, KUSUM KATIKI::IRGC 59099-1, SATHIYA::IRGC 59225-1
34	Nepal	249	AAMJHUTTE, AATTE, ACHHAME MASINO, ACHHAMIYA, AKELEY MASINO, ANANDI MASINO, ANDI, ASAME MASINO, ASAMIYA BASMATI, ATTE, ATTE MARSI, ATTE PAHELE, ATTE(LOCAL), BANDHAN, BANGE MASINO, BANSHAFOR, BANSPHOOL, BANSPHUL, BARCHHA BAHADUR, BARDANA, BARKHE TAULI, BARSHE-TAULI, BASMATI, BASMATI ANPJHUTTE, BASMATI GOLA, BASMATI LAMO, BASMATI MASINO, BASMATI MASINO(PURPLE TIP), BASMATI NOKHI, BASMATI PAHADE, BASMATI RED, BASMATI UZARKA, BASMATI WHITE, BEGAMI, BHADAIYA THELAIYA, BHALU TAULI, BIRUMPHOOT,CHENGUL MASINO, CHHOTI MASHINO, CHIEWRE, CHINA(EARLY), CHINIYA, CHIRAKHE, CHOBO, CHOBO GHAIYA, CHORO, CHULTHA MASINO, DAILEKH(LOCAL), DARAMALI, DARJILINGE, DARMALI, DARMARI, DEHRADUNE, DHANUSH BAN, DHERA DUN BASMATI, DHUSUNI, DOLAKHA MARSI, DOLAKHE, DORMALI, DUDHRAJ, DUDY MASHINU, DURGA, EKLE MASINO, GADAR UZARKA, GAHUME MASINO, GAJ GAUR, GAJALEE GHAIYA, GAJPATI, GANJALI MASINO, GARUE GHAIYA, GHAIYA,GHAIYA LOCAL, GHAIYA(BIJARI), GHAMRI, GHIEW KUAR, GHIEW KUMARI, GUDURA, GUNDRIK BHOG, HANSA RAJ, HANSROJ, HIMALI, HIMALI DHAN, INDRA BELI, JAGAR, JAMRA, JARMANI, JARNELI, JARNELI CHAURELI, JARNELI DHAN, JARNERI, JEENA MASINO, JERNELY, JETHO BUDO, JHALI B, JHALI(EARLY), JHINUWA, JHINUWA KALO, JHINUWA MASINO, JHOOPE MASHINO,

SN	Country	Times distributed	Distributed accession name/number
34	Nepal	249	JHYALI DHAN, JINUWA, JIRE MANSARA, JUMALI, JUMLI MARSHI, JUMULA 2, JUWARI, KAKANI 3 A, KALA NAMAK, KALA NIMAK, KALAM KATHI, KALO BASMATI, KALO JHINUWA, KALO MASINO, KALO PHALAME, KALODHAN, KANAK JIRA, KANJEERA PAHENLOO, KANJIRA, KANTI MASINO, KARMA SETO, KARME MASINO, KATHE, KATHE JHINUWA, KATHE JHINUWA DHAN, KATUNNE GHAIYA, KATUWA KUMALE, KHARELI, KHARPALI MASINO, KHOACHHA PATI, LAHARE GHAIYA, LAILA MAJNU, LAL AHU, LAL SAR, LIDEE GHAIYA, LUMLE-SOGROGATE, MADHESA, MADHU SARMASINO, MADHUSAR MOTI, MADISHE, MALABHOG, MALBHOG, MALBOGHI, MANBHOG, MASHINO MADESHE, MASINO, MASINO BASMATI, MASINO BHNAGENE, MASINO JUTE, MASINO ZOLO, MASINO(OR JETHABUDHA), MASINU AROMA, MASULI, MIRAMPHOOL, MORRINGI, NASWA MASINU, *O. nivara, O. rufipogon*, PAHELE, PAHELI, PAHELO MASINO, PAHELO PHALAME, PAHENLE, PAHENLEY, PAHENLI, PAKHA ZERMANI, PALPALEE, PALSA MASINO, PALSA(LAL KAMAL), PATLE, PHALAME, PHAUDAR MASINO, PHOKINARA MASINO, PHOUDAL, POKHARA MASINO, POKHARELI MASINO, POKHARELO MASINO, POKHRELI, RAJ BHOG, RAJ BHOGE MASINO, RAM DULARI, RAM SALEE DHAN, RAM SALI, RAMANI, RAMDULAR, RATO BASMATI, SABITRI, SAMDHI DULARI, SANO BEGANY CHIYA, SANOCHOBO, SATARIYA MASINO, SATHIYA, SETO JHINUWA, SETO JINUWA, SIJALI, SULSIDANE MASINO, TAGMARE, TAKMARE, TARA, TAULEE, TAULEE HAIYA,TAULI, TAULI GHAIYA, TAULI MASINO, THADE MASINO, THANGRA MASINO, THANKOTE MARSI, THANTAR, THAPACHINI, THAPACHINIA, THATHAR, THATHAR BAGARI, THOSAR GHAIYA, THULI DHAN, TIMURE MASINO KALO(BLACK), WAKHALDHUNGE, WHITE ATTE
35	Netherlands	8	BASMATI LAMO, CHHOTE DHAN, DAINY, DUDHI SAROO, GARURA, MANA MURI, SIM JIRA, SIMGIRA
36	New Zealand	1	CHHOMRONG DHAN
37	Nigeria	6	BAGERI, GORA(LOCAL), JUMALI, JUMULA 2, PURAMI MARSHI
38	North Korea	4	BAJAR BHANGA, CHENGULA, SUNAWHO, USHI
39	Pakistan	28	ASAMIYA BASMATI, BANDHAN, BASMATI, BASMATI DHAN,CHHITA,DARMALI, DEHRADUNE, DHERA DUN BASMATI, IR-44595, JHAR, JHAR DHAN, JHARANGA DHAN, JHARNADHAN, JUMULA 2, KHERA, MASINO BASMATI, NEP-98-030, NEP-98-034, NEP-98-068, SIMTHARO, TINNA
40	Panama	1	BANSPHUL
41	Papua New Guinea	1	ANDI
42	Peru	4	BASMATI, TANKI, ULAKA
43	Philippines	142	4, 19, 32, 33, 44, 9000717, 063/88/41, 8800201, 00080220, 8800208, 00080222, 8800215, 00080227, 8800216, 00080228, 8800217, 00080229, 8800225, 00080231, 8800254, 00080255, 8800323, 00059626, AKELEY MASINO, ANDI, BAGAR THIMAHA, BAKAI, BANAHU, BANDHAN, BANGO MASINO, BASMATI, BASMATI, BASMATI DHAN, BASMATI LAMO, BASMATI LAMO::IRGC 58881-1, BASMATI WHITE, BAYARNI, BHOOLANI, CHAIA ANASER, CHALISE, CHARIKOTE MARSI, CHAURELI, CHHOTE DHAN, CHHOTE DHAN::IRGC 58930-1, CHHOTI MASHINO, CHIRUAKHU, DAINY, DALE MAID, DUDY MASHINU, DURGA, FARAM BAGADE, GAJALI, GAJPATI::IRGC 58981-1, GARDAR B, GARDI, GAURE DHAN, GHAIYA, GHANDRUK, GOKHUE SAIER, GOLA BACHI, GOPAL::IRGC 61953-1, GORA(LOCAL), GUNDRIKBHOG, GURRA, HIMALI, I 352, III 175A, JAGAR, JAMRA, JHALI, JHALI A, JHALI B, JHALI DHAN, JHINUWA, JUMALI, JUMLI MARSHI, JUMULA 2, JUNGEMARSI, KALA NIMAK, KALO, KALO BASMATI, KALO GUNDE DHAN, KALO MAHELI, KALO MARSHI, KALODHAN, KALOSAR, KAMRI, KATAKA(BANGE MASINO), KATUYHAR DHAN, KHUMAL 3, KUNDWA SAPHED, LALKI SARO, LATSIK F, FLAXAMI, LESPAR B, LUMLE, LUMLE-SOGROGATE, MANA MURI, MURI::IRGC 23973-1, MANSARA, MASINO BASMATI, MASINU AROMA, MUTURI B, NAGINA 22, NAKHI, NANIA, NEMAI, NEP-W-017, NYAULI,OHA, PASHNI, PHALAM, PHOUDAL, PURBIA (KALANSAR)::IRGC 59189-1,RAKSALI, RAM JHOKE, RAMBILAS, ROTODHAN B, SABITRI, SANKHARIKA A, SANO DHAN, SARJU 49, SATHI, SATHI BAGARI, SATHIYA, SHYAM ZIRO, SIKICHAN(EARLY), SITA, SITA MATA, SOKAN, SUSPALIMARSI, TARA, THALIE, THAPACHINIYA::IRGC 16234-1, TULSHIRAM, USHI, VII 189, VII 198, VII 200, VII 44, VII 95, WHITE ATTE
44	Portugal	8	BASMATI LAMO, CHHOTE DHAN, DARMALI, JUMALI, JUMULA 2, MANA MURI,

SN	Country	Times distributed	Distributed accession name/number
45	Senegal	56	ANJANA RICE(DHAN), BABURAM, BAJAR BHANGA, BANSHAFOR, ANSPHUL, BHADAIYA, BHERANI, BHOOLANI, BOMBAY JARAN, BUDDHABIR, CHENGULA, CHOBO GHAIYA, DHERA DUN BASMATI, GAJI, GAJPATI::IRGC 58981-1, GHAIYA LOCAL, GOPAL::IRGC 61953-1, HAPALI, JAULEA, JHABARI SARO, JHALI, JHAWI, JHINUWA, JHYALI DHAN, JUDI, JUMALI, KALA NIMAK, KAMULI, KANGRESSI, KARMULI, KASKI LOCAL, LAHARE GHAIYA, LALAK, LATIGHAWAR, LIKHOLE MARSI, MOTY CHUR, NAGINA 22, NEBUE RICE, NEMAI, PADHANEE, PADMA, PEALEA, PHALAME, PURBIA, (KALANSAR)::IRGC 59189-1, PUTUJE, RAM DULARI, RAM KAJARA, RANGO, SETO GADDAR, SHANSAR, SONKHAS CHA, TAKMARE, TAULEE GHAIYA, THAPACHINIYA, THAPACHINIYA::IRGC 16234-1, THULE MARSHI
46	Singapore	5	ANADI, BASMATI DHAN, GOLA BACHI
47	South Korea	80	063/88/21, 063/88/23, 063/88/42, ANADI, ANANDI, ANATI, AURI(JHAR DHAN), BAGERI, BAGHA TAULI, BAJAR BHANGA, BAKAI, BANDHAN, BASMATI, BASMATI ANPJHUTTE, BASMATI DHAN, BASMATI GOLA, BASMATI LAMO, BASMATI MASINO, BASMATI NOKHI, BASMATI PAHADE, BASMATI RED, BASMATI UZARKA, BASMATI WHITE, BHOOJA SALO, CHHOTE DHAN, CO ANADI, DARMALI, DHERA DUN BASMATI, DUDHI GADDHAR, DUDHI SARO, GAMADEE, GAMADI, GAMLARI, GHAIYA, GHAIYA(BIJARI), HALIDA::IRGC 59005-1, IR-44595, JILI DHAN, JUMULA 2, KALA NAMAK, KALO BASMATI, KALOMASINO DHAN, KHACHCHA DHAN, KHOILE, MANA MURI, MARINAKER ANASE, MARSHI, MARSI, MASINO, MASINO BASMATI, NABO, NEP-98-030, NEP-98-034, *O. nivara, O. rufipogon*, RAI MANULA::IRGC 64138-1, RATO BASMATI, RATO MARSI, ROTODHAN B, SARAIYA DHAN, SATHI SARO, SEHWANI, SETO JINUWA, SETO MARSO MUTANT, SHYAM ZIRO, SITA, THAOLAE, TINNI, TOLI ANADI, YANGKHUKE
48	Spain	2	JHARA, TINNA
49	Sri Lanka	14	BARAGAULE DHAN, BASMATI, BASMATI DHAN, BASMATI LAMO, CHHOTE DHAN, DARMALI, DHAYA, JUMALI, JUMULA 2, KAKANI 2, MANA MURI, *O. nivara*, TANKI
50	Switzerland	57	AANGA, AATTE, AHE(LOCAL), ANADEE, ANADI, ANADY, ANANDI, ANDI, ANJANA, ANJANA RICE(DHAN), APTHUTTE, ASAMIYA BASMATI, ATH HAGARI JARAHAN PADDY, ATTE MARSI, ATTE(LOCAL), BABURAM, BALAM SER, BASMATI, CHAMPASARY, CHINIYA DHAN, DEVARASI, JALMANI, JARMANI, JARNERI, JULEARI MARSI, KAKANI 2, KAKANI 3 A, KALA NIMAK, KAMOD, KARI KAMAR, MOTANGE PAHELLO LAULE, ,NABO, NEP-98-025, NEP-98-028, NEP-98-063, NEPALSE THAPACHINIYA, OIRI, PALIJA, PHULPATA, SIMTHARO, SOKAN, SULSIDANE MASINO, TAULEE GHAIYA, THAPACHINIYA, THULI DHAN, TIMURE MASINO KALO(BLACK), TINA SARY, TINNI, TULSIPHOOL, TUNDE, VIII 71, WANPAKI, YANGKHUKE, ZANELI, ZEENA MASINO
51	Taiwan	49	063/88/23, 063/88/41, 063/88/42, 8800206, 00059593, 8800222, 00059597, AMAGHAUD, AMERICAN, ANANDI, ANGA, APTHUTTE, BAGETAULI::IRGC 61909-1, BANDHAN, BANGE MASINO, BASMATI GOLA, BASMATI LAMO::IRGC 58881-1, BASMATI PAHADE, CHHOTE DHAN, CHHOTE DHAN::IRGC 58930-1, CHIOOLEE KATHE, CO ANADI, DAINY::IRGC 58943-1, DARMALI, DUDHI SAROO::IRGC 16261-1, DUMSIKALAM::IRGC 58968-1, GAJPATI::IRGC 58981-1, GOPAL::IRGC 61953-1, GUNDRIK BHOG, IR-44595, JENGAR::IRGC 59027-C1, JHAR DHAN, JUMALI, JUMALI::IRGC 9542-C1, JUMULA 2::IRGC 13375-1, KAKANI 2::IRGC 13373-C1, KHERA, MANA MURI::IRGC 23973-1, NEP-98-063, NEP-W-021, *O. nivara*, OIRI, PATLE::IRGC 27635-1, PURBIA (KALANSAR)::IRGC 59189-1, TARA::IRGC 59244-1, THAPACHINIYA::IRGC 16234-1, TINNA, TINNI,
52	Tanzania	2	JUMALI, JUMLI MARSHI
53	Thailand	86	063/88/19, 063/88/21, 063/88/23, 063/88/27, 063/88/41, ANDI WHITE, BADARI DHAN, BANDHAN, BANSBARELI, BASMATI, BASMATI DHAN, BASMATI GOLA, BASMATI LAMO, BASMATI MASINO, BASMATI MASINO(PURPLE TIP), BASMATI NOKHI, BASMATI PAHADE, BASMATI RED, DAINY, DARMALI, DUDHI SAROO, GAJPATI,GAJPATI::IRGC 58981-1, GOPAL, GORA(LOCAL), HIMALI, IR-44595, JADO, JHARA, JHARAN, JHARANGA, JHARANGA DHAN, JHARNADHAN, JUMULA 2, KHERA, KRAULI, LAMANI, LATIGHAWAR, MANASARA, NEP-98-025, NEP-98-057, NEP-98-061, NEP-98-063, NEP-98-064, *O. nivara, O. rufipogon*, PAHELE, PAHELO PHALAME, PATLE, PURBIA(KALANSAR), SIDALI, SIMTHARO, SUGA PANKHI, TINNA, ZUNZALO
54	Turkey	1	ARUNA

SN	Country	Times distributed	Distributed accession name/number
55	United Kingdom	245	063/88/19, 063/88/21, 063/88/27, 063/88/41, AAMJHUTTE, AATTE, ACHHAME MASINO, ACHHAMIYA, AKELEY MASINO, ANANDI MASINO, ANJANA, ASAME MASINO, ASAMIYA BASMATI, ATTE, ATTE MARSI, ATTE PAHELE, ATTE(LOCAL), BANSPHUL, BARKHE TAULI, BARSHE-TAULI, BASMATI, BASMATI ANPJHUTTE, BASMATI GOLA, BASMATI LAMO, BASMATI MASINO, BASMATI MASINO(PURPLE TIP), BASMATI NOKHI, BASMATI PAHADE, BASMATI RED, BASMATI UZARKA, BASMATI WHITE, BEGAMI, BHALU TAULI, BIRUMPHOOT, BOYA, CHENGUL MASINO, CHHOTI MASHINO, CHINIYA, CHIRAKHE, CHOBO, CHOBO GHAIYA, CHORO, CHULTHA MASINO, DAILEKH(LOCAL), DARAMALI, DARJILINGE, DARMALI, DARMARI, DEHRADUNE, DHERA DUN BASMATI, DOLAKHA MARSI, DOLAKHE, DORMALI, DUDHRAJ, DUDY MASHINU, EKLE MASINO, FARMA, GAHUME MASINO, GAJALEE GHAIYA, GANJALI MASINO, GARUE GHAIYA, GHAIYA, GHAIYA LOCAL, GHAIYA(BIJARI), GHAMRI, GHIEW KUMARI, GUDURA, GUNDRIK BHOG, HANSA RAJ, HANSROJ, HIMALI, HIMALI DHAN, INDRA BELI, JARMANI, JARNELI, JARNELI CHAURELI, JARNELI DHAN, JARNELLE DHAN, JARNERI, JEENA MASINO, JERNELY, JETHO BUDO, JHALI B, JHINUWA, JHINUWA KALO, JHINUWA MASINO, JHOOPE MASHINO, JHYALI DHAN, JINUWA, JIRE MANSARA, JUMALI, JUMLI MARSHI, JUMULA 2, JUWARI, KAKANI 3 A, KALA NAMAK, KALO BASMATI, KALO JHINUWA, KALO MASINO, KALO PHALAME, KALODHAN, KANAK JIRA, KANJEERA PAHENLOO, KANJIRA, KANTI MASINO, KARME MASINO, KATHE, KATHE JHINUWA, KATHE JHINUWA DHAN, KATUNNE GHAIYA, KHARPALI MASINO, LAHARE GHAIYA, LIDEE GHAIYA, LUMLE-SOGROGATE, MADHESA, MADHU SARMASINO, MADHUSAR MOTI, MADISHE, MALABHOG, MALBHOG, MALBOGHI, MANA MURI, MANBHOG, MANSARA, MASHINO MADESHE, MASINO, MASINO BASMATI, MASINO BHNAGENE, MASINO JUTE, MASINO ZOLO, MASINO(OR JETHABUDHA), MASINU AROMA, MIRAMPHOOL, MORRINGI, NASWA MASINU, *O. nivara, O. rufipogon*, PAHELE, PAHELI, PAHELO MASINO, PAHELO MASINO, PAHELO PHALAME, PAHENLE, PAHENLEY, PAHENLI, PAKHA ZERMANI, PALPALEE, PALSA MASINO, PALSA(LAL KAMAL), PATLE, PHALAME, PHAUDAR MASINO, PHOKINARA MASINO, PHOUDAL, POKHARA MASINO, POKHARELI MASINO, POKHARELO MASINO, POKHRELI, RAJ BHOG, RAJ BHOGE MASINO, RAKSALI, RAM DULARI, RAM SALEE DHAN, RAM SALI, RAMANI, RAMDULARI, RATO BASMATI, SAMDHI DULARI, SANOCHOBO, SATARIYA MASINO, SATHIYA, SETO JHINUWA, SETO JINUWA, SIJALI, SOKAN, SULSIDANE MASINO, TAGMARE, TAKMARE, TALLY, TAULEE, TAULEE GHAIYA, ,TAULI, TAULI GHAIYA, TAULI MASINO, THADE MASINO, THANGRA MASINO, THANKOTE MARSI,THANTAR, THAPACHINI, THAPACHINIA, THATHAR, THATHAR BAGARI, THOSAR GHAIYA, THULI DHAN, TIMURE MASINO KALO(BLACK), TINNA, WAKHALDHUNGE, WHITE ATTE
56	United States	327	063/88/19, 063/88/21, 063/88/23, 063/88/27, 063/88/41, 063/88/42, AATTE, ACHHAMIYA, ADALAT, AHE(LOCAL), AKELEY MASINO, AMAGHAUD, ANADI DHAN, ANAGA, ANDI KALO, ANDI WHITE, ANGA, ANJANA, ANP JHOOTE, ANPAKI, ANTI (ANADI-DHAN), ASAME, ASAMIYA BASMATI, AURI(JHAR DHAN), BABURAM, BAGAR DHAM, BAGERI, BAGETAULI, BAGETAULI::IRGC 61909-1, BAKAI, BALAMACHI, BALUMSANE, BANDAR KUHI, BANDHAN, BANGALUWA, BANSBARELI, BARAM KARTIKA, BASMATI, BASMATI DHAN, BASMATI LAMO, BASMATI LAMO::IRGC 58881-1,BASMATI UZARKA,BATESURA, BEGAMI, BELGUDI, BENGSAR, BHADIYA DHAN, BHASEY GRURA, BHAT KHANYA, BHUTAHI LAL DEYA, BHUWA DHAN, BIRUMPHOOT, BOOMBOLI GHAIYA, BUWA DHAN, C 5905, CHABO GHAIYA
57	Ussr	1	MASINO BASMATI
58	Uzbekistan	11	CHHOTE DHAN, DARMALI, JADAN MARSHI, JHINUWA, JUMALI, JUMULA 2, KALO MAHELI, LAME, MANA MURI, RAM KAJARA, TALLY
59	Venezuela	7	AMP JHUTE DHAN, ANADI, ASAMIYA BASMATI, BASMATI, JUMALI, SILANGE
60	Vietnam	93	063/88/19, 063/88/21, 063/88/27, AKELEY MASINO, ANGA, ASAMIYA BASMATI, BANDHAN, BASMATI, BASMATI ANPJHUTTE, BASMATI DHAN, BASMATI GOLA, BASMATI LAMO, BASMATI MASINO, BASMATI MASINO (PURPLE TIP), BASMATI NOKHI, BASMATI PAHADE, BASMATI RED, BASMATI UZARKA, BASMATI WHITE, CHHITA, DARMALI, DHERA DUN BASMATI, HANSRAJ, HIMALI, JHARA, JHARAN, JHARANGA, JHARNADHAN, JUMALI, KALA NAMAK, KALA NIMAK, KALOMASINO DHAN, KT31-1, KT32-2, MASINO BASMATI, MASINU AROMA, NABO, NAGINA 22, NEP-98-020, NEP-98-025, NEP-98-028, NEP-98-029, NEP-98-030, NEP-98-034, NEP-98-057, NEP-98-061, NEP-98-064, NEP-98-068, *O. nivara, O. rufipogon*, RATO BASMATI, SAJANI, SOKAN, TINNA, TINNI, TOLLI 27-8

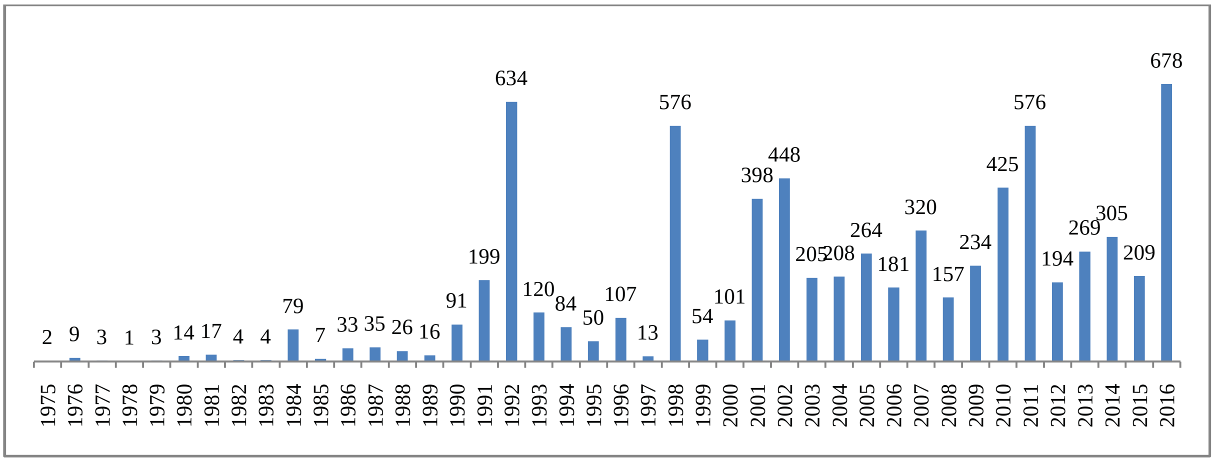

Figure 3. Distribution frequency of Nepalese rice accessions from IRRI Genebank over the years

Table 3. Nepalese rice and their uses in research and production in different countries

SN	Landraces/accessions from Nepal	Country	Uses	References
1	Chhomrong	Bhutan	Production as upland rice	BR Sthapit 2016, personal communication
2	Chhomrong	Bhutan	In blast resistance breeding, only variety that was unaffected during 1996 rice blast epidemic in Bhutan	Matsushita et al 2011
3	Sabitri	China	As parent for upland adaptation, identified major QTLS for heading days, plant height and yield	R Bhattarai 2016, email Correspondence)
4	*O. nivara* (IRGC93198)	India	Resistance to brown plant hopper	Sarao et al 2016
5	Hardinath-1, Radha-4, Radha-12	India	For grain production	SN Sah 2016, personal communication
6	Sukha-5, Sukha-6, Lalka Basmati, Kalanamak	India	For grain production	RB Yadav 2016, personal communication
7	*Pakhe Dhan*	Japan	One major QTL for cold tolerant detected, using in breeding cold tolerant varieties	N Tomooka, K Ebana 2016 email correspondence
8	*Anjana Dhan*	Japan	Cadmium absorption controlling gene (OsHMA3) identified	N Tomooka, K Ebana 2016 email correspondence
9	*Badari Dhan*	Japan	used for the absorption of water and use of nitrogen	Matsunami et al 2012, 2013
10	Laila Majanu, Sautenia Dhan	Korea	Genetic analysis of multiple pistil	Heu et al 1987
11	Pokhareli Machino	Korea	Found an opaque endosperm with about 10% amylose content	Heu and Kim 1989
12	Chhomrong	Madagascar	Production as upland rice, as parent for cold tolerance	Raboin et al 2014
13	*Jumli Marshi*	Madagascar	In cold tolerance breeding	Raboin et al 2014
14	O. *nivara*	Philippines	Discrete genetic entity	Banaticla-Hilario et al 2013
15	*Gamadi Dhan*	Philippines	Found Gamadiness controlled by two complementary dominant genes and found to be linked with the neck leaf gene (*nl*) of Takahashi's linkage group	Heu and Shrestha 1986
16	*Mansara, Ghaiya, Kalomarshi-3, Ratomarshi* and *Setomarshi*	Philippines	Genetic analysis for cold tolerance	Shahi and Khush

SN	Landraces/accessions from Nepal	Country	Uses	References
17	Jumli Marshi	Sweden	Studied global transcriptional response to cold stress (+4uC) and identified 4,636 genes significantly differentially expressed within 24 hours of cold stress	Chawade et al 2013
18	Darmali, IR-44595, Bagetauli::IRGC61909-1, Basmati Lamo, Chhote Dhan, Dainy::IRGC58943-1, Dudhi Saroo::IRGC16261-1, Dumsikalam::IRGC58968-1, Gajpati::IRGC58981-1, Gopal::IRGC61953-1, Jengar::IRGC59027-C1, Jumali::IRGC9542-C1, Jumula 2, Kakani 2::IRGC13373-C1, Mana Muri, Patle::IRGC27635-1, Purbia (Kalansar)::IRGC59189-1, Tara::IRGC59244-1, Thapachiniya::IRGC16234-1, Anjana Dhan, Badari Dhan, Jena 035, Kalo Dhan, Nepal 8	USA	High density rice array map	McCouch et al 2015

Aromatic rice such as basmati from Nepal is well known for its distinct aroma and elongating grains. Chhomrong has covered over 85% of upland rice area in Bhutan and Madagascar (BR Sthapit 2016, email communication). Two varieties namely Chhomrong and Sabitri are widely used in breeding and genetics of cold tolerance, blast resistance and adaptation. Chhomrong (Chumroo in Bhutan) was found resistant to blast and grown widely in Bhutan. Chumroo was the only variety that was unaffected during the 1996 rice blast epidemic in Bhutan (Matsushita et al 2011). Chhomrong Dhan was also used as source of cold tolerance genes in Madagascar (N Ahmaid 2016, email communication). Four Nepalese rice varieties, namely Chomrong, Khumal-2, Khumal-6 and OR367-SP11 have been releasd in Bhutan for general cultivation and two other varieties Radha-4 and Machhapuchhre-3 are under research station in Bhutan (A Tamang 2017, email communication).

The global transcriptional response to cold stress (+4uC) was studied in the Nepalese highland variety Jumli Marshi (japonica type) and 4,636 genes were identified as significantly differentially expressed within 24 hours of cold stress (Chawade et al 2013). Jumli Marshi is a highly adapted upland chilling tolerant Nepalese rice variety and is used extensively in breeding for new chilling tolerant rice cultivars both in Nepal and other countries. Shahi and Khush (1986) had analyzed cold tolerance in Mansara, Ghaiya, Kalomarshi-3, Ratomarshi and Setomarshi.

Most of the researchers and breeders use Nepalese rice as the possible source of cold tolerance, drought resistance and absorption ability of water and nutrients in Japan. Pakhe Dhan was used for cold tolerance study in Japan and one major QTL was detected and has been tried for breeding cold tolerant cultivars. Cadmium absorption controlling gene (OsHMA3) was identified in *Anjana Dhan*. *Badari Dhan* has also been used for the absorption of water and use of nitrogen (Matsunami et al 2012, 2013).

Sabitri has been used as background parent for upland adaptation in China (R Bhattarai 2016, email communication). Mapping population derived using Sabitri had been developed and mapped using SSR markers. Three major QTLs were detected on 3, 7 and 9 chromosomes for heading days, plant height and yield, respectively. About 24 rice landraces from Nepal were used for high density rice array mapping (McCouch et al 2015, https://ricediversity.org/data/).

Gamadi, a native rice cultivar from Nepal in which the panicle remains enclosed within its flag leaf sheath up to maturity, was genetically studied (Heu and Shrestha 1986). Gamadiness is controlled by two complementary dominant genes and these genes have been proposed as *"Ga"* and *"Gb"* and found to be linked with the neck leaf gene (*nl*) of Takahashi's linkage group VI + IX. An opaque endosperm with about 10% amylose content was found in an indica cultivar, Pokhareli Machino from Nepal (Heu and Kim 1989). Heu et al (1987) reported that the multiple pistil originating from Double Rice is identical to those of Nepali varieties Laila Majanu and Sautenia Dhan, and is linked with the *la* (laziness) gene of linkage group VIII.

O. nivara from Nepal was found very distinct and considered as discrete genetic entity by Banaticla-Hilario et al (2013). *O. nivara* (IRGC93198) from Nepal was also found resistance to brown plant hopper (Sarao et al 2016).

Rice export

Although Nepal exported substantial quantities of rice in the 1970s and mid-1980s, the country stopped exporting it from 1988 onwards (Government of Nepal 1992). In informal way, seeds of Hardinath-1, Radha-4, Radha-12, Sukha-5, Sukha-6, Lalka Basmati and Kalanamak are exported to India from some of Tarai areas of Nepal (SN Sah and RB Yadav 216, personal communication). Grains of Radha-4 and Samba Mansuli are also exported to India for consumption. Earlier, seeds of Chhomrong, Khumal-4 and Jumli Marshi were exported to Bhutan, Madagascar and Korea for cultivation and breeding.

Most commonly studied landraces were Jumli Marshi for cold tolerance, Chhomrong for cold tolerance and blast resistance, *O. nivara* for brown plant hopper. Some released varieties were used directly for grain production in Bhutan, India and Madagascar. There are many rice landraces that have global potential (aromatic, drought tolerance, diseases and insect pests resistance, etc) and need to explore their potential for utilization at commercial scale.

Acknowledgements

We are thankful to BR Sthapit, S Lee, N Tomooka, R Bhattarai, HN Bhandari, R Dhakal, N Ahmadi, N Youngwang, SN Sah and RB Yadav for providing with necessary information.

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Rice Nursery Raising Methods in Nepal

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सारांश

गुणस्तरीय बेर्नाले धान बाली उत्पादनमा प्रत्यक्ष प्रभाव पार्दछ । गुणस्तरीय बेर्ना उत्पादनको लागि मूख्यतया भरपर्दो स्रोतको गुणस्तरीय बीउ, ब्याड राख्ने जमिनको छनौट, ब्याडको तयारी बीउ छराइको तरिका, रेखदेखका साथै अन्य व्यवस्थापकीय कुराहरूले प्रत्यक्ष प्रभाव पार्दछ । नेपाली किसानहरूले गुणस्तरीय बेर्ना उत्पादनलाई खासै ध्यान दिएको पाइँदैन र गुणस्तरीय बेर्ना उत्पादन गर्नु नै किसानहरूको लागि एक चुनौती बन्ने गरेको छ । अधिकांश नेपाली किसानहरूले धुले र हिले ब्याडको मात्र प्रयोग गरेको पाइन्छ । हाल धानका विभिन्न उन्नत ब्याडहरू जस्तै ड्यापोग, सुधारिएको ड्यापोग, ववल ट्रे, सुधारिएको म्याट तरिका आदिको विकास भएता पनि कृषकस्तरमा प्रयोगमा आएका छैनन् । यसर्थ, उचित वातावरणमा उचित तरिकाहरूको चयन गरी धानको बेर्ना उत्पादन गर्नको लागि कृषकहरूलाई प्रोत्साहित गरेमा नेपालमा धानको उत्पादन बढाउन सकिने कुरा सुनिश्चित देखिन्छ ।

Summary

The successful rice production is directly influenced by the quality of raised seedlings. The success of raising healthy seedlings mainly depends on selection of quality seed, selection of site, good field preparation, sowing and regular supervision of seedbeds and other management practices. Nepalese farmers are not prioritizing the production of vigorous seedlings in their nurseries. Producing healthy seedlings is a challenge for many farmers in Nepal. Most of the Nepalese farmers are found to use wet and dry bed nurseries only. However, there are some other improved methods such as dapog, modified dapog, bubble tray and modified mat nursery which are not gaining popularity among Nepalese farmers. Quality seed from reliable sources, use of appropriate methods under field conditions, seed treatment, seeding practice and density, water management, plant protection, uprooting and transportation of seedlings are the most important factors determining the production of quality seedlings for transplanting. Different methods have their own merits and demerits and can fit under different situations. In addition to dry and wet bed nurseries, Nepalese farmers must be encouraged to use different improved nurseries with package of practices to increase the productivity of rice in Nepal.

Keywords: Buble tray, Dapog, Modified dapog, Modified nursery, Nursery, Productivity, Rice

Introduction

Properly managed seedbed with adequate plant nutrition, optimal seeding densities and use of seedlings at appropriate age are important factors to get vigorous plant stands after transplanting (Lal and Roy 1996). Nursery facilitates timely transplanting and quick stand establishment of the crop. It can facilitate efficient weed control and further intercultural operations in transplanted rice field. Methods of raising nursery depend on local cultural practices, soil type and availability of water. However, many Nepalese farmers are not prioritizing the production of vigorous seedlings in their nurseries. The success of raising healthy rice seedlings in the nursery mainly depends on selection of quality seed, selection of proper site, good field preparation, sowing of seed, regular supervision of the seedbed and other management practices. The yield and yield components of the rice crop is affected negatively by using high seed rates in the nursery (Singh et al 1987). There are different methods developed for raising rice nursery.

Nursery raising methods

In general, the direct seeding and transplanting practices are followed in rice planting by the Nepalese farmers. Based on land and water management practices, rice lands are classified as low land (rainfed and irrigated) and upland (dry land). The seedlings are prepared in nursery beds if transplanting method is used. In transplanting system, the robust and healthy seedlings are produced in the nursery bed and transplanted in the main field. The nursery area needed is about 15−20% of the total farming area. In Nepal, the farmers mainly use wet and dry bed nurseries in their farm. Other newly developed improved methods such as dapog, modified dapog, bubble tray and modified mat nurseries have not gained popularity among farmers in different parts of the country.

Dry bed nursery

This method is practiced in areas where water is not sufficient to grow seedling in wet nurseries. Seedbed of convenient size are prepared by raising the soil to a height of about 10-15 cm. Conventionally Nepalese farmers are using very high seed rates (>600 g/m^2) in their nursery, resulting in lean, thin, weak and non-vigorous seedlings (Adhikari 2013). So, it is suggested that the use of 100-200 g of seeds per m^2 of seedbed is better to get healthy and vigorous seedlings that will give better yield after transplanting (Wopereis et al 2009). The prerequisites for raising dry seedbed nursery are as fallows.

Site selection for nursery

Before establishment of nursery, healthy, fertile soil free from objectionable weed seeds and volunteer plants should be selected. If possible, the land should be open, sunny and nearby the main field. Nursery area should be well drained and have permanent source of irrigation. Nepalese farmers use the same terrace for nursery bed each year which has resulted in the infestation of weeds, other harmful pests and soil borne pathogens.

Seed selection

The seed should have good quality and should be true to type of any variety. Seed should be free from insect/pests, diseases, weeds and foreign matters. The seed must be bold, viable with high germination capacity (>85%) and should be collected from reliable sources.

Seed treatment with pesticides and salt water

Fungal diseases can be prevented by using broad spectrum fungicide such as Bavistin WP or Thiram or Dithane M-45 or Cerasanor Agrisan GN at 2-2.5g/kg seed 5-7 days before sowing. In case of bacterial disease (bacterial leaf blight), Streptocycline or Agrimycin-100 at 1g/litre of water can be used after salt-water treatment. The seed should be treated with salt water with the ratio of 1:5 (1 kg common salt in 5 litres of water). The floated light seeds should be removed and bold seeds should be cleaned with fresh water 2-3 times and dried.

Time of sowing

In mountain area, the seeding starts from 1st week of May, while in mid hills and Tarai areas it starts from 3rd week of May to 1st week of June for long duration varieties, and 2nd week of June to 4th week of June for short duration varieties. In case of spring rice, 3rd week of February to 2nd week of March is the best time for nursery raising. October is the best month for boro rice nursery raising.

Seedbed preparation

Field should be ploughed 3-4 times till the soil become fine and pulverized. Nursery area should be divided into narrow bed of 1.5 m width and 6 m length (9 m^2 beds). The drainage channel of 50 cm wide should be constructed in between the beds and 15 cm high from the ground level. A total of 50-60 such beds (9m^2 sized) are sufficient for one hectare area of main rice field.

Manure and fertilizers

It is better to apply well-decomposed manure or compost plus 450 g of super phosphate for 9 m^2 area at the time of final bed preparation and mix them thoroughly in the soil. In area where Khaira disease (due to zinc deficiency) is prevalent, practice of spraying $ZnSO_4$ at 5 kg + lime 2.5 kg dissolved in 1000 liters of water/ha on nursery beds at 10 days and 20 days after seeding is done. If nitrogen deficiency is observed in the nursery, 1 kg of ammonium sulphate or 0.5 kg of urea per 100 m^2 area should be applied. If second top dressing is required, 0.3-0.6 kg of urea per 100 m^2 is applied in N deficit areas. Traditional practice of applying chopped pieces of locally available green manuring species such as *Asuro (Adhatoda vesica)*, *Khirro (Sapium spp)*, *Titepati (Artemisia vulgaris)*, *Banmara (Eupatorium adenophorum)*, *Bakaino (Melia azadarach)* etc on seedbed as mulch also prevail in some parts of Nepal.

Seed rate and sowing

Seed rate depends upon test weight, number of seedlings used per hill, crop geometry and germination percentage of seeds. About 50 kg seeds per 500 m^2 nursery area for one hectare of main field is recommended. The seeds are sown uniformly on the seedbed. Continuous seeding maintaining 10 cm distance is maintained in case of row sowing. The sown seed should be covered immediately with a thin layer of soil (1-2 cm depth).

Irrigation and after care

Generally there is no need of irrigation under optimum soil moisture condition. However, in other conditions water management should be done carefully so as not to float the loose beds.

Figure 1. Dry bed nurseries

Uprooting of seedlings

Uprooting of seedlings should be done between 15-21 days after germination for early varieties and 30-35 days for late varieties. The optimum height of seedling is 15 cm.

By this method, seedlings would be shorter and stronger with a longer root system. Seedlings are hardy and resistant to adverse field conditions to some extent, compared to seedlings from wet-bed nursery. This method requires more time, and is not suitable for all types of soils especially in sandy and stiff clay soil where seedlings are usually thin and slender compared to wet bed nursery.

Wet bed nursery

Wet bed method of raising rice nursery is used when irrigation is easily available. It is practiced in rainy season when soil is always wet and there is a possibility of occurrence of rainfall. Since 65% of rice area is rainfed, this method is less practiced by farmers in Nepal. The following prerequisites are required for raising wet seedbed.

Soaking and incubation of seeds

Seeds are soaked in clean water for about 24 hours. The water is drained off and the clean wet seed is transferred into a gunnysack or basket lined with leaves of cotton cloth. Incubated seed container is put in a warm, shady place for approximately two days (48 hours), making sure to moisten the sack minimum three times a day. Mix the seed periodically by rolling container or mix it by hand to avoid damage by heat caused by suffocation or for proper aeration. Letting the radicals grow longer should be avoided, as they will penetrate the walls of the sack and/or intertwine.

Figure 2. Process of incubation of rice seed

Seedbed preparation

Deep ploughing is done by using deep turning plough before two weeks of seed sowing. Before 1-2 days of seed sowing, the field should be saturated by flood irrigation. The soil is ploughed 1-2 times using local plough followed by leveling. After 1-2 days, the nursery area should be divided into narrow beds of 1-1.5 m width and of any desirable length upon slope usually 8-10m. The drainage or irrigation channel of 50 cm width should be constructed in between the seedbed and raised the bed 8-10 cm height from the ground.

Figure 3. Wet bed nurseries

Manure and fertilizers

About 6-10 tonnes of well decomposed FYM/compost is sufficient for one hectare area of nursery bed. The manure should be applied at first ploughing. Other fertilizer dose and applying practices are similar to dry bed method.

Sowing of seed

Broadcast the pre-sprouted seeds on the beds uniformly being sure to achieve an even distribution. Uniform broadcasting of about 2-3 handfuls of seed per m^2 of seedbed is recommended. About 40-50 kg seeds are required to transplant one hectare area of main field.

Irrigation

Seedbed should be kept saturated with water for 5 days and then water level should be increased gradually up to 5 cm as the seedlings grow. Moistening of the bed by splashing water is necessary in case the rain does not occur regularly.

Uprooting of seedlings

Uprooting is generally done at 21-25 DAS for early and 30-35 DAS for late varieties and the transplanting is done within 24 hours of uprooting of seedlings. In this method, seedlings grow rapidly and are easy for uprooting. The insect, pest, disease and weed problems are minimal. However, this method seems to be difficult and costly. This practice is not possible in water shortage areas. The establishment of rooting system is poor and seedling transplanting shock is higher compared to dry bed nursery.

Dapog bed nursery

This method has been introduced in Nepal from Philippines. It is not so popular among farmers in Nepal. This method is easy, faster and seedlings can be raised anywhere on a flat firm surface but water supply should be very reliable. Rice endosperm contains sufficient amount of food to permit young seedling to grow for up to 2 weeks without getting any nutrients from outside except air, water and sunlight. In this method, nursery is constructed to raise the seedlings without any contact of soil. The prerequisites for raising dapog bed are discussed below.

Preparation of seedbed

Seedbed can be prepared on an even but slightly raised (4-5 cm) land surface in an open field or on even cemented floor. The width of each bed is maintained about 1.5 m and length as convenience. Surface of the seedbed should be covered evenly and completely with polythene sheet, or banana leaves after removing midrib. All the sides of the bed are protected by banana bracts or by wood so that the seeds will not go away from the seedbed after irrigation.

Figure 4. Dapog bed nurseries

Seed rate, sowing and irrigation

The dry or pre sprouted seeds are broadcasted uniformly over plastic or banana leaves. About 50 kg of seeds can be broadcasted on 40 m^2 seedbed which will be sufficient to cover one hectare area of main field. After sowing, slightly pack the seeds using a board to make a uniform layer up to 1.5-2 cm. The seeds should be slightly pressed once a day till 4^{th} day with a board to keep them compacted. Moisture can be conserved by covering the seed with the gunny bags lightly. Sprikling of water over gunny bags for about 3-4 times a day is necessary to avoid water deficit in the bed. The seedling will be ready within 9-14 days after sowing.

Uprooting of seedlings

The seedlings are not uprooted from the nursery bed like in the dry and wet bed method. The entire seedlings mass are simply rolled up like a carpet with roots facing outside and carried to the transplanting field. The interlocked roots are loosened very carefully before transplanting. The uprooted seedlings with 6-7 cm height is transplanted for about 3-4 seedlings per hill in already prepared land. If seedlings are not transplanted within 2 weeks, the nutrients supplied from seed endosperm will be finished and the seedlings will start to die off. This method requires very less area for seedling raising, saves almost half of the time for seedling raising, no need of extra plant nutrients for growing seedlings is avoided and cost of uprooting of seedling is minimal. This method is better for short duration varieties compared to traditional ones.

However, under this method, the seedlings are weak, thin, slender and small. The seedlings are not transplanted in the field if the amount of water is high. Seedlings are very delicate and survive only for about two weeks. The seedlings should be handled by skilled persons and they require extra care and frequent irrigation.

Modified dapog bed method

Modified dapog bed method is developed to minimize the risk of seedling drying after 2 weeks in dapog bed method. This method is also not popular in Nepal. In this method, seed is in contact with soil or ash or saw dust where small amount of plant nutrients are supplied through manure and fertilizers. After 2 weeks, the seedlings are ready to transplant (at four-leaf stage). The prerequisites for raising wet seedbed are as fallows:

Preparation of nursery bed

In this method, the bed may be prepared on cemented flour or on compact earthen beds as in dapog method. The beds are 1-1.5 m wide with convenient length or usually 10 m is practiced with 10 cm height. The surface of the bed is packed tightly and kept at uniform levels. The beds are covered with polythene sheets; sands or ash up to a thickness of 2.5 cm on the beds. Other management practices are similar with dapog bed method.

Seed sowing and irrigation

The dry or pre sprouted seeds should be sown on sand/ash medium uniformly at one grain thickness. Seedbed is covered by gunny bag and sprinkling is done to retain moisture. The channels around the beds are filled with water up to the brim. Then the gunny bag is removed from the seedbed after 3 days. After 4-5 days, the level of water should be increased slightly (1 cm). From the 8th day after sowing, ammonium sulphate solution (28 g of A/S + 4 liters of water for 4m^2 area) is applied to the seedlings on alternate days up to the 16th day. Thereafter, seedlings will be ready for transplanting from the 12th day onwards. If water is not available in the main field for transplanting, the life of the seedlings can be prolonged for more than 3 weeks by keeping them in a nursery bed.

Uprooting

The seedlings are ready for transplanting after two weeks of seed sowing. The seedlings are strong, thick and larger compared to dapog bed method because of extra supplement of plant nutrients from outside. The seedlings can be transplanted in the field if the amount of water is high. It requires skilled person, good care and better management compared to dry and wet bed nurseries. Before uprooting, the beds should be watered lightly. The seedlings can be used for manual as well as mechanical transplanting.

Bubble tray nursery

This is newly developed method and is not popular in farmer's level in Nepal. In this method, plastic trays with holes are used for raising seedlings. About 12-15 day old seedlings with "root balls" are prepared for transplanting. The size of each plastic tray is 59 cm by 34 cm with 434 embedded holes. The total number of trays required is 750 for one hectare transplanting of rice.

Preparation of seeding trays

The soil media is prepared using fine top soil (cultivated clay loam soil) with sand 1:20 (sand and top soil) and well decomposed organic manure (FYM 8 t/ha) mixing well. The media is put into the holes of the tray up to brim and press slightly to fix the soil in the holes.

Seed sowing and irrigation

Well treated 3-4 bold dry seeds are put in a hole in each of a tray and covered by same media maintaining 2-2.5 cm depth of seed. Gunny bag or cotton cloth is put over the tray and sprinkle is done to keep gunny bag or cotton cloth moist. The tray should be put in sunny places. From the 8th day after sowing, ammonium sulphate solution (28 g of Ammonium sulphate + 4 litres of water) can be applied to the seedlings on alternate days if the color of seedlings seems yellowish up to 16th days after sowing. After 2 weeks (at 4 leaf stage) the seedlings are ready for transplanting. If water is not available in time for transplanting, the life of the seedlings can be prolonged for more than 3 weeks by keeping them in nursery trays.

Figure 5. Modified dapog bed nursery

Preparation of seedlings for transplanter (modified mat nursery)

The scientists from Integrated Rice Research Consortium (IRRC) under International Rice Research Institute (IRRI), Philippines and Tamilnadu Agriculture University (TAU), India developed newly modified mat nursery for growing best quality seedlings in 2008. This method is very new and is not practiced by the Nepalese farmers till now. In this method, seedlings are produced in the soil mix layer and will be ready within 15-20 days after seeding. An individual farmer can apply this method easily in her/his farm. Mechanical transplanting requires tray or wooden frame or banana stalk to prepare frame based on frame of transplanter. The prerequisites for raising seedlings for transplanter are as fallows:

Land selection for nursery

A good, dry and easily accessible part of farm land should be selected as nursery area. The land must be open and sunny.

Prepare nursery bed using plastic sheet or banana leaves

A bed should be prepared having 1m width with 40 m length and 0.15 mm height. The land should be leveled uniformly. Plastic sheet of 40 m x 1 m size is sufficient for one acre (4047 m^2) area of land and is spread over the bed. The length and width of bed is marked with nylon ropes and sticks and the polythene sheet is placed firmly on leveled area. Holes on polythene sheet are made to fix the sheet using pointed wooden pegs. The wooden stripes of about one inch thickness are put around the bed as bund to protect the seed from movement loss. The sheet is covered with farm soil which must be free from soil borne pathogens. The soil is leveled by using wooden stripe. The thickness of soil should be maintained 1 inch (2.5 cm). The depth and consistency of bed should be checked with fingers.

Prepare soil mixture

Mixture of 70-80% soil plus 15-20% organic manure plus 5-10% fresh or charcoal rice hull is prepared and about 4 m^3 soil is needed for 100 m^2 nursery area or one hectare main transplanting field. The soil mixture is laid by using wooden stripe on the top of plastic sheet or banana leaves.

Seed sprouting and sowing

About 15-20 kg seed is required to plant 1-2 seedlings per hill for 20 cm apart. The seed is incubated for 24 hours and then after gunny bag is put loosely for 24 hours. Condition is moistened by sprinkling water 3-4 times. The pre-germinated seeds of 2-3 mm long sprouts are used for sowing. Pre-germinated seeds are sown uniformly and seed are covered maintaining 2-3 cm by firm soil. The bed is covered by banana leaves or gunny sacks. Sprinkle water is given immediately after seed sowing and to maintain moist for next 4 days. On 5th day, the cover is removed and entire nursery area is irrigated with water maintaining 1 cm water level after flooding.

Use of nitrogenous fertilizer for top dressing

If seedlings become yellow due to lack of nitrogenous fertilizer, 0.2% urea solution can be used.

Uprooting

Seedlings will be ready for transplanting after 12 days. Seedling at 4th leaf stage is best for transplanting. The soil around the bed is cut with a knife. The pieces are cut as per the width of transplanter tray. The pieces are taken to the required site for transplanting. In this method, the community nursery can be promoted through this technology in Nepal instead of individual nursery.

This nursery required less amount of seed, fertilizer and nursery area which can reduce the cost up to 50%. Seedling separation from nursery is very easy and results less damage of seedlings. The produced seedlings are healthier and faster growing which produces higher yield.

Figure 6. Nursery raising in tray

Nursery pest management

Some of the major rice insects are Caseworm *(Nymphula depunctalis)*, Armyworm *(Spodoptera mauritia),* Thrips *(Stenchaetothrips biformis),* Green leaf hopper *(Nephotettix nigropictus, N. cincticeps, and N. virescens),* seedbed beetle, termites, stem borers etc. Each insect may attack the nursery at particular stage of its lifecycle to a threshold level. Similarly, major diseases such as Blast *(Pyricularia oryzea),* Brown spot *(Drechslera oryzae),* Rice Tungro virus diseases etc. Insect/pests and diseases should be controlled by using integrated approach before their threshold level.

Conclusion

Rice is the major crop of the Nepalese farming system. The successful rice production is directly influenced by the quality of raised seedlings. The success of raising healthy seedlings mainly depends on selection of quality seed, selection of site, good field preparation, sowing and regular supervision of seedbed and other management practices. Quality seed from reliable sources, use of appropriate methods under field conditions, seed treatment, seeding practice and density, water management, plant protection, uprooting and transportation of seedlings are the most important factors, which determine the production of quality seedlings for transplanting. For producing quality seedlings different types of seedbed nurseries are in practice. Mostly Nepalese farmers adopt dry seedbed nurseries and wet seedbed nurseries to raise rice seedlings. However with the advancement of technologies and mechanization in agriculture, various practices like dapog, modified dapog, modified mat nursery and bubble tray nursery are also in practice in many places of our country.

Acknowledgements

The author would like to appreciate the initiative of Mr. Dila Ram Bhandari, Director General of Department of Agriculture for publishing historical document related to rice. The author acknowledge the supports and feedback gained from number of well-wishers during preparation of this manuscript.

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धानः उन्नत खेती प्रविधि

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परिचय

नेपालमा धान बाली आदि कालदेखि नै खेती गरिँदै आएको र हाम्रो खाद्य सुरक्षासँग जोडिएको बाली हो। धान बाली राम्रो उत्पादन लिनको लागि जग्गाको छनौट, गुणस्तरीय बीउ, मलखाद, सिँचाइ तथा झारपात, रोग र किरा नियन्त्रणको आवश्यकता पर्दछ। तसर्थ धान उत्पादनमा माटोको किसिम तथा माटोको अवस्था (पि.एच.) एवम् माटोको उर्वराशक्ति, हावापानी, बालीको जात र आधुनिक उत्पादन प्रविधिलाई अवलम्बन गर्दै वैज्ञानिक पद्धति अनुसार बाली लगाउन जरुरी हुन्छ। जमिनमा उचित घुम्तीबाली, कम खनजोत, कोशेबालीको प्रयोग एवम् बाली-चक्रको व्यवस्थापनमा ध्यान दिनु पर्दछ। यस बालीमा प्रशस्त मात्रामा प्राङ्गारिक मल र सन्तुलित रूपमा रासायनिक मलको प्रयोग गर्न सकेमा प्रति इकाई अपेक्षित उत्पादकत्व हासिल गर्न सकिन्छ। साथै सूक्ष्मतत्वहरू खासगरी जिंकको कमी हुन नदिई समय-समयमा जिंकको प्रयोग गर्नु पर्दछ। मलखादको साथै धान बालीको संवेदनशील अवस्थाहरू जस्तै बेर्ना सर्ने, गाँज लाग्ने, दाना लाग्ने आदि अवस्थामा सिँचाइ अपरिहार्य हुन्छ। धान बालीको उत्पादन बढाउन समयमै झारपातको नियन्त्रण गर्नु पर्दछ। झारपातहरू हातले गोडेर, मेशिनको प्रयोग गरेर वा झारनाशक विषादीको प्रयोग गरेर नियन्त्रण गर्न सकिन्छ। यसैगरी धान बालीमा लाग्ने रोग तथा किरा नियन्त्रण गर्न पनि उत्तिकै आवश्यक हुन्छ। यसरी धान बालीमा व्यवस्थापकीय पक्षलाई ख्याल गर्दै उचित समयमा बाली कटानी गर्दा अपेक्षित उत्पादकत्व हासिल गर्न सकिन्छ। नेपालमा धानखेती सिजन अनुसार निम्न तरिकाले खेती गर्ने गरिन्छ।

चैते धान : माघदेखि आषाढ महिना
भदैया धान : आषाढदेखि आश्विन १५ सम्म
बोरो धान : मंसिरदेखि जेष्ठ १५ सम्म
वर्षेधान : आषाढदेखि मंसिर १५ सम्म
घैया धान : फाल्गुन १५ देखि भाद्र १५ सम्म

जातको छनोट

धान बालीको उत्पादकत्व बढाउन उपयुक्त उन्नत जातको क्षेत्रगत प्रयोगका साथै अन्य प्रविधिको समुचित उपयोग हुन जरुरी छ। धान खेती गरिने क्षेत्रहरूको वर्गीकरण भौगोलिक स्थिति, वर्षातको मात्रा, सिँचाइको सुविधा र खेती गरिने सिजन र अवस्था आदिको आधारमा गरिएको हुन्छ र बेग्ला-बेग्लै क्षेत्र र अवस्थाका लागि छुट्टा-छुट्टै जातहरूको सिफारिस गरिएको हुन्छ। त्यसैले आफ्नो खेती गरिने क्षेत्रअनुसार सकेसम्म नयाँ वा भर्खरै सिफारिस गरिएका उन्नत वा रैथानेजातहरू लगाउँदा बढी उत्पादन लिन सकिन्छ। हरेक ३-४ वर्षमा बढी उत्पादन लिन नयाँ जात फेर्नु पर्दछ र सोही अनुसार बीउ पनि बल्याउँदै सुदृढीकरण गर्नु पर्दछ।

बीउको छनोट

धान खेतीबाट राम्रो उत्पादन लिनको लागि बीउको महत्वपूर्ण भूमिका हुन्छ। बीउको छनोट गर्दा पूर्ण विकसित, पुष्ट तथा हेर्दा चम्किलो र अन्य बाहिरी वस्तुहरू नमिसिएको हुनु पर्दछ। बीउको जात शुद्ध अर्थात् अर्को जातसँग मिसिएको हुनु हुँदैन। त्यसैले बीउ आधिकारिक संस्था सरकारी फार्म/केन्द्र, राष्ट्रिय बीउ बिजन कम्पनी लिमिटेड र नेपाल सरकारबाट स्वीकृत प्राप्त संस्थाबाट मात्र खरिद गर्नु पर्दछ। खरिद बीउमा यथार्थ संकेतपत्र (Truthful label) अनिवार्य लगाएको हुनु पर्दछ। बीउको गुणस्तरको लागि बीउको

संरक्षण तथा बीउको भौतिक तथा आनुवंशिक शुद्धतालाई सुरक्षित राख्नु पर्दछ। स्वस्थ बीउबाट भुस वा आंशिक रूपमा भरिएको दाना, छिर्केमिर्के वा बेरङ्ग भएको दाना, रोगी वा किराबाट नोक्सान भएको निष्कृय पदार्थलाई हटाउनु पर्दछ। १.५ किलो युरियालाई ४० लिटर पानीमा मिलाएर घोल बनाई बीउलाई छान्न सकिन्छ। यसो गर्दा भुस वा रोगी बीउ पानीको सतहमा आउँछन् जसलाई हातले हटाउनु पर्दछ। यसरी युरियाको घोलबाट छुट्याएको स्वस्थ बीउलाई निकालेर २–४ पटकसम्म सफा पानीले धोएर छाँयामा सुकाउनु पर्दछ। यसैगरी नून पानीले पनि बीउ छनौट गर्न सकिन्छ यसका लागि ५ लिटर पानीमा १ किलो नून घोली उक्त घोलमा कुनै पनि धानको जातको बीउ छान्न सकिन्छ। बीउको उमारशक्ति कम्तीमा ८५ प्रतिशत भएको हुनु पर्दछ।

बीउको उपचार

धानमा डडुवा/मरुवा रोग नलागोस् भनी बीउ छर्नुभन्दा पहिले बीउलाई विषादीमा उपचार गराउनु उपयुक्त हुन्छ। यदि रोग मुक्त जातहरू लगाइएको छ भने बिषादीले बीउ उपचार गर्न जरुरी छैन। सकभर रोगमुक्त जातहरूनै छनौट गर्नु उपयुक्त हुन्छ। बीउ उपचार गर्ने विषादीमा कार्बेन्डाजिम वा थिराम ढुसीनाशक विषादीद्वारा २ ग्राम प्रति किलो बीउका दरले उपचार गर्नु उपयुक्त हुन्छ। ब्याक्टेरियल रोगको उपचारका लागि स्ट्रेप्टोसाइकिलिन वा एग्रीमाइसिन-१००, एक ग्राम १ लिटर पानीमा मिसाएर सो घोलमा बीउलाई छर्नुभन्दा पहिले उपचार गर्नु पर्दछ। बीउलाई *Trichoderma harzianum* अथवा *Pseudomonas fluorecens* जस्ता सूक्ष्मजीवद्वारा जैविक आवरण (*Biopriming*) गर्न सकिन्छ। जैविक आवरण गर्नका लागि बीउलाई ८ घण्टासम्म पानीमा भिजाउनु पर्दछ। त्यसपछि पानी निथारेर र जैविक नियन्त्रण घोल (सिफारिस गरिएको मात्रामा) मिलाउनु पर्दछ। बीउ छर्नुभन्दा १२–१४ घण्टा पहिले बीउलाई थुप्रो पारेर चिसो बोरा वा पोलिथिनले छोपेर राख्नु पर्दछ। यसरी जैविक उपचार गरिएको बीउलाई बढी आर्द्रता भएको स्थानमा राख्नाले जैविक नियन्त्रक घोल चारैतिर फैलिन्छ र एउटा सतह बनाउँछ। यस किसिमको उपचारले बीउबाट सर्न सक्ने रोगको रोकथामको साथै बीउको अंकुरण क्षमता बढ्छ र बोटको राम्रो विकास हुन्छ।

जग्गाको छनोट

ब्याड राख्ने जमिनको छनोट झार नभएको, प्रांगारिक पदार्थ प्रशस्त भएको, सिँचाइ र निकासको सुविधा भएको, रोपाइँ गर्ने खेतदेखि नजिक, आफूले रेखदेख सहजै गर्न सक्ने हुनु पर्दछ। साथै गत वर्ष ब्याड नराखेको जग्गा भएमा जातीय मिश्रण हुने सम्भावना कम हुन्छ र नाबो पनि मिसिने सम्भावना कम हुन्छ। त्यसैले यस्तो स्थानमा ब्याड राखेमा जातीय मिसावट कम हुन्छ।

ब्याड राख्ने तरिका

ब्याडको जमिन राम्रोसँग जोताई गरी झारपात निकालेर फाल्ने। खलोको नजिक ब्याड हुनुहुँदैन। सम्भव भएसम्म जमिनलाई राम्रोसँग जोती पानी लगाई छोड्ने। पानी लगाएको १० दिनपछि पुनः जोती ब्याड तयार गर्ने। नेपालमा खासगरी हिले र धुले गरी २ किसिमबाट धानको ब्याड राखिन्छ। जुन क्षेत्रमा नर्सरी ब्याड राख्ने बेलामा प्रशस्त पानीको उपलब्धता हुँदैन सो ठाँउको लागि धुले ब्याड राखिन्छ। यस्तो ब्याडमा धुलो माटोमा बीउ छरिन्छ। धुले ब्याड राख्दा सामान्यतया एक रोपनीमा राखेको ब्याडले दश रोपनी क्षेत्रफलमा रोपाइँ गर्न सकिन्छ। सामान्यतया ब्याडको चौडाई १ मि. र लम्बाई १० मी.भएको राम्रो मानिन्छ तर आवश्यकता अनुसार बढाउन/घटाउन सकिन्छ। हिले ब्याड तयार गर्दा बीउलाई १८-२४ घण्टा (तापक्रम अनुसार भिजाउने समय फरक हुन्छ) जुटको बोरामा भिजाउने र बोराको मुखलाई राम्रोसँग बाध्नु पर्दछ। २४ घण्टापछि बोरा खोलेर बीउलाई सफा पानीले राम्ररी पखाल्नु पर्दछ। पखालेको बीउलाई थुप्रो बनाई २४ घण्टा छायाँमा चिसो जुटको बोराले ढाक्नु पर्दछ। यसरी ढाकेर राखेको बीउलाई १२ घण्टामा एक पटक राम्ररी चलाई चिस्यान कम भएमा हल्का पानी छर्कनु पर्दछ। ढढाइएको अंकुरित बीउलाई हिल्याइएको खेतमा छरिन्छ। धुलेब्याडको बेर्नामा मरुवा (ब्लाष्ट) रोग र हिले ब्याडको बेर्नामा डडुवा (ब्याक्टेरियल लिफ ब्लाईट) रोग बढी लाग्ने सम्भावना रहन्छ। धान बेर्ना वा धानको पातमा देखिने मरुवा रोग बढी लाग्ने क्षेत्रमा बीउ छर्नुभन्दा पहिले वेभिष्टीन (५० डब्लु.पि.) विषादी १ केजी बीउमा ३ ग्रामका दरले मिलाई बीउ छरेमा वा धान बीउलाई हिले ब्याड बनाई छरेमा उक्त रोग कम लाग्दछ (मानन्धर ०५५/५६)।

ब्याड तयार भएको ५–६ घण्टापछिमात्र बीउ एकनासले छर्नु पर्दछ। पानीको राम्रो सुविधा भएको ठाँउमा यस किसिमको ब्याड उपयुक्त हुन्छ। हिले ब्याड राख्दा सामान्यतया एक रोपनीमा राखेको ब्याडले बीस रोपनी क्षेत्रफलमा रोपाइँ गर्न सकिन्छ। प्रति २५ वर्गमिटरको ब्याडको लागि २५०–३७५ के.जी. कम्पोष्ट मल ब्याड बनाउँदा र डि.ए.पि. ५०० ग्राम ब्याडको अन्तिम तयारी गर्दा

प्रयोग गर्नु पर्दछ। १ हेक्टरको रोपाइँ गर्नको लागि ५०० वर्गमिटरमा ४५ के.जी. बीउ राख्नु पर्दछ। हाल नेपालको केही क्षेत्रहरूमा सामुदायिक नर्सरी स्थापना मार्फत् राइस ट्रान्सप्लान्टरबाट धान रोप्ने प्रचलन पनि बढ्दै गएको छ। यसरी नर्सरी राख्दा प्रति हेक्टर २५० देखि ३०० वटा ट्रे र २० देखि २५ के.जी. बीउको आवश्यकता पर्दछ। वर्षे धान र चैते धानको ब्याड राख्दा तापक्रम र सिँचाइ व्यवस्थाको ख्याल गर्नु पर्दछ। चैते धानको ब्याड राख्दा माघको अन्तिम वा फागुनको पहिलो सातातिर प्रशस्त गोबर मल/कम्पोस्ट मल राखी ब्याडमा तापक्रम बढाउन पर्छ भने वर्षे धानमा तापक्रमबाट ब्याड जोगाउन पर्छ। उच्च पहाडी तथा जुम्ला जस्ता क्षेत्रमा धानखेती प्रविधि र ब्याड राख्ने प्रविधि फरक हुनाले सोही अनुसारको प्रविधि अनुसरण गर्नु पर्छ।

रोपाइँको लागि जमिनको तयारी

रोपाइँ गर्नुभन्दा एक हप्ता अगाडि कान्ला खुर्कने, आली लगाउने र मुसाका प्वाल भएमा टाल्ने गर्नु पर्दछ। गह्रामा पानी लगाएर झारपात कुहाउनु पर्दछ। जमिनलाई पानी लगाई २ पटक राम्रोसँग जोतेर हिल्याउने र पाटा लगाई सम्याउने गर्नुपर्दछ। खेतलाई बारम्बार जोतेर सम्याउने कार्यले माटो एकनासले हिलिन्छ र समतल हुन्छ जसका कारण सम्पूर्ण बेर्नालाई एकरूपले पानी र पोषण मिल्छ र एकनासले उत्पादन हुन्छ। तयारी जमिनमा ४ देखि ५ से.मी.सम्म पानी जमाउने र प्राङ्गारिक मललाई जग्गाको तयारीको बेला राम्रोसँग माटोमा मिलाउनु पर्दछ। डि.ए.पी. र पोटासलाई माटोको अन्तिम तयारीसँगै हाल्नु पर्दछ। पहाडका गह्राहरूमा गोरुले जोत्नु पर्छ भने तराई र भित्री मदेशमा ट्र्याक्टर र गोरु दुवैले जोत्न सकिन्छ र सोही अनुसार जग्गा तयार गर्नु पर्छ।

रोपाइँ गर्ने समय र दूरी

नेपालको उच्च पहाडमा चैतको पहिलो हप्तादेखि बैशाखको पहिलो हप्तासम्ममा रोपाइँ गर्ने गरिन्छ। पहाडमा जेठको पहिलो हप्तादेखि साउनको पहिलो हप्तामा (सामान्यतया असारको १५ गते देखि ३० गतेसम्म) रोपाइँ गरिन्छ। तराईमा सामान्यतया जेठ १५ देखि साउन १५ सम्ममा रोपाँइ गर्ने गरिन्छ।

रोपाइँ गर्दा बेर्नाको उमेरले उत्पादनमा महत्वपूर्ण भूमिका निर्वाह गर्दछ। निकै सानो बेर्ना रोप्दा अप्ठ्यारो हुने र बढी उमेरको बेर्ना रोप्दा बालीको उत्पादन कम हुन जान्छ। अगौटे जातको लागि २-३, मध्यम अवधि जातको लागि ३-४ हप्ता र लामो अवधिको जातको लागि ५-६ हप्ताको बेर्ना रोपाइँ गर्नको लागि उपयुक्त हुन्छ। एक लाइनदेखि अर्को लाइनको दूरी २० देखि २५ से.मी. र बोटदेखि बोटको दूरी १५ से.मी. तथा २/३ बोट एक ठाँउमा रोप्दै जानु पर्दछ। बीउ रोप्दा २-३ वटा बीउ/गाँज रोप्नु पर्छ।

धान बालीमा मलखादको प्रयोग

धान बालीमा मलको प्रयोग गर्दा खेतमा भएको मलिलोपना, धान बाली लगाउनुअघि लगाइएको बाली प्रणाली र प्राङ्गारिक पदार्थको उपलब्धतालाई ध्यान दिनु पर्दछ। स्थानीय स्रोतको परिचालनमा हरियो मल (सकेसम्म कोशेबालीमा ढैंचा, सनाइ र यस्तै अरू कोशेबाली), एजोला, गोठेमल, कम्पोष्ट मल, पिना, ब्लुग्रीन एल्गी आदी प्रयोगमा ल्याउन सक्दछौं। हरियो मलको रूपमा प्रयोग हुने बालीलाई फूल फुल्नु अगाडि नै माटोमा मिलाउनु पर्दछ। यी मलहरू प्रयोग गरेपछि नपुग मात्रा मात्र रासायनिक मलको रूपमा दिनु पर्दछ। धान बालीको लागि सामान्यतया ६ मे.टन कम्पोष्ट मल र १०० : ३० : ३० के.जी. नाइट्रोजन : फस्फोरस : पोटास प्रति हेक्टर सिंचित क्षेत्रको लागि र असिंचित क्षेत्रको लागि ६० : २० : २० के.जी. नाइट्रोजन : फस्फोरस : पोटास प्रति हेक्टर सिफारिस गरिएको छ। यसअनुसार सिंचित क्षेत्रको लागि १९२ के.जी. युरिया, ६५ के.जी. डि.ए.पि. र ५० के.जी. पोटासको आवश्यकता पर्दछ भने असिंचित क्षेत्रको लागि ११३.४ के.जी. युरिया, ४३.४८ के.जी. डि.ए.पि. र ३३.३३ के.जी. पोटासको आवश्यकता पर्दछ (कृषि डायरी २०७३)।

धान बालीमा मलखादको सही सदुपयोग गरी बाली उत्पादन लिनको लागि कम्पोष्ट मल, फस्फोरस र पोटासको सम्पूर्ण मात्रा र नाईट्रोजनको आधा मात्रा खेतको तयारीको अवस्थामा नै खेतमा मिलाउनु पर्दछ भने नाईट्रोजनको बाँकी मात्रालाई दुई भाग गरी पहिलो भाग गाँज निस्कने बेलामा र दोश्रो भाग बाला पसाउने बेलामा टपड्रेसको रूपमा प्रयोग गर्नु पर्दछ। युरिया टपड्रेस गर्दा सिँचाइ गरेको २-४ दिनपछि वा वर्षातको पानी परेर रोकिएपछि मात्र गर्नु पर्दछ। यदि सिँचाइको व्यवस्था हुन नसकेमा २ प्रतिशतको युरियाको घोल पातमा स्प्रे गर्नु पर्दछ। यसका अलावा मलखादलाई तलको तालिका बमोजिम पनि प्रयोग गर्न सकिन्छ **(तालिका १)**।

तालीका १. धान बालीमा मलखादको मात्रा

मलखाद	असिंचित क्षेत्र		सिंचित क्षेत्र		कहिले
	प्रति रोपनी	प्रति कठ्ठा	प्रति रोपनी	प्रति कठ्ठा	
कम्पोष्ट	६०० के.जी. (२० डोको)	४०० के.जी. (१३ डोको)	६०० के.जी. (२० डोको)	४०० के.जी. (१३ डोको)	जमिन तयारी गर्दा
डि.ए.पी.	४.५ के.जी.	३.० के.जी.	५.५ के.जी.	३.७ के.जी.	जमिन तयारी गर्दा
पोटास	२.५ के.जी.	१.७ के.जी.	४.२ के.जी.	२.८ के.जी.	जमिन तयारी गर्दा
युरिया	२.० के.जी.	१.३ के.जी.	२.३ के.जी.	१.५ के.जी.	रोपेको २५ देखि ३० दिनमा
	२.० के.जी.	१.३ के.जी.	२.३ के.जी.	१.५ के.जी.	रोपेको ४५ देखि ५५ दिनमा

स्रोतः कृषक सहयोगी पुस्तिका

धान बालीमा जिंक सूक्ष्मतत्वको पूर्ति गर्नको लागि जिंक सल्फेट २०-३० के.जी. प्रति हेक्टरका दरले जमिनको अन्तिम तयारीमा प्रयोग गर्नु पर्दछ । यदि माटोमा प्रयोग गर्न नसकिएमा ५ के.जी. जिंक सल्फेटमा २.५ के.जी. चुना मिसाएर १००० लिटर पानीमा घोली १०-१० दिनको फरकमा पातमा छर्कनु पर्दछ । प्राङ्गारिक मलको प्रयोग जमिनको तयारीभन्दा करीब १ महिना अगाडि गर्दा राम्रो हुन्छ ।

सिँचाइ व्यवस्थापन

अन्य बालीको तुलनामा धान बालीलाई धेरै पानीको आवश्यकता पर्दछ। धान बाली रोपेको २-३ (२-३ पात हुने अवस्था) हप्तासम्म सिँचाइको सुनिश्चितता हुनु पर्दछ । यसैगरी रोपाइँपछि गाँज राम्रोसँग लाग्ने अवधिमा २ देखि ५ से.मी.सम्म खेतमा पानी रहनु पर्दछ। यसको अतिरिक्त गाँज निस्कने बेलादेखि बाला निस्कने तथा फूल लाग्ने बेलासम्म पानीको अभाव हुन दिनु हुँदैन। यसकारण धान बालीमा गाँज हाल्ने र फूल फुल्ने अवस्थालाई सिँचाइ आवश्यकताको संवेदनशील अवस्था (Critical stage) भनिन्छ। खेतलाई बाली वृद्धिको चरणअनुसार सिँचाइ र निकासको व्यवस्था मिलाउनु पर्दछ। बेर्ना रोपिसकेपछि अधिक सिँचाइ गर्दा बेर्नाको गाँज हाल्ने क्षमता कम गराउँछ। जसले गर्दा कम उत्पादन हुन्छ।१ किलो धान उत्पादन गर्न २०००-२५००० लिटर पानीको आवश्यकता पर्ने हुनाले धान बालीले धेरै पानी प्रयोग गर्ने स्वतः स्पस्ट हुन्छ तसर्थ गाँज हाल्ने समयमा सुकाउने र भिजाउने (Alternate drying and wetting) प्रणालीले सिँचाइ गर्दा पानीको सही सदुपयोग हुन जान्छ। यस किसिमको सिँचाइ प्रणाली बेर्ना रोपेको केही दिनपछि पसाउन थालेको पहिलो अवस्थासम्म गर्न सकिन्छ । पसाउन थालेको पहिलो अवस्थादेखि फूल फुलेको एक हप्तासम्म खेतमा ५ से.मी. पानी जमाएर राख्नु पर्दछ। धान बाली कटानी गर्नुअघि दाना परिपक्व भएपछि सम्पूर्ण पानी सुकाउनु पर्दछ।

खाद्यतत्वहरूको कमी भएमा देखिने लक्षणहरू

धान बालीलाई चाहिने मुख्य तत्वमा कार्बन, हाइड्रोजन, र अक्सिजन मुख्यतया हावा र पानीबाट प्राप्त हुन्छ भने नाइट्रोजन, फस्फोरस र पोटास माटोबाट नपुग्ने हुनाले कृत्रिम तरिकाले मलको रूपमा दिनु पर्छ। यसको अलावा अरू सूक्ष्म पोषक तत्वहरू पनि धानलाई आवश्यक पर्दछ । यी पोषक तत्वहरू माटोले बिरुवालाई आवश्यकता अनुरूप दिन नसके बिरुवा बढ्न सक्दैन । नाइट्रोजन कम भएमा बिरुवाको पातमा हलुका पहेंलोपना देखापर्दछ र बूढापातहरूमा पहेंलोपना देखा पर्दछ। यसरी नै फस्फोरसको कमीमा पातमा बैजनी रंङ्ग (गाढा हरियोमा रातो मिसिएको) देखापर्दछ । बिरुवा गाढा हरियो र ठाडो देखिन्छ । पोटासको कमीले बिरुवाको पुराना पातमा खैरोपनको पहेंलोपना (पातको किनारा डढेको) देखा पर्दछ। म्याग्नेसियमको कमीमा बिरुवाले धानको बूढा पातमा सुन्तला रङ्गको पहेंलोपना देखिन्छ। गन्धकको कमी भएमा पातमा फिका पहेंलोपनको हरियो देखिन्छ। क्याल्सियमको कमीमा पात बेरिनुको साथै पहेंलोसहितको सेतोपना देखापर्दछ। जस्ता (जिङ्क) तत्वको समस्या नेपालको प्रायः सबै जिल्लामा देखा परेको छ, तर तराईमा यसको प्रकोप बढी पाइन्छ। यसको कमीमा बिरुवाका पात र डाँठ कमलो हुन्छ पातमा बदामे रंङ्को खैरो दाग देखा पर्ने भएकोले यसलाई खैरा रोगको नामले पनि चिनिन्छ। बोट बढ्न सक्दैन र गाँज पनि कम हाल्दछ। फलामको कमीमा निस्कन लागेका पातहरूमा अन्तर्नशीय पहेंलोपना देखा पर्दछ। पछि गएर त्यो सेतोमा परिणत हुन्छ। फलामको कमीको लक्षण घैया धानमा बढ्ता देखिन सक्दछ। यसरी नै म्याङ्गानिजको कमीमा पनि नयाँ पातमा अन्तर्नशीय खैरो किसिमको पहेंलोपना देखा पर्दछ। तामाको

कमीमा धानको पातमा पहेंलो धर्सा जस्तो देखा पर्नु, पात आकासे रङ्ग (नीलो हरियोमा परिणत हुनु) र ओइल्याउनु जस्ता लक्षणहरू देखा पर्दछ। भुसिने क्रिया पनि बढ्दछ। सुहागको कमीमा नयाँ पात सेतो र टुप्पो बटारिएको देखिनुका साथै पातको विकास हुने ठाउँ नै मर्नु तथा बाला निक्लन नसक्नु जस्ता लक्षणहरू देखा पर्दछन्। सिलिका आवश्यक खाद्यतत्व नभए पनि यसको कमीमा धानका पातहरू लत्रने, बाली ढल्ने, रोगको आक्रमण बढने जस्ता समस्याहरू देखा पर्दछन्।

झारपात व्यवस्थापन

धान बालीमा देखा पर्ने प्रमुख झारहरू दुबो, सामा, मडिलो, छत्रे, बन्सो, कोदे झार, कानेझार, काँडे लुडे आदि हुन्। झारपातले धानको बिरुवासँग खाद्यतत्वको लागि प्रतिस्पर्धा गर्ने, रोग तथा किराको लागि अनुकूल वातावरण पैदा गर्नुका साथै सिँचाइ प्रणालीको क्षमतालाई असर पार्ने हुँदा समयमा नै झारपातको व्यवस्थापन गर्नु पर्दछ। झारपात तीब्र गतिमा बढ्ने भएकोले आवश्यक पर्ने खाद्य तत्वका लागि बालीसँग प्रतिस्पर्धा गर्छ, जसले गर्दा उत्पादनमा प्रत्यक्ष असर पार्दछ। झारपातबाट हुने नोक्सानी झारपातको किसिम र खेती गर्ने तरिकामा पनि भर पर्दछ। यदि वर्षा नभएको खण्डमा झारपातलाई बढ्न दिएर रोपाइँ गर्नुभन्दा पहिला २० दिनको फरकमा दुई पटक जोतेर झारपातलाई माटोमा मिलाउनु पर्दछ। यसो गर्नाले झारपात राम्रोसँग गल्ने र माटोको उर्बराशक्ति पनि बढेर जान्छ। रोपाइँ गर्ने खेतलाई राम्रोसँग हिल्याउँदा पनि झारपात कम गर्न सकिन्छ।

रोपुवा धानमाभन्दा छरुवा धानमा झारपातको प्रकोप बढी हुन्छ। तसर्थ छरुवा धानमा छरेको १ महिनाभित्र नगोडे वा झारपात नियन्त्रण नगरे धानको उत्पादनमा उल्लेखनीय ह्रास आउँछ। गोडमेल गरी झार नियन्त्रण गर्न धान रोपेको २५–३० दिनसम्म पहिलो गोडाई गर्नु पर्छ र झारपात बढी मात्रामा देखिएमा दोस्रो गोडाई गर्नु उपयुक्त हुन्छ। झार गोड्नका लागि हाते झार गोड्ने मेशिन वा विद्युतीय झार गोड्ने मेशिनको प्रयोग गर्न सकिन्छ। रोपाइँको १५ दिनपछि प्रत्येक १० दिनको फरकमा रोटरी वीडर प्रयोग गर्नु पर्दछ। गोडमेलबाट झारको व्यवस्थापन गर्न सम्भव नभएको अवस्थामा झार मार्ने विषादीको प्रयोगबाट पनि नियन्त्रण गर्न सकिन्छ। धान रोपाइँ अथवा छरिसकेपछि झारनाशक विषादीको प्रयोग गर्न सकिन्छ। रोपाइँ गरेको धानमा ब्यूटाक्लोर गेडा ८०० ग्राम प्रति कट्ठा अथवा १.२५ के.जी. प्रति रोपनीको दरले धान रोपेको ५ दिनभित्र समान रूपले छर्नु पर्दछ र २४ घन्टासम्म पानी थुनी राख्नु पर्दछ। पछि आएका झारलाई हातले गोडमेल गरी व्यवस्थापन गर्न सकिन्छ अथवा प्रटीलाकोर वा नोमिनीगोल्ड २५० मि.लि. प्रति हेक्टरको दरमा रोपेको २५ देखि ३५ दिनमा प्रयोग गर्न सकिन्छ।

धान बालीमा रोग किरा नियन्त्रण विषादीको प्रयोगभन्दा रोग र किरा प्रतिरोधक जात लगाउनु राम्रो उपाय हो। यसको अलावा एकिकृत शत्रु जीव व्यवस्थापन जस्तै घुम्ती बाली, परजीबीको प्रयोग, राम्रोसँग खनजोत, झारपात हटाउनु, हिउँदमा जोति छोड्नु, धानका ठुटाहरू उखेलेर जलाउनु र पुर्नु आदि प्रविधि अपनाई रोग/किराको नियन्त्रण गर्नु उचित हो। यदि यी विधिबाट रोग/किरा नियन्त्रण नभएमा मात्र विषादीको प्रयोग गर्नु पर्दछ। धान बालीमा लाग्ने मुख्य मुख्य रोग/किराको क्षति तथा तिनको नियन्त्रण संछिप्त विधि तल दिइएको छ।

धानमा लाग्ने प्रमुख रोगहरू र व्यवस्थापन

ब्लास्ट (मरुवा) रोग Blast (Pyricularia oryzae)

यो रोग लागेमा पातमा, आँख्लामा, बालाको घाँटीमा र अन्य भागमा लाम्चो दाग वा थोप्ला देखिन्छन्। आँख्लामा आक्रमण भएमा सजिलै भाँचिन्छ। यसको व्यवस्थापनका लागि रोग अवरोधक जातको खेती गर्ने, सन्तुलित मलखाद प्रयोग गर्ने तथा नाइट्रोजनयुक्त मल मात्र प्रयोग नगर्ने। कासुवी (कासुगमाइसिन) वा बिम (ट्राइसाइक्लाजोल) १-२ मि.लि. प्रतिलिटर पानीका दरले छर्ने।

ब्याक्टेरियल लिफ ब्लाइट (डढुवा रोग) Bacterial Leaf Blight (Xanthomonas oryzae pv. oryzae)

पातको किनारामा भिजेको जस्तो दाग देखिन्छ। दाग बढ्न र किनारा तरंगी (wavy) हुन्छ र पहेंलो वा हलुका खैरो हुन्छ। कलिलो बोटमा रोग लागेमा बिरुवा ओइलाउने र मर्ने जसलाई 'क्रेसेक' भनिन्छ। यसको व्यवस्थापनका लागि रोग अवरोधक जात प्रयोग गर्ने। सन्तुलित मलखाद प्रयोग गर्ने तथा नाइट्रोजन युक्त मल मात्र प्रयोग नगर्ने।

खैरो थोप्ले रोग Brown Leaf Spot (Bipolaris oryzae)

यसको लक्षणस्वरूप पात पहेंलिनुका साथै पातमा खैरो वा काँसजस्तो रंगका देखिन्छन्। मलखादको कमी विशेष गरी नाइट्रोजनको कमी भएमा यो रोग लाग्न सक्छ। यो रोगको व्यवस्थापनको लागि सन्तुलित मलखाद प्रयोग गर्ने।

पातको फेद डढुवा रोग Sheath Blight (Rhizoctonia solani)

यसको लक्षणस्वरूप बिरुवाको तल्लो भागदेखि लिफ सिथमा बेआकारका दाग देखिन्छन् । फेदमा वा लक्षण भएको ठाउँमा स्क्लेरोसिया (Sclerotia) बन्न सक्छ । यसको व्यवस्थापनका लागि भ्यालिडामाइसिन २ मि.लि. प्रतिलिटर पानीका दरले छर्ने । सन्तुलित मलखाद प्रयोग गर्ने ।

धानमा लाग्ने प्रमुख किराहरू र व्यवस्थापन

गबारो किरा (Rice Borer)

यसका लक्षणहरूमा बिरुवाको कलिलो अवस्थामा आक्रमण भएमा मृत वा सेतो गावा वा गुबो देखिन्छ । बिरुवाको फूल फुल्ने अवस्थामा आक्रमण भएमा भुसमात्र भएको सेतो बाला देखिन्छ । यसको व्यवस्थापनका लागि चाँडै पाक्ने जातहरू लगाउने । धान रोप्ने बेला धानको बेर्नाको टुप्पा चुँडेर रोप्नाले पुतलीले पारेका फुल (अण्डा) नष्ट हुन्छन् । डाइथोएट (रोगर, अल्टागर, नुगर आदि) ३५ ई.सी. १–१.५ मि.लि. प्रति लिटर पानीमा हाली बेर्ना सारेको ३० र ६० दिनको आसपासमा पुतलीहरू देखिएमा छर्ने । परजीवि किरा ट्राइकोग्रामा ५० हजार देखि १ लाख प्रति हेक्टरको दरले रोपाइ गरेको ३–४ हप्तापछि छोड्ने । धान खेतको आलीमा भटमास लगाउने ।

पतेरो (Rice Bug)

यसका लक्षणहरूमा पातमा बढी आक्रमण भएमा पात पहेंलिने हुन्छ । बालामा आक्रमण भएमा दानामा खैरो दागहरू देखिने र फोस्रा दानाहरू हुने गर्दछ । यसको व्यवस्थापनका लागि झारपात हटाउने । धानको गेडामा दूध पसाउन सुरु अवस्थामा विषादी छरेमा किरा नियन्त्रण गर्न सकिन्छ । किराको प्रकोप ज्यादै भएमा मालाथिएन ५० ई.सी. २ मि.लि. प्रति लिटर पानीमा अथवा साइपरमेथ्रिन २५ ई.सी. वा फेन्भेलेरेट २० ई.सी. ०.५ मि.लि. प्रति लिटर पानीका दरले कुनै एक विषादी छर्ने ।

धानको फड्के किराहरू (Hoppers)

यसका लक्षणहरूमा फड्के किराहरूले बिरुवाको डाँठबाट रस चुसेर खान्छन् जसले गर्दा बिरुवा सुकेर मर्छन् । बिरुवाहरू गाँजिन र बढ्न सक्दैनन् । यसको व्यवस्थापनका लागि धानखेतमा माकुरा र माइरिड वर्गको संरक्षण गर्ने । किरा लागेको खण्डमा ३ देखि ४ दिनको फरकमा खेतबाट पानी निकास गरी खेतलाई सुख्खा बनाएर फेरि नयाँ पानी जमाउनु पर्दछ । डाइथोएट (रोगर, अल्टागर, नुगर आदि) ३५ ई.सी. १–१.५ मि.लि. २ लिटर पानीमा हाली छर्ने ।

बाली कटानी तथा भण्डारण

धान बाली राम्रोसँग पाकेपछि मात्र काट्ने व्यवस्था मिलाउनु पर्दछ । साधारणतया धानको बाला निस्केको ३०-३५ दिनमा धान पूर्णतया पाकेको हुन्छ र काट्नको लागि तयार भएको मान्नु पर्दछ । धान काट्दा खेतबाट १२-१५ दिन पहिलेदेखि नै पानी हटाउनु पर्दछ । चैत्र महिनामा रोपेको धान आषाढ-श्रावणमा काटिन्छ भने आषाढ-श्रावणमा रोपेको धान कार्तिक-मंसिरमा काटिन्छ । धानको बाला निहुरी, सुनौलो रङ्गमा परिणत भई, ९० प्रतिशत पातहरू पराले रङ्गमा परिवर्तन भएपछि धान पाक्दछ (अधिकारी २०५२) । धानको लागि ८० प्रतिशत बालाको रंग परालको रंगसँग मिल्दोजुल्दो र करीव २१-२४ प्रतिशत चिस्यानको मात्रा रहेको अवस्थामा बाली काट्नु उपयुक्त हुन्छ । काँचो अवस्थामा बाली काटेमा बीउ राम्रोसँग नछुट्टिने, दाना थेप्चो हुने, चुट्न गाह्रो हुने, चिस्यान बढी हुने, भण्डार गर्दा रोग तथा किराको आक्रमण बढी हुने, तथा उमारशक्ति राम्रो नहुने हुन्छ भने बाली ढिला काटेमा धान ढल्ने तथा दाना झर्ने, बासना आउने जातमा बासना हराउने, दाना सजिलै फुट्ने, चरा तथा मुसाद्वारा बढी नोक्सान गर्ने हुनाले उपयुक्त अवस्था हेरी बाली कटानी गर्नु पर्दछ ।

बाली काटी पाँजा मिलाई सुकाउँदा मुठा बाँधी बिटा बोक्न सजिलो हुन्छ । यसरी बिटा जम्मा गरी कुनियो लगाई दाइँ गर्ने चलन छ । आजभोलि बाली चुटानीको लागि थ्रेसरको प्रयोग बढ्दो रूपमा प्रयोगमा आइरहेका छन् भने तराईको ठूला फाँटहरूमा कम्बाइन हार्भेष्टरको प्रयोग पनि सुरु भएको छ ।

दाइँ गरेपछि धान पराल छुट्याइन्छ र धानलाई राम्रोसँग सुकाई सफा गरी भकारी, डेहरी, मान्द्राको भकारी, मेटलबिन आदिमा राखिन्छ भने परालको टौवा बनाई थन्काइन्छ । धान भण्डार गर्ने ठाँउहरू घुन, पुत्ला, चरा, मुसा, पानी, हुरी बतासबाट सुरक्षित हुनु पर्दछ । स्थानीयरूपमा बनाइने माटोको भकारी गोबर माटोले राम्रोसँग लिपपोत गरी कुन महिनामा झिक्ने हो सोहीअनुसार

थन्काइन्छ । खायन र बीउको लागि प्रयोग गर्ने धान छुट्टाछुट्टै भण्डार गरिन्छ र यसरी भण्डार गरिने धानलाई सुकाएर १२–१३ प्रतिशतको चिस्यान कायम राखिन्छ ।

बीउ व्यवस्थापन: बीउ उत्पादनको लागि खेती गर्दा बीउ प्राविधिकको सल्लाहअनुसार गर्नु पर्दछ । कृषकले आफ्नै खेतीबाट उत्पादित धानको बीउ राख्नुपर्दा २ किसिमबाट छान्न सकिन्छ ।

गऱ्हो वा प्लट छनौट गरेर : आफूलाई चाहिने जति बीउ उत्पादन हुने गरी राम्रो मल जल पुगेको, बोट अग्लो होचो नभएको, रोग किरा नलागेको गऱ्हो वा प्लटको छनौट गर्ने । छानिएको गऱ्हो वा प्लटमा देखिएका नाबो बेजातीय बोट, रोग र किरा लागेका बोटहरू हटाउने र बाँकी बालीलाई छुट्टै काट्ने, सुकाउने गर्नु पर्दछ ।

बाला बल्याएर : आफूलाई चाहिने जति बीउ प्राप्त हुने गरी स्वस्थ तथा समान बोटका राम्ररी पाकेका बाला बल्याएर पनि शुद्ध बीउ लिन सकिन्छ । यसरी छानिएका बीउलाई झारी सकेपछि ३-४ घाम सुकाई केलाई गरेर हावा नछिर्ने भाँडा जस्तै सिड बिन, भकारी, घ्याम्पो वा बोरामा राख्नु पर्दछ । तर धान खेतीबाट राम्रो उत्पादन लिनको लागि हरेक ३-४ वर्षमा बीउ फेर्नु पर्दछ ।

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Direct Seeding and Broadcasting Systems of Rice Production in Nepal

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सारांश

संसारको आधा भन्दा धेरै जनसंख्याको मुख्य खाना धान हो । हालैका वर्षहरूमा मुख्यतः पानीको बढ्दो कमी, श्रमको कमी र उत्पादनको उच्च लागत गर्दा छरूवा धान खेती मौलाएको छ । यसमा उम्रिएको बीउ तयारी धुलो माटोमा, पानीको सतहमा वा सुक्खा माटोको सतहमा रोप्न सकिन्छ । उत्पादन सामाग्रीको कम प्रयोग हुने भएकाले यो प्रविधि प्रचलित छ । यस प्रविधिको सफलता समतल जमिन, राम्रो खडा बाली, सटीक पानी व्यवस्थापन, झारपात व्यवस्थापन र पोषक तत्व व्यवस्थापन आदिमा भर पर्दछ । हालसम्म यस प्रविधिका लागि कुनै जातहरूको विकास नभएता पनि पैत्रिक जातहरू र वर्णशंकर जातहरू उपयुक्त पाइएका छन् । छरूवा धान खेती अपनाउँदा सामान्यतया नाइट्रोजन, फस्फोरस, सल्फर, जिंक र फलामजस्ता पोषकतत्वहरूको कमी हुने गर्दछ । झारपात, डडुवा रोग, बाली ढल्ने र स्थिर उत्पादकत्व यस प्रविधिसँग जोडिएका केही चुनौतीहरू हुन् भने यस प्रविधिको अनुसरण गर्दा उपयुक्त संरक्षण अभ्यासको प्रयोग गर्न सकियो भने पानीको अभाव र श्रमको न्यून उपलब्धता हुने अवस्थामा समेत नर्सरीमा बेर्नाे उत्पादन गरी गरिने धान खेतीबाट हुने उत्पादनको तुलनामा केही न्यून वा समान उत्पादन हुने सम्भावना रहेको छ ।

Summary

In recent years, there has been a shift from Transplanted Rice (TPR) to direct seeded rice cultivation mainly driven by the increasing water scarcity, shortage of labor and high cost of production. It involves sowing pre-germinated seed into a puddled soil surface (wet seeding), standing water (water seeding) or dry seeding into a prepared seedbed (dry seeding). Direct Seeded Rice (DSR) has received much attention because of its low-input demand. The most important prerequisites for a successful crop of direct seeded rice are land leveling, good crop establishment, precision water, weed and nutrient management. There are no varieties till date specifically targeted for DSR but many of the inbred varieties and hybrids bred for puddled transplanted are found suitable. Direct seeding follows aerobic cultivation. So, the nutrient dynamics are altered. Several key nutrients like N, P, S, Zn and Fe are likely to be a constraint in DSR. Weed infestation can cause large yield losses in DSR. In addition, blast disease, crop lodging and stagnant yields across the years are major challenges. Whereas, DSR with suitable conservation practices has potential to produce slightly lower or comparable yields as that of TPR and appears to be a viable alternative to overcome the problem of labor and water shortages.

Keywords: Conservation practices, DSR, Rice, Water scarcity, Weed management

Introduction

Rice, a semi-aquatic annual grass (*Oryza sativa* L.), is the foremost staple food for more than half of the world's population. Ninety percent of all rice is grown and consumed in Asia (FAO 1997). It is estimated that by the year 2025, the world's farmers should produce about 60% more rice than at present to meet the food demands of the expected world population at that time (Fageria 2007). Lots of efforts and new concepts are emerging to increase the production and productivity of rice (Uprety 2006). One of such emerging concepts is Direct Seeded Rice. Direct seeded rice refers to the process of establishing the crop from seeds sown in the field rather than by transplanting seedlings (Farooq et al 2011). Three methods of direct seeding are known, namely, dry-DSR, wet-DSR and water seeding.

Prior to the 1950s, direct seeding was most common, but was gradually replaced by puddled transplanting (Rao et al 2007). In Nepal, Upadhyaya (1996) estimates that over 90% of rice cultivation is done by transplanting into puddled soil. Traditional transplanted puddled rice is valuable for resource use efficiency. It conserves water, increases nutrient availability while suppressing the weeds (Surendra et al 2001). Puddling over time degrades the soil; destroys soil aggregates; reduces permeability and forms hard pans of soil in shallow depths (Sharma et al 2003). Furthermore, the need of ponded water for customary practice of puddling delays rice transplanting by one to three weeks (Ladha et al 2009). In Asia, dry seeding is extensively practiced in rainfed lowlands, uplands and flood-prone areas, while wet seeding remains a common practice in irrigated areas (Azmi et al 2005, De Dios et al 2005). Direct seeding in Nepal is done in dry fields on uplands. This practice is more prevalent in the hills in upland areas (Ghaiya land). Direct seeding is also done in western Nepal in lowlands where labor is limited and the eastern lowlands where water gets stagnated during monsoon.

Direct seeding: Current status

In recent years, there has been a shift from transplanted rice to direct seeded rice cultivation in several countries of southeast Asia (Pandey and Velasco 2002). This shift was mainly driven by the increasing water scarcity, shortage of labor and high cost of production. Direct seeding avoids three main basic operations, namely: puddling, transplanting and maintaining standing water. In addition to higher economic returns, DSR crops are faster and easier to plant, have shorter growth duration, require less labor, consume less water (Bhushan et al 2007), conducive to mechanization (Khade et al 1993) and have less methane emissions (Wassmann et al 2004). Yield in DSR is often lower than transplanted rice principally due to poor crop stand, high percentage of panicle sterility, higher weed and root-knot nematode infestation (Singh et al 2005). High weed infestation and nutrient deficiencies are a major constraint for broader adoption of DSR.

Production technology for direct dry seeded rice

The production technology of DSR revolves around weed management, crop establishment and likely shifts in weed flora due to adoption of direct-seeded rice (Ravi Gopal et al 2010). The most important pre requisites for a successful crop of direct seeded rice are precise land leveling, good crop establishment, precision water management, weed management and nutrient management (Kumar and Ladha 2011).

Land preparation

DSR can be done by both conventional or conservation tillage. For conventional till, field should be pulverized to maintain good soil tilt. Proper land leveling is an important pre-requisite for DSR. Laser leveling is a good option but may not be feasible to all. Use of local equipment's like raiser and planking can equally be effective. A level field facilitates uniform irrigation, leading to a uniform crop stand and improved weed control and efficient use of fertilizers (Jat et al 2006 and Lantican et al 1999). Land leveling saves 20-25% of irrigation water (Rickman 2002). DSR yield is correlated with precision of land leveling (Lantican et al 1999). For zero tilled direct seeded rice, existing weeds should be burned down by using herbicides such as paraquat (at 0.5 kg ai/ha or glyphosate at 1.0 kg ai/ha) (Gopal et al 2010, Lantican et al 1999). In areas with high weed infestations 1-3 summer ploughings are recommended.

Seeding time

Where irrigation facilities are available, it is better to sow the crop 10–15 days prior to the onset of the monsoon (Gopal et al 2010, Kamboj et al 2012, Kumar and Ladha 2011, Ravi Gopal et al 2010). Optimum time of planting results in improved rainwater use efficiency by 40-50% and enhances the total productivity of cropping system up to 30% (Kumar and Ladha 2011). The optimum time of dry seeding rice in the mid hills is the middle of May while in the foothills the optimum time is late May to early June. In the Tarai (plains), the optimum time is late May to early June. Late sown crop carry a greater risk of heavy rain shortly after sowing which will impair the establishment, more so for clayey soils. The monsoon rains generally starts later in the mid and far western Tarai and sowing can be done in the first week of June. Direct seeding in the lowlands of eastern Nepal is done in standing water from the monsoon which continues to do so even after harvest till January and February. So seeding is done in April-May in residual soil moisture. In the far west, direct-seeding is done after one or two rainfalls, when soil has sufficient moisture to germinate the seed. In this condition, rice and weeds germinate together and weeds become a problem. When rice plants are 20-25 cm tall, they are ploughed with a thin plough. By this action, rice population becomes thin and weeds are controlled to some extent.

High seed rates are used mostly in areas where seed is broadcasted with an aim to suppress weeds or when water seeded (Moody 1977). About 80-100 kg/ha seed rate is used. The seed rate is the same as for upland rice but double the rate of transplanted rice. Higher spikelet sterility and fewer grains per panicle are common in very dense populations (Kabir et al 2008). Moreover, dense plant populations at high seed rates can create favorable conditions for diseases, eg sheath blight (Guzman and Nieto 1992, Mithrasena and Adikari 1986) and insects (eg brown plant hoppers) and make plants more prone to lodging (Islam et al 2008).

Planting machinery

For accurate and precise seeding, rice should be drilled with a multi-crop planter fitted with inclined plate's seed metering systems and inverted T-type tynes. Seed drills with inverted-T tynes are suitable for seeding into both tilled and non-tilled soil. With these precise seed-metering planters, better crop establishment with a lower seed rate and more precise plant-to-plant spacing can be done (Gupta et al 2006). When no or only anchored residues of the previous crop (eg wheat) are retained, the same multi-crop planter can be used for seeding if fitted with suitable tynes (eg inverted T). However, if loose or bulky crop residues are present on the soil surface (eg mung bean, loose straw), the Turbo Happy Seeder should be used. Seed-cum-fertilizer drills for 2-wheel tractors are available in Nepal, and can be used for DSR in the small farm holdings in the foot hills, inner Tarai and Tarai region. The depth of seeding needs to be adjusted to achieve a seeding depth of 1-2 cm.

Seed priming

Seed priming is an effective approach to address the drought stress as DSR is sown at a shallow depth (<2 cm) in advance of the monsoon rains (Farooq et al 2006). Priming involves storing the seeds overnight in a gunny bag. The seeds should be sown shortly after priming. Seeds can also be soaked in fungicide and antibiotics solution. Priming with imidacloprid resulted in increased plant height, root weight, dry matter production, root length, increased yield by 2.1 t/ha compared to control (non-primed), which was attributed to higher panicle numbers and more filled grains per panicle (Farooq et al 2011).

Cultivar selection

There are no varieties till date specifically targeted for DSR but many of the inbred varieties and hybrids bred for puddled transplanted are found to be suitable. Varieties with faster growth, better early vigour for weed competitiveness (Jannink et al 2000, Zhao et al 2006), efficient root system to tap soil moisture during dry periods are suitable for DSR. Early planting of photoperiod-insensitive and early heading rice varieties with better drought tolerance are better suited for dry-seeded rice. Lodging resistance is another desirable trait for direct seeding (Mackill et al 1996). High yielding varieties have higher germination percentage and are more suitable for this method. Local varieties are tall and lodging susceptible, so they are not suitable for direct seeding. Broadcasting seeds results in more lodging even with high yielding varieties.

Table 1. Suitable cultivars for DSR in the Tarai and mid hills of Nepal

Variety	Duration (Days)	Yield (kg/ha)	Region/situation
Hardinath-1	110-115	5.0	Tarai and inner Tarai
Tarahara-1	115	4.2	Eastern and central Tarai
Radha-4	120-25	3.2	Foothills and Tarai region
Sukha-1	125	2.5-3.6	Tarai and inner Tarai, river basin
Sukha-2	125	3.3-3.5	Tarai and inner Tarai, river basin
Sukha-3	125	3.2-4.2	Tarai and inner Tarai, river basin
Ram Dhan	138-148	4.9	Chitwan
Sabitri	140-145	4.0	Tarai and innerTarai
Samba-MasuliSub-1	145-150	4.0	Tarai, innerTarai, Irrigated and rainfed lowland
Khumal-4	144	6.3	Mid hills
Khumal-8	158	9.8	Mid hills
Khumal-10	145	4.5	Mid hills
Gorakhnath	120-125	6-7	Tarai, innerTarai, irrigated and rainfed lowland
Arize 6444	135-140	7-8	Tarai, innerTarai, irrigated and rainfed lowland
Bioseed -786	120-125	7-8	Tarai, innerTarai, irrigated and rainfed lowland
RH-245	120-125	5-6	Tarai, innerTarai, irrigated and rainfed lowland
Loknath-505	120-125	5-6	Tarai, innerTarai, irrigated and rainfed lowland
Raja	120-125	5-6	Tarai, innerTarai, irrigated and rainfed lowland

Source: Guidelines for dry seeded rice (DSR) in the Tarai and Mid hills of Nepal 2014.

Nutrient Management

Direct seeding follows aerobic cultivation of paddy, so the nutrient dynamics are altered (Farooq et al 2011). Several key nutrients like: N, P, S, Zn and Fe are likely to be a constraint (Ponnamperuma 1972). In addition, N losses in DSR are very high. Fertilizer recommendations for DSR are similar to that of transplanted rice except that a higher dose of nitrogen should be used to balance out the higher nitrogen losses (Kumar and Ladha2011). A 100-120kg N/ha in 3-4 splits and P2O5 at 40kg/ha, K2O at 30 kg/ha, and ZnSO4 at 25kg/ha (in Tarai) is recommended. A full dose of P and K and one- third N as basal at the time of sowing should be given. The remaining two-third dose of N should be top-dressed at tillering and panicle initiation (Kamboj et al 2012). IRRI uses a leaf color chart (LCC) to manage N. The color of rice leaves is monitored at regular intervals of 7–10 days and N is applied whenever the color is below a critical threshold value (IRRI 2010). Use of slow-release or controlled-release N fertilizers offer advantage due to their delayed release thus, reducing losses, labor cost and increasing efficiency (Shoji et al 2001).

In aerobic soil, Fe-oxidation by root-released oxygen reduces rhizosphere soil PH and limits release of Zinc from highly insoluble fractions (Kim and Bajita 1995). Basal application of zinc to the soil is found to be the best to avoid its deficiency. If zinc is not applied at sowing, it can be applied as a foliar spray (0.5% zinc sulfate and 1.0% urea) 30 days after sowing (DAS) and at panicle initiation.

Soil application of Fe can be done to correct the deficiency of Fe. Foliar application, however, was observed to be superior to soil application. The symptoms appear in the form of yellowing, stunted plants, and seedling death. The crop should be sprayed with 1% ferrous sulfate solution as soon as the symptoms appear (with repeat applications after a week if the symptoms persist).

Water management

Precise water management, particularly during crop emergence phase (first 7-15 days), is crucial in direct seeded rice (Kumar et al 2009). Water management should be such that the field can be irrigated and drained whenever needed. Initially, 3 cm of water depth is needed. Water should not be excessive otherwise, tiller numbers will be reduced. Frequent irrigation is needed to keep the soil moist in the root zone, especially on lighter soil, which may require irrigation every couple of days. During the active tillering phase and the heading to grain-filling stage, the topsoil should be kept close to saturation. For clay soil the appearance of hairline cracks on the soil surface is a general indication of the need for irrigation. Water productivity in DSR compared to transplanted rice indicated better water-use efficiency (Gill et al 2006). Water stress at the time of anthesis results in maximum panicle sterility.

Weed Management

Weed management is the major constraint for successful production from DSR (Singh et al 2009). The DSR fields are infested with weeds of greater diversity (Tomita et al 2003). These weeds when uncontrolled can be enough to reduce rice yield to zero. Weed control is more expensive and problem, since rice and weeds germinate together, and there is no water layer to suppress weed growth (Fukai 2002). The germinating seeds remain on the top of the soil, so there are more problems with birds, rats, snails and weeds. Weedy rice has emerged as a serious threat in DSR fields. It is highly competitive and causes severe rice yield losses (Farooq et al 2009). The common weeds of DSR are classified as below.

Grasses: *E. crusgalli, Echinochloa colona, Leptochloa alba, L. chinensis, Eragrostis tenella, Brachiaria reptans, Dactyloctenium aegyptium, Paspalum sp., Digitaria ciliaris.*

Broad Leaf Weeds*: Trianthema monogyna, Eclipta alba, Caesulia axillaries, Sphenochlea zeylenica, Commelina sp., Lindernia crustaceae, Euphorbia hirta, Amaranthus viridus, Celosia argentia, Digeraarvesis.*

Sedges: *Cyperus rotundus, C. difformis, C. iria, Fimbristylis miliaceae.*

Emerging problematic weeds in DSR*:* Weedy *rice, Leptochloa chinensis, Eragrostis japonica, Dactyloctenium aegyptium*.

FAO recommends an integrated approach that combines preventive, cultural and chemical methods desirable for effective and sustainable weed control in Dry-DSR (Maity and Mukherjee 2008). Stale seedbed technique reduces weed emergence as well as the soil weed seed bank (Rao et al 2007).This technique is highly desirable in fields with long term weed problem. Weeds are encouraged to germinate by giving one or two irrigations 2-4 weeks prior to sowing, and then killed by either a nonselective herbicide (glyphosate or paraquat) or tillage. If the soil is suitable for sowing, a nonselective herbicide should be used to kill the weeds and the crop can be sown without any tillage. If the soil is dry, irrigation should be given prior to herbicide application. In zero tilled-DSR, retention of 15-20 cm standing residues of the preceding wheat crop decreases weed infestation in DSR and improves soil quality. Seeding rice and sesbania crops together and then killing sesbania with 2, 4-D ester about 25-30 DAS can reduce the weed population by nearly half without any adverse effect on rice yield (Kamboj et al 2012). *Sesbania* grows rapidly and suppresses weed. This practice is found more effective when combined with a pre-emergence application.

A wide range of herbicides is available for controlling weeds. Pre-plant herbicides like Glyphosate (1.0 kg ai/ha or 1% by volume) and paraquat (0.5kg ai/ha or 0.5% by volume) are recommended. Pendimethalin (1.0 kg ai/ha), oxadiargyl (0.09 kg ai/ha),and pyrazosulfuron (0.02 kg/ha) have also been reported to be effective as pre-emergence herbicides for DSR (Gopal et al 2010). Post emergence application (15-25 days after sowing) of bispyribac sodium 25 g ai/ha was found very effective for most grasses. Bispyribac works well in saturated soil conditions (Kamboj et al 2012, Kumar and Ladha 2011).

Conclusion

DSR is being practiced with various modifications in tillage/land preparation and crop establishment. This system has not gained popularity despite the fact that many research studies have suggested its benefits over transplanted rice. DSR with suitable conservation practices has potential to produce slightly lower or comparable yields as that of TPR and appears to be a viable alternative to overcome the problem of labor and water shortage. If weed and water control are done properly, equal production (in comparison with TPR) can be obtained through this method. To date, no specific varieties have been developed for this purpose. Existing varieties used for TPR do not appear to be well-adapted for seedling growth in an initially oxygen-depleted micro environment. As a result, farmers often resort to the costly practice of increasing the seeding rate for DSR by 2-3 times.

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Introduction of Rice and its Cultivation Practices in Jumla

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सारांश

नेपालको जुम्ला जिल्ला संसारको सबैभन्दा बढी उचाईमा धान फल्ने जिल्लाको रूपमा परिचित छ । ऐतिहासिक पृष्ठभूमी हेर्दा जुम्ला सदरमुकाम एक ठूलो तालको रूपमा रहेको तथा सन्त चन्दननाथले लाछल कृति पाईकालोसँग मिलेर पानी काटेर ताल सुकाई खेतीयोग्य बनाएको तथा भारतको कश्मीरबाट काली मार्सी जातको धान ल्याई खेती गरेको किंवदन्ती पाइन्छ । चन्दननाथले पहिलो पटक धान खेती गरेको लाछो ज्यूलाको गुरू फोक्टो कर्णाली अञ्चलकै पहिलो धान खेती भएको स्थान हो भन्ने मान्यता रहेको छ । जुम्ला जिल्लामा चैत्र महिनाको ८ गते बीउको छनौट गरी १२ गते भिजाउने, १६ गते पानी तर्काई न्यानो कोठामा उमार्नको लागि राख्ने तथा उम्रिसकेको बीउलाई चैत्र २० गते नर्सरीमा छर्ने गरेको पाईन्छ । जुम्लाको धान खेती हुने जमीनलाई दरा र भेगमा वर्गीकरण गरिएको छ । जिल्लामा धेरै दराहरू रहेका छन् । धान खेत हुने जमिनलाई ज्यूलो भनिन्छ । जुम्लामा धानको सामाजिक तथा सांस्कृतिक सम्बन्ध रहेको पाइन्छ । धान रोपाईको समयमा बाजागाजाका साथ गीत गाउँदै खुशियाली साटासाट गर्दै रोपाइँ गर्ने तथा हिलो खेल्ने यहाँको प्रचलन रही आएको छ । मानिसको जन्मदेखि मृत्युसम्मका धार्मिक तथा सांस्कृतिक अवसरहरूमा धानको प्रयोग भएको पाइन्छ । जुम्लाका अधिकांश जनताहरू कामको सिलसिलामा अन्यत्र जाने तथा धान लगाउन घर फर्किने प्रचलन रहेको हुँदा धान भिजाउने दिन चैत्र १२ मा घर नफर्केमा उक्त व्यक्ति मरे सरह/विरामी हुने त्यहाँको प्रचलित भनाई रहेको पाइन्छ ।

Summary

Jumla District of Nepal is known as place for rice cultivation at highest altitude in world. As per a Hindu mythology, Jumla was supposed to be a big lake which was drained by Saint Chandannath with the help of support of Lachhal Kriti Paikalo, and later rice was cultivated after bringing Kali Marsi from Kashmir of India. The first rice transplanted field in Karnali by Chandannath is supposed to be *GURU PHOKTO* of *LACHHO JYULA* In Jumla, sorting of rice seed on the 8th of *Chaitra* (around 21ist March), soaking on the 12th (around 25th March) removing water from soaked seed on the 16th and broadcasting the sprouted seed on the 20th of *Chaitra* (first week of April) were in practice. The cultivated land of the district has been divided into Dara and Bheg. There are many *Daras* in Jumla. The cultivable land is commonly known as Jyulo. Rice has social and cultural relations in Jumla. At the time of transplanting rice, people share their happiness with the songs in traditional musical instruments along with mud playing. People have religious and cultural relation with rice that has been used from birth to death of people in several ceremonies. In Jumla, members of family who are out of home for earning money are expected to come on the day of seed soaking ie twelfth of *Chaitra*, and, if any outgoing members do not return home at that day, it is thought that something went wrong (sickness or death) with the absentee family member.

Keywords: Jumla, Jyulo, *Kali marshi*, Rice, Twelfth of Chaitra

Introduction

Chhumchaur (3050 masl) in Jumla is the highest place in the world where rice is cultivated. The district covers an area of 2531km^2 with population of 10,892 in 2011 (DDC Jumla 2012). The origin of Nepali Language is from Sinja valley of Jumla. *Jumli Marshi*, a *japonica* type of cold tolerant rice landrace is being cultivated at the bank of *Tila* River in Jumla probably since 1,300 years back. The *Tila* Valley as well as the *Sinja Khola* Valley is covered with paddy fields growing the 'Kala Marshi' rice variety, unique red rice that is sought after for its special taste. This indigenous variety of rice is popular in these areas because it is superior for grain production. It matures in about 210 days within average yield of 2.2 t/ha. It has been used as a donor parent of cold tolerance in our breeding program (NARC 1997).

Historical background

It has been speculated that there was a great lake in the place where the district headquarters of Jumla is located now. *Saint Chandan Nath* on his way to Manasowar met Lachhal Kriti Paikalo (LKP), a brave young guy at Tatopani, now Tatopani VDC of *Lachho gaun*. With the intention to settle human beings in this area, Saint took the help of LKP to open the lake at Khalla chaur making an outlet for the water to pass. From there, the water of the lake drained downwards and the pond was dried up for human settlement and cultivation. It is believed that *Saint* Chandan Nath brought *Kali Marshi* rice from Kashmir, India and gave to LKP along with specific rice cultivation training. It is said that the rice seeds brought by Saint Chandan Nath was first transplanted in *Lachho jyula*.

Figure 1. Jumli Marshi


Figure 2. Tatopani, Jumla where saint Chandan Nath introduced Kali Marshi (*picture shows rice-barley cropping pattern*)

Guru Phokto of Lachho is said to be the first place of transplanting of rice in Karnali. LKP is said to be the first person who transplanted rice in Jumla before 1300 BC (Devkota 1990). The process of rice cultivation in the area has been date specific such as: seed sorting to be done on the 8th of *Chaitra* (around 21st March), soaking on the 12th (removing the soaked seed from the water and keeping in the warm room for sprouting on the 16th and broadcasting the sprouted seeds in the seedbed on the 20th (first week of April) of *Chaitra*.

Land holdings of the farmers

Land holding size of the rice cultivating farmers in Jumla varies from less than one *ropani* (500 m^2) to 10-15 *ropani* (DADO Jumla 2015). Social status of an individual farmer is measured on the basis of size of holding of rice field in Jumla. The more the size of rice field, the higher the social status and vice versa. More than 90% of the paddy field is owned by high castes (*Brahmin, Kshetri and Thukuri*) and around 10% belongs to Dalit (tailors, smiths, shoe makers) and marginalized groups of the district.

During the fiscal year 2015/016 rice in Jumla was cultivated in 2,950 hectares with a production of 7,375 tonnes having productivity of 2.5 t/ha (DADO Jumla 2015). *Jumli Marshi*, a local rice popularly grown in Jumla has productivity of 40% of national productivity of the rice (3 t/ha) (CDD 2015, ARS Jumla 2012).

Land classification for rice cultivation

On the basis of rice cultivation and human settlement, the Karnali zone has been divided into different *Dara* (agglomerated settlement) and *Bheg* (specific belt). There are lots of rice cultivable lands commonly known as *Jyula* or *Jyulo* in Karnali region. Major *Dara* and *Jyula* of Karnali zones are given in following **Table 1**.

Table 1. Major *Dara* and *Jyula* of Karnali zones

Districts	*Dara*	*Jyula/Jyulo*
Jumla	Aashi, Pansaya, Sinjha, and Chaudabis	Lachho Jyulo, Synjha Jyulo, Kudari, Lamra, Gidikhola, Siridhuska, Chinnasim Raulo Jyulo, Simjyulo, Kholikot Budthapa Jyulo, Malavid Jyulo, Sara Jyulo, Talichaur Jyulo, Ukhadi Jyulo, Kotsangu Jyulo, Urthu and Tirkhu Jyulo
Kalikot	Kalikot, Barabisa, Raskot, Palata, Sanni, and Rakal	Thirphu, Sappata, Fagoti, Fukot, Syuna, Sanni, Malkot, Mehelmudi, Raku, Bharta, Kalikot, Oda, Chilkhaya, Jubitha, Tadi, Manma, Vigma Jyulo
Mugu	Gum, Khatyad and Karan	Dhaina, Bhattachaur, Srinagar, Karkibada, Khatad, Sukadhik, Rola, Seri, Gima Jyulo
Humla	Galba and Soru	Maila, Darma, Faya, Chhipra, Radho, Rodikot, Ripa Unapani, Galbagaad, Sarkhegad, Piplang, Melchham, Yanchhu, Nalna
Dolpa	Tibrikot	Tripurakot, Sera (tallo ra mathillo), Saldang, Patigo, Likhu, Bhotan, Sura and Narkhu, Fulching Jyulo

According to elderly people, the division of districts into *Dara* was based on the amount of rice production in that belt. Far western Nepal including Karnali zone in Nepal is rather known for food defecit. Therefore, many people in other parts of the country are not aware of the fact that rice is actually grown in Karnali zone also. It is strange to hear from the people, "Is *Bhat* (rice) available in Karnali?" without knowing the geography, economics and agriculture of the zone.

Socio-cultural affiliation with rice transplantation

During rice transplanting in main field of Jumla, the surrounding environment becomes very enchanting with songs, musical instruments and funny jokes. Rice transplantation and weeding are exclusively performed by the women farmers. Pleasant sound from instruments such as *Damahaa*, *Narsingha, Sanahai, Jhyali, Bansuri* enthralls the environment with joy. Cloth puppet (*Putali*) is erected at the centre of the largest field (*Daba*) during rice transplantation. Carefree mud playing (muddling) and singing by the women folks makes the environment very lively and cheerful. If someone has undergone through pleasant incidents such as: the birth of a son, marriage ceremony, promotion in the professional carrier etc, then the concerned person and elders from the households are fully engaged in the transplanting field with extra gusto. Delicacy is also an important aspect while transplanting the largest field.

Social and religious attachment of rice

Rice is used in every social event to express happiness and sorrow. On the one hand, it is used as *Tika* (marking on the forehead) with curd (*Dahi and Chamal*) in case of happiness, joy, at the start of any good works and victory over problem. On the other hand, it is used on tombs and on the way to carry the dead body to crematory. Rice has many cultural and religious associations in Karnali region. Culturally it is attached from womb to the tomb. Pregnant woman are given preference to take rice rather than the bread and a woman right after delivery is provided with the rice diet cooked in ghee for three times a day. Community people are called for rice party; *Janti* (members of a marriage procession) and *Malami* (members of a funeral procession) are fed rice. A household which can't feed rice to the guest is said known as poor in the Karnali region. Beside this, rice in Jumla is used as *Khatte* (puffed rice), *Kheer* (rice pudding), *Selroti* (ring bread), *Laddu* (rice sweet) and *Chiura* (beaten rice). It is also used in other religious and auspicious occasions such as ritual worship of gods, child birth, marriage, out migration of family members and return of the out migrated members. Rice straw is the main source of animal feed during winter season. By seeing the hip of the rice straw, outsider can guess whether the household belongs to poor or rich strata.

There is a proverb that "A Jumli is considered to be dead, if he does not appear in the house by the 12th of Chaitra (around 25th March)" that means any members of the family who are out of home for earning money are expected to come home by the day of seed soaking on 12th of Chaitra (around 25th March) and if any outgoing member does not return home, it is thought that something wrong might have happened to him (Paudel 2011). It is learned that any of the family member not returning home on 12th of Chaitra (around 25th March) might have met some ill fate or is stuck with an urgent work or sick or death (Saund 2010). This proverb is deeply rooted with the importance given to rice cultivation and its' traditional value. Moreover, the day is taken as 'god gifted' by the Jumli people. Exactly the same date specific process of rice cultivation practices is followed in Jumla district even today.

Methods of rice cultivation in Jumla

Soaking of seed

Rice seed is soaked in water for 3 days during the last week of March (12th of Chaitra/25th of March*)* and dried for 3-4 hours under shade after removing from the water. Thereafter, seeds are incubated over the jute sack covered with *Bhoj Patra* (*Bitulla utilis*), woolen clothes (*Radi, Pakhi, Phare*), pine needles etc and are kept nearby fire-place (*Chulo*) for 4-5 days. During this period, careful attention is given to maintain heat and moisture. To maintain moisture some water is gently sprinkled to the newly germinating seeds with more precaution so that the germinated seeds are not broken.The seed starts sprouting and it is planted on the well prepared wet seedbed on 20th of Chaitra (first week of April).

Preparation of nursery bed and seeding

The practice of nursery bed is unique in Jumla. Preparation of land is done in two different places, at first preparation of seedbed is done nearby house with easy access, reliable source of water for irrigation and insurance of protection from domestic animals and birds. After selecting the nursery bed, it is cleaned by broom to remove different weed seed and soil is burned by thatches and field is made neat and clean. About 50-75 *doko* (15-20 kg in single *doko)* of FYM is applied per ropani of land. Then after, ploughing of the field is done around 12-14th Chaitra (25-27th March).

After 2-3 days germinated seeds are broadcasted over seedbed which are prepared before 15 days with special care and management. Just after seeds are spread over seedbed, these are then covered with char-coal and ashes made from burnt dung cakes (*Goptila*) evenly on the seedbed to enhance the soil temperature and fertility. Regular monitoring, careful observation, optimum irrigation and protection from the birds and rats is done in the seedbed. To protect from birds, especially from house sparrow, various types of mimicry are kept on the seedbed.

Land preparation

Rice is planted in the well puddled field. After the harvest of barley or wheat, the primary tillage (ploughing) is carried out twice with the help of local wooden plough. The plough is drawn by bullocks. Then the field is well bunded around, water is filled in the terraces and puddling of soil is done with the help of local plough and toothed plank. The puddled field is leveled with the help of wooden plank. Ploughing and puddling is done by males. Digging the corners and turning of weeds can be done by male or female.

Transplanting field

As mentioned before, transplanting of rice is done in the first week of *Jestha* (May-June) to the last week of Ashad (June-July). Rice transplanting field is categorized in to different names ie *Chiute* (fallow land where land remains fallow after rice harvest until next rice crop is grown: rice - fallow cropping pattern) where only one rice crop is taken and *Juwadi* (cultivated land with the rice-barley cropping pattern). Transplanting of rice is done in well puddled field when the seedlings are two months old ie first week of May (Second week of

Jestha). Seedlings are transplanted randomly one seedling per hill by maintaining a distance of 5-7 cm between plants. The transplanting is the main task of the women. In Jumla, rice transplanting must be completed within two weeks, if delayed there will be problem in grain filling due to low sunshine and solar radiation. After transplanting, the field is flooded with gravity flow of water until last week of Shravan (mid-August).

Other cultural operations like composting, seedling pulling, transplanting in the main field and weeding are also done by the female members. Close co-ordination is seen among female farmers to carry out the compost and cow dung. One day they carry the compost of one household and the next day they carry for the other households which is particularly known as *Parma* system. After a week of rice transplanting, soybean or black gram seeds are planted on the bunds of rice field. The intercrop matures along with rice by the end of October.

Weeding

Weeding is generally done twice: the first weeding after 15-20 days after transplanting and the second weeding after 30-40 days after transplanting. Weeds are uprooted manually with the help of iron rake. Floating weeds are removed with the help of toothed wooden plank. Manual weeding is mainly done by women. As Jumla was declared as an organic farming district in 2009, there is no use of chemical fertilizers, pesticides and herbicides.

Harvesting, threshing, drying and storage

Harvesting

Harvesting of rice is like a local festival of Jumla. Nearly by six months (180 days), rice crop becomes ready for harvesting. Harvesting is generally done from last week of October (second week of *Kartik*). Harvesting is done by cutting the rice plants leaving about 5 cm stubble. This is the right time for sowing barley in rice- barley cropping pattern. In Jumla, open system of grazing cattle is more common. On very short time of rice harvesting, cattle are allowed to graze on green grasses in the rice field since there are no green grasses in the other field. This is also makes rice harvesting unique system in Jumla where nearby farmers are compelled to harvest their rice on the same day otherwise cattle may graze on the other plots where rice is not harvested. By seeing eco-social condition and maturity of the rice crop, elder of the society (*Mukhiya*) announces the date of rice harvesting (*Dhana Pasne Din*).

Threshing

The harvested rice is staked in small bundles. The rice bundles are brought to the well prepared threshing floor or in beside of the same field covered by kinds of cloth called *Phare* (made from goat wool) for threshing. Bundles are threshed by beating on logs or treading under feet. The threshed straw is then treaded by bullocks to completely exhaust grains from the panicles. Harvesting, threshing and transportation from the field to the threshing floor are done by the male as well as female.

Drying and storage

Grains are transported in jute bags from field or from threshing floor to home. Paddy grains are dried under sunshine for 2-3 days, filled in jute bags or stored in *Bhakari* (wooden silos) or in *Daalo* (earth-shaped basket of bamboo strips) or in *Dharo* (earthen pots) or in trenches (6'×4'×3'). Rich farmers make trenches inside the house in which rice can be stored for 2-3 years. Aged rice is considered of better cooking quality and taste, and taken as a symbol of social prestige. To avoid the damping, bedding material like pine needles are spread at the bottom, the sides are plastered with a mixture of cow dung, clay and litters. Mouth of the trench is covered with wooden plank or flat stones and then plastered.

Insect pest and diseases of rice

Rice stem borer (*Chilo partelous*) and gundhi bug (*Leptocorisa acuta*) are seen in the standing crop at vegetative and reproductive phase of the crop however the loss by this insect is very few. House rat (*Bandicota bengalensis*) is the major pest during storage condition and farmers are managing this pest by keeping the rat bait in house and some time by zinc sulphide as and when it is necessary. Blast disease of rice (*Pyricularia oryzae*) is the main problem of Jumli Marshi rice. Due to this disease Jumli Marshi is on the verge of extinction from Jumla. Lesser grain moth and grain weevil are the main insects of the storage. Sterility is more common on Jumli Marshi than that on improved varieties like Chandannath-1, Chandannath-3 and Lekali-3. Cold injury and nutrient deficiency are the cause of sterility in Jumla.

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Rice Culture and its Organic Way of Cultivation in Nepal: Past Evidences

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सारांश

धान नेपाली समाजको खाना, संस्कृति र इज्जतका साथै देशको भूदृश्यको सौन्दर्य पनि हो । खाद्य बालीको रूपमा धान उपयोग, प्रकार र खेती गर्ने तरिकाका साथ नेपालीको वैदिक समाजकै धरोहरको रूपमा छ । नेपालीहरूले धानलाई अनन्त कालदेखि नै सम्मानका साथ विविध प्रयोजनमा उपयोग गर्ने र चुनौतीहरूलाई स्वीकार गरी प्रतिकूलतालाई अनुकूल बनाउदै यथासम्भव ठाउँहरूमा यसको खेती गर्दै आएका छन् । धान खेती जल, जमिन, जैविक विविधता जस्ता प्राकृतिक देनको रूपमा तथा मानव सृजनशिलताको कारण नेपालमा विश्वकै उच्चतम भूभागसम्म पनि धान खेती गर्न सकिएको हो । यसो गर्दा जनताले कुनै रासायनिक पदार्थको प्रयोग बिना नै सफलतापूर्वक धान खेती गर्न समय र स्थान सुहाउँदा जात, रोप्ने समय, माटोको पोषण व्यवस्थापनका विविध प्रविधिहरूको विकास गरेका थिए । ती प्रविधिहरू मूलतः स्थानीय बाली प्रणाली सुहाउँदा धानका जातहरूको छनौट र तिनका लागि उपयुक्त प्रविधि विकास तथा यथास्थानमा प्राप्त स्रोत साधनको सदुपयोगमा आधारित थिए । प्रस्तुत लेखले नेपाली समाजमा धानको महत्व र व्यापकता अनि देशका विभिन्न प्रतिनिधि स्थानहरूमा रासायनिक मल र विषादी नहुँदा पनि कसरी शताब्दियौंदेखि यसको खेती गरिंदै आएको थियो भन्ने तथ्यमा प्रकाश पार्ने प्रयास गरेको छ ।

Summary

Rice is the food, culture and prestige of Nepalese society as well as the beauty of our landscape. As a food crop, rice has been a legacy of the Vedic society to Nepalese with its diversity in landraces, cultivation techniques and use. People have been using rice, with due appreciation, for varieties of purposes for the time immemorial, and have been cultivating this crop in all possible locations by challenging all sorts of adversities. Bounty of natural endowments like land, water, biodiversity and ingenuity of the people allows rice cultivation in Nepal even in the highest possible elevation of the world. In doing so, people developed diversified technologies suitable to locations in terms of farming method, planting season, variety, nutrient management, etc without using any chemicals. The technologies were mainly based on the available resources with due recognition of their value in rice farming, and by selecting suitable land races that fit to the cropping system coupled with compatible cultivation practices. This paper succinctly sheds light on the importance and pervasiveness of rice crop in Nepalese society, and how rice was being cultivated in various representative locations of the country for centuries when there were no chemical fertilizers and pesticides.

Keywords: Cropping system, Culture, Organic, Rice, Technology

Introduction

Rice is an important food crop of Nepal. It has been embedded in culture, tradition, and food habit of Nepalese people for time immemorial. Rice enters into Nepalese's life from birth until death as staple diet. Rice also serves an important diet during religious ceremonies and festivals, wedding parties and final rites. It is so deeply rooted in Nepalese livelihood and culture that rice is mentioned in customary expressions when people greet each other during meal period. The common expression is, "*bhat/khana/bhuja khanu/linu bhayo*? (Have you taken meal?)" In fact, meal in Nepalese society in instantly associated with rice. Rice symbolizes a prestigious diet though it is not cultivated in all parts of the country and in all the seasons due to topography, water availability and suitable temperature. Even in the high himalayas where rice production is not common, people's preference goes more to rice. Rather than merely satisfying hunger rice is considered as a superior food. Similarly, rice is also essential for performing all individual and community rituals. Comparing with other cereal crops, rice is the most superior and indispensable. Hence, rice remains the crop of name, fame and gem as it is a "grain of gold" and the heart of Nepalese culture.

Rice was, and still remains, customary since some amount of quality dehulled rice (*chamal*), specially colored with turmeric, cotyledons of black gram (*chhanta*) and other many food items made from rice are offered to the daughter who is just married off and goes as a bride to live with her husband in a different village. The ritual of offering quality rice during the seeing off of the daughter continues till she is young and comes less frequently to her natal home (*maita*). It signifies the affluence of both of the families, their status in the community and their closer ties. Not only this, but not even a single community or family event, be it joyous or mournful, is complete without rice; in worshiping God, welcoming newly born baby or sending off departed souls where *chamal* as *aksheta* forms the key of the ritual. Therefore, rice is widely and preferably cultivated in all the possible locations: from urban areas to remote villages, from the elevation of 60 m in south-eastern plains to more than 3,050 meters (Bista 2004) in north-western mountain ranges; in the deltas, in the valleys of major rivers, on the slopes and basin of the himalayas, swampy and dry lands and so on. In short, rice is the life, the prestige of society, culture, politics, business and the beauty of the landscape, and of the people. Lurching rice plants with drooping panicles in layers of terraces in hills and massive rice fields in Tarai mesmerize every one. Vedic literature appreciating agriculture puts rice at the heart of agriculture in the following way.

अन्नं ही धान्यसंजातं धान्यं कृष्या बिना च ।
तस्मातं सर्बं परित्यज्य कृषिं यत्नेन करायेत् ।।

Rice is produced from paddy, and paddy is not available without agriculture. Therefore, agriculture has been accorded high priority. Rice is one of the oldest crops of Nepal and cultivated forms of rice (*Oryza sativa* L.) might have been first originated in the moist southern slopes of himalayan foot hills of our country. During ancient time, Sages (*Rishi*) used to meditate in perfect harmony of the himalayan ranges for the realization of super natural power in which they needed different kinds of rice, barley and sesame for *Puja* (worship) and *Hawan* (offerings to the fire God) with pure water from holy rivers (Sahi 1999).A large number of landraces of rice with their versatile uses, including the healing properties, have been mentioned in Surut, a complete book on Ayurveda in vedic writing, as follows (Bhaidya 1968 as quoted in Sahi 1999).

शाली धान्यं ब्रिहि धान्यं शुकधान्यं तृतिकम् ।
शिम्बीधान्यं क्षुद्रधान्यं मित्युक्तम् धान्यं पञ्चकम् ।। १
शालयो रक्त शाल्याद्या ब्रीह्यः षाष्टिका दयः
यवादिकं शुकधान्यं शिम्बिधान्यकम् ।
कंग्वादिक क्षुद्रधान्यं तृणधान्यंच तत् स्मृतम् ।।२।।

This further signifies the importance of rice not only in Nepalese agricultural system but it is the crux of life support system of the country. This paper makes an attempt to illustrate how rice was cultivated in earlier days, some fifty years ago, before the introduction of chemical fertilizers and pesticides.

Rice and some associated myths in practice

If someone hears any matters of appreciations from others or good words about him/her, he or she would immediately say "*Tero/tapainko mukhma dudh bhat jawos"* (may you be fed the rice mashed in milk). Similarly, if someone talks eloquently and clearly, the audience would say "*Phaleka chamal jasta kura"* (smart talk as clear as polished rice). Special dish made from raw rice, newly harvested paddy with curd and sugar used to be one of the holy and festive foods in the country that symbolized the onset of paddy harvesting. Similarly, eating *Chamal* from newly harvested *Ghaiya* with milk from newly calved buffalo was considered to be prestigious and festive in Lamjung and Gorkha areas. Rice is considered to have diagnostic and has also healing properties. Traditional faith healers in rural communities always use *Chamal* to diagnose (*jokhana herne*) the ailments in a patient by spreading *chamal* on clean metal (preferably brass) plate and making their alignments, pairs and arrangements. Similarly, *Chamal* of Anadi, a special rice landrace, was considered to have cooling effect, and was commonly used in healing the ailments associated with heat in Dhading areas of mid hill. Keeping *Chamal* with water outside overnight and eating it in the morning from *Falgun* (February-March) to *Jestha* (May-June) was considered beneficial even for the patients of Arthritis. Overall, rice (*Chamal)* wash (*Chaulani*) of any paddy with the juice of leaves of *Gholtapre* or *Punarnava* (*Boerhavia diffusa*) is said to remove the internal heat to treat the patient suffering from internal disorder associated with heat.

Rice environment

There is a great diversity in rice growing environment in Nepal determined, mainly, by the land type and configuration, water availability, method of crop establishment and plantation season. Based on land type and configuration, it may be upland (*Pakho*), where water cannot be stored long for rice, and lowland (*Khet*) where water can be stored. Depending upon the water availability rice lands may be rainfed (*Sagare or Aakase*), or irrigated (*Sinchit*). Even in rainfed there may be upland where the water is not always secured either due to insufficient rain or because water does not stagnate longer (sandy soil); low land where water is available for most part of rice crop mainly due to sufficient rain/nature of soil (clay); and extra lowland (S*im or Dhap khet*) where water remains in the field throughout the year either due to the high water table or there is the small perennial source available (*Jaruwa*). Irrigated land types may also be with assured irrigation throughout the year permitting two or even three crops of rice a year or with partial irrigation to produce two or even only one rice crop/year depending upon the source of water.

Depending upon the method of crop establishment, rice crop may be direct seeded or transplanted. Even in transplanted system, especially in the mid Tarai, (Siraha and Saptari districts) there is a special variant known as double transplanting (*Kharuwan or Khaur*) in which individual rice plants (tillers) are separated from the hill at the maximum tillering stage and transplanted in the gaps being formed either due to heavy flooding or drought or in the field following the harvesting of crop such as jute. Such transplanted single plants do not produce tillers as they are at their reproductive stage, and bear single long panicle with good yield. Based on the planting season, rice may be boro or winter rice (*Hiunde Dhan*); spring rice (*Chaite Dhan*); early rice (*Bhadaiya dhan)* in Tarai and *Bhabar* and *Ghaiya Dhan* in hills planted in May-June and harvested in the month of August); and normal rice or main season rice (*Mul dhan*). There are many ecotypes and varieties suitable to these heterogeneous environments and people have been adopting these production systems with varieties of local cultivation practices suitable to their locality.

Rice cultivation system

Ghaiya (upland rice)

This system is common in hills, mountains, foothills, and some northern drier parts of Tarai. The common cropping systems for *Ghaiya* in hilly areas, generally are: *Ghaiya*-millet-fallow, *Ghaiya*-mustard/black gram-fallow, *Ghaiya*- mustard/black gram-maize, *Ghaiya* + maize-mustard/black gram, *Ghaiya*-wheat-fallow-millet-fallow-Ghaiya (two years rotation in Doti and Dadeldhura), etc. Cultivation system common in mild hills: Gorkha, Lamjung, Tanahun, Doti, Dadeldhura, etc, is presented here. The crop is planted at the start of spring with summer shower starting at the end of *Chaitra* (start of April). The field is ploughed thoroughly and applied with 30-40 *doko* (750-1000 kg) of FYM/ropani and well mixed in soil. In Doti and Dadeldhura, the manuring system consisted of mixing forest litters with cow dung in the month of *Shrawan* (July-August) and *Bhadra* (August-September), storing the mixture in heap or pit and broadcasting it in the month of November. If the field is occupied with wheat, the manure is broadcasted in standing wheat crop in its seedling stage. Penning of cattle to fertilize the field after harvesting of *Ghaiya* and before planting of mustard during *Bhadra* (August-September) and *Aswin* (September-October) is also common in Lamjung and Gorkha. Seed @60-80 kg/ha was broadcasted followed by ploughing. Lower amount of seed was used if the crop was mixed with maize. Mixing *Ghaiya* with *Sathiya* (maize variety that matures in 60 days) was common. *Kanak jeera, Seto Darmali, Begani* (late and tough), *Seto Chiura* with fine grain (common for making *chiura*, bitten rice) were some of the common varieties of *Ghaiya* in the locality. Boiled dried maize grain during the planting of *Ghaiya* was customary to offer as meal for those working in the field. There was a tendency of transplanting *Ghaiya* as well in some places. Dante (bullock drawn wooden log with teeth fitted at its lower side that slightly tears the crop field) is used to run on the planted field to control weeds. This was generally done in dry condition. In such operation, most of the weeds and *Ghaiya* either were uprooted or were just pressed to the ground. Later *Ghaiya* plants would stand again but weeds would not. Gap filling was used to be done after 30-45 days following the summer pre-monsoon rain. One weeding then after in the month of *Jestha* (May-June) was performed by women with hoe. No pest and disease were commonly observed. However, if something unexpected was found in the field, sheep were left to run over the field, and sometimes cattle urine was sprinkled against wide varieties of pest and diseases. The crop was harvested in the month of *Bhadra* (August-September) which, generally, would coincide with the calving of buffalos.

Lowland rice or main rice

There were varieties of practices in rice faming depending on the location and environment.

Method of planting

It is known from the elderly, while asking about the system of rice cultivation some 50-60 years ago, that transplanting was common in eastern parts and hilly regions whereas direct seeding was popular in many parts of western Tarai and inner Tarai areas such as Chitwan, Nawalparasi and most of the districts in the far west. The system of direct seeding consisted of first soaking the seeds for 24 hours, put the seeds under sun for few hours and keep in the warm place to sprout. Then the sprouted seeds were broadcasted in puddled fields with water stagnated. Draining of water after two-three days and irrigating the field again up to stagnation after a week, was the practice. Generally, seeding was done at the end of *Aashad* (June-July) for fine grained rice whereas coarse grained were seeded in the month of Shrawan (June-July). In Kailali, Sothiyari (short duration landrace) was planted at the end of *Shrawan* (2nd week of July) and harvested after 60-80 days. It was reported in Chitwan that direct seeding was common only in case if the rainfall delayed.

Raising nursery

The practice of raising seedlings: dry or wet bed, depends upon the availability of water. Most of the farmers used dry bed to raise the seedlings. The nutrient management for the nursery differs by location and so is the time of raising seedlings. Farmers in Kathmandu valley raised nursery in the month of *Jestha* (May-June), in which various systems of nutrient management were adopted. For example, farmers in Lalitpur used 4 *doko* (~100kg) of black soil by crushing it and spreading uniformly on the bed for 2½ kg (one *pathi*) of seed to plant over one Ropani of field. But in Bhaktapur, in addition to black soil, farmers used manures from different sources; households wastes, oil cakes, animal manures and night soils. Use of green materials available around was also common in many parts either for incorporation or for mulching. Farmers were very keen to coincide the initiation of agricultural operations including nursery raising on an auspicious day. For example, farmers in Bhaktapur started their nursery only after *Akshya Tritiya*. Farmers in Jumla had fixed day to start raising seedlings on the 12^{th} of *Chaitra* (March-April). In Kavre, both dry and wet beds were common but seedlings were raised in the month of *Baisakh* (April-May). In Siraha and Saptari, rice activities would start in the *Rohini Nakshetra*. Raising nursery stretched from *Falgun* (February-March) (for *Gadame* or *Chaite dhan*) to *Aashad* (June-July) for (*Gamadi* or *Dulhniya* or *Sathiya, Auns* and main season rice).

Manuring the rice field

It is obvious that there were no any synthetic chemical fertilizers available for soil/crop nutrient management. Farmers had to rely totally on *pancha tatwo* (earth, air, fire, water and ether or sky), and accept crop yield as their effect in the form of boon or bang. Available soil, plant and animals were at the center of management. Most of the farmers relied on the inherent soil fertility; use of black/forest soil, slashing of bench terraces/ridges, use of legumes in bonds in summer, and keeping field fallow in winter; animal manures, crop residues, forest litters incorporation or mulching with green succulent plants and twigs of trees and shrubs or nutrient rich muddy water from the streams during first rain, etc. However, there are many more other practices among farmers depending upon local conditions regarding the materials used, and their mode of application to enhance production and productivity.

For example, old farmers in Lalitpur areas of Kathmandu valley say that generally, they use nothing but black soil to enrich rice field. Black soil was brought by digging deep in the place where there is deposition, generally at the bank of rivers such as Bagmati, Bishnumati, Manahara, etc or in their own field close to the river or digging down to the depth of the river bed even if farther from the rivers. Farmers used to dig the pits collectively and the process proceeds as follows: dig the pit of about 20 feet, go straight digging a tunnel with a slight slope of about 6 feet long, take soil from there as much as possible, and proceed further if needed depending upon the labor availability and the quantity required. This also depends on the distance to the field and labor to carry it. Slashing of benches of terraces and bonds of the field is performed in *Mangsir* (November-December). At that time if the field is fallow, digging it in a pattern with ridges and furrows is done. Preparation of field for transplanting starts in the month of *Falgun* (February-March) by applying black soil @100 *dokos*/*ropani* and spread it without crushing. In the land occupied by wheat, black soil was stored in heap at the corner of the field. In the month of *Jestha* (May-June), after harvesting the wheat crop, black soil was spread uniformly throughout the field. At the start of rain, the clod of black soil would just be soft up to the mud with slight stirring and puddling, which made the field ready for transplantation. It is interesting to note that in *Brahmin* and *Chhetri* communities, use of black soil was not that common partially, because they had sufficient animals to manure the field, and partially their fields were bit farther from the source of black soil, not easy to carry along that long distance. At the time of transplanting, well mashed mud is added to the bunds to offer a beautiful look to the field and make the bunds stronger, supplying nutrients to the ridge crops, checking weeds and retaining water. But in the field cultivated with potato, FYM was also commonly used. Similar was the practice with the farmers in Bhaktapur area. However, they used a lot of animal manures, household composts including night soils and oil cake.

Black soil was so closely attached to the farming communities of Kathmandu that two villages, Kalimati and Gongabu were named after it. In Gongabu area the digging of Kalimati was very common and festive. It is said that once while digging the pit for Kalimati near Satsaya Phant at the bank of Seshmati Khola (Bishnumati), a golden cock suddenly sprang up crowing and the place was named as Gongabu after it (in Newari language Gong means cock and Bu means field).

In Sundarijal area of Kathmandu, farmers mostly relied on animal manure but differed from other parts of the valley in the sense that they used to bring mustard cake from Nakhkhu where professional oil expellers resided. They used to make oil cakes in the shape of big bread and sell to villagers. Farmers from Sundarijal were the buyers. They also used to go Bode for rice husks. Bode farmers used to buy rice from Sundarijal and give husk back to them. Then the farmers used to crush the mustard cake in *Dhiki* and mix it with rice husk, and put the mixture in animal shed as bedding material. Forest litters were also brought from the nearby forest and added to the bedding materials. Uttis (*Alnus*) was mostly used for that purpose. The bedding materials would be in the bed till they were completely soaked with urine. Then the bedding was collected, put in heap and fermented for 3-4 months. The compost was spread just before the ploughing to make the plot ready to transplant.

In eastern hilly parts of Nepal (beyond Koshi), people used to cultivate only one rice crop a year and inherent soil fertility was sufficient enough to harvest bumper crop. Local compost and jute residues were also used as additional fertilizer. Due to sufficient nutrients in the field, and no or less biotic stresses, productivity and production were sustainably maintained. In Siraha and Saptari, soil management consisted of ploughing the field in *Falgun* (February-March) forming big clods, crushing it with one plough in *Baisakh* (April-May), just after rain, which would help the weeds to sprout profusely, and ploughing the field again with weeds during field preparation would provide sufficient amount of organic material serving as manure. The practice of penning cattle in the field by making open sheds and allowing them to move freely during day time grazing on rice residues and leaving their excreta on the field, cattle trampling the residues which would be mixed in the soil throughout the winter season also added the nutrients. Cultivation of mungbean in summer, before rice, was very common practice and was very good for improving soil fertility. The crop was planted in the month of *Chaitra* (March-April) and picking was done after 85-90 days leaving the residues to be incorporated in the field. Inclusion of grass pea following rice, which would fix nitrogen in the soil, and thereby helped maintaining soil fertility, remained a good practice for long time. Incorporation of jute in cropping system would leave a quite good amount of organic matter in the soil. In addition, *Ghur* (a mixture of ash and partially burnt materials produced from slow burning of rice straw, cow dung and other household wastes in the yard to keep family/community members warm in winter days), produced a reasonably good amount of manure from *Mangsir* (November-December) to *Falgun* (February-March) which contributed significantly to enhance soil fertility.

Old farmers in Chitwan told that the main source of soil fertility in rice field was the organic manure, the rural compost/FYM. Oilcake was rather common in Chitwan to fertilize the soil as the area was famous mustard cultivation. As most of the farmers kept large herds of animal and allowed them to roam around the fields in winter after harvesting paddy, which consisted of cutting of the panicle only. The herd would eat rice residues partially and trample them, and also added dung that maintained fertility status of the soil. Winter legumes, where possible also, contributed to add nitrogen in the soil. Most of the fields were fallow in winter where a remarkable luster growth of weed flourished after the first rain. This also, upon incorporation, would add to soil fertility. Generally, farmers in western Chitwan did not use fresh dung in rice fields rather they used it in mustard field. In Nawalparasi, farmers told that due to sufficient land, they used to cultivate only one parcel of land (in one side from the community) in one year and kept that part fallow next year using the other side of the village to cultivate rice- a type of rotational farming, which naturally restored the fertility.

In Kavre, generally, carrying of manure from households far for rice crop was not common. Penning of cattle, products from slashing terrace benches, incorporation of profusely grown weeds during field preparation, and careful use of first flood water from streams were the main source of soil fertility in the Patlekhet areas of the district. In Kailali, first flood water of the streams coming from *Churia* hill, weeds from rice field, rice residues (only the panicles were harvested) left in the field, were the common source of soil fertility in rice growing areas. Allowing the cattle to roam around the field and trample the partially eaten rice stubble, and mixing them with soil worked as fertilizer. In Parbat, the system of fertilizing rice field consisted of carrying the undecomposed FYM to rice field keeping aside the well decomposed manure for *bari* land in maize and other crops. However, for nursery they used decomposed manure. Most part of maintaining soil fertility consisted of raw cow dung with bedding materials, products from slashing the terrace benches and incorporation of green plant materials such as *Melia*, *Artemisia*, *Wrightia*, *Albezzia* and incorporation of weeds in situ before transplanting, and at the time of weeding. Use of blackgram and soybean in the bonds was and still is rather common in all the hilly areas of the country.

Besides, cultivating rice landraces based on their suitability to land and soil type, water demand and availability, crop duration, purpose of use, etc were common features in all the rice faming sites in the country that contributed significantly in sustaining productivity and production of the crop.

Plant protection

Discussion with the people in eastern part of the country revealed that due to the only one crop of rice in a year and no alternate host in the field, there were fewer incidences of pest and diseases demanding no plant protection measures. No pest and diseases, before the introduction of insecticides, were seen damaging the crop in Bhaktapur, according to the locals. In Nawalparasi, very few insects were there to manage or not at all to damage the crop. If occurred, pegging of drumstick sticks in the field against hispa was in use. Adding pig excreta at the mouth of irrigation cannel and dragging of branch of Bayar (*Zizifus*) was common against a wide variety of insects. The *Tharu* community of Chitwan used to peg the cherry sticks brought from hills against gundi bug and shaking the plants was in practice. Putting buffalo dung in irrigation water and draining out of the water was done against leaf roller and hispa. Borer, leaf roller, grasshoppers, were the observed pests but without remarkable damage. In Kavre areas, it is beleived that cloud and thunder in *Shrawan* (July-August) invites the insects and the same event in *Bhadra* (August-September) symbolize to control or remove. Shaking rice plants with a stick of *Ruish*, brought from mountains and dragging of raspberry branches along the crop field were used to control the insects. Insects at the later stage of crops were found not causing damages.

In Siraha and Saptari, placing the branch of a naked wood apple or *Zizifus* in vertical position in the middle of the fieldwas used against mealy bug. By swinging a ball made of old clothes soaked in kerosene oil, and lighting it up was a practice to control variety of insects. Local rice varieties were very resistant to insects and diseases. Ploughing field with the plough made of *Jamun* (*Syzygium*) in Chitwan was supposed to keep varieties of insects away. Cutting of rice plant from ground level at harvest minimized the infestation of borer and cutting insects. Incorporation of leaves and twigs of *Khirro* (*Wrightia*) is found to keep many insects away. Placing of *Kans* (*Saccharummunj*) plant with flower in upright position in the field keeping them taller than the rice plants was supposed to be helpful in controlling the borer. Incorporation or mulching of Ashuro (*Adathoda*), Titepati (*Artemisia*) were used in saving nursery bed from various insects.

Conclusion

Rice, an important food crop and the crop of prestige, has been cultivated from the time immemorial in Nepal. The crop has been used for various purposes depending upon the locality. However its attachment with food and culture is common. Farmers were using various techniques to cultivate the crop. However, most of the farmers relied on the response of landraces, inherent soil fertility, use of black/forest soil, slashing of bench terraces/ridges, use of legumes in bonds in summer, keeping field fallow in winter, animal manures, crop residues, forest litters, incorporation or mulching with green materials, first flood water from the streams, etc for soil fertility. Similarly, use of suitable landraces and various plant and household materials were used to manage the pests.

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Upland Rice (*Ghaiya dhan*) Cultivation in Nepal

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सारांश

नेपालमा कूल धान खेती हुने क्षेत्रफलको करिब ९ प्रतिशत क्षेत्रमा घैया धान खेती गर्ने गरिन्छ । घैया खेती मुख्यतया बारी, टार जग्गाहरूमा गरिन्छ । तथापि, नेपालको हिमाल, पहाड, बेसी तथा तराईका केही क्षेत्रमा घैया धान खेती प्रणाली एउटा प्रचलनको रूपमा रही आएको छ । किसानहरूले घैयालाई एकल बाली वा मिश्रित बालीको रूपमा समेत लगाउने गरेको पाइन्छ । घैया धान खेतीमा चैत्र बैसाखमा अथवा वर्षात सुरु हुनुभन्दा केही अघिपछि बीउ छरी भाद्र आश्विन महिनाभित्र उब्जनी लिइन्छ । असिंचित आवोहवामा खेती गरिने हुँदा घैयामा न्यून मात्रामा बाह्य कृषि उत्पादन सामाग्री प्रयोग गरिन्छ । घैया खेतीका लागि हालसम्म केही थोरै जातहरू सिफारिस भएका छन् । स्थान विशेषका रैथाने जातहरू पनि कृषकहरूले प्रयोग गर्दै आएको पाइन्छ । घैया धानको न्यून उत्पादकत्व (१-२ मे. टन प्रति हेक्टर), झन्झटिलो गोडमेल, सघन श्रममुखी खेती तरिकाले साथै कतिपय टारहरूमा सिँचाइ सुविधा उपलबध भएकाले गर्दा पनि यसको खेती घट्दो क्रममा रहेको छ । यद्यपी, उच्च उत्पादन दिने छोटो अवधिका आधुनिक जातको प्रयोग तथा प्रभावकारी झारपात व्यवस्थापन सहितको उत्तम बाली व्यवस्थापन अभ्यास अपनाउन सकेको खण्डमा घैयाबाट पनि मुख्य रोपुवा धान सरहकै उत्पादन लिन सकिन्छ ।

Summary

The upland rice is popularly known as *Ghaiya dhan*, which covers around 9% of the total rice growing area in Nepal. It is cultivated mainly in the *Bari* and *Tar* lands. However, it is one of the rice production systems rooted as a culture in mountains, hills, foot hills and some parts of Tarai in Nepal. Farmers grow upland rice mainly as sole crop or sometimes mixed with other crops. In upland rice cultivation, rice seed is broadcasted in April-May or just before or after the onset of monsoon and harvested in the month of September-October. As *Ghaiya* is cultivated in rainfed environments, low levels of external inputs are applied. Until now, very few varieties are recommended for upland rice cultivation. Many local landraces are also cultivated by the farmers in Nepal. Low productivity ranging between 1-2 t/ha, tedious weeding practices, labor intensive cultivation and development of irrigation facilities in many *tars* has lead rice area to gradually decline. However, if good agronomic management and use of early maturing high yielding modern varieties are adopted, comparable yield to transplanted main season rice can be achieved.

Keywords: Agronomic management, *Ghaiya* dhan, Rainfed, Upland rice, Yield

Introduction

The upland rice is popularly known as *Ghaiya dhan* in Nepal. It is grown in the uplands of Nepal covering at least 9% (1, 26,000 ha) of the total rice growing area (Ojha 2011). In other word, it can also be referred as the upland rice if grown in rainfed, naturally well drained soil with bunded or unbunded fields without surface water accumulation (IRRI 2015). *Ghaiya dhan* plays a significant role in food security of poor households where application of external inputs like fertilizers and irrigation is a problem and profitable alternative crop is also unlikely to grow in future. It is a crop of socially and economically disadvantaged ethnic groups in Nepal (Ojha 2011). Most farmers in upland areas grow landraces which are generally tolerant to environmental stresses but yield potential is lower than that of modern varieties. Modern semi-dwarf varieties for irrigated land generally have not been adopted in traditional upland areas (Gupta and O'toole 1986). Upland environment is generally characterized with drought prone, erosive soils with poor physical and chemical properties. So, the farmers under such environment are growing low yielding upland rice varieties which are drought tolerant but tend to lodge under high level of external inputs like fertilizer and irrigation.

In Nepal, *Ghaiya* has been grown for years in subtropical environments (IRRI 1995). Lamjung, Gorkha, Tanahun and Kaski districts in the western development region are the major *Ghaiya* producing districts in Nepal. It is cultivated mainly in the *Bari* and *Tar* lands. However, it is one of the rice production systems rooted as a culture in mountains, hills, foot hills and some parts of Tarai in Nepal. Farmers grow the upland rice crop either sole or mixed with maize in some parts of hilly region (CDD 2015). Limited research activities are carried out in Nepal by National Rice Research Program, Hardinath; Regional Agricultural Research Station, Lumle and Agriculture Research Station, Surkhet. Besides, LIBIRD (an NGO) is also working in the research and development of this crop.

Figure 1. Upland rice field near Sundarbazaar, Lamjung

Time and method of sowing/cultivation

Dry upland rice is cultivated in two types of lands: (1) Higher altitudes where the land is fallow in winter. Rice is seeded in well prepared soil in the month of *Chaitra* or *Baisakh* (April-May) and the germination takes place by utilizing the moisture conserved from winter rains. This crop takes full growth only after monsoon rains and matures in *Bhadra* or *Ashoj* (August-September or September-October). (2) Regular rainfed uplands of lower hills and Tarai. Rice is sown after the onset of monsoon or just before the onset of monsoon and harvested in September-October. If irrigation facility is available, direct seeded rice should be planted 10-15 days prior to the onset of monsoon. Sowing of rainfed upland rice should be determined by the soil moisture level and probable onset of monsoon. In certain areas of Nepal, especially in the lower hills of Gorkha, Lamjung and Tanahun districts, upland rice fields are prepared by ploughing the field with local wooden plough during pre-monsoon and rice seeds are broadcasted directly in the field and again ploughing is done to cover the seeds when there is sufficient moisture in soil to germinate the seed. The optimum plant population in *Ghaiya* is maintained in two ways; the first one is sowing or broadcasting the seeds at the recommended seed rate and after 2-3 weeks of seed germination, thinning is done at the time of first weeding with the use of oxen plough by covering the mouth of the oxen with bamboo net locally known as *Makhundo* or *Korko* or *Mohola*; and the second one is sowing the seeds continuously on ridges made at 20 cm distance which will later be maintained at 10-15 cm plant to plant distance at the time of first weeding.

Varieties and yield

There are very few recommended varieties for upland rice cultivation. Many local landraces are also cultivated by the farmers in Nepal. Upland rice has low productivity ranging between 1-2 t/ha depending on the soil fertility. The varieties suitable for upland rice cultivation are early maturing (in less than 100 or 110 days), high yielding and drought resistant dwarf varieties. Some of the varieties suitable for upland rice are Ghaiya-1, Ghaiya-2, Bindeswari, Radha-4, Hardinath-1 and varieties of Sukha dhan series (Sukhkha dhan-1 to 6). Until now two varieties have been released specially for *Ghaiya* cultivation in Nepal which are namely; Ghaiya-1 and Ghaiya-2. Ghaiya-2 released in 1987, is a 113 days maturing variety with a yield potential of 3.4 t/ha recommended for the rainfed upland condition of the Tarai region. Whereas, Ghaiya-1 is comparatively new variety released in 2010, with crop duration of 115 days and yield potential of 2.5-3.5 t/ha recommended for rainfed upland conditions of Tarai, *Tars* and valleys of mid hills. Ghaiya-2 is an upland variety, which is also grown under irrigated conditions in *Chaite* (spring) season as its yield is higher (more than 5 t/ha) in spring and is good for beaten rice (Pokhrel 2015).

Figure 2. An upland rice variety in the farmers' field

Seed rate

Seed rate for growing *Ghaiya* varies as per the time, method and variety. However, it is sown at the rate of 60-80 kg/ha. Within this range more the fineness of seed the lower will be the seed rate and vice-versa.

Fertilizers

As *Ghaiya* is cultivated in rainfed environments, low levels of external inputs are applied. FYM or compost and chemical fertilizers applied in combination yields better. It can be cultivated with application of FYM (6 tonnes) and chemical fertilizers Urea (113.4 kg/ha), DAP (34.8kg/ha) and Potash (33.4kg/ha) which is also the general recommendation of cultivating rice in the rainfed condition (AICC 2014).

Weeding

Weeding is considered as one of the tough works in upland rice cultivation. Manual weeding is in common practice where first weeding is done at one month after sowing and optimum plant population is maintained and later at 60 DAS. Weeds should be removed from the field. Farmers claim that the tedious weeding practice is one of the reasons of reduced *Ghaiya* cultivation nowadays. Moreover, lower yield per hectare, availability of irrigation for fresh vegetable production, labor intensiveness and disappearance of local landraces contributed to the gradual declination of its production practice. For chemical weed control, application of herbicide propanil @3kg ai/ha at 21 DAS is recommended (WARDA 2015).

Figure 3. Locally made wooden rake (*Dante*) for weed removal from the upland rice field

Local weed management practices includes the use of homemade wooden rakes popularly known as *Dant*e which is manually operated (**Figures 3**). It has wooden pegs (usually 6) fixed in such manner that weeds can be removed easily through its use inside the rice field.

Diseases and pests

All major diseases and pests of main season rice are also the problem for *Ghaiya* too. The major diseases are blast and brown leaf spot. Avoiding higher dose of nitrogen application and applying nitrogenous fertilizer on split application basis helps reduce the disease infestation. Similarly, seed treatment with Bavistin at 2g/kg of seeds, use of disease resistant varieties etc should be done. If chemical control needed, spraying of Trikaal at 1.5 ml/water can be done.

In major pests, shoot borer attack is the main problem which can be controlled with good crop husbandry practices. Biological control of shoot borer with applying *Trichogramma* at 0.1 million/ha is very effective. Applying chemicals like Furadon at shoots or soil application in granules form should be done if heavy infestation is seen (AICC 2014).

Acknowledgements

The author is indebted to Mr. Dila Ram Bhandari, Director General of DoA for his continuous inspirations and valuable suggestions during prepartion of article. Thanks also goes to Krishna Bhadra Adhikari, SADO Lamjung for proving relevant photographs for this articles.

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Weeds in Rice Crop and their Management Practices in Nepal

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सारांश

झार हाम्रो कृषि कार्यको महत्वपूर्ण अवयव हो । अन्य शत्रुजीवहरूले जस्तै झारको किसिम र घनत्व हेरी बालीनालीको उत्पादनमा ह्रास ल्याउँछ । झारको किसिम र घनत्व हेरी रोपाइँ र छरूवा गरेको धानमा सरदर १४ देखि ९३ प्रतिशतसम्म उत्पादनमा ह्रास आएको विभिन्न अनुसन्धानबाट देखिएको छ । रोपाइँ गरेको धानमाभन्दा छरूवा धानमा झारको प्रकोप बढी देखिएको छ । नेपालमा झारपात विज्ञानको अनुसन्धान सन् १९७० को अन्तिम र १९८० को सुरूका दशकमा झारपात विज्ञान इकाई, बाली विज्ञान महाशाखा, कृषि विभाग (हाल नेपाल कृषि अनुसन्धान परिषद् अन्तर्गत) मा भएको थियो । असिको दशकको अन्तिमबाट झारपात विज्ञानको महत्वलाई ध्यानमा राखी विभिन्न बालीहरूमा झारको संकलन, सम्वर्द्धन र पहिचान, इकोलोजी, बायोलोजी र व्यवस्थापन सम्बन्धी अनुसन्धान एवम् तालिम हुँदै आएको छ । नेपालको विभिन्न क्षेत्रमा रोपाइँ तथा छरूवा धानमा गरिएको अनुसन्धानबाट २३ परिवारका ६० किसिमका चौडापाते, घाँस र मोथा जातका झारहरूको पहिचान गरिएको छ । साथै, धान खेतमा देखिने झारहरूलाई एकिकृत व्यवस्थापनका तरिकाहरू पहिचान गरी सरोकारवाला समक्ष पुऱ्याई उत्पादन वृद्धिमा टेवा पुऱ्याईएको छ । बिगत केही वर्षदेखि देशका कतिपय ठाँउमा पटपटे, पानी वन्दा जस्ता झारहरूको संख्या धानखेतमा बढी देखिन थालेको छ । हाल देशमा कृषि मजदुरहरूको कमी, छरूवा धानमा तुलनात्मक रूपमा झारहरूको बढी प्रकोप एवम् विश्व व्यापार संगठनका मापदण्ड पुरा गर्नु पर्ने अवस्था आदिले झारपात विज्ञानको दायरा फराकिलो बनाउनुका साथै चुनौतीहरू पनि थपिदै गइरहेका छन् ।

Summary

Weeds are important components of our agricultural systems. Weeds are estimated to cause yield losses from 14 to 93% in transplanted and direct seeded rice depending on weed type and density. Weeds are the major constraint in direct seeded rice compared to transplanted rice. In Nepal, weed science research was started in the late 70's and early 80's by Weed Science Unit, Agronomy Division, Khumaltar under Department of Agriculture (now Nepal agricultural Research Council). Different research on weed collection, identification, preservation, ecology, biology and management were started from the late 80's on various crops. About sixty weed species of twenty three families falling in broadleaf, grass and sedges were recorded in transplanted and direct seeded rice from different agro-ecological regions of Nepal. Integrated weed management methods were identified as good strategy for rice and such practices have been extended to farmers. Weeds like *Alternanthera philoxiroides* and *Pistia startiotes* are becoming big problem to rice growers in many parts of the country. Weed science research got more challenges due to: lack of agricultural labors on time, more weed problems in direct seeded rice and the obligations to fulfill the regulations of world trade organization.

Keywords: Direct seeded rice, Integrated weed management, Weed science research, Weeds, Yield loss

Introduction

Weeds are important components of our agricultural systems. Weeds are always considered as one of the important pest with regard to its negative effect on crop yield. There are number of definitions of weeds like a plant out of place, any plant growing where it is not wanted, an undesirable plant, special form of vegetation that are highly successful in agricultural environments. A plant is a weed either because it interferes with human activity or welfare or it occurs spontaneously in human disturbed habitats. Weeds compete with crops for water, nutrients, air and light that in terms of resource need and use no other pests share the intimate association that weeds have with crops.

There are no crops and cropping systems that are not affected by the weeds. Hence in crop production, weed is still a major cause of crop losses. It is very difficult task to assess the crop yield losses due to weeds unless an artificial environment is created to separate their effects from those caused by insects, diseases, soil and atmospheric conditions. Weeds are estimated to cause yield losses of 17–47% in transplanted rice and 14–93% in upland rice (Ranjit et al 1988).

Weed research initiation in Nepal

Weed research in Nepal began in late 70's and early 80's at Agronomy Division under the Department of Agriculture in rice, wheat and maize. In the beginning this field has not received preferences as other plant protection sectors. Slowly weed science research became one of the mandates of Agronomy Division, NARC. Very little focus was given in taxonomy, biology and integrated methods of weed management and training until early 80's. With the creation of Weed Science Research Unit, under the Agronomy Division, weed research was expanded in different aspects like taxonomy, weed ecology and biology; management and training with limited man power. But gradually this unit established linkages with international research organizations, weed science societies to enhance research and capacity building. Weeds and weed management research was started much intensively in various rice cultures in different agro ecological regions in collaboration with Regional Agricultural Research Stations, Agricultural farm/stations and DoA in farmers' fields from the end of 80's. Herbariums of rice weeds from different research stations and farmers' fields were maintained at Weed Science Unit, Agronomy Division, Khumaltar. Weed science research got more challenges due to lack of labor on time and increased wage rate for the weeding operation. Weeds were the major constraint factors in dry direct seeded rice compared to transplanted rice. Documentation on rice weed research in Nepal in the field of taxonomy, weed biology, management were available in the form of journals, proceedings, brochures, booklets, newsletters, posters, etc.

Weed classification

Rice weeds are categorized in three groups based on their morphology such as:

Broadleaf	Have wider leaves than those of grasses and sedges
Grass	Has long narrow leaves with parallel venation and round hollow stem
Sedges	Resemble with grasses but with solid triangular stems and the leaves are aligned up and down the stem in three rows.

Sometimes these weeds are categorized according to their life cycle such as:

Annual	Complete life cycle in one season
Biennial	Require two growing seasons to complete their life cycle
Perennial	Live for three or more years, some simple perennials propagate and spread primarily by seed whereas creeping perennials propagate and spread primarily by vegetative means such as bulbs (large fleshy leaf base), stolens (above-ground stem roots), rhizomes (below-ground stem), tubers (enlarged fleshy rhizomes) (Ranjit 2011)

Many researchers have surveyed and reported rice weeds in transplanted and direct dry seeded rice from different agro-ecological regions of Nepal. Around 43 genuses including many species from 25 families were reported from different areas of Nepal (Ranjit and Bhattarai 1988, Ranjit 1997, Ranjit 2011, Dongol et al 1986, Joshi and Gretzmacher 1999, Bhatt et al 2009, Moody 1986, 1989, Ali et al 1992, 1993, Arkadius et al 2015, Regmi and Ranjit 1985, Regmi 1992). The number of weeds were less in vertical distribution than in horizontal distribution in direct dry seeded rice (Ranjit et al 2007). Among many weed species associated in rice crop in Nepal, some of the common rice weeds are listed below.

Table 1. Common rice weed species

Scientific Name	Common Name	Local Name	Family Name	Remark
Broad-leaved weeds				
Ageratum conyzoides	Goat grass	Gandhe	Asteraceae	DSR

Scientific Name	Common Name	Local Name	Family Name	Remark
Aeschynomene aspera L.	Joint vetch	-	Papilionaceae	TPR
Alternanthera sessilis (L.) DC	Sessile joyweed	Bhirungi	Amaranthaceae	DSR
A. philoxiroides (Mart.) Griseb.	Alligaterweed	Patpate	Amaranthaceae	TPR, DSR
Amaranthus spinosus L.	Spiny pig weed	Kande lunde	Amaranthaceae	DSR
A. veridis L.	Slender amaranth	Latte sag	Amaranthaceae	DSR
Ammania coccinea Rottb.	Purple ammania	-	Lythraceae	TPR
Caesulia axillaris Roxb.	Spittle weed	Galaphulle	Asteraceae	DSR, TPR
Commelina benghalensis L.	Day flower	Kane	Commelinaceae	TPR, DSR
Commelina diffusa Bura F.	Day flower	Kane	Commelinaceae	DSR, TPR
Cyanotis axillaris (L) D. DonSweet	Spreading dayflower	Tane jhar	Commelinaceae	DSR
Eclipta Prostrata L.	False daisy	Bhringiraj	Asteraceae	TPR, DSR
Eichhornia crassipes (Nart) solms	Water Hyacinth	Jal Kumbhi	Pontederaceae	TPR
Galinsoga ciliate Blake	Hairy galinsoga	Chitlange	Asteraceae	DSR
Ipomoea aquatica Forsk	Swamp cabbage	Karmaiya	Convolvulaceae	TPR
Jussiaea repens	Water primrose	-	Onagraceae	TPR
Lemna minor L.	Duckweed	-	Lemnaceae	TPR
Lindernia cordifolia	-	-	Scrophulariaceae	TPR
Lippia nodiflora Rich	Garden fogfruit	Kurkur	Verbenaceae	DSR
Ludwigia octovalvis (Jacq.) Raven	Long fruited primerose willow	-	Onagraceae	TPR
L. hissopifolia (G Don) Exell	Seedbox	Lwangjhar	Onagraceae	TPR, DSR
Monochoria vaginalis (Burn f.) C. Presl ex Kunth***	Monochoria	Nilo Jaluke	Pontederaceae	TPR
M. hastata (L.) Solms	Arrowhead monochoria	Jaluke	Pontederaceae	TPR
Murdaniya nudiflora (L.) Brenan	Dove weed	-	Commelinaceae	DSR
Polygonum hydropiper (L.)	Hydropiper	Pire	Polygonaceae	TPR
P.viscosum Han	Stickyjoint weed	Pire	Polygonaceae	
Potamogetonnes natans L.	Ribbon weed	Telia	Lythraceae	TPR
Ranunculus Scleratus L.	Crow foot	Nakkore	Ranunculaceae	TPR
Rotalla rotundifolia wall	Red stem	----	Lythraceae	TPR DSR
*Sagittaria sagittifolia Linn***	Arrow head	Laph	Alismaceae	TPR
S. guayanensis H.B.K.	Arrow head lily	-	Alismaceae	TPR
Sphenoclea zeylanica Gaertn	Goose weed	---	Companulaceae	TPR
Spilanthus paniculata wall ex Dc.	Para cress	Latoghans	Asteraceae	DSR, TPR
Grass				
Cynodon dactylon	Bermuda grass	Dubo	Poaceae	DSR
Echinochloa colona (L)***	Jungle grass	Banso	Poaceae	TPR DSR
E. Crusgalli (L) Beav.***	Barnyardgrass	Sanwa	Poaceae	TPR
E. glabrescens	-	-	-	-
Eleusine indica Gaertn.	Goose grass	Khode jhar	Poaceae	DSR
Eragrostis pilosa	Indian Love grass	Charidana	Poaceae	DSR
Ischaemum rugosum Salisb	Saramollagrass	Madilo	Poaceae	DSR
Leptochloa chinensis (L.) Nees	Chinese Sprangle top		Poaceae	DSR
Leersia hexandra Sw.	Southern cutgrass	-	Poaceae	TPR
Panicum dichotomiflorum L.	False pany grass	Banso	Poaceae	DSR
Paspalum distichum L.	Knot grass	Ghunde dubo	Poaceae	TPR DSR
P. scrobiculatum L.	Knot grass	-	Poaceae	DSR

Scientific Name	Common Name	Local Name	Family Name	Remark
Typha ungustata Bory and Chaub	Narrow leaf Cattail	Pater	Typhaceae	TPR
Sedge				
C. difformis L.	Small flower umbrella sedge	Mothe	Cyperaceae	TPR DSR
C. iria L.	Rice flat sedge	Mothe	Cyperaceae	TPR DSR
C. kyllinga	-	Mothe	Cyperaceae	DSR
Cyperus rotundus L.	Purple nutsedge	Mothe	Cyperaceae	DSR
C. sanguinolentus	Purple glume flat sedge	Mothe	Cyperaceae	TPR
Eleocharis	Spike rush	-	Cyperaceae	TPR
Eriocaulon	Club rush	-	Cyperaceae	TPR
Fimbristylis littoralis (L.) Vahl	Hoorah grass	Zhiruwa	Cyperaceae	TPR, DSR
F. dichotoma (L.) Vahl	Forked fringrush	-	Cyperaceae	DSR TPR
Juncus sp.	Rush	-	Juncaceae	TPR
Scirpus juncoides	Club rush	-	Cyperaceae	TPR DSR
Fern				
Ceratopteris thalictroides (L.) Brogn	Water sprite	Jyau	Parkeriaceae	TPR
Marsilia crenata Presl.	Water clover	Jal Pyauli	Marsiliaceae	TPR
Pistia stratiotes L.	Water cabbage/Lettuce	Pani banda	Araceae	TPR

Among the serious world's weeds, many are associated with rice crop (Holm et al 1977) such as *Cyperus rotundus, Cynodon dactylon, Echinochloa crusgalli, Echinochloa colona, Eleusine indica, Echhornia crassipes, Portulaca oleracea, Digitaria sanguinalis, Amaranthus hybridus, Cyperus esculentus.*Weeds like *Alternanthera philoxiroides* and *Pistia stratoites* are becoming a great problem to rice growers (Ranjit et al 2012, Ranjit 2013).

Alternanthera philoxiroides

Pistia stratoites

Figure 1. Rice weed species

Management of rice weeds

The main objective of weed management is to decrease weed density below the critical threshold level. Eradication of weeds is not the aim of weed management. Weed management technique varies depending upon the size of the farm, culture, crops and economic status of the farmers. Preventive weed control measures must be taken for all the rice cultures to minimize the spread of weeds. This includes weed-free rice seed, keeping the levees and irrigation canals free of weeds, frequent cleaning of tools and machines and not allowing the weeds to produce seeds. Weed seed contamination on rice seed depends on the management of farmers to farmers. During the seedbed preparation, the number of weed seeds ranged from 1 to 94 per sample. 94 weed seeds were recorded from 258 gram of rice seeds (Ranjit 1995). Besides preventive methods, integrated weed management (IWM) methods are adopted to manage rice weeds in different rice cultures in Nepal.

Hand weeding

Manual weeding is the most common weed control practice in rice throughout the Nepal. This is the oldest, simplest, direct and environmentally sound method of controlling weeds in rice fields as long as labor is cheap and available. Weeding should be done early in crop growth before the critical period of competition. One to two and two to three weeding are done depending on weed intensity in transplanted and direct dry seeded rice respectively (Malla et al1979, Malla and Ranjit 1981, Ranjit et al 2012).

Figure 2. Hand weeding in various rice culture

Water management

Many weeds can be controlled with water management in transplanted rice. Maintaining the water level from 5-10 cm, most of the grasses are controlled, however, few sedges and broadleaf weeds remain. Integration of other weed management practices with water level maintained wherever possible could enhance on suppression of weeds in the rice field.

Mechanical weeding

Rotary weeder is an effective in controlling weeds in transplanted rice. However, it needs the soft and moist soil to operate and certain plant spacing. The integration of rice transplanter/seed drill and mechanical weeder may give a very good control of weeds because the weeder works well in row planting. Seed drill was introduced during the 90's. Recently rice transplanters were demonstrated among the rice growers. Combination of transplanting and direct seeding machine plus weeder may solve the problem of present labor constraints.

Figure 3. Use of weeder to manage rice weeds

Crop cultivars

Rice cultivars also play an important role on suppressing the weeds. Study conducted at Khumaltar showed that Khumal-4 rice variety has more suppressing ability on weeds as compared to Khumal-7 and Chinung-242 (Ranjit 1999). Mostly the tall rice variety has more competitive ability than the short stature one. Some of the important characters such as: earliness, rapid canopy covers, increased plant height, early root growth need to be considered to generate the competitive rice cultivars (Devkota et al 2013). Rice cultivars suitable for direct seeding for hills and Tarai were: Sukha-3, Hardinath-1, Radha-4, Sona

Masuli, Sukha-1, Sukha-2, Sabitri, Khumal-4, Khumal-8 and Khumal-10 (Devkota et al 2013, Ranjit and Suwanketnikom 2003, Ranjit et al 2004, 2008).

Figure 4. Competitive study of rice varieties

Cultural practices and nutrient management

Weed flora as well as weed density depends on different cultural practices. Weed population is less in transplanted rice than in direct sown rice. *Caesulia axillaris, Ischaemum rugosum* and *Echinochloa* sp. were more in direct sown rice and *Fimbristylis littoralis* and *Cyperus iria* were less but these weeds are more in transplanted rice (Ranjit et al 1997). Judicious uses of nitrogen especially after the weed removal will certainly favor the crop than the weeds (Ranjit et al 2010, 2012).

Chemical weed control

Herbicides became an important component of agricultural production worldwide. The tendency to use more herbicide in agriculture is intensifying all over the world including developing countries. The use of herbicides in Nepal seems to be very low.

Among various herbicides butachlor is widely applied in the rice. An increasing trend was noted on use of butachlor. Although herbicides save labors but its continuous application of the same herbicide leads to build up weeds especially the perennials that are not controlled by the herbicides. Hence to prevent the weed build up, crop and herbicide rotation should be practiced. Integration of the minimum dose of herbicide plus hand weeding or other methods should be practiced to prevent the weed build up and minimize the seed bank in the soil. But due to changes in social life, labors are not easily available and it is becoming increasingly difficult to do the farm operations on time. Possible advantages of herbicides includes fast control in large areas, less drudgery than manual, control in critical period, selective control, control of special weed problems, broad spectrum and economy. However, there are many constraints in herbicide use. It needs technical skill and special equipment. It is environmentally hazardous and secondary weeds may become a primary problem.

Rice herbicides and their uses in Nepal

In many intensive crop growing areas of Nepal, attraction towards the herbicide is on the rise. The use of herbicides in Nepal seems to be very low, however, an authentic data is not available for herbicide use. But the quantity of some particular herbicide applied is huge in comparison to other pesticides use in many potential areas of Nepal. A number of herbicides alone or in combination with cultural practices were tested in transplanting and direct seeded rice. List of these herbicides are given below.

anilophos	ethoxysulfuron	2,4-D Nasalt	pendimethalin	Thiobencarb
azimsulfuron	fluchloralin	oxadiazon	piperophos	Pyrazosulfuron
bispyribac sodium	glyphosate	oxyfluorfen	pritilachlor	Penoxsulam
bensulfuron methyl	naproanilide	paraquat	prometryn	Trichlorpyr
butachlor	nitrofen	Propanil	quinchlorac	2,4-D ethyl ester

Pre-plant, pre-emergence and post emergence herbicides were used to manage weeds in transplanted, direct dry seeded, no till direct seeded rice and system of rice intensification (SRI) (Malla et al 1979, Malla and Ranjit 1980, Ranjit et al 1988, Ranjit and Srivastav 1997, Ranjit and Bellinder 2002, Ranjit, Suwanketnikom 2005).

Figure 5. Weed management with pre post herbicides plus cultural method in DSR

Zero-till direct seeded rice

Buckwheat cover mulch followed by pre plant herbicides such as glyphosate, followed by rice seeding followed by pre-emergence herbicide suppresses the broadleaf and sedges.

Buckwheat cover mulch followed by incorporation by ploughing the field followed by rice seeding followed by pre-emergence herbicide suppresses the broadleaf and sedges

Sesbania or cowpea cover mulch followed by pre plant herbicides such as glyphosate followed by rice seeding followed by pre-emergence herbicide followed by a post emergence herbicide bispyribac at 15- 20 DAS (Ranjit et al 2012).

Figure 6. Cover mulch/co-culture

Proper sprayer and nozzles must be used to apply the herbicides to enhance the efficacy. Flat fan nozzles are recommended to spray herbicides (Bellinder et al 2002). Weeds are one of the constraint factors in rice production. Manual weeding is becoming difficult due to migration of young generation from village to urban areas for better life, education and job. Scenario of rice culture is changing from transplanting to direct seeding especially the big land holders. As the shift of transplanting to direct dry seeding, weeds became the major constraint factor in the production system and herbicides are becoming alternative option of manual weeding. Weed science research has faced increasing challenges due to lack of agricultural labor on time, weed problem in direct seeded rice and the obligation to fulfill the regulations of world trade organization. Rice weed study revealed that about 46 genuses with 60 species from 23 families were recorded from different agro ecological regions of Nepal.

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Cultivation of Spring and Boro Season Rice in Nepal

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सारांश

सिंचित जग्गामा बोरो र चैतेधान दोहोरो धान खेती प्रणालीको लागि एउटा विकल्पको रूपमा लिइन्छ, जसको माध्यमबाट उत्पादन दोब्बर गरी देशमा विद्यमान खाद्य असुरक्षा र गरिबी घटाउन सकिन्छ । तराई क्षेत्रमा बोरो र तराई तथा तल्लो पहाडी क्षेत्रमा चैतेधान खेती सफल भएको पाइएको छ । यसको खेती वर्षैभरि सिँचाइ हुने कुला, नाला र स्यालो टूववेलको माध्यमबाट खेती गर्ने सिंचित जग्गा भएका कृषकमा लोकप्रिय भईरहेको छ । हालसालै देशको मौजुदा सिंचित जग्गा बढेको छ र चैतेधान खेती लगभग ५० वटा जिल्लाहरूमा भइरहेको पाईन्छ । नेपाल सरकारले चैतेधान खेती गर्ने कृषकलाई अनुदान दिने व्यवस्था पनि गरेको छ । चैतेधान खेतीको लागि हर्दिनाथ–१, चैते–२, चैते–६ र सिएच–४५ जातहरूलाई कृषकहरूले लगाइरहेको पाइन्छ भने बोरो सिजनमा एउटा मात्र धानको जात (जया) को खेती गरेको पाईन्छ ।

Summary

Spring (*chaite*) and boro rice are options for double rice patterns under irrigated condition, which help to increase the yield in Nepal. These yield advantage can contribute considerable achievement for food security and poverty reduction in the country. The success of spring and boro rice cultivation have been observed in the country and these are being popular among farmers where irrigation is available round the year by using canal, shallow and deep tube wells. In recent years, the area under irrigation has reached to 35.6% and spring rice is grown in 50 districts in the country. Government has given the subsidy to spring rice growers in Nepal. Nowadays, Hardinath-1, Chaite-2, Chaite-6 and CH-45 are being grown by the farmers in spring season whereas Jaya is a single rice variety grown by farmers in boro season.

Keywords: Boro rice, Food security, Irrigation, Spring rice, Subsidy

Introduction

It is grown in diverse ecosystems that have been classified on the basis of water regime, irrigated and rainfed. About 64% of the rice growing area is under irrigation, out of which, 28% of the total rice cultivated area is under round the year irrigation and 35.6% is under seasonal irrigation (MoAD 2013). Indeed, varietal development program led to the development of varieties for increasing rice production under irrigated ecosystem in the early 1950s in Nepal (Mallick 1981). Adaptation of improved short duration varieties contributed to increase a total rice production in most Asian countries in the last decades (Khush 1986). Spring rice is cultivated in different parts of the country where irrigation is available round the year by using canal, shallow and deep tube wells. Spring rice is grown in 7.4% of the total rice areas in the country (CDD 2015). Nonetheless, the extent of areas under spring (*chaite*) rice is in increasing trend. In Tarai areas, spring rice growers are generally using pump set operated shallow/deep tube well to irrigate their field when irrigation is required. So far, 11 spring rice varieties have been released in Nepal. Out of 11 spring rice varieties, five rice varieties were de-notified and six varieties are being grown in the country. It is necessary to develop a high yielding suitable variety as options for the spring rice growers to meet the demand. Dominant spring rice varieties are Hardinath-1, Chaite-2 Chaite-6, Chaite-4 and CH-45 (CDD 2015). The crop generally needs varieties with 110-125 days maturity in spring season for the timely planting of the second main season rice crop.

As mentioned in the *Chaite* rice is reported to be cultivated in 50 districts (mountain-5, hills-29 and Tarai 16 districts) in an area of 112313 hectares. Out of this, the share of OPVs, hybrids and local is 90.16, 1.31 and 8.53%, respectively. The coverage area of spring rice for mountain, hill and Tarai found to be 5.48, 24.85 and 69.67%, respectively (CDD 2015)

Boro rice has potential to increase the rice grain yield per unit area but still in low acreage. In irrigated areas, boro is the option for the double rice cultivation where farmers are ready to adopt input-intensive production technology. It is traditionally being grown in Jhapa, Morang and Nawalparasi districts. It is grown in November, transplanted in January/February and harvested in May/June. It has inherent high yield potential because of: clear sunshine, less risk of crop failure, high input use and fewer pests and diseases infestation (Singh et al 2000). It has been found that boro rice produced grain yield of 6.5-7.5 t/ha. The higher yield of boro is due to low cloud-cover, high sunshine and cool nights. So far no boro rice varieties have been released in Nepal. However, a single boro rice variety Jaya is being grown by farmers in prevailing districts. Eastern Tarai does not have favorable growing environment for wheat cultivation because of the shorter duration of the winter season and predominance of clay water logged soil. Similarly, sterility is also becoming serious problem in wheat crop in such areas. Thus, a farmer does not want to grow wheat in such areas. But once irrigation facilities are available, farmers prefer to maximize production by allocating land to spring or boro rice than to wheat in those areas. The success of boro rice cultivation has been observed in Morang, Jhapa, Sarlahi, Nawalparasi and Siraha districts and it is being popular in irrigated condition. The varieties developed so far for spring and boro season and their characteristics are given in **Table 1** and **2**.

Table 1. Varietal characteristics of spring *(chaite)* rice genotypes

SN	Name of variety	Important traits/characteristics
1	Hardinath-1	Suitable for double rice pattern, high yield, short duration (suitable for *chaite* and *bhadaiya*), blast and bacterial leaf blight resistant, tasty
2	Chaite-2	Suitable for double rice pattern, high yield, short duration (suitable for *chaite* and *bhadaiya*),blast and bacterial leaf blight resistant, tasty
3	Chaite-6	Suitable for double rice pattern, high yield, short duration (suitable for *chaite* and *bhadaiya*), blast and bacterial leaf blight resistant, tasty
4	Bindeshwori	Short duration (*chaite* and *bhadaiya*), weed competitiveness, high yield, suitable for upland, tasty, blast and bacterial leaf blight resistant
5	CH-45	Suitable for double rice pattern, high yield, short duration (*chaite* and *bhadaiya*)blast and bacterial leaf blight resistant, good taste
6	Chaite-4	Suitable for double rice pattern, high yield, short duration (suitable for *chaite* and *bhadaiya*), blast and bacterial leaf blight resistant, good taste

Table 2. Varietal characteristics of promising boro rice genotypes

SN	Name of variety	Important traits/characteristics
1	S1P1-59203-33	High yield, long duration, blast resistant, good taste, suitable for boro and normal season, good for para boil, beaten and popped rice
2	DR11	High yield, long duration, blast resistant, good taste, suitable for boro and normal season, good for beaten and popped rice
3	BR-29	High yield, long duration, blast resistant, good taste, suitable for boro and normal season, good for beaten and popped rice
4	SACGA-4	High yield, long duration, blast resistant, good taste, suitable for boro and normal season, good for beaten rice
5	IR47686-4-4-3-1	High yield, long duration, blast resistant, good taste, suitable for boro and normal season, good for beaten and popped rice

S.N.	Name of variety	Important traits/characteristics
6	Jaya	High yield, long duration, blast resistant, good taste, suitable for boro and normal season, good for beaten and popped rice

Cropping patterns

Farmers are growing different succeeding crops in rice-based system. But they do not know the suitable crops which can give them profit as well as maintain soil fertility. Therefore, different rice based crop rotation have been designed to grow the more profitable and could help to enhance soil fertility. The following spring and boro rice based Patterns are being practiced in Nepal.

Rice-Rice-Potato
Rice-Maize-Potato
Rice-Green manure (Dhaincha/Sun hemp)-Rice-Potato
Rice-Rice-Vegetable

Constraints of spring and boro rice

The varieties developed for spring and boro rice so far is gradually losing their popularity due to climate change. Those varieties are also not able to meet the social and cultural requirement of the people in the country. Similarly, a lot of associated problems prevail in spring and boro rice cultivation such as onset of monsoon during harvesting, low temperature at seedlings stage, requirement of more water and less varietal options. Similarly, Jaya a single genotype is being used for boro rice cultivation, which may suffer with a number of problems. Boro rice varieties with tolerance to cold injury at seedling stage and short duration are present demand of farmers. Growing of short duration varieties facilitates harvesting in dry climate and timely planting of normal season rice. But the major problem that faced by boro growers with low temperature which often goes below 15^0c during the middle of November to middle of February is affecting normal physiological and biochemical process of crop at the seedling stage and early crop establishment stage. Chuong and Omura in 1982 reported that boro rice suffers from extreme cold stress during seedling stage, moisture stress in the mid-season and high temperature at grain filling stage. In addition to variety, seedling management in the seedbed is required to save the enough prospectus of boro rice cultivation in eastern Tarai where irrigation facilities are available through tube well (Gupta et al 2002). But it has been found that inadequate desirable boro varieties, quality seed, insufficient technical knowhow, shortage of irrigation and market price are common constraints for boro rice expansion.

Varietal improvement on spring and boro rice

Primary concern is to develop modern varieties to suit in spring and boro rice cultivation. National Rice Research Program (NRRP) started systemic breeding works from 1950s to collect, utilize and select exotic varieties and local landraces for varietal development. However, no systemic varietal development works on boro rice has been done in past. A total of 11 spring rice varieties have been developed and released for spring season. Despite of a relatively small area of boro rice in Rangeli and its adjoining villages of Morang district, its cultivation began with the help of labor from Assam who came to work in these villages. Though, efforts were made in late 1990s at NRRP, Parwanipur and Regional Agricultural Research Station, Tarahara for initiating the varietal testing work in Morang and Jhapa. A set of 12 normal rice varieties were composed and screened in boro season to see their performances. Among them, Jaya was found superior with respect to tolerance to cold injury at seedling and early vegetative stages and grain yield in Boro season. Later, Dr Peter Hobbs brought some elite boro rice varieties from Bangladesh and India. He also initiated research work on this rice though rice-wheat project in collaboration with National Wheat Research Program and NRRP. Based on the results Jaya, DR-11 and BR 29 performed better in boro season. NRRP has demonstrated boro rice varieties DR-11 and BR 29 at Jhapa and Morang districts among the farmers. Farmers preferred these varieties and they started to cultivate DR11 and

Jaya in boro season. NRRP had started to test boro rice varieties through INGER (International Network for Genetic Evaluation of Rice) nursery since 2000. Since then, INGER nursery is being conducted to identify suitable rice varieties for boro season. The promising genotypes S1P1-59203-33, SACGA-4, BRRI-38, BR-29 and IR47686-4-4-3-1 showed encouraging yield in boro season. SACGA-4 is a suitable genotype to be proposed for release in boro season.

Opportunities

Farmers are indeed, interested in growing of spring and boro rice cultivation because of its high yield and good market price. Newly harvested grain can be sold with high price because traders use this grain for *chiura* (beaten rice). Most of the lands are having high moisture where neither legume nor wheat can be grown in winter. However, these lands can be used to grow either spring or boro rice with satisfactory yield. Farmers aspired to grow spring and boro rice by using Alternate Wetting and Drying (AWD) irrigation system where farmers can save irrigation cost. AWD irrigation system can save nearly 25-30% water as compared to conventional irrigation. Spring and boro rice have more yields with less diseases and insects. Because irrigated rice contributes more than 75% of the total rice production, enhancing its yield potential would be a key requirement. Based on the water availability rice is taken up as a single crop or as high as double crops in a year in the subtropical regions of the country. Boro rice has importance in the agricultural scenario of Nepal especially in eastern Tarai districts due to the following reasons.

- Unlike the onset of monsoon during harvesting of spring season rice, boro rice is relatively risk free because it can be harvested before onset of monsoon and farmers can get sufficient time to prepare land for normal season transplanting which encourage them to cultivate boro rice.
- With the increasing irrigation facility, the area can be brought under boro rice cultivation to achieve higher production in eastern part of the Tarai. Lowland area can also be utilized by cultivation of boro rice, which remains fallow due to excessive moisture and late rice genotypes. If these areas can be converted into boro and spring rice, we can increase rice production and secure food security.

Strategy for spring and boro rice

A country like Nepal, where there is limited land and a dire need to transform from mono rice cultivation into double rice cropping systems, should carefully weigh the options and scope for adopting spring and boro rice technologies for increasing rice production. In Nepal, water resources are regarded as key strategic natural resource having the potential to be the catalyst for all round development and economic growth of the country. Indeed, it is necessary to increase production and reduce production costs. Therefore, government should focus in extending spring and boro rice cultivation through AWD irrigation system in changing context of climate change. There should also be provision of subsidy to farmers on growing spring and boro rice. Most of the developed spring and boro rice varieties are susceptible with cold injury at seedling and early vigor stage. Thus, varieties with cold tolerance at seedling and early vigor stage need to be developed. Prospects of accelerating growth in rice production by conventional means as in the past were less encouraging because of seed replacement was very low. Therefore, it is necessary to increase rate of replacement of farmers' seeds with quality seed. In fact, fertilizers are considered an important for increasing rice production and productivity. Farmers need adequate amount of chemical fertilizers timely to obtain good yield. For controlling diseases and pests, more innovative ways need to be adopted as IPM approach. Such methods could include possible options to control diseases and pests in proper manner with economically viable, environment friendly and appropriate control measures. However, very often, there is serious technology transfer gap, which are indicates poor linkages among stakeholders. Therefore, suitable linkages should be established with GOs and NGOs to implement proven technologies and empower farmers to become partner in the system.

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Dormancy Period in Rice Varieties and its Effect on Rice Production

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सारांश

नेपालको विभिन्न आवोहवा तराईदेखि मध्य एवम् उच्च पहाडमा विविध धानका उन्नत एवम् परम्परागत स्थानीय जातहरूको खेती गरिएको छ । यी धानका जातहरूमा हुने विभिन्न गुणहरू मध्ये बीउमा सुषुप्त अवस्था एक महत्वपूर्ण गुण हो । यसको प्रभाव धान बालीको उत्पादन र भण्डारमा पर्ने गर्दछ । यिनै धानका जातहरूमा सुषुप्त अवस्थाको किसिम र अवधि, सुषुप्त अवस्था हटाउनेबारे जानकारीहरू आदि संकल गर्ने प्रयास यहाँ गरिएको छ । प्राय जसो प्रयोगमा रहेका उन्नत एवम् स्थानीय जातहरूमा सुषुप्त अवस्था रहेको तर सी.एच.-४५, पूर्वी तराईमा लगाईने जातमा नगण्य सुषुप्त अवस्था रहेको पाइयो । पश्चिम तराईमा प्रचलित रहेको र ढिलो पाक्ने जानकी जातको धानमा सुषुप्त अवस्था गाढा र लामो अवधिको रहेको पाइयो । सामान्यतया पहाडमा लगाइने जातहरूमा सुषुप्त अवस्था कम र छोटो अवधिको रहेको छ भने तराईमा जातहरूमा बढी र लामो रहेको पाइयो । प्राय पूर्वी तराईमा लगाइने जातहरूको बीउमा उत्पादन क्षेत्रको प्रभाव अनुसार अन्य क्षेत्रको भन्दा बढी सुषुप्त अवस्था देखा परेको छ । यो एक अनुकूलन प्रक्रिया हो जस्ले वातावरणीय प्रतिकूल प्रभावलाई न्यून गराउँछ । धान बालीको बीउको सुषुप्त अवस्था हटाउन बीउलाई ५० डिग्री सेन्टिग्रेड तापक्रममा ३ देखि ५ दिनसम्म सुकाउन उपयुक्त हुन्छ । यी सुषुप्त अवस्थाको जानकारीहरू भविष्यमा अन्य अनुसन्धान कार्यमा समेत उपयुक्त हुने देखिन्छ ।

Summary

Improved and local varieties of rice have been grown in diversified production environment of Tarai, mid-hill amd mountain region of Nepal. Seed dormancy is an important ecologically beneficial quality trait in rice varieties. It has direct effect on production and storage of paddy. Attempts have been made to assemble a comprehensive review of dormancy behaviors and dormancy period, breaking techniques in Nepalese rice varieties. Review showed most of the improved and local varieties of rice to possess dormant period. However, the dormancy period was found negligible in CH-45 and fewer varieties grown in eastern Tarai. Janaki, a long duration variety of normal season and popular in Western Tarai, encountered strong and long period of dormancy among the cultivated rice varieties under production system. The tropical varieties in Tarai are more intense in dormancy with long duration compared to temperate varieties of hills. Seed lots of same variety produced in different locations exhibited different level of dormancy and duration was also prolonged. Seeds produced in Eastern Tarai possessed high level and prolonged dormancy in comparison to other region. Dormancy is an adaptation mechanism that helps to minimize the effect of unfavorable environmental conditions In general, pre-drying seeds at 50^{o}C for 3 to 5 days prior to germination are found effective in breaking dormancy for most of the cultivated rice varieties. These information on dormancy period is expected to be useful for further research works in future.

Keywords: Dormancy, Environmental condition, Improved, Local varieties, Rice, Seed

Introduction

Cultivation and diversity of rice variety in Nepal is fascinating with unique the diversity of rice growing environments. A good number of rice varieties have been developed and released suitable to these varied agro-ecosystems and diverse production environments. Based on agronomic behaviors, growing seasons and production environments, these varieties are categorized as: early to late maturing varieties, upland-rainfed to irrigated and submerged rice and likewise Tarai (sub-tropical) to hill (temperate) varieties. These varieties need specific condition of temperature, moisture and level of oxygen for their optimum growth and yield. Among many factors, rainfall and humidity are the important ones that affect rice production in quality and quantity. One of the important properties of rice plant to its production and storage is the seed dormancy which according to Naylor (1983) is defined as a genetically inherited physiological trait as inability or failure of matured seeds to germinate even under conditions favorable for germination. However, the intensity and length of duration depend on the season, type of seed, and production environment during seed development (Johnston 1989, Copeland and MacDonald 1995). It could, therefore, be primary and secondary dormancy and could be of endogenous or exogenous dormancy based on diverse mechanisms imposed.

Seed dormancy in rice is very critical which is generally diverse among the varieties and production environments. The tropical varieties in Tarai and late maturing varieties are more intense in dormancy with long duration compared to temperate (hill) and early maturing varieties. Dormancy has also been reported to vary among the species of rice. *Japonica* varieties are less dormant than the *indica* types. Furthermore, wild species of rice are normally found with strong dormancy compared to the cultivated ones. It is the adaptation mechanism that helps wild species to withstand the long duration of unfavorable environmental conditions, remain viable until the suitable conditions to germinate and conserve the species (Waheed et al 2012). Attempts have been made to assemble a comprehensive review of seed germination and dormancy behaviors and dormancy, breaking techniques in Nepalese rice varieties including improved and landraces, in Seed Science and Technology Research laboratory in Khumaltar, Nepal.

Intensity and duration of dormancy

It is common observation encountered in seed testing of fresh harvested seeds of rice varieties that seeds do not germinate under the controlled and favorable condition (ISTA 1993) and fail to provide premium benefits to seed producers based on seed quality parameters. It is due to the seed dormancy in fresh rice seeds, a period of resting after harvest which is referred as after ripening period. It is necessary to have this period in every rice seeds to occur germination and it is been observed in all varieties of rice with few exception like: CH- 45, Taichung-176, Chainung-242. CH-45 are non-dormant varieties with sprouting on standing crop even in a slight moist and humid condition. The studies on behavior of dormancy found a considerable variation between the rice varieties in intensity and duration of this stage (**Table 1, 2** and **3**). In successive studies, the hill (temperate) varieties under study found little and comparatively short period of dormancy (**Table 1**) than that of the varieties for Tarai condition (sub-tropical) (**Table 2**). Janaki, a long duration variety of normal season and popular in western Tarai encountered strong and long period of dormancy among the cultivated rice varieties under production system. However, landraces under study were found to possess little to moderate dormancy compared to the improved cultivars.

Table 1. Intensity and duration of seed dormancy in rice varieties for hill condition after attaining the harvest maturity

Genotypes	Cross parentage	Germination (%)		Duration of dormancy (days)	Recommended domains
		Sprout	Fresh*		
Taichung-176	Tsai-Yuanchung/Dee-Geo-Woo-gen	98	0		Mid-hill and Kathmandu valley
Chainung-242	Hsingchio 4/Taichung 150//Taipe 17/T 45	100	0		Mid-hill and Kathmandu valley
Khumal-2	Jarneli/Kn-LD-361-DLK-2-8	89	9	84	
Khumal-4	IR 28/Pokkhreli masino	96	4	42	Mid-hills
Khumal-5	Pokhreli Masino/KA-1B-361-BLK-2-8	88	10	84	
Khumal-6	IR 13146-45-2-3/IR 7492-18-6-1-1-3-3	89	9	86	Kathmandu valley and similar areas
Khumal-7	Chaina 1039 DEF MUT/Kn 18-361-1-8-6-10	88	11	98	
Khumal-8	Jumli marshi/IR 36	97	3	28	*Tar*, foot and mid-hills
Khumal-9	K 28-76-D-1/Kn18-214-1-4-3	95	5	42	
Khumal-11	Akudaka/Barkat	98	2	28	Kathmandu Valley

Genotypes	Cross parentage	Germination (%)		Duration of dormancy (days)	Recommended domains
		Sprout	Fresh*		
Chandannath-3	Selection from Yunlen-1	96	3	28	Jumla and similar high-hills
Chandannath-1	Selection from Jingling 78-102	98	2	28	Jumla and similar high-hills
Manjushree-2	Fuji 102/NR 10157 (Jumli Marsi)/IR 9129-159-3//kn-lb-361-1-8-6-3	99	1	28	Kathmandu valley
Machhapuchhre-3	Fuji 102/Chhommrong dhan	97	2	28	Mid and high-hills
Chhommrong	Selection from Ghandruk dhan	98	2	28	Eastern and western high-hills
Palung-2	BG 94-2/Pokhreli Masino	98	1	28	High-hills

*Source: ABD 2000, ABD 2001, ABD 2009; * fresh seeds are dormant seeds in rice.*

Table 2. Intensity and duration of dormancy in rice varieties for Tarai condition after attaining the harvest maturity

Genotypes	Cross parentage	Germination (%)		Duration of dormancy (days)	Recommended domains
		Sprout	Fresh*		
Rampur Masuli	Lalnakanda/IR 30	94	3	28	Tarai, inner Tarai & Foot hills
Loktantra	Mahasuri/IR 4547-6-2-2	95	5	28	Tarai, inner Tarai & low and Mid-hills
Chaite-4	BG 34-8/IR 28//IR 2071-625-1-252	95	5	28	Tarai and inner Tarai
CH-45	Selection at IRRI	94	0		Tarai and inner Tarai
Janaki	Peta 3/TN1//Ramadja	72	23	276	Western Tarai
Mithila	Fortuna//Miltor 6*2/Azucena	92	7	28	Tarai and inner Tarai
Hardinath-1	BG 95///79-3348/H4//BW228-1-3	94	5	28	Tarai and inner Tarai
Radha-12	TN1/T141/Annapurna	96	3	28	Eastern Tarai
Chaite-2	BG 34-8/IR 2061-522-6-9	84	15	98	Tarai and inner Tarai
Radha-4	BG 34-8/IR 2071-625-1	92	7	56	Mid and Far western Tarai
Mansuli	MayangEbos 80*2/Taichung 65	99	1	28	Across Tarai and inner Tarai
Barkhe-3004	Kallinga -3/IR 36	96	3	28	Tarai and inner Tarai
Sabitri	IR 1561-228-1/IR 1737//CR94-13	97	3	28	Across Tarai
Radha-krishna-9	IR42/Masuli	97	1	28	Tarai and inner Tarai
Radha-7	Janaki/Masuli	96	3	28	Tarai and inner Tarai
Radha-32	Na	93	5	28	Tarai
Radha-17	Na	94	2	28	Tarai
Radha-11	Local selection in India	97	3	28	Central Tarai
Ramdhan	Mahsuri/IR 30	94	4	28	Central Tarai
Bindeswori	TN 1/Co29	79	14	78	Tarai and inner Tarai
Makwanpur-1	Ob678/IR20/114	93	4	28	Tarai and inner Tarai
Sunaulo Sughandha	Local selection	85	10	70	Tarai

*Source: ABD 2009; * fresh seeds are dormant seeds in rice.*

Table 3. Intensity and duration of dormancy in landraces of rice

Genotypes	Cross parentage	Germination (%)		Duration of dormancy (days)	Recommended domains
		Sprout	Fresh*		
Kanchi Masuli	Landrace	100	0		Tarai, popular across Tarai belt
Kalanamak	Landrace	96	2	28	Eastern Tarai

Genotypes	Cross parentage	Germination (%)		Duration of dormancy (days)	Recommended domains
		Sprout	Fresh*		
Seto Basmati	Landrace	97	2	28	Tarai, Kachorwa, Bara
Tunde Basmati	Landrace	90	8	42	Tarai. Kachorwa, Bara

*Source: ABD 2009; * fresh seeds are dormant seeds in rice.*

Production environmental effect on seed dormancy in rice varieties

Various studies on seed dormancy and their environmental causes have been undertaken. In a study on dormancy behavior in a few of early (Chaite-2, Chaite-4); upland rainfed (Ghaiya-2) and normal (Radha-4, Radha Krishna-9, Radha-11 and Radha-12) rice varieties for Tarai condition showed differential response in degree and duration of dormancy with the production environmental effect (**Table 4**). Seed lots of same variety produced in different locations exhibited different level of dormancy and duration also prolonged. Seed lots produced in Tarahara (Eastern Tarai) possessed high level and prolonged dormancy across the varieties under study except Radha-4 (**Table 4**). It is the temperature and the moist condition that affect the regulation and patterns of dormancy loss (Robert 1988). It could be the physiological mechanism of the seed varieties to adapt in Eastern region for undesired rainfall and consequences of moist and humid climate at the time of harvest.

Table 4. Sprout percentage, extent and duration of dormancy in rice varieties showing the effect of production environment in attaining the physiological maturity

Location	Dormancy	Chaite-2	Chaite-4	Ghaiya-2	Radha-4	Radha-9	Radha-11	Radha-12
RARS/P	Sprout (%)	83-97	88-98	88-98	89-96	80-96	66-99	18-96
	Extent (%)	16-0	10-0	9-0	10-0	15-0	33-0	78-0
	Duration (d)	224	168	168	224	238	70	154
RARS/T	Sprout (%)	73-96	88-98	-	86-97	86-96	44-96	12-99
	Extent (%)	25-0	11-0	-	7-0	10-0	55-0	86-0
	Duration (d)	252	252	-	154	238	238	168
RARS/N	Sprout (%)	66-93	-	83-97	84-92	84-93	-	-
	Extent (%)	29-0	-	13-0	9-0	15-0	-	-
	Duration (d)	154	-	196	168	154	-	-

Source: ABD 1997, ABD 1999.

Genetics of seed dormancy in rice

Seed dormancy in rice is controlled by a single dominant gene "G" and influenced by duration of maturity and the production environment (Tung and Serrano 2011). However, other studies have shown that the seed dormancy and pre-harvest sprouting (PHS) behavior in rice are governed by many genes (Cai and Morishima 2000, Miura et al 2002, Dong et al 2003, Li et al 2004). In rice genome, Cytochrome P459 and Gibberllic acid 20-oxidase (GA20-oxidase) are the genes possibly involved inducing seed dormancy. A similar observation is made with a varied response toward the dormancy linked loci in a molecular study of seed dormancy behavior in Nepalese rice varieties (Maharjan 2010). The varieties found genetically different for the trait and supported how they behaved differently in dormancy determination test. Hill Varieties which are comparatively less dormant are found to closely linked and grouped together in a separate cluster (Maharjan 2010). Likewise, the early rice varieties also exhibited differently and clustered together with few outliers. However, the Tarai (sub-tropical) varieties exhibited varied responses and they clustered into different groups. Janaki, the most popular variety in Western Tarai with strong dormancy was found to differ from rest of Tarai varieties for the studied loci.

Breaking techniques of dormancy in rice varieties

Seed dormancy is always a problem in assessing the germination of rice varieties in seed quality testing laboratory. There are various methods used in order to break down seed dormancy. Scarification grinding of seeds with sand or abrasives, stratification using chemicals ($KN0_3$, gibberlic acid, H_2SO_4, HNO_3); pre-drying (heating), chilling, dehulling, use of temperature shift, immersion in boiling water - are the techniques used in breaking dormancy in rice.

Several studies have been undertaken on these techniques to break seed dormancy in rice varieties. Different techniques are found suitable for breaking dormancy specific to the varietal genotypes, type of dormancy and extent of dormancy. In general, pre-drying seeds at 50^{o}C for 3 to 5 days prior to germination are however found effective in breaking dormancy for most of the cultivated rice varieties including of improved (Hill and Tarai) and the landraces. It is the temperature that affects the rate of dormancy in dry seeds (Robert and Totterdell 1981). However, pre-soaking seeds in water at 40^{o}C for 48 hours have been found to work in breaking dormancy in few varieties for Tarai. In Jumla there is always a practice of rice seed soaking in warm water for overnight in warm room which is actually a kind of traditional way of breaking the resting stage for uniform germination in field.

Advantages of dormancy and its effect on crop production

Seeds on harvest undergo the post-harvest processes of drying, cleaning, processing, and grading and finally they are stored in storage for a prolonged period till the next crop season. It is the seed dormancy that keeps the seeds viable and maintains the seed quality in storage. Dormancy is therefore advantageous to have a period of resting in seeds in storage for uniform germination of plantation. It also helps seeds to withstand the adverse conditions and remain intact and viable to germinate on when favorable conditions is approached. It is true in case of wild species of rice and helps the species in conserving the germplasm. Furthermore, dormancy is advantage in the cases which renders resistance to pre-harvest sprouting on delay in harvesting the crop. Furthermore, it also prevents germination in drought condition until the favorable condition prevails, maintain the plant stand uniform and contribute in production. However, it is the physiological and varietal trait of rice varieties to survive the seasonal stresses due drought and rainfall in standing crop and in storage.

Conclusion

Seed dormancy is an important ecologically beneficial quality trait in rice varieties. It could be a factor in having successful germination and crop stand establishment. It has been found different in degree and duration among the varieties from few weeks to a prolonged period. In general, it is a natural mechanism of adaptation that is found to overcome in storage, a process referred as after ripening. Rice varieties produced in Tarai have been found with strong dormancy with pronounced effect of production environments. It is therefore the seed development and surrounding environments that play critical role in induction of dormancy. It could be advantage to the varieties in withstanding the stress conditions and could contribute in quality and quantity of crop and seed production. However, it is problematic in testing of freshly harvested rice seeds. This is an attempt to put together the seed dormancy information of rice varieties under production in Nepal.

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System of Rice Intensification (SRI): The Global Context and Relevancy in Nepal

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सारांश

सघन धान खेती प्रणाली (एस.आर.आई.) आधुनिक कृषि प्रणाली अन्तर्गत बढी उत्पादन र आम्दानी लिन सकिने प्रविधि हो । छिटो र चाँडो नर्सरीको तयारी, बेर्नाको कम घनत्व, कम सिँचाइ आदि यस प्रविधिका सिद्धान्तहरू अवलम्बन गरी हालैका वर्षहरूमा यस प्रविधिको व्यापक अनुसरण भइरहेको छ । यो प्रविधिले अत्याधिक वाह्य उत्पादन सामाग्रीको माग नगर्ने भएकाले स्रोत नभएका गरिब र सिमान्त कृषकहरूको लागि समेत उपयोगी देखिन्छ । हाल संसारमा ५४ देशका १० मिलिएनभन्दा बढी कृषकहरू यस प्रविधिबाट लाभान्वित भएका छन् । नेपालमा खाद्य सुरक्षा प्रवर्द्धन गर्ने सन्दर्भमा धान एक प्रमुख बाली हो । तथापि, धानको न्यून उत्पादकत्वका कारण खाद्य सुरक्षा सम्बोधन गर्न कठिनाई परिरहेको अवस्था विद्यमान छ । तसर्थ, परम्परागत धान उत्पादन प्रणालीको रूपान्तरण गरी नयाँ प्रविधिको अनुसरण गरी धानको उत्पादन र उत्पादकत्व वृद्धि गरी खाद्य सुरक्षाको सवाल सम्बोधन गर्नु आजको आवश्यकता हो । यसै सन्दर्भमा कम कृषि सामाग्रीको प्रयोग मार्फत धानको उत्पादकत्व वृद्धि गर्ने उद्धेश्य पूर्तिका लागि एस.आर.आई. एक महत्वपूर्ण प्रविधि हुन सक्ने देखिएको छ । यसैलाई मध्यनजर गरी नेपालमा १९९८ देखि यस प्रविधिको अनुसन्धान तथा अनुसरण हुँदै आइरहेको अवस्था छ । नेपालमा गरिएका विभिन्न अनुसन्धानबाट यस प्रविधिको प्रयोगबाट प्राप्त उत्पादकत्व र लागत फरक-फरक रहे पनि परम्परागत रूपमा गरिएको धान खेती प्रणालीको भन्दा बढी उत्पादकत्व र कम लागत रहेको पाइएको छ । यस प्रविधिका धेरै फाइदाहरू भए पनि सबै भौगोलिक क्षेत्रमा उत्तिकै प्रभावकारी पाइएको छैन । त्यसैले यस प्रविधि अन्तर्गतका नेपालका सन्दर्भमा अपनाउन सकिने कार्यहरू जस्तै कलिलो बेर्ना, प्रांगारिक मलको प्रयोग, नियन्त्रित सिँचाइ आदि अवलम्बन गर्न सकिएमा धानको उत्पादकत्व वृद्धि गर्ने राष्ट्रिय सोचमा एस.आर.आई. प्रविधि कोशेढुंगा सावित हुन सक्ने देखिन्छ ।

Summary

System of Rice Intensification (SRI) is the technology of modern agricultural era in rice farming for higher and profitable production. Adoption of SRI following the principles of early and quick establishment of healthy plants; reduced plant density; and reduced and controlled water applications, has been increasing. SRI is a low external input method and can be suitable technology for the small and marginal farmers, who are facing severe food deficiency due to low yield. Yield obtained by adopting SRI is higher than conventional methods in most of the cases. More than 10 million farmers of 54 different countries have been benefited by SRI. In Nepal, Rice is one of the most important staple cereals to contribute to the food security which is urgent to be addressed through transformation of conventional practices of rice cultivation. In this context, System of Rice Intensification (SRI) can be a potential innovative rice farming practice to substantially increase the productivity with less agronomical inputs. Realizing the benefits of SRI, it was first introduced in Nepal in 1998 with some initial trials in Khumaltar. The various SRI trials conducted in Nepal showed variations in yield. However, SRI was observed superior to conventional rice farming technology with respect to cost and yield. Despite the several benefits of SRI, it has not been effective among all farmers across the different geographical domains. So, choosing the doable parts of SRI technology ie, younger seedlings, early weeding by mechanical weeder, use of organic manure and AWD irrigation, can be a better technology to meet the national interest of increasing yield per unit area of rice.

Keywords: Control irrigation, Food security, Productivity, Rice farming, SRI

Introduction

System of Rice Intensification (SRI) was developed initially during the1980s by French priest, Fr. Henri de Laulanie in Madagascar. The name of SRI "system de riziculture intensive" first appeared in his paper in 1993. SRI has become popular gradually with the effort of Prof. Norman Uphoff (former Director of Cornell International Institute for Food, Agriculture and Development) and other pioneers. The history of SRI dissemination outside the Madagascar is not very old. It started in 1999 in China followed by Indonesia (1999/2000) and India (Uphoff 2007). Today the trials of SRI and good performance results have been conformed in more than 50 countries (htpp://ciifad.cornell.edu/sri/countries). With respect to total cultivated area under SRI, China (Uphoff 2007), India (WWF 2007, Prasad et al 2007), Cambodia (Koma 2007), Madagascar, Indonesia (Sato 2006) are the leading countries. More than 4 dozen other countries followed them in trials and dissemination of SRI.

Rice is the crop of the developing world. Majority of poor people in the world are living in main rice growing areas. In those areas, the productivity of rice is low and directly affects poor, small and marginal farmers. So, the most direct way of reducing poverty is to increase the productivity of rice in those regions (Uphoff 2007). In this context, relevance of SRI to smallholders is high because it does not require extra external inputs other than those required conventionally. By using locally available seeds, labor, compost/FYM and a small amount of water farmers can increase the rice yield. Some studies have shown that this is highly advantageous specially for the small farmers (Anthofer 2004).

Major technological components of SRI

SRI is a combination of some ideal practices used for exploring full potential of rice plant. The main technological components of SRI include (Stoop et al 2002, Uphoff 2007): rapid and shallow transplanting of very young seedlings carefully, single planting rather than in clumps of 4-6 plants/hill, spacing the plants widely apart in square pattern (25x25 cm or wider), no continuous flooding (but alternate wetting and drying) during the vegetative stage but thin layer of water (moisten soil) kept on the field during reproductive stage. Controlling weeds by weeding with a rotating hoe, applying compost in preference to chemical fertilizers are also other techniques of SRI. Above mentioned practices show that without increase in external inputs and investment, farmers can increase rice yield from their fields. It is the beauty of SRI, especially for the resource poor small and marginal farmers, who are facing severe food deficiency due to low yield that they will be able to increase their productivity. More than 10 million farmers of 54 different countries have been benefited by SRI.

Possible processes and mechanisms in SRI

Most of the SRI proponents emphasized on the mechanisms, which can produce better rice yield. The contributing factors are larger root system (Barison 2002, Koma 2007), more fertile tillers per unit area (Stoop 2005, Uprety 2005, Barison 2005), larger panicles with more numbers of grains, more 1000 grain weight than conventional method. Some empirical research have given insight into the mechanisms behind those findings.

Young seedlings

Transplanting young seedling before their fourth phyllochron stage of growth produce more tillers and larger root system (Uphoff 2007). Larger root system absorb more nutrients and water from more depth of the soil and contribute to high productivity.

Single planting

Single planting reduces competition between plants in the common space. Some studies have found that higher rice production can be achieved by single planting than more rice planting in the same space (San-oh et al 2004). They also found single plant has more tillers, more roots, more cytokinins synthesis, less leaf senescence, more photosynthesis and more yield.

Wider spacing with square pattern

Similarly wider spacing provides sufficient areas to develop root and shoot in rice plants. There will be less shading and more photosynthesis in leaf. Due to sufficient space for the root, there will be less competition for the common space and nutrients, which ultimately help better production.

Water management and rice

Water management is a very important factor for rice root development. Yang et al (2004) found that continuous water-logging decreased the development of root morphology and its activity. But alteration between anaerobic and aerobic soil condition enhances root growth and nutrient availability (Ceesay et al 2006).

Weed management and soil aeration and rice

Weeds generally compete for nutrients and space with rice plants. Timely management of weed with rotary weeder reduces negative effect of weeds on growth and development of rice plants. At the same time, the weeder incorporates the weeds back into the soil and increase the organic matter content. It also aerates the soil and has positive effect on root development and nutrient uptake from the soil.

Organic matter amendment and rice

Organic matter has a very important role in improving soil properties and crop growth and development. In one way, it supplies nutrients to the plants and also helps to regulate the mineral nutrients within the soil. Some researchers have studied the role of organic matter in rice cultivation and found positive effects in growth, development and yield (Eneji et al 2001, Yang et al 2004).

System of rice intensification

SRI benefit (summery of different findings)

Increase in yield/ha - 52% (21 to 105%) • Increased net income/ha - 128% (59 - 412%) • Reduction in cost of production - 24% (7 - 56%) • Reduction in water requirement - 44% (24 - 60%) • Shorter time to maturity (1-3 weeks less) • Protection against biotic stresses pests/diseases (Sheath blight, leaf folder, brown plant hopper) - 70% reduction in incidence • Tolerant to abiotic stresses - drought, storm damage, extreme temperatures • Higher milling outturn (by ~ 15%) - lower chalkiness.

Source: Uphoff 2007, Thakur et al 2010.

Existing rice production system

Conventionally farmers are using older age seedling (30-60 days), lot of seedlings (5-15 seedlings/hill), dense planting (40-60 hills/square meter), water flooded fields during the crop duration (if water is available), minimum use of compost or FYM (it is common in hills and hill-migrants farmers in Tarai), haphazard use of chemical fertilizers and single manual weeding. To improve our existing rice farming, we need to change the way of management. We need to use less seeds, less seedlings and less water in an efficient way. Similarly, farmers use different type of rice varieties like short duration (90-120 days), medium duration (130-145 days) and long duration (150-170 days). Some varieties are photo-sensitive and some are photo-insensitive. We can use this diversity to adjust farmers' needs and farmers can use those varieties according to their soil, cropping system and agro-ecological situations. Generally there are two rice seasons: early/spring (March-June) and main/rainy season (July-November) but in some districts winter rice cultivation (December-May) is also in practice.

Two types of nursery beds are in common practice. Dry seedbed is practiced in hilly areas and the Tarai (for spring season) but majority of farmers use wet puddle seedbed for nursery. Average seed rate used for conventional method is 50-70 kg/ha. Transplanting of rice seedling in puddle fields is a common practice but some farmers also use direct seeding method. The common fertilizer used (for majority of farmers) in rice farming is Urea (for top dressing).For the past few years, use of zinc-sulphate and DAP (di-ammonium phosphate) is also increasing. However, the use of balanced dose or recommended dose (100:60:40 kg NPK/ha) of chemical fertilizers is very limited. Use of insecticides for stem borers and gandhi-bug, fungicides for blast and other fungal diseases, weedicide to control weeds at early stage are other practices used in Nepalese rice farming.

Socio-economic aspects: Relevancy of SRI to smallholders

SRI method seems like a good alternative to the smallholder rice farmers for high and profitable production. Most of the report around the world reported that it is low external input method and the productivity is very high. Its net-profit is high as compared to conventional methods. Despite its obvious benefits SRI has not taken off as expected (Moser and Barrett 2003). In the short span of time (less than one decade) SRI has been disseminated in more than four dozen countries around the world (http;//ciifad.cornell.edu/sri/countries). But except for some countries like China, India, Vietnam, Cambodia, Indonesia, Thailand, total area and number of SRI adopting farmers is still small.

History of SRI in Nepal

SRI was first introduced in Nepal in 1998 with some initial trials in Khumaltar (Evans et al 2002). Nepal was one of the first countries outside Madagascar where SRI methods were piloted. Most of the early SRI trials did not produce expected results and were not very encouraging, perhaps because there was not adequate water control to maintain aerobic soil conditions (Uphoff 2006). In 2002-2003, Farmer Field Schools in the Sunsari-Morang Irrigation Project undertook replicated SRI trials which produced an average of 8 t/ha of grain yield, more than that produced by either improved or conventional practice. This was a turning point when SRI was given attention as an alternative method in rice farming. A number of research activities grew thereafter and the results showed superiority of SRI over conventional system of rice cultivation with respect to yield, use of water and economic benefit. (Bhatta and Tripathi 2005, Dhakal 2005, Uprety 2006). People and Resource Dynamics in Mountain Watersheds of the Hindu Kush-Himalayan Region (PARDYP), sponsored by the International Centre for Integrated Mountain Development (ICIMOD), began SRI program in 2004 with few farmers in Jhigu Khola watershed area in central Nepal and expanded the program to 15 villages in 2005 where over 100 farmers participated in SRI Farmer Field Schools (FFS). In 2008, SRI was successfully introduced at Madana (2500 m), southern part of Humla district of Nepal. At the same time, SRI tested in Tarai revealed that excluding weeding cost, there was 28% yield advantage with 20x20 cm and 33% with 30x30 cm spacing over farmers' practice with manual weeding (NARC 2008). In 2010, demonstration plots of SRI were established in Kailali and Dolpa districts. Several SRI trainings in early 2011 involving government agencies, UN and bilateral aid groups, and national NGOs increased the spread of SRI in different parts of the country. At the same time study conducted in 4 Village Development Committees in Morang district, farmers were found to have achieved 118% increase in rice yield with SRI methods compared to non-SRI methods (Karki 2010). Similarly an experiment conducted in Chitwan showed that grain yield was higher by 49% (8.8t/ha) as compared to farmers' conventional practice (Dhital 2011). In early 2012, the Ministry of Local Development prioritized SRI as an important intervention for food security in Nepal (SRI-Rice 2014b). In 2013, several research articles were published indicating successful adoption and adaptation of SRI over the past few years (Dahal and Khadka 2012, Dhital 2013, Basnet 2013, Khadka and Rawal 2013, Uprety 2013). It is estimated that the total area (as of mid-2013) covered by SRI is around 1,000 hectares stretched over 35 districts in Nepal (SRI-Rice 2014).

SRI method has been tested and promoted in Morang since 2003. In 2015, average yield of SRI farmers was 6.4 t/ha (3.2-9.9 t/ha) in spring season and 5.5 t/ha (3.5-7.8 t/ha) in rainy season. Yield variation was because of varieties and soil conditions, but in both seasons SRI yield was visibly higher than the district average (4.1 t/ha). Yield variation of rice was different according to varieties used in SRI method. Masinu (different Basmati varieties) produced lowest average yield (4 t/ha) which was almost double the yield of those varieties produced by conventional methods. Chaite-2, coarse grain, short duration (120 days) and high tillering variety, produced highest yield (9.9 t/ha) followed by Ranjit, Hardinath-1 and Swarna Sub-1. Fine grain varieties Samba Masuli Sub-1 produced 5.3 t/ha with average yield of (4.2-6 t/ha).

The SRI controversy

In a short span of time SRI travelled a long distance around the world. Initially its proponents were concentrating in its promotion, rather than research about its mechanism behind the performance. So, majority of publications are focused on SRI principles and practices as well as report on cost benefit analysis. They were published to disseminate the information to the new people. Similarly, in later stage, large number of research based papers were published in standard review journals and presented in different international seminars and conferences.

Among the publications, several reported about higher yield of SRI method in comparison to conventional method (Barison 2002, Anthofer 2004, Satyanarayana 2004, Kabir 2006, Sato 2006, Uprety 2006). Some of them reported SRI as a "water saving method" (Singh and Talati 2005, Sato 2006, Bindraban et al 2006, Ceesay et al 2006). However, these claims of yield increase have been received with skepticisms or outright dismissal by several scientists. Critics pointed to the constraints of underlying physiological mechanisms and the extents to which SRI has indeed been adopted (Dobermann 2004, Latif et al 2005, McDonald et al 2006). Such controversies and criticism have decreased after 2007 and several new findings were published from around the world about SRI mechanism. There are some debates about SRI regarding cost of production and profitability within available literature. Latif et al 2005, Barison 2002 reported about high production cost for SRI method but others contradict with those findings (Uprety 2006, Anthofer 2004). But there is no more contradiction about SRI profitability, everywhere.For the resource poor farmers it is more profitable than conventional methods (Anthofer 2004, Barison 2002).

SRI faces serious criticisms mainly from the scientific circle as having unconfirmed field observations (Sinclair and Cassman 2004). The main basis for this claim is said to be the paucity of empiricism regarding SRI as expected by the scientists (Uphoff 2011). Sinclair and Cassman (2004) referring to Sheehy et al (2004) stated that there was no evidence found for the yield advantage claimed by the SRI system and they even proposed that yield reported in SRI system should not be accepted. Latifa et al (2004) in Bangladesh, after a series of experiments, reported that several of the key management principles stated in SRI, in fact, had little effect on rice yields, increased labor demand and poor economic performance, making it an unattractive choice for rice farmers in Bangladesh. Critics of SRI have pointed out correctly that little agronomic research had been done on the new rice methodology at the time to support some of the claims made about it when these were first presented; there were indeed few published articles in the peer-reviewed literature (Uphoff 2011). However, due to the dominance of research paradigm focused on the high yielding agro-chemical responsive varieties and associated technologies, SRI still faces resistance from scientific communities in many countries.

Conclusion

To increase the productivity and production of rice, SRI has been found effective but it may not be suitable for all farmers and across all types of agro-ecological situations. It was observed that farmers tested and tried to re-shape any new technology according to their agro-ecological and socio-economic situations and within their boundaries. They choose doable part of any package of practices/technology for their regular use which is a mix of conventional and SRI method. So extension agencies need to facilitate technology dissemination process, just to provide all possible alternatives of improvement. This enhances farmers to choose appropriate practices for their situations. SRI package (younger seedling, early weeding, mechanical weeder, use of organic manure and AWD irrigation) will be useful to increase yield of rice farmers. Water plays a vital role to choose appropriate rice farming system. So improving water distribution systems and maintaining its reliability will be a positive intervention to disseminate SRI method.

Acknowledgements

The authors would like to thank and appreciate Mr. Dila Ram Bhandari, Director General of Department of Agriculture, for his continual efforts and initiation in preparing such a historical document. The author would also like to express

sincere thanks to those who have directly or indirectly contributed with constructive feed backs and suggestion during preparation of this manuscript.

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Grain Legumes in Rice Based Cropping System of Nepal

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सारांश

नेपालको धान खेती पद्धतिमा कोशेबाली खेती अभिन्न अंग हो । कोशेबाली खेती नेपालमा धान खेती गरिने तराईका खेतदेखि पहाडका बारीको डिलमा समेत गरिन्छ । यसलाई बालीचक्रमा केही स्थानमा एकल बालीको रूपमा खेती गरिन्छ भने केही स्थानमा धान तथा तेलहन बालीसँग मिश्रित बालीको रूपमा खेती गरिन्छ । यसरी कोशेबाली खेती गर्दा बाली विविधीकरण तथा बाली सघनतना बढ्नुका साथै माटोको उर्वराशक्ति बढ्ने तथा बालीमा रोगकिरा लाग्ने समस्या कम हुन्छ । त्यसैले धान बालीको उत्पादन दिगो रूपमा बढाउनको लागि नेपालका विभिन्न क्षेत्रमा गरीने धानखेती पद्धतिमा कोशेबालीलाई समावेश गर्न अपरिहार्य छ । यसै लेखले नेपालमा कृषकले अपनाएका धान तथा कोशेबाली खेती पद्धतिको छोटकरीमा विवेचना गर्ने प्रयास गरिएको छ ।

Summary

Grain legumes are an integral part of cereal based cropping system of Nepal. They have been grown under conditions ranging from those in upland to lowland rice bund. Legumes are grown as a sole crop in crop rotation with rice or in mixture with oilseeds. They could also be grown as a intercrop or relay crop on rice bunds. The major principle behind this system is benefits from crop diversification, intensification, restoration of soil fertility and reduction of risks due to pests and diseases. Thus to sustain and improve rice productivity, legumes have 'to be introduced in rice-based cropping systems (RBCS) in different rice-growing areas of Nepal and this article attempts to briefly describe different cropping systems in rice and grain legumes prevailing in Nepal.

Keywords: Cropping system, Intensification, Intercrop, Legumes, Relay crop, Rice, Soil fertility

Introduction

Grain legumes have been grown under conditions ranging from those in upland to lowland rice bund in Nepal since time immemorial. In Nepal, more than dozen grain legume species are cultivated in altitude ranging from 160-2400 m either as sole or mix or intercropping. Therefore, grain legumes are an integral part of cereal based cropping system of Nepal. They have significant contributions on: crop diversification, intensification, restoration of soil fertility and reduction of risks due to pests and diseases. Moreover, grain legumes supply dietary protein of majority of Nepali and have considerable potential for export. Soybean (*Glycine max* L. Merril.), blackgram (*Vigna mungo* L. Hepper.), cowpea (*Vigna unguiculata* L. Walp), ricebean (*Vigna umbellata* L. Ohwi and Ohashi), common bean/rajma (*Phaseolus vulgaris* L.) and horsegram (*Macrotyloma uniflorum* Lam. Verde.) are important summer legumes grown in mid to high hills. While, in Tarai lentil (*Lens culinaris* subsp. *culinaris* Medikus), pigeonpea (*Cajanus cajan* L. Millsp.), chickpea (*Cicer arietinum* L.) and grasspea (*Lathyrus sativus* L.) are grown as sole crop in rotation with rice or in mixture with oilseeds. Grain legumes are grown as intercrop/mix crop/relay crop or on rice bund. Availability of short duration determinate grain legumes varieties such as mungbean (*Vigna radiata* L. Wilczek), cowpea (*Vigna unguiculata* L. Walp) and kidney bean made possible to increase crop intensity of rice-maize and rice-wheat system in Tarai and river basins in mid hills (Shrestha et al 2012). In upland rice (Ghaiya), the common practice of farmers is direct seeding of dry seed broadcasting. The cropping systems involving rice and grain legumes in Nepal are:

Lowland rice (Blackgram or Soybean or Pigeon pea in bund) – Wheat + Field pea or Chick pea
Lowland rice (Blackgram or Soybean or Pigeon pea in bund) – Wheat + Tori + Field pea
Lowland rice – Maize/Mung bean or Cowpea

Lowland rice – Wheat – Mung bean or Blackgram
Lowland rice – Rajma – Spring Maize
Lowland rice + Pigeonpea (on bunds)
Lowland rice - Lentil or Chick pea – Fallow
Lowland rice – Lentil – Spring maize
Lowland rice – Lentil – Rice
Lowland rice/Lentil or Grasspea – Fallow
Lowland rice – Lentil + Field pea + Linseed + Grass pea
Lowland rice – Lentil + Tori or Mustard – Maize (or fallow)
Lowland rice – Fieldpea – Maize
Upland rice (early) – Blackgram
Upland rice + Soybean
Upland rice/Green Blackgram - Wheat (Deukhuri valley)
Symbols:/= relay, + = inter or mix cropping, - = followed by

Bund planting of grain legumes

Rice bunds are prepared in lowland field or irrigated rice fields. After the completion of rice transplanting, the seeds of grain legumes such as soybean, blackgram, ricebean or pigeonpea are dibbled in weed free bund. Seeds of soybean, blackgram and ricebean are directly planted on the edges of rice fields (bund) in lowland (*khet*) mainly in hills/midhills, and to small extent in inner Tarai. In Bamti Bhandar VDC of Ramechap, there is also a practice of raising soybean seedling in nursery and transplanting 20-25 days old seeding in rice bund. Soybean as allay or intercropping with irrigated rice is also practiced in high hills (2,400 to 3,050) of Jumla (Paudel 2011). Growing small seeded determinate or semi-determinate ricebean on rice bunds is a very common practice in mid-western and far-western regions of Nepal (Khadka and Acharya 2009). In Sundarbazar VDC of Lamjung, and Purkot and Bhanu VDCs of Tanahun farmers grow rice bean and cowpea on the bunds between rice fields (Adhikari and Haefele Undated). In Ramechap, ricebean is planted on mid May to mid July on rice bunds particularly at lower foot hill regions where farmers do not provide stakes for ricebean but instead, upper shoots or tips of vine are cut down to maintain size (Paudel 2008). Indeterminate rice bean is grown in larger terraces bund when plants grow hanging from bund. In Lamjung district (Bhujung VDC), farmers practice rice bund planting of finger millet.

Figure 1. Bund planting of soybean in mid hills

In central and eastern Tarai, pigeonpea and or blackgram are grown on rice bunds. Post rainy season (Aug/Sept planting) pigeonpea varieties (medium-duration) are popular in the eastern part.

Figure 2. Bund planting of blackgram and pigoen pea in central Tarai

Mix/intercropping of summer grain legumes

In mid western mid hills (Surkhet), farmers practice mixed cropping of soybean and upland rice (Ghaiya Dhan), where soybean broadcasted at first weeding of rice. Tharu communities in Deukhuri valley have traditional practice of relay cropping of local green mash (green blackgram, *Vigna mungo* with early maturing local rice varieties (RK Neupane, personal communication). Local green mash is relayed under rice, harvested in Nov/Dec and wheat sown immediately.

Relay cropping in rice

Traditional farmers of Tarai grow lentil, chickpea and grasspea as relay crop in rice. Lentil, a rich source of protein (20-25%), Fe (64-127 mg/100 g) and Zn (35-88 mg/100 g) (NGLRP 2006 2008) is the major grain legume of Nepal, and under rice relay system occupies about 50% of lentil area. The optimum time of lentil relay is broadcasting of seeds 1-2 weeks prior to rice harvest. Similarly, Grasspea the most adapted crop to drought and excess soil moisture conditions (Adhikari et al 1987) is also considered as valuable fodder and tender leaf as green vegetables is relayed in rice. In Tarai, farmers grow short duration cowpea, pigeonpea and mungbean (*Vigna radiata* L. Wilczek) as relay cropping in upland rice (RK Neupane, personal communication). Some traditional farmers of Kathmandu Valley practice relay cropping of pea (*Pisum sativum* L.) and fababean *(Vicia faba* L.) with rice (comm. RK Neupane).

Figure 3. Broadcasting of lentil 1-2 weeks before rice harvest

Technologies

Most of technologies generated upto now are for sole crop in system perspectives. There has been very little work on grain legumes inter or mix cropping with rice or bund planting in Nepal. Some of suitable varieties for intercropping, bund planting, planting ratios are presented here.

Varieties

Soybean variety Lumle-1, white color grain containing 53% protein recommended for low to high hills (400-1600 m), and excellent for bund (*Khet* land, 300-1200 m), produced 22% higher yield than local and Seti in Lumle research command area (Sthapit et al 1989) with relatively soft seeds (Joshi et al 1994).

Table 1. Soybean varieties for intercropping and bund planting in Nepal domain

Cultivars	Parentage	Year release	Cropping system	Recommended Domain
Seti	KS 419 x KS 525 (Taiwan)	1990	Maize Intercrop/bund	Mid hills
Lumle 1	Local selection (Nepal)	1994	Bund, Maize or Millet intercrop	Khet land (300-1200 m) Bari land (1200-1500 m)
Puja	PK 416 (India)	2006	Mono/Maize Inter/bund	Tarai/inner Tarai
Sathiya	Local (Nepal)	-	Bund planting/Maize intercrop	Mid hills

Sources: Subedi et al- Up-date research highlights of crop science section, Technical Paper No. 7/91, Lumle Agricultural Centre, Pokhara, Nepal, Bharati and Neupane 1989- A Proposal of KS 419 x KS 525, Cobb and DB 1601 Soybean Genotypes for Release - 1989.

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Prospects of Rice-Fish Integration Farming System in Nepal

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सारांश

यस लेखको प्रमुख लक्ष्य एकै स्थानमा धान बाली र माछापालन प्रणालीको समीक्षा गरी आगामी दिनहरूमा धानखेतमा माछा पालन प्रविधि विस्तारको दिशा निर्दिष्ट गर्नु हो । यो उद्देश्य प्राप्तिका लागि चीन र दक्षिण एसियाबाट प्रकाशित भएका वैज्ञानिक कार्यपत्रहरूको अध्ययन गरी यथार्थ जानकारी हासिल गर्ने प्रयास गरिएको छ । प्राप्त धेरै जसो विवरणमा धानखेतमा एकीकृत धान र माछा पालन पद्धतिमा धानखेतीको उत्पादकत्व वृद्धी गर्ने, वातावरणीय दिगोपना र आर्थिक दृष्टिकोणबाट फाइदामूलक रहेको यथार्थ चित्रण भएको पाइन्छ तर धानखेतमा माछा पालन प्रविधिको नेपालमा सन्तोषजनक विस्तार भएको पाइएको छैन । यसो हुनुको कारणमा धानखेत लगायत कृषि कार्यमा अत्यन्त बढी विषादीको प्रयोग प्रमुख रहेको छ । साथै, न्यून उत्पादन, माछाका भुराको सहज आपूर्ति नहुनु, सहायक उत्पादन सामाग्रीको अभाव आदि समेत यस प्रविधि विस्तारमा अवरोधकको रूपमा रहेका छन् । तसर्थ यस अवस्थालाई हृदयंगम गरी धान खेतमा माछापालन प्रविधिको बिस्तारित रूप अन्तर्गत मूल्य श्रृंखलामा आबद्ध सबै अंग जस्तै, ह्याचरी, नर्सरी, सहकारी वा समूह र बजार पनि संलग्न गराई कार्य संचालन पद्धति उपनाउन सकेमा धानखेतमा माछापालन प्रविधिको विस्तार गरी धान तथा माछाको उत्पादन र उत्पादकत्व बढाउन सकिने प्रशस्तै सम्भावनाहरू रहेका छन् ।

Summary

The purpose of the present paper is to review the experiences of rice-fish farming performance and synthesize some future perspectives. To achieve this objective an indepth literature review was done on relevant publications especially from south Asia and China in order to obtain required information. Most studies including our field data suggest that rice-fish integrated farming system is beneficial from various perspectives for increasing productivity, environmental sustainability and economic benefits. Despite the fact that the rice-fish integrated approach has been poorly adopted in recent past, most likely due to indiscriminate use of pesticides in the rice fields. Other inherent criticism had been the low fish volume output, readily unavailability of fingerlings and accessories including inputs needed in this system. Most of the problems were also due to the rice-fish farming practices which were performed only in small units of rice field. To overcome the problems of low fish volume output and several others, it is suggested that the rice-fish integrated farming system should be operated, at business scale with value chain actors acquainted with hatchery, nurseries in vicinity for timely supply of quality fingerlings, to rice-fish systems operation in group or cooperatives with market facilities. This way, better harvest and benefits could be obtained leading to faster adoption of the technology in this system.

Keywords: Adoption, Pesticides, Productivity, Rice, Rice-Fish farming, Value chain

Introduction

Rice-fish integrated fish farming is one of the most ecological and environmental friendly approaches of rice and fish production together from the same space where rice alone was produced (Dela Cruze 1994, Gurung et al 2002, Halvart and Gupta 2004, Hu et al 2016, **Figure 1**). There are probably very rare commodities except aquatic organisms which can be collectively cultivated in rice-field along with rice cultivars. Recently, not only fin fish but ducks, prawn, crab and pearl are also known to have been cultivated along with rice in rice fields (FAO 2001, Fernando 2002, Hu et al 2016). These examples suggest that actually the rice-fish integrated technology, if harnessed properly considering the coverage area of rice cultivation, indeed possess immense potentiality for overall productivity enhancement (Little et al 1996, Berg et al 2012, Baba et al 2013).

Rice-fish farming is one of the primitive agriculture practices in Asia (Yunus and Hardjamulia 1989, Dela Cruz 1994, Halwart and Gupta 2004, Miao 2009). However, it was only in 1964, Department of

Agriculture, introduced rice-fish farming system in Nepal (Wagle 2000). Despite of highly encouraging physical, technical and economic feasibility of rice-fish farming in mountain valleys and terraces of Nepal, the technology has not been widely adopted due to several technical, socio-economic and management problems (Gurung 2013). Presently, the area under rice-fish farming is estimated to be about 100 hectare producing only 45 tonnes of fish per year (MoAD 2014) in Nepal.

Rice-fish farming enhances land productivity by mutual interactions between rice and fish in rice field (Halwart and Gupta 2004, Tsuruta et al 2011). Actually the production of rice in rice field due to the space occupied by trench and refuse do not reduce, contrarily and very interestingly increases (Gurung et al 2002, Hu et al 2016) rice yield. Studies in Nepal have shown that the yield of rice in average increases about 12-16% on addition to the fish yield. The increase in rice yield despite decreased in areas was due to the increased nutrient load by fish (~2 g per fish per day) that enhances the rice productivity along with fish activities such as browsing and feeding controlling parasite, harmful insect, better aeration to rice plant (Tsuruta et al 2011). The activities by fish around paddy roots damage parasite colonies, control weeds by which rice productivity are enhanced (**Figure 1**). In Nepal, the fish production under the rice fish integration in a season was about 529 kg per hectare per season in mid hill conditions (Gurung et al 2002).

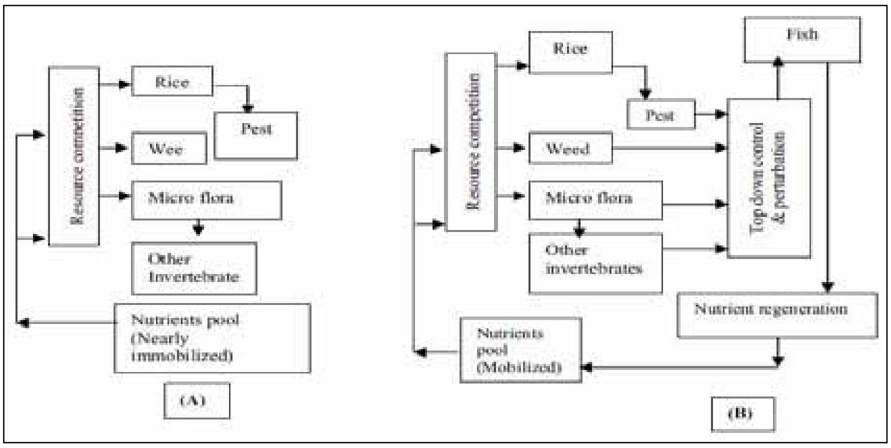

Figure 1. A schematic representation of abiotic–biotic factor interactions in rice-fish integrated system for enhancing rice and fish production
Source: Gurung et al 2002.

Generally, small volume of fish harvest is one of the major criticisms of rice-fish farming due to short culture period and other problems such as stocking of small size fish (Fernando 2002). Since, fish in rice field is an intermediate crop produced with fairly small efforts and investment, therefore fish yield should not be considered small in terms of socio-economic impacts. Instead the fish output from the rice field should be considered as ‘Bonus’ out of the rice field. However, the young farmers involved in other agricultural activities in vicinity such as tomato, potato and other vegetables production actually compared and expressed discontent that the turn over from the rice field is meager.

Fish is one of the most acceptable foods in Asia. Traditionally fish is one of preferred animal protein as food for every segment of population. In Nepal, fish consumption per capita is far below than those of other Asian countries and global fish consumption (Gurung in press). Main reasons of low fish consumption are associated with scarcity of fish and poor economic conditions prevailing in rural areas. Such problems could be overcome by expanding simple and low-cost fish farming practices in rice fields, which might help to increase rice as well as fish supplies not only for nutritional benefits but also for additional employment opportunities to the population living in remote and rural parts of the country.

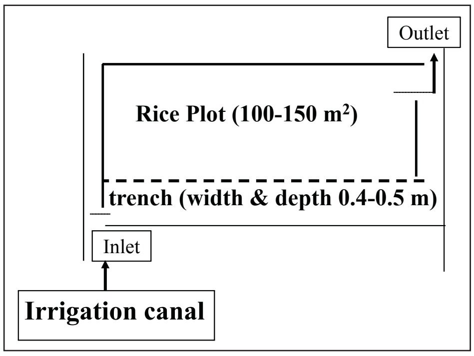

Figure 2. Trench design for rice-fish culture in rice field

Unwise use of insecticides for increasing agriculture production has resulted poor soil fertility and environmental degradation for sustainable land use and biodiversity. Rice-fields are natural and common feeding and breeding ground for many fish. In the past, rice fields were used as fishing ground. However, indiscriminate use of insecticides has made the rice field as forbidden habitat for fish. Recently, public health hazards and adverse impact on biodiversity, and soil fertility due to the rampant use of insecticides have been more apparent and realized. As one of the solutions for controlling the harm of insecticides in agriculture sector, IPM (Integrated Pest Management) techniques have been recommended as a tool for pest control using biological methods (Dela Cruze 1994).

In Nepal, the concept of rice-fish farming was implemented as one of supplementary activities by the government agencies around 1960-70 (Wagle 2000). At the beginning the practices was well accepted by the farmers, but gradually the practice faded away due to several reasons, such as very low priority to the program despite of huge potentiality and popularity. So, in this paper we aim to review the history, initiation, partial success, lesson learnt, new efforts, findings and way forward to scale up the rice fish farming in Nepal. During 2000-03 with the support of Hill Agriculture Research Project and Nepal Agricultural Research Council conducted some field tests to access the production level of fish and rice in rice-fish integration in mid hills and probably, the first time in southern plains Tarai (Gurung et al 2002). The results were encouraging especially in southern tarai showing the results that instead of using smaller, comparatively larger rice-field for integration with fish production gives better results and the general criticism of low volume fish production might be overcome.

Origin of rice-fish farming system abroad and Nepal

Rice-fish farming originated in China in the in ancient time (Fernando 2002, Miao 2010). Still China ranks the number one lead country in having practices of rice fish farming in the world. Besides that Indonesia, Malaysia, Bangladesh, India, Burma, Thailand and several other countries are known to have substantial practices of rice-fish integrated farming. In Nepal, practice of rice-fish farming was initiated by then Fisheries Development Section of Department of Agriculture, where fry of common carp was recommended to stock at the rate of about 250-300 per *ropani (*500 m^2) of rice field after putting screen at the inlet and outlet of the rice field with purpose to prevent the escape of stocked fish and unnecessary entry of unwanted wild fish (Pradhan 1979).

The fish stocking was recommended after two weeks of rice plantation so the roots of the rice plant could hold the soil adequately. The dikes of the rice field was recommend to be at least 2.5 feet wide and tall, so water could be hold adequately without any seepage. It was also recommended to raise the water level gradually in the rice field with baby fish getting bigger and rice plant getting taller. In the rice field conventional feeding was also recommended and suggested to harvest the fish about 1-2 weeks earlier than the rice. This approach applied in some parts of Bhaktapur, Kathmandu and Lalitpur district were successful. But, the increasing advocacy of using pesticides in those days to control the rice pest for increasing production seemed fatal to integrated rice-fish integrated farming approach. The other reasons were rapid urbanization and increasing prices of agricultural land, which not only harmed the rice-fish integration approach, but was fatal to agriculture production especially in peri-urban areas.

Rice field as natural habitat of fish

In Nepal the concept of fish harvest from rice field is a very primitive because rice fields are the natural habitats for fish, where many fish prefer to breed and use the productive, warm and secure place to use as nurseries for small hatched out larval fish. Indeed rice field provides quality planktonic food to nurse the hatchlings and fry. Thus, rice fields could be designed to hold more fish, if someone is willing to harvest not only the rice but both fish as well at business or commercial scale. Still the scene of angling in rice field in remote areas could be seen easily in rice field during post monsoon; nevertheless the efforts nowadays may not be that rewarding to anglers.

Capture of fish in rice fields in mountain valleys, hills, and Tarai is a primitive practice since ancient time in Nepal. Earlier, Until 25-30 years ago around 1984-85 (before extensive use of pesticides), the villagers used to visit rice fields to capture the fish in special basket made up of bamboo sticks. The other popular method was the use of rod and line for catching fish. The fishing by using bamboo basket trap and rod was common in all areas of Tarai, inner Tarai and mid hills. The fish captured in rice field were either consumed at home with family or excess fish were sold to others. Mostly the species captured belonged to '*Sidre*', '*Kande*', '*Fusre*', '*Bhitte*' (mostly *Puntius* spp, *Barilius* spp) and '*Bhoti*', '*Hile*' (*Channa* spp) in mid hills as well tarai. These species mostly breed in monsoon season on flooding water in rice field. The *Puntius* and *Channa* migrate up to the rice field from streams, lakes and ditches for spawning in rice field. Since the rice-field offer abundant food, warm soothing water temperature, and gentle or delayed flows of the water, thus favoring the best location for nursing of larvae in productive water. Generally the fish captured by bamboo baskets and angling were 'spent' adults, which already released the ova and milt.

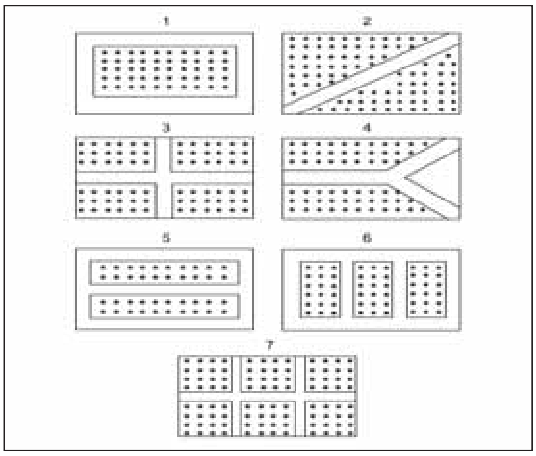

Figure 3. Design and construction of fish trenches in rice-fish farming, common practice in Indonesia, 1- Peripheral trench, 2- diagonal trenches, 3- crossed trenches, 4- Y-shaped trench, 5- peripheral with one central longitudinal trench, 6- peripheral with two equidistant transverse trenches, 7- latticed trenches (After Halwart and Gupta 2004).

General practices of rice-fish integrated farming in Nepal

In general, the practice of rice-fish farming occurred mostly in peri-urban areas not very farm from the

Figure 4. Rice-fish farming with trench system where no rice plant has been planted

Figure 5. Rice-fish farming with centrally located refuse system where no rice plant has been planted

town, and in those rice plots which are not very far from the farmers house. The pit or trench or refuse along with the dikes are prepared first (**Figure 3, 4, 5, 6**). The net screen to fit that into the inlet and outlet should also be prepared beforehand. All usual practices of fertilization and harrowing are performed other than, where trench or refuge is located. The rice field after harrowing as per norms, standard ways of straight row planting at 25-30 cm between row to row with 3-4 seedlings is performed. The inorganic and organic manure application would be DAP, Urea, Potash for basal dose before transplanting and urea for top dressing.

In early first week the planted rice cannot hold the soil adequately, therefore they are left to grow for next 2 weeks after the plantation. Then, first the screen nets are installed at the inlet and outlet. Water is filled into the trench, pits or refuse. Fish are stocked into the rice field. The size of the baby fish preferably should be bigger than 5 g, but may depend on the availability and the purpose of fish rearing.

Care should be taken to check the water temperature in the rice field as a precaution. If the water temperature in the rice field and bucket or bags where fingerlings are contained differ drastically with a difference of more than 2^0C and the timing is not appropriate for example strong sun shine afternoon, then there could be high risk of thermal shock to fish causing mortality of the fish. Therefore, preferably the stocking time onto the rice field should be either in early in the morning or evening without differences in water temperature in the rice field and the bags containing the fingerlings. If it is raining, one can stocks the fish even in the middle of the afternoon after balancing the water temperatures in container and the rice field.

Figure 6. Growing fish in rice-fish farming been planted (A) rice field with slightly extended trench

Figure 7. Extended trench (A) cum refuse (B) in integrated rice-fish farming in western Tarai

After stocking the fry or advanced fingerlings they should be carefully monitored. If neighboring farmers want to use the pesticides for controlling pest, they should be politely consulted. In such case for the safety of the fish the inlet stream should be blocked or diverted to flow the toxic water for 3-4 hours to other sides, but not in the plot where fish have been stocked. This sort of management can rescue the fish in rice fish by avoiding the use of poisonous water. If the toxic water could not be diverted and concentration of the pesticides is high, there could be probability of fish dyeing in the rice field (**Figure 8**).

After releasing the fish into the rice-field, from next day they should be fed. If commercial fish feeds are not available finely grinded chicken feed can be fed. The moist feed dough can be prepared and put that into some container in the trench area (**Figure 9**). If pellet feeds are available that can also be fed. Generally, the feeding should be carried out always in same place. The feeding rate could be 2-5% of the total body weight of the stocked fish at least twice a day. The rice could be routinely fertilized as per schedule with organic and inorganic fertilizers; these would not harm to the fish, instead the fertilizers support the growth of the fish indirectly via production of natural food to the fish.

Figure 8. Fish mortality due to pesticide contaminated water in rice field

Figure 9. Feeding tray setting and feed for stocked fish in rice-fish system

With gradually increasing height of the rice plant the water level in the rice field should also be raised. The increasing water level in rice field helps to increase the natural food for fish, and also allows free movement of fish to all the parts of the rice field. This actually facilitates the fish to graze all around the rice field because of their access to all parts of the rice field. As a result the fish might grow faster in such environment. The fish in the process of grazing, especially the common carp (*Cyprinus carpio*) browses the bottom sediments of the rice field. This process released the deposited nutrients into the water column which are readily absorb through the roots of the rice, and planktons also uptake the nutrients. These uptake and absorption help to grow faster the rice plant. The browsing activities of fish might turn the water turbid which does not allow the sunlight to reach into the bottom. This hinders the growth of many weeds and other plants germinating and growing in the rice field. On the other hand, the fish feedings, swimming and grazing activities shook the plants. In this process insects are fallen down into the water and consumed by fish. These actions reduce the impact of insect pests on rice plants. Many bacterial and viral colonies developing in the roots of the rice plant are known to be consumed and destroyed by the fish activities.

Figure 10. The stocked fish in the rice-fish farming (A) and some harvest in the trench (B)

Figure 11. Some harvested fish from rice-fish integrated farming

Care should be taken during the heavy rainfall to check the water level, flood situation, over flow, choking of the inlet and outlet stream which might cause trouble in the rice field. The stocked fish in the rice field should be checked time to time along with the rice for their proper growth and general health conditions (**Figure 10 A**). Generally, common carp in time interval of about 120-150 days should reach about 100-200 g individual weight, if properly grown in appropriate stocking density. In favorable conditions bigger size fish can also be expected, similar to smaller size in unfavorable situation. At the end, generally fish should be harvested or transferred 1-2 weeks before the rice. Because, maintaining the water level in the rice field might delay the rice ripening. Therefore, fish are removed first, in general (**Figure 10 B, 11**).

After stocking the fingerlings into the rice field, many predators like snake, birds and frogs might cause harm to the fish. In such case, the snake can be captured by putting snake traps in the rice field. The snake trap can be easily prepared by using the chicken mesh wire (**Figure 12**). The trap should be half sunken horizontally into the rice field after putting a frog inside the trap as bait. The snake might enter into the trap to eat the frog but cannot get back from the trap.

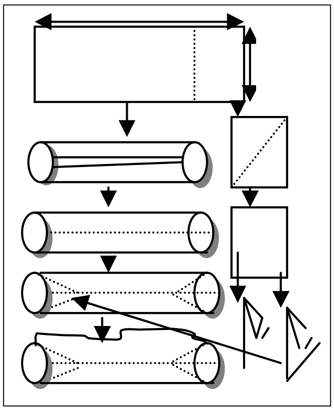

Figure 12. Construction of snake trap by chicken mesh net

Potentiality of rice-fish farming system in Nepal

Nepal is basically the rice consuming country similar to many other south East Asian countries. Fishes food is acceptable to all ethnic communities without any controversies. However, the mountain and hills are comparatively deprived of fish availability comparing to southern Tarai where thousands of wetland and floodplains provide more opportunities to supply in household level (Gurung 2016). This fact is also supported by the fish species richness in the southern plains. Moreover, the present average of 529 kg/ha fish yields from rice field suggest, if only 22% of irrigated rice field could be brought under rice-fish farming. The total yield of fish from rice-fish farming alone could achieve concurrent national fish production of about 31723 t/year, which is total production of different aquaculture and open water fisheries activities of Nepal (Gurung et al 2002). These signify the importance and potentiality of rice-fish farming in Nepal. However, indiscriminate use of pesticide in rice field, accessibility and supply of inadequate large-size fish seed is one of the main constraints for poor adoption of rice-fish farming. Gautam and Yadav (2007). reported that in early rice (spring rice), fish farming in field condition in Jhapa district with *Nila tilapia* and common carp, rice yield increased 4-10% in rice-fish integration over sole cropping of rice.

Evolutionary trends of rice-fish farming

The improvement in rice-fish farming seems to have taken place in Nepal in following steps.

- Rice field with some improvement in dikes, inlet and outlet
- Rice field with trench
- Rice field with pit system
- Rice field with refuse system

Rice field with some improvement in dikes, inlet and outlet

It is recommended that the stocking of fish into the rice field for integration is only possible after some improvements in dikes, inlet and outlet. In general, the rice field require to hold more water than in usual in rice-fish integrated system, thus on precautionary scale the dike of the rice field should be relatively stronger with slightly more width (**Figure 3, 4, 5, 6, 7**). In general the recommended dike should be around 2.5 feet wide (Prada 1979). However, the width of the dike might depend on the scale of rice-fish operation as well as location. If the operation of rice-fish has to be operated in larger area for example in one hectare or more areas in southern Tarai, it is not only the width but depth also might need to be extended by about 1 or 1.5 feet considering the slopes, contour and location etc.

The rice field where fish stocking is intended should also have screens at the inlet and outlet ends, so the fish would not escape through water flows from the rice field. Care should be taken that mesh size of the net must be smaller than the size of the stocked fish. To some extent the mesh net might also control the entry of unwanted fish and other organisms inside the rice field (Prada 1979).The dikes should high and strong enough to hold at least 30 cm water in the rice field without leakage and seepage. The plots for rice-fish farming should be located close to the reliable irrigation or water supply system.

Rice field with trench

The trench is a pre-requisite to make the rice-fish farming successful. The trench is deep part of rice field which are often constructed close to the dike or differently in various location of rice-field depending on the choice and other requirement (**Figure 4, 5**). The trench is about 1.5 to 2 feet deep shallow part that accumulates more water to hold the fish securely at the time of drought, intermittent water supply or other emergencies. Generally, water temperature in rice field in the afternoon increases substantially high, in such emergency when the fish cannot tolerate the heat they can hide and protect themselves in relatively cooler water in the trench. The trench can be constructed of various designs that have been shown in **Figure 3, 4**.

Rice field with pit system

To take the better advantages of fish production in integrated fish farming, pit system is also used (**Figure 5**). In this system, a pit of circular, rectangular or circular shaped are dug either on middle or corner side of the rice field. The pit size may vary according to the size of the rice field. The depth of the pit is maintained at about 2 to 2.5 feet to hold the water and fish during the emergency. Generally in areas where poaching is problem, in such case farmer prefer to construct the pit in the middle of the rice field. The pit could be made a little more spacious by linking the pit with trench in the rice field (**Figure 5**).

Rice field with refuse system

More professional farmers who are well acquainted with the benefit of rice-fish integrated approach mostly prefer the construction of refuse system in rice field. The refuse system is actually a smaller pond attached to the rice field. Where, water level in rice field and refuse ponds are continued, so the fish could easily access the rice field for grazing or feeding activities (**Figure 7, 8**). Usually the refuse system that is a smaller pond along with the rice field may be slightly deeper of about 1 m than the rice cultivated area covering approximately 10% of the total area of the rice field. At maximum, the water depth of 20-30 cm could be maintained in the area of planted with rice depending on the height of the rice plant. In rice fish culture with trench and refuse pond system, total requirement for growing season (maintained) of 151 days to 210 days.

Which fish and rice varieties are suitable for rice-fish integrated system?

The most acceptable fish species suitable to integrate with rice since ancient period is Common carp (*Cyprinus carpio*) and *Tilapia*. The general features of the fish which are suitable to grow with rice integration should be growing well in shallow water, resistant to water temperature fluctuation, high tolerability to high water temperature, low dissolved oxygen, turbidity and easy to market in smaller size.

In many areas of China and other parts rice fields are also used to grow small fry to fingerlings stages (DelaCruz 1994); even hatchlings can also be nursed to fry stage (Halwart and Gupta 2004). Such skill of fish handling could be acquainted with increased experiences on rice-fish farming. In China grass carp, bighead, silver carps are also cultivated in the rice-field in integrated approaches. In rice-fish integration the preferred stocking size of fingerlings is 5-10 g at the stocking density of 7500 per hectare. Bigger the fish at stocking, bigger fish can be expected at harvest.

Fish harvesting should be carried 10-15 days before rice harvest, when rice grain become harder. The early harvest of fish allows the drying of the rice field and thus the rice. If the fish are too small at the time of harvest one can transfer the fish into other rice field or ponds for further growth. In general, it has been estimated that production of fish might occur 100-200 kg per hectare in one cycle without feeding, while in feeding condition the production might achieve up to 400-500 kg per hectare with relatively larger size fingerlings about 5-10 g at stocking. Saikia and Das (2008) claimed the production of fish up to 500 kg per hectare in farmer's field of Arunanchal Pradesh reaching the fish up to 400-500g each in a season.

It is not only fish but ducks (Practical Action 2015) and crabs, prawn are also known to integrate with rice cultivation in many areas (DelaCruz 1994, FAO 2001). Japan was once known to be one of the pioneers in integrating rice-fish farming, but industrialized economy perhaps was the reason that did not allow further advancement.

Suitable rice varieties for rice-fish integration

One of the basic principles of rice breeders is to develop such breed which could mature in earliest possible days giving high yield etc. Since the fish is secondary production and the primary commodity is rice, fish should be prioritized after the rice. In general, fish could be compatible to any specific rice variety. Nevertheless, to harness the best production of rice as well as fish by integrating system some of the desirable traits in rice variety could be expected which might be delineated as follows:

- The rice variety should be of a little more water resistant type.
- Non-lodging, disease and pest resistant, possibly dwarf, high yielding.
- In Nepal, some of the tested varieties of rice in rice-fish integration were *Chaite dhan* (Spring rice), Sabitri and some others (Wagle1989, 2000).

Ecological benefits of rice-fish farming

There are immense ecological benefits of rice-fish integrated farming (**Figure 1**). The fish in the rice field could function as one of IPM (Integrated Pest Management) tools to control and eradicate many of the pests of the rice (Dela Cruz 1994). The common carp and Tilapia are omnivorous fish which consume prey of animal origin as well minute plants (Gurung et al 2002). The control of weed plant is not only through consuming them, but the fish activities in rice field helps to uproot and destroy them. As a result the plants cannot colonize the rice field, and pest cannot rest on the plant for egg laying, spawning and feeding to spread their population. The eggs, larvae or pupae of the prey are consumed or destroyed by fish. The fish also help in weed control in rice fish integrated farming. So the extra cost required for weed removal could be saved by stocking fish into the rice field (Gurung et al 2002). The details schematic diagram how rice-fish integration could give ecological benefit to farmers has been illustrated in **Figure 1**.

Causes for poor adoption of rice fish farming in Nepal

Generally it is blamed that despite long term attempts, the rice-fish integrated approach of productivity enhancement of rice field could not be popularized in Nepal compared to other countries, where the approach is more popular. The main causes of the poor adoption of rice-fish farming could be delineating as follows:

- Unavailability of appropriate fingerlings for rice-fish integration,
- Mortality due to pesticide use by neighboring farmers,

- Uncertainty of fingerlings to be stocked at time appropriate,
- Poor infrastructural set up at organization level of rice-fish farming promoters,
- Poor knowledge of rice-fish integration among farmers and extension agents,
- Lack of policy guidance and support to rice fish farmers,
- Poor participation, ignorance and lack of recommendation for integrated rice-fish farming by agronomists,
- Higher fish escape due to flooding and other reasons,
- Inadequate willingness of farmers to adopt rice-fish farming due to modification requires and cost involvement,
- Theft of the fish,
- Fish loss due to higher predation by water snakes, birds and reptiles,
- Subsistence turnover, uninterested to big farmers,
- Indecisive tenant's due to dual ownership of the rice field and
- Uncertainty of rain fall for water supply

In general, rice-fish farming is a lucrative option to enhance the rice field productivity because the inclusion of fish in rice field could be probably one of the best options. Despite of having such opportunity to harvest not only rice, but fish also at the end, the adoption is poor in Nepal. Why the rice-fish farming could not be popular and rapidly expanded? The answer of this question could be several, which probably can be discussed into following headings:

Social

If fish is cultivated in rice fields far from the owner's house then there are high chances of poaching. In such case the rice-fish farming should be encouraged through cooperative, group or community approach.

The pesticide, although the farmer involved in rice-fish farming may not be using but could be easily victimized to adjacent rice-fish integration if the water from the neighboring user enter into the rice field. In such case the owner should be always attentive and should coordinate with the neighbors using pesticides

Environmental

The poor adoption of the rice-fish farming technology is probably directly associated with the popularity of the pesticide use. The rampant use of pesticides has been considered as one of the main reasons that hindered the rapid adoption of rice-fish farming practices. The rice-fish farming does not prohibit the use of pesticides but the use should be regulated or managed intelligibly.

Technical and input availability

Although the slogan of rice-fish farming might be attractive, but implementation on practical ground by digging trench or refuse is indeed difficult unless the farmers are very well convinced. Because, if the integration is not successful then in next year the farmers would require extra finance and labor to readjust the rice field back in order.

Various inputs are essential to begin a new intervention and most inputs required for the rice–fish farming are not easily available in the market. This unavailability could play a big role for poor adoption. For example, there is a severe lack of appropriate size fingerlings to stock into the rice field. In general, fingerlings more than 5 g body weight are recommended to stock in rice field, but obtaining bigger size fingerlings unless the owner themselves rear them is very difficult for majority of farmers. Similarly, small fish handlings tools and equipment such as drag net, mesh screen, scoop net, fish feed are not easily available in the market. These also hinder the adoption of rice-fish integration. Snake as a predator along with birds and some reptiles could be a nuisance for fish stocked in rice field. The ways of controlling the predators should be taught to farmers.

Institutional

It would be unfair to conclude that rice-fish farming could not be successful in Nepal because adequate efforts from the government and innovation sides have never been continued. The rice fish programs were conducted only on experimental scales, which have been always successful (Wagle 1989, 2000, Gurung et al 2002). However, the recommendation made by such successful results could not be implemented, because of several constraints such as low priorities for follow up, inadequate human resources, motivation etc. The rice-fish farming has huge potentiality, therefore it should be implemented through proper planning and strategy. Until this sector is well established, only the specifically designed institutions should be involved by avoiding institutions targeting to achieve business scale performance focusing Tarai zone for larger land areas. The provision of hatchery ensuring fingerlings supply mechanisms should be developed alongside. The irrigation authorities should prioritize water supply to rice fish farming areas for productivity enhancement.

What is business scale rice-fish operation?

It is assumed that rice-fish farming would have been adopted well if:

- No intervention causing harm to fish by rampant use of pesticides in rice field had occurred,
- If, there would have been plentiful and abundant supply of quality fingerlings close to the rice fields,
- Lastly, if group or communities could have emerged for rice-fish farming approach in villages with larger coverage area so that social security might have been developed under rice fish farming.

So, these assumption lead to synthesize the idea that benefits of rice-fish integration would be more result oriented in larger areas of Tarai area, if communities could be involved for business model operation, comprised of rice-fish farming area with fish hatchery, nurseries for timely supply of fingerlings for rice-fish integration, research, extension governance, irrigation facilities and market place.

Way forward

In Nepal, rice-fish practice have mostly been attempted on subsistent level. Although the rice-fish integration is socially, environmentally, economically beneficial, it is often criticized for low volume output of fish. For possible answer, we questioned whether a business level enterprise associated with several value chain actors could resolve the issues of low volume output? However, in considering several constraints faced in the past during the operation of rice-fish farming practices we would like to suggest that more intensive packages of practice involving: proactive farmers groups or cooperative ensuring timely delivery of quality fingerlings, accessories, input along with marketing and other value chain actors would be the pre-requisite. It is expected that rice-fish integrated activities, if implemented at business scales involving communities especially in Tarai, market, fish hatchery and nursery facilities the promotion and adoption would be rapid. It is anticipated that operating the rice-fish farming approach at business level operation would definitely provide better insight for adoption of the technology at a faster rate. Being socially acceptable, environmentally friendly and economically profitable, rice-fish integration in Nepal in areas where assured irrigation is available both in normal (June-November) and early (February-June) season rice should be promoted. This will help generate income and enhance per unit productivity of rice and fish as whole.

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International Year of Rice, the National Rice Day and Influencing Factors for Increasing Yield Potentiality in Nepal

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सारांश

कृषिजन्य वस्तुको उत्पादन र उत्पादकत्व बढाउनको लागि नेपालले वि.सं. २०३२ साललाई कृषि वर्ष मनाएको थियो । तत्पश्चात् धान बालीलाई महत्वमा राखेर २०६१ सालपछि हरेक वर्षको असार १५ गतेलाई नेपाल सरकारले राष्ट्रिय धान दिवसको रूपमा मनाउँदै आएको छ । धान बालीको उत्पादन बढाउनको लागि सूर्यको किरण तथा तापक्रमको महत्वपूर्ण भूमिका रहने हुनाले जलवायु मैत्री कृषकले धान खेती गर्दा धान बालीमा फूललाग्ने तथा पाक्ने समयमा सूर्यको किरण प्रशस्त पर्ने गरी समय मिलाउनु पर्दछ । कम लागतमा नै खेती गर्न सकिने यस प्रविधिको अनुसरण गरी कम लागतमा नै उत्पादन वृद्धि भई अतिरिक्त आम्दानी हुने गर्दछ ।

Summary

Nepal had celebrated 2032 B.S (1976 A.D) as the Agriculture Year focusing mainly on major agricultural commodities including rice so as to increase productivity and production of crops. Since then (after 2004 A.D), the Government of Nepal has been celebrating National Rice Day on the 15th Asar (last week of June) every year. However, the fact remains that this particular day of the year has been celebrated by farmers for time immemorial. Harnessing solar radiation effectively to increase rice production is the best option for enhancing rice yield in Nepal. Therefore, climate conscious farmers must have to know the distribution pattern of solar radiation in the different months of the year, so as to increase rice grain yields by coinciding the reproductive as well as ripening stages during higher intensity of solar radiation. This is really no cost/non-cash input technology ie free-gift of nature and thus the farmers will be greatly benefited by following this principle without incurring extra expenditure.

Keywords: International Year of Rice, National Rice Day, No-cost technology, Productivity, Rice, Solar Radiation

Agriculture year 1976 (2032 BS)

Nepal had celebrated 1976 (2032 BS) as the Agriculture Year focusing mainly on major agricultural commodities including rice, so as to increase productivity and production of crops. The special issue on 'rice' in Nepali language was also published to mark the occasion. Exhibitions/fairs were also organized. The print and electronic media were used to create public awareness concerning the importance of rice in the country. Upon the request of 43 countries including Nepal, UNO had declared 2004 as the International Year of Rice.

International year of rice 2004

Rice is one of the important and staple foods for most people in the world and it is the crop with the longest history of cultivation. About 1 billion people in the world are still hunger stricken because of insufficient food supply and as many as 14 million children under the age of four die of hunger every year. In 2002, these factors prompted the government of the Philippines, along with 43 other countries including Nepal to formally request that the UN General Assembly declare 2004 the International Year of Rice (IYR). The General Assembly of the United Nations (UNGA), at its 57th session, decided to declare the year 2004 as the International Year of Rice (IYR) with the theme, Rice is Life which reflects the importance of rice as a primary food source, and is drawn from an understanding that rice-based farming systems are essential for food security, poverty alleviation, improved livelihoods, and global peace.

The novel idea about importance of rice to alleviate hunger and enhance livelihood had been circulating among major agricultural organizations since 1999 due to growing concern that fundamental issues needed to be tackled on a global level. Thus, it is obvious that we should promote rice and improve our understanding of on the world's most widely consumed grain. In 1966 too, the UN had designated rice as the first ever agricultural commodity as the Crop of the Year with the theme of Freedom from Hunger. Hunger was the big story in Asia in 1966.

National rice day in Nepal

The author, one of the senior agronomists under the Nepal Agricultural Research Council (NARC) was instrumental for convincing the Government of Nepal to declare Asar-15 (June 29 of each year) as the National Rice Day (NRD) because Nepalese culture of eating beaten rice mixed with curd/yoghurt while transplanting rice in the flocculated mud by almost every Nepali on this very day is a huge cultural phenomena in Nepal. As a result, Nepal during the International Year of Rice-2004 also declared the 15th Asar as the National Rice Day in line with the UNO (Basnet 2004). This was evident from the IRRI that "Year achieves high-profile in Nepal (IRRI 2004)". Since the year 2004 onward, Asar 15 has been the auspicious day for rice planting in Hindu culture where peasants start the day by planting rice and then follow up with a feast of curd and beaten rice (*Dahi chiura*). Since 2004, Nepal is celebrating National Rice Day every year covering the themes such as "Rice is life" or "Support to food security through increasing the productivity of rice (2008 and 2009)"; "Conserve agricultural land and increase rice production (2010); "Promote rice farming, ensure better agro-tourism (2011)"; "Rice-A gift for food security (2012), "Increase rice production, ensure prosperous economy (2013)" and "Modernization in rice farming, minimization in food import (2014)".

Harnessing physiological efficiency for enhanced rice production

Rice is basically a short-day plant. It initiates panicle primordial in response to short photoperiods. Panicle primordia may be initiated late or they may not develop when the plant is subjected to long photoperiods. Rice varieties are photoperiod sensitive, insensitive, weakly sensitive and strongly sensitive. The critical photoperiod of most varieties ranges from 12 to 14 hours. Physiological efficiencies for harnessing rice productivity holds true in a country where there is rainfed rice cultivation in time when sky is hazy and cloudy which is hindering rice productivity in Nepal (Basnet 1987). There are chances of enhancing rice productivity during summer season (February–June) when effective solar radiation could be harnessed and by providing irrigation facilities. Followings are some of the physiological aspects that, if harnessed, properly could enhance rice productivity in Nepal.

Photoperiodism and agronomic implication

The length of a day, defined as the interval between sunrise and sunset, is known as photoperiod. The response of the plant to photoperiod is called photoperiodism. Photoperiod-insensitive varieties can flower and ripen throughout the year provided that the irrigation is available. Thus, the use of photoperiod-insensitive varieties makes the planning of rice cultivation more flexible and more suitable to the multiple cropping systems. Most traditional rice varieties in the tropics are sensitive to photoperiod. Their flowering and ripening is fixed and could be properly utilized through photoperiodism. Hence, most feasible modern varieties can be promoted as alternatives by tapping this opportunity.

Solar radiation

Solar radiation is radiant energy from the sun, measured as a total amount (direct beam solar radiation plus sky radiation) expressed in calories per square centimeter per day. Only, the visible part (380-720 mm) of the total solar energy is important for photosynthesis. Plants make food by photosynthetic process. Solar radiation is not just a form of heat, its spectral bands are also important. The amount (duration and intensity) of sunlight or radiation received, is a critical factor affecting rice production. In monsoon climate, light intensity is quite often low during the rainy months. This sharply limits yield and response to inputs like fertilizers, pesticides and modern varieties. To make the best out of the available sunlight timings of plantings as well as various methods of cropping should be tried. Solar radiation is one of the most important factors in predicting rice yields over wide range locations (Yoshida 1981). Bright sunny weather during flowering is absolutely necessary as most of the grain yield in rice comes from post flowering photosynthesis. The radiation energy/sunshine hours accumulated during the one or two months preceding harvest, greatly influence final grain yield. With the advent of modern photoperiod non sensitive rice varieties, photoperiod has become less important in rice culture. Cloudiness in the rainy season reduces the sunlight available for photosynthesis.

In the tropics, solar radiation is higher in the dry season than in the wet season. Consequently, the productivity per hectare per day of rice during dry season is usually higher. The excessively cloudy weather during the wet season is often considered a serious limiting factor to rice production in monsoon Asia. Climate conscious farmers must have to know the distribution pattern of solar radiation in the different months of the year to boost rice grain yields by coinciding the reproductive as well as ripening stages during higher intensity of solar radiation. This is really no-cost technology and thus the farmers will be greatly benefited by following this technique without spending extra money. Solar radiation is the free-gift of nature and certainly helps to boost rice productivity or end hunger (Basnet 1987).

The importance of solar energy in tropical agriculture was recognized only after the WW-II. The average daily solar radiation available during the monsoon season in tropics is one-and-a-half times lower than that available in the temperate rice-growing regions like in: Po Valley, Italy, Suicca, Spain, New South Wales, Australia, or Davis, California, America. But because of farmers' dependence on rainfall, the farmers of rainfed rice in the tropics must grow rice when there is low sunlight intensity. In the tropics, the correlation between solar radiation for 45-day period before rice harvest (from panicle initiation to crop maturity) and grain yield was highly significant. Earlier experiments indicated a strong correlation between grain yield and solar radiation during the last 30 days of rice growth. Subsequently, Philippines-based IRRI research indicated that the increase in dry matter between panicle initiation and harvest was highly correlated with grain yield. These results indicate that the amount of solar energy received from as early as panicle initiation until crop maturation is important for the accumulation of dry matter during that period. The accumulation of starch in the leaves and culms begins about 10 days before heading. Starch accumulates markedly in the grain during the 30-day period of grain production. With irrigation, the dry-season rice yields in the tropics (11 t/ha reported at IRRI) should be similar to those reported for the temperate region (12.5 tonness per hectare) (Yoshida 1981).

In Tarai and inner Tarai of Nepal two rice crops can be grown, ie early (dry) and monsoon (wet) season rice. The paddy productivity per hectare per day in early (dry) season was 20-25% more than the normal (monsoon crop) season at the Hardinath Agriculture Farm (now National Rice Research Program) located in the Dhanusha (Basnet 1987). Region like this in Tarai and inner Tarai of Nepal could receive 600 calories per square centimeter per day of solar radiation after flowering in early/dry season (February-July) rice but the unit of solar radiation was 500 calories per square per day only after flowering in monsoon season (July-November) rice (Basnet 1987).

Solar radiation and growth stages

The requirement of solar radiation with rice crop differs from one growth stage to another. Shading during the vegetative stage only slightly effects yield and yield components. Shading during the reproductive stage, however, manifests a pronounced effect on grain number. The shading during ripening reduces grain yield considerably because of a decrease in the percentage of filled grains. Solar radiation at the reproductive stage has the greatest effect on grain yield; that at the ripening stage, the next highest effect; and that at the vegetative stage, an extremely small overall effect. The shading during ripening reduces grain yield considerably because of a decrease in the percentage of filled grains. That is why, Australia, Italy and the

United States of America used to get higher rice productivity due to the very strong solar radiation in the maturing period of these countries (Yoshida 1981).

Table 1. Effect of shading at different growth stages on yield and yield components of rice variety IR 747B2-6*

Sunlight (%)	Grain yield (t/ha)	Harvest index	(Number of panicle/m²)	Filled spikelets (%)	1,000 grain wt. (g)
		Vegetative stage			
100	7.11	0.49	41.6	88.9	20.0
75	6.94	0.48	40.6	89.9	19.9
50	6.36	0.51	38.3	89.5	19.9
25	6.33	0.51	38.1	84.3	19.8
		Reproductive stage			
100	7.11	0.49	41.6	88.9	20.0
75	5.71	0.47	30.3	87.8	20.3
50	4.45	0.40	24.4	89.4	19.5
25	3.21	0.36	16.5	89.4	19.1
		Ripening stage			
100	7.11	0.49	41.6	88.9	20.0
75	6.53	0.49	41.1	81.1	20.0
50	5.16	0.44	40.6	64.5	19.5
25	3.93	0.38	41.7	54.9	19.1

** Yoshida and Parao 1976.*

Table 2. Monthly solar radiation at selected locations of several rice growing countries (Solar radiation=Cal/cm²/day) and solar radiation at the special day of the months for Australia, Italy and USA (solar radiation=Cal/cm²/day)

Country and location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Japan, Saga (1)	206	295	330	393	381	322	375	444	349	349	298	228	331
Thailand, Bangkok (2)	424	434	481	516	427	425	420	392	374	393	421	428	427
India, Madras (1)	476	556	608	574	568	486	432	456	532	397	356	370	484
Indonesia, Jakarta (1)	361	382	400	396	374	361	388	426	451	422	397	370	394
Nepal, Janakpur (3)	390	450	537	580	623	613	514	474	457	529	461	406	503
Special day of months/in different countries	Jan1	Feb5	Mar2	Apr1	May7	Jun1	Jul2	Aug3	Sep1	Oct12	Nov1	Dec1	Average
Australia, Mt. Stromlo	628	554	450	349	268	208	231	308	432	512	603	646	432
Italy, Milano (1)	62	133	220	366	493	499	515	430	325	188	84	47	280
USA, Davis (1)	158	256	402	528	636	702	690	611	498	348	216	148	433

Source: Yoshida S and FT Parao 1976.
Meteorological Department, Bangkok 1964-1967.
Hardinath Agriculture Farm, Baniniya, Dhanusha, Janakpur, Nepal 1976-77.

Table 3. Solar radiation (cal/cm/day) for wet season and dry season against potential yield of rice

Season	Average solar radiation (cal/cm/day	Potential yield (t/ha)
Wet season rice (maturity days)	300	5-6
Dry/early season rice (maturity days)	500	8-9

Conclusions

The yields per hectare per day of spring rice is about 20 to 25% more as compared to monsoon/main season/rainy season rice because of higher intensity of solar radiation especially during reproductive and ripening stages. Paddy should be grown in such a way, where it gets maximum amount of solar radiation especially during reproductive and ripening stages. Therefore, climate conscious or climate-smart farmers must have to know the distribution pattern of solar radiation in the different months of the year, so as to increase rice grain yields by coinciding the reproductive as well as ripening stages during higher intensity of solar radiation. This is really no-cost/non-cash input technology and thus the farmers will be greatly benefited by following this principle without spending extra money.

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Agricultural Mechanization in Rice Production through Government Subsidy Program 2016 in Nepal

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सारांश

धान उत्पादनमा श्रमको अभाव र उच्च लागतको समस्यालाई न्यूनीकरण गर्न कृषि यान्त्रिकीकरणले महत्वपूर्ण भूमिका खेलेको हुन्छ । कृषि यान्त्रिकीकरणको प्रयोगबाट सामान्यतया १५ देखि २० प्रतिशत बीउ, २० देखि ३० प्रतिशत समय र मलखाद, ५ देखि २० प्रतिशत श्रमको बचत तथा १५ देखि २० प्रतिशत उत्पादकत्व बढाउन सकिने आधारहरू समेत पाइएका छन् । यान्त्रिकीकरणको यसै पक्षलाई ध्यानमा राखी नेपाल सरकारले धान बालीमा कृषि उपकरणहरूको प्रयोगलाई बढवा दिन कृषि यान्त्रिकीकरण नीति तथा यान्त्रिकीकरणसँग सम्बन्धित आवधिक परियोजनाहरू संचालन गरी अनुदानमा विभिन्न किसिमका कृषि उपकरणहरूको वितरण गरिरहेको छ । तथ्याङ्कलाई विश्लेषण गरेर हेर्दा आर्थिक वर्ष २०१५/०१६ मा सबैभन्दा बढी यान्त्रिकीकरणको लागि अनुदानको प्रवाह मध्य पश्चिमाञ्चल विकास क्षेत्रमा भएको देखिन्छ भने निजी क्षेत्रबाट सबैभन्दा बढी कृषि यन्त्र तथा उपकरणहरूको आपूर्ति पश्चिमाञ्चल विकास क्षेत्रमा भएको देखिन्छ । यसबाट धान उत्पादनका लागि प्रयोग गरिने उपकरणहरू बढी माग हुने क्षेत्रमा आपूर्ति हुनुपर्ने देखिन्छ । उत्पादनका लागि प्रयोग हुने कृषि औजार तथा उपकरणहरूमा पावर टिलर र मिनि टिलर सबैभन्दा बढी माग भएका उपकरणहरू रहेको पाइएको छ ।

Summary

Agricultural mechanization not only fulfills the scarcity of human labor for rice production but also helps to minimize the cost of cultivation. The mechanization, when used properly, a farmer can save: seeds 15-20%, fertilizer 20-30%%, time 20-30%, labors 5-20%. This also results in: increase in cropping intensity by 10-15% and higher productivity by 15-20%. Realizing the importance of mechanization, government has formulated mechanization policies and some periodic projects to promote use of farm machines for rice production in Nepal. The data revealed that the flow of subsidized farm machines was maximum in the mid-western development region during the fiscal year of 2015/016. However, the supply of farm machines by private sector was found maximum in the western development region indicating the higher demand of farm machines than in other development region. The result showed the need of channelizing subsidy program more in western development region with higher demand of farm machines for rice production. Among the various agricultural tools, machines and implements used in rice production, the demand for power tiller and mini tillers for agricultural operation (rice production) was found maximum.

Keywords: Mechanization, Mechanization policy, Rice, Subsidy, Supply

Background

Agricultural mechanization implies the use of various power sources and improved farm tools and equipment, with a view to reduce the drudgery of the human beings and animals, enhance the cropping intensity, precision and timelines of efficiency of utilization of various crop inputs and also to reduce the losses at different stages of crop production (Verma 2008). Agricultural mechanization is the application of engineering technology into the field of agriculture, in order to improve agricultural output, as well as deliberate conscious departure from the peasant and subsistence agriculture into commercial agriculture. This process also involves the development and management of machines for field production, water control, material handling as well as post-harvest operation (Rahman and Lawal 2003, Owombo et al 2012).

In recent years, demand for mechanization is increasing with acute labor scarcity and high cost of production (as a result of increased wage rate) in farming due to the migration of male youths for foreign employment resulting in the feminization of agriculture. Wage rate in agriculture has doubled in the last 10 years and households receiving remittance income has more than doubled in the last one and half decade from 23% in 1995 to 56% in 2010. (CBS 2011). Female headed households have also doubled in last 15 years from 13% in 1995 to 26% in 2010 (CBS 2011).

Increased attraction of returned migrant youth in commercial agriculture, increased road connectivity in rural hills and mountains and realization of agricultural mechanization among the planners and policy makers have brought about the scope of agricultural mechanization in Nepal. Past studies on efficiency of farm mechanization reveals that if the mechanization used properly a farmer can save: seeds 15-20%, fertilizer 20-30%, time 20-30%, laboures 5-20%, and increase in cropping intensity by 10-15% and higher productivity by 15-20% (Singh 2008).

Status of use of agricultural machines for rice production in Nepal

The traditional wooden tools and implements have continued to remain in use in the hills and mountains for rice production in Nepal. There has been some improvement in their design and performance capabilities over time. Due to the lack of physical facilities (viz road networks and electricity) and cultivation in narrow terraces in hilly areas; hill agriculture is mainly depended upon human and animal power for rice production.

Animate power is the main source of power, in Nepalese agriculture. Human power and animal power occupies 36.3 and 40.5% of the total farm power available in the country respectively. The available mechanical power in the country is only 23%. Most of the mechanical power is concentrated in the Tarai. Share of available mechanical power in Tarai is 92.28% that of total available mechanical power of Nepal (FBC 2006). Most of the agricultural machines used in farms of Nepal are used in rice fields.

Mechanization of agriculture in Nepal for rice production is still at infant stage. There were about 870.3 thousand holdings using the most common agricultural equipment, iron plough in 2001/02. This number increased to 1073.441 thousand holdings in 2011/12. The use of tractors has been increasing slowly. From 8.2% of the total holdings using tractors in 2001/02 it increased to 22.05% in 2011/12. Thresher occupies a very important place among equipment used in farming operation. The use of thresher in farming operation has also been increasing. From 210.4 thousands of holdings using it in 2001/02 it increased to 803.154 thousands in 2011/12. Pumping set, which is also very important agricultural equipment for the purpose of irrigation, has increased from 6.3% holdings using it in 2001/02 to 14.31% holdings in 2011/12. Though farm mechanization in Nepal is still at incipient stage, there are indications of improvement. Use of equipment such as power: tillers, sprayers, rower pumps, combine harvesters are on the rise. However, the number of animal drawn carts has stagnated over the decade. (CBS 1992, 2002, 2012)

Shortage of labor, youth migration for foreign jobs and high cost of cultivation has created demand for ATIM (agricultural mechanization) since last couple of years. So, agricultural mechanization became the only one option for sustaining agriculture for farmers. Furthermore, ATIM supplemented by increasing rural road construction activities throughout the country helped to boost the import of tractors, power tillers, and mini tillers. This helped to increase the total number of tractors (4 wheels and 2 wheels) and power tillers from 34336 in 2005/06 to 106693 in 2014/15. Similarly, the number of pump sets increased from 30 in 1965 to 109641 in 2013. There has been considerable progress in agricultural mechanization in Nepal with various types of machinery being adopted, primarily through imports by the private sector and its engagement with farmers. Most agricultural mechanization is taking place in the Tarai and, to a lesser extent, in the lower hills and valleys. There are suppliers of all major makes of tractors, power tillers, and pump sets in Nepal. The machinery-supply industry is becoming more competitive as the number of actors increases along with the demand for machinery. Several power-operated agricultural machines are now in use in Nepal (Biggs and Justice 2011), including water pumps tractors both 4 wheel and 2 wheel; harrows, rotovators, seed drills, threshers, combine harvesters, and also agricultural processing machines: rice, oil, and pulse mills; as well as laser land-levelers.

Policy arrangement to promote rice in Nepal

Policy

Investment on agricultural mechanization and institutional set-up and efforts on agricultural mechanization in Nepal has not been as expected. Currently government of Nepal has formulated the agriculture mechanization policy 2014 to contribute to reduction in poverty and achievement of sustainable development through agricultural mechanization in Nepal. Mechanization policy has envisioned facilitating, supporting and regulating role of the state and active participation and role of private sector in mechanization. It has focused to support small scale mechanization and commercialization of agriculture in the context of geographical, social and small-scale farming. Moreover, the ongoing Agriculture Development Strategy and concept paper for the fourteen plan has given priority to use agricultural machines in crop field in Nepal.

Existing government initiatives to promote use of agricultural machines in rice field in Nepal

In order to compensate the demand of labor for rice production in Nepal, government of Nepal has taken some of the initiatives to promote the use of agricultural machines in Nepal. Ministry of Agricultural Development has launched some of the foreign aid supported projects. Mega Rice Promotion Program, fine and aromatic rice production programs are projected, formulated and implemented through Crop Development Directorate. Similarly, Kisan Ka Lagi Unnat Biu Bijan Karyakram, Irrigation and Water Resource Management Project (IWRMP), Project for Agricultural Commercialization and Trade (PACT), Raising Income for Small and Medium Farmers (RISMFP) are some of the foreign supported projects focused on rice and other commodities with the activities like infrastructural support, machinery support, small irrigation supports etc. District Agriculture Development Offices of all districts have formulated various activities to promote rice farming through devolved budget.

Supply of mechanization tools by MoAD during the fiscal year of 2015/016

As mentioned above, MoAD has been continuously paying its attention to make maximum use of agricultural farm machines in rice field to meet the demand of labor and reduce the cost of cultivation. Accordingly, MoAD has distributed various agricultural tools and implements in subsidy through central and district level programs. The details of distribution of farm machines generally used in paddy fields under subsidy program is presented in the table below.

Table 1. Distribution of farm machines by MoAD under subsidy program

Development region	Tractor	Power tiller	Mini tiller	Harvester	Thresher	Seed processing machines	Rice transplanter	Weeder	Winnowing machine
Eastern	9	477	144	1	257	9	2	126	0
Central	10	593	910	2	141	21	8	5	5
Western	3	273	421	0	25	14	2	26	76
Mid Western	10	633	83	2	416	15	0	3	751
Far Western	4	247	145	0	34	12	4	230	155
Total	36	2223	1703	5	873	71	16	390	987

Source: DADO (75) 2016.

The table shows that altogether 6304 subsidized farm machines were distributed by District Agriculture Development offices through central level and devolved programs. According to DADO, the demand for agricultural machines to be used in paddy fields was in increasing trend. It could be because of labor shortage and higher cost of production for rice farming. More specifically, DADOs distributed maximum number of power tillers (2232) followed by mini tillers. This shows that the power tillers and mini tillers have gained popularity among farmers for agricultural operations, especially in hilly districts of Nepal. Rice transplanters and harvesters were mainly distributed in Tarai region of the country.

Supply of mechanization tools by Private sector during the fiscal year of 2015/016

Due to the lack of adequate resources, government can not fulfill the demand of agricultural machines to all farmers at a time. Realizing the importance of agricultural machines to reduce the drudgery of labor and minimize the cost of production, the private sector is also making involvement for supplying agricultural farm machines for rice farming in Nepal. The details of supply of agricultural farm machines (especially for rice production) through private sector is presented in the table below.

Table 2. Supply of farm machines by private sector during the FY 2015/016

Development region	Tractor	Power tiller	Mini tiller	Harvester	Thresher	Seed processing machines	Rice transplanter	Weeder	Winnowing machine
Eastern	3056	725	52	10	3958	7	2	0	4
Central	1888	263	604	26	678	3	0	0	70
Western	1836	373	246	115	1666	7	0	27	9044
Mid-Western	725	267	33	0	200	6	0	0	1419
Far Western	800	169	34	6	3546	5	3	20	2049
Total	8305	1797	969	157	10048	28	5	47	12586

Source: DADO (75) 2016.

The table shows that 33942 farm implements were supplied in the market by private sector in Nepal during the fiscal year of 2015/016. The statistics shows the winnowing machines supplied for rice processing to be highest one. However, there was significant number of tractor supplied in the market, which shows that farmers have been gradually using tractors in agricultural operations. Similarly, the date revealed significant number of threshers, power tiller used for rice farming in Nepal.

Based on the data mentioned above, it can be concluded that the government should give priority in supplying tractors, power tillers and mini tillers under subsidy program for promotion of paddy business in Nepal.

Comparative analysis for the distribution of subsidized farm machines across the geographical domain during fiscal year of 2015/016

The percentage share of total number of subsidized farm machines was found the highest in mid-western development region followed by central development region. The data shows the more flow of subsidy amount in mid-western development region for distribution of farm machines for agricultural operation (especially for rice production). The graphical sketch showing the supply of subsidized farm machines across the geographical domains is presented below.

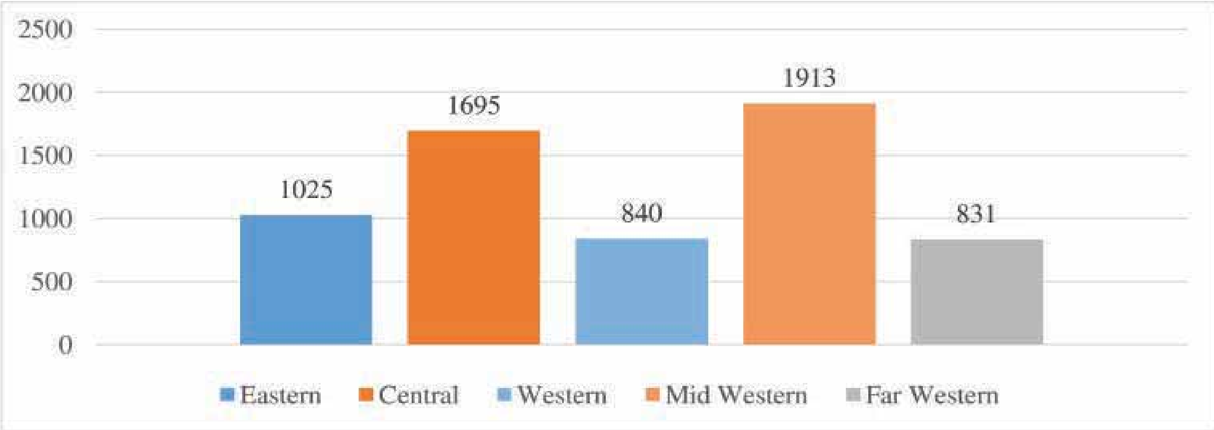

Figure 1. Supply of subsidized farm machines in Nepal (Especially for rice production)

Source: DADO (75) 2016.

Comparative analysis for the supply of farm machines across the geographical domain during fiscal year of 2015/016

The percentage share of total number of supply of farm machines from the private sector was found the highest in western development region followed by eastern development region. The data shows the more involvement of private sector for making transactions of agricultural machines in western region. It can also be concluded that the demand for agricultural machines was the highest in western development region followed by eastern region. The graphical sketch showing the supply of farm machines from the private sector across the geographical domains is presented below.

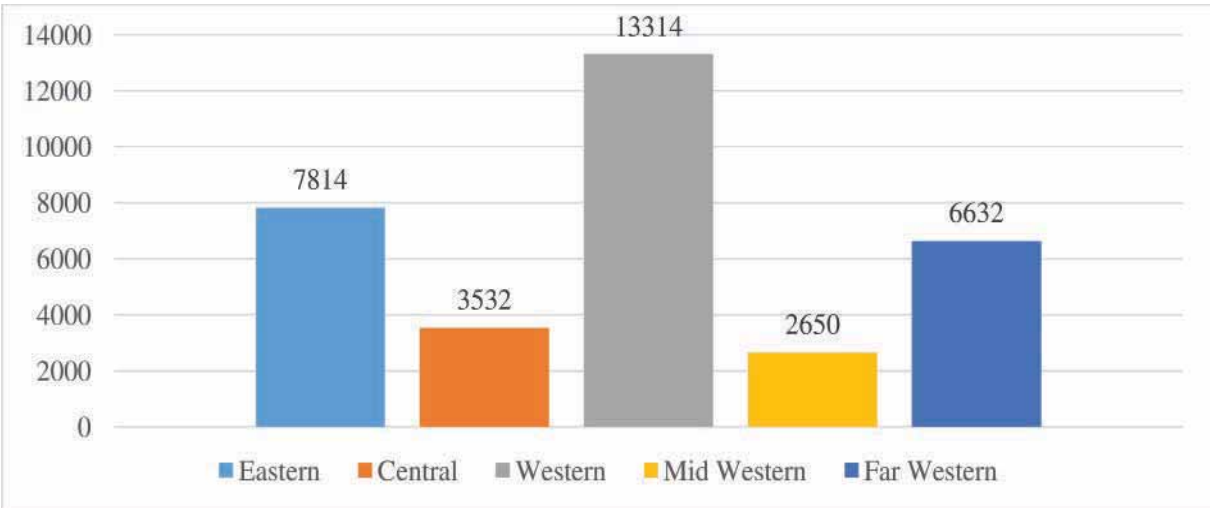

Figure 2. Supply of farm machines by private sector in Nepal (Especially for rice production)

Source: DADO (75) 2016.

Conclusion

Agricultural mechanization plays a key role in improving agricultural production in developing counties and should be considered as an essential input to agriculture. Agricultural mechanization not only fulfills the scarcity of human labor for rice production but also helps to minimize the cost of cultivation. Realizing the important of mechanization in rice, government of Nepal has made some of the policy arrangements and has also formulated some of the special programs to promote rice farming in Nepal. The subsidy program of distributing the subsidized farm machines for rice production in Nepal is becoming popular and one of the effective ways to mechanize rice farming in Nepal. However, distribution of subsidized farm machines have not been rational. It seems to be regionally biased and need some correction for distribution in the days to come. Demand of tractors, power tillers and mini tillers for the agricultural operations has been gradually increasing in recent years. So, the government of Nepal should give priority to supply these farm machines under the subsidy program to promote rice farming in Nepal.

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Use of Agricultural Tools, Implements and Machineries for Rice Production in Nepal

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सारांश

कृषि यन्त्रहरूको उपयुक्त प्रयोगका माध्यमबाट समय र श्रमको बचत हुनाका साथै बालीको उत्पादन लागतमा समेत कमी ल्याउन सकिन्छ । नेपालमा धान बालीमा कृषि यन्त्रको प्रयोगको औपचारिक सुरुवात वि.सं. २०१० सालमा कृषि मन्त्रालय अन्तर्गत कृषि इन्जिनियरिङ महाशाखाको स्थापना पश्चात् भएको मानिन्छ । त्यसपछि नेपाल कृषि अनुसन्धान परिषद् अन्तर्गत कृषि इन्जिनियरिङ डिभिजन, जनकपुर कृषि विकास आयोजना र विभिन्न राष्ट्रिय तथा अन्तर्राष्ट्रिय संस्थाको कृषि यान्त्रिकीकरणमा संलग्नता आदि कृषि यान्त्रिकीकरणका लागि कोसेढुंगाको रूपमा रहेका छन् । नेपालमा जग्गाको तयारीदेखि बाली भन्डारणसम्म विभिन्न प्रकारका कृषि यन्त्रहरूको प्रयोग हुँदै आएको छ । नेपालमा १९७० को दशकभन्दा पहिले धान बाली उत्पादनमा परम्परागत रूपमा चलिआएका कृषि यन्त्रहरूको प्रयोग भएको पाइन्छ । १९७० को दशक पश्चात् चार पाङग्रे र दुई पाङग्रे ट्याक्टर, पम्पसेट, हलर, सिड ड्रिल, रिपर, धान मिल धान रोप्ने ट्रान्सप्लान्टर, धान गोड्ने विडर र धान कुट्ने, चुट्ने, सफा गर्ने कम्बाइन हार्भेस्टर आदि यन्त्रहरूको आयात एवम् प्रयोगसँगै धान बालीमा कृषि यन्त्रहरूको प्रयोगले गति लिएको पाइन्छ भने धान बाली उत्पादनमा कृषि यन्त्रहरूको व्यापकता भने १९८० को दशक पश्चात् मात्र भएको पाइन्छ । १९९० को दशकदेखि हालसम्म विभिन्न आधुनिक कृषि यन्त्रहरूको प्रयोग नेपालको भूगोल सुहाउँदो किसिमबाट भइरहेको छ । तथापि, धान बालीमा आधुनिक कृषि यन्त्रहरूको प्रयोग अपेक्षाकृत रूपमा हुन सकिरहेको छैन । तसर्थ, मानव संसाधन विकास, सचेतना वृद्धि र चुस्त र प्रभावकारी नीति तर्जुमा गर्नु नै नेपालको धान बाली उत्पादनमा कृषि यान्त्रिकीकरण प्रवर्द्धनका लागि आजको आवश्यकता हो ।

Summary

Agricultural tools, implements and machinery (ATIM) are the tools or device and machinery which when used properly in the field, save time and labor, reduce drudgery and cost of cultivation of the commodity. The formal use of agricultural implements in rice production is recorded after the establishment of Agricultural Engineering Division (AED) in 1953 under the Ministry of Agriculture. Establishment of Agriculture Engineering Division under Nepal Agricultural Research Council (NARC), Janakpur Agriculture Development Project (JADP), Directorate of Agriculture Engineering under Department of Agriculture and involvement of national and international organizations are some of the milestones to promote agricultural mechanization in rice production. In Nepal, starting from the land preparation to the crop storage after harvesting of rice, various agricultural equipment and machines are used. Before 1970s, only the traditional types of implements and machines like: spade, hoes, wooden plough etc were used in rice fields in Nepal. The use of farm machines in rice cultivation got momentum during the 1970s with the introduction of 4 wheel tractors, 2 wheel tractors, cultivators, pumping sets, rice hullers, seed drill, reapers and other farm machines in the Tarai region and in government farms. The use of farm machineries in rice field was fairly increased during 1980s. Similarly, 4 row manual trans-planters, modified pedal thresher, power operated multi crop thresher, power tillers, mini tillers and farm machines were introduced to the rice fields during the period of 1990-2015. Thus, different types of farm machines specially 4 row manual transplanters, power transplanters, power rice weeders and combine harvesters are used for the cultivation of rice across the geographical domains of Nepal. However, the use of modern day farm machines has not got momentum as expected. So, human resource development, awareness creation regarding use of farm machine to save labor, time and minimize the cost of production and effective and efficient policy environment creation are the present needs to promote the agricultural mechanization of rice in Nepal.

Keywords: ATIM, Geography, Mechanization, Policy, Rice

Background

Agricultural Engineering Division (AED) was established in 1953 as an agricultural engineering unit to develop physical infrastructure of different offices and also to repair and maintain the vehicles of those offices under the Ministry of Agriculture inside Singhdurbar complex. Later on, it was shifted to Shreemahal Pulchowk. The unit was headed by first agricultural engineer, Hut Ram Baidya. It was later promoted to section and then to division under the Department of Agriculture (DOA). Its major contribution was in the development of infrastructure for the establishment of new organizations, farm development activities: including farm layout, irrigation facilities and other construction works of various farm stations and for DADO offices under the DOA throughout the country. Infrastructures have been utilized even these days with minimum problems of farm development. After the establishment of Nepal Agricultural Research Council (NARC) in 1991, Agricultural Engineering Division (AED) has been continuously concentrating its efforts in research in order to develop appropriate technology in agriculture engineering. In 1994, AED/NARC was also designated as the National Institute and focal point of Asia and Pacific center for Agricultural Engineering and Machinery (APCAEM), former Regional Network of Agricultural Machinery (RNAM). The main mandates of AED/NARC are: to conduct research to develop agri-engineering related technologies, to test and evaluate the result and forward recommendations. Its present activities include:

- Agricultural mechanization research: Crop, horticulture, livestock and fishery sector,
- Development of appropriate technologies,
- Validation and up scaling of AED technologies,
- Conservation tillage up scaling in Tarai and valleys,
- Soil and water resources engineering,
- Post-harvest engineering research,
- Survey on Tarai and hill mechanization. (Sah and Basnyat 2015).

Likewise in 1971, Janakpur Agriculture Development Project (JADP) was established at Naktajhij, Dhanusha with the support of Government of Japan/JICA. Promotion of deep tube wells and modern agricultural equipment and implements (tractors, power tillers and threshers) were launched. Furthermore, Agriculture Development Bank during the decade of 1973/74 provided loan with priority on tractors and pumping sets for farmers. This program boosted agricultural mechanization. Internal Rice Research Institute (IRRI) and International Maize and Wheat Improvement Center (CIMMYT) supported: zero till seed drill, reaper, multi crop thresher, rice transplanter and so on through various projects (eg Rice-Wheat Project) to NARC.

Agricultural Implement Research Centre (AIRC) under the DoA, was established in 1959 at Ranighat, Birgunj and it started the production of agricultural tools such as: plows, harrows, sickles, spades etc. In 1964, Agricultural Tools Factory (ATF) was established with technical and financial assistance from the USSR and it further helped production of iron plows, harrows, cultivators, pedal threshers, pump sets, etc. These equipment and tools were distributed throughout the country through ATF branches and dealers. This initiated agricultural mechanization especially in rice, wheat and maize. AIRC was amalgamated into agricultural tools factory and Nepal joined Regional Network of Agricultural Machinery (RNAM) as the ninth participating country in 1987. Privatization of ATF was done in 1996. National focal point of RNAM was moved in 1994 to AED/NARC from a cabinet decision. Research and Development Division of ATF was handed back to AED/NARC in 1994 and renamed as Agricultural Implements Research Centre (AIRC). The main activities of this center include design and development of agricultural implements; testing and modification of agricultural mechanization; conducting on station and on farm research related to resource conservation.

Directorate of Agricultural Engineering (DoAE) under DoA of MoAD was established in 2004 (Presently situated in Hariharbhawan, Lalitpur). The main objectives of DoA E are: extension of agricultural engineering technologies; short term training, demonstration of agricultural machinery; post-harvest resource center development; development of custom hiring centers and post-harvest control and so on. (Sah and Basnyat 2015)

Agricultural Tools, Implements and Machinery (ATIM) are the tools or devices and machineries which when used properly in the field, save time and labor, reduce drudgery and cost of cultivation of the commodity. Use of ATIM is increasing for land preparation in rice cultivation in Nepal. For land preparation, human labor, animal draft and tractor (tractor, power tiller and mini tiller) are used. Manual Labor as well as Seed drill, Zero till drill and even rice-transplanter are used for transplanting rice. In case of weeding, manual labor, manual rice-weeder and power-weeders are used. Likewise for harvesting, manual sickles are common tools. Use of power tiller attached reapers and combined harvester are increasing in some districts (Morang, Sunsari, Bara, Parsa, Rupendehi, Kapilvastu, Kailali and Kanchanpur) of Tarai. In the mountains and the hills, pedal operated and power operated threshers, and bullocks are common. In the Tarai, power operated threshers, bullock trampling and tractor trading are commonly used.

Status of use of ATIM

The Status of ATIM has been grouped into rice duration, before 1970, during 1970 -1979, during 1980-1989, during 1990-1999, during 2000-2009 and during 2010-2015. The status of these periods has been described as follows.

Status of ATIM before 1970

Agriculture engineering unit was established in 1953. Engineer Hut Ram Baidya was the first agricultural engineer to head the unit. AIRC was established in 1959 in Ranighat, Birgunj. ATF was established in 1964 with technical and financial assistance from the USSR. Likewise, JADP was established at Naktajhij, Dhanusha with the support of Government of Japan/JICA on deep tube wells, which helped to increase the use of agricultural machinery and equipment for rice (eg power tiller, manual weeder, and thresher).

The use of ATIM was at infancy stage before 1970. In 1965, a small number of four wheel tractors was introduced. Most of the farming activities except land preparation and threshing to some extent were done manually in the mountains, hills and the Tarai region. In the mountain, fields were mostly prepared using manual labor using hand tools like, spade, hoes, pointed hoes and wooden plough. In the hills, traditional local plough, iron plough and wooden clod breaker and leveler were used whereas in the Tarai, traditional plough, iron plough, animal drawn disc harrow, tractor attachable cultivator, animal drawn leveler and tractor drawn scraper were used. In regards to plant protection, manual sprayer/duster in the mountains and manual power operated sprayers were commonly used in Tarai.

In case of threshing rice, grown in the very limited area like Jumla, it was almost manually threshed in the mountains. In the hills, bullock trampling was common. However, threshers (pedal operated and power operated) were used particularly in the valleys and river basin. In the Tarai, bullocks trampling and tractor treading were very common and power operated threshers were also gaining popularity (Department of transport management and CBS 1993/1994).

For seed treatment of rice, seed dressing drums were used by a few farmers in the hills and the Tarai. For de-husking and milling, hand pounding *Okhal* (traditional wooden instrument) was common in the mountains, whereas in the hills, leg pounding (*Dhiki*) was common and power operated rice mills were established at few locations especially in the valleys and major urban areas in the country. For cooking, cooking stoves using rice husk and firewood were popular in the areas where rice husk was easily available in the hills, especially in the Kathmandu valley as well as in the Tarai where firewood was not easily available or expensive.

The number of four wheel tractors and power tillers increased from 64 in 1964 to 1925 in 1975 and 2514 in 1980. Likewise, number of power tillers increased from 100 in1975 to 424 in 1980, pump sets increased from 30 in1965 to 9986 in 1980.

Status of the use of ATIM during 1970-1979

National Trading Limited (NTL), Kathmandu and Bhajuratna Agency Pvt. Ltd Kathmandu had directly helped in the promotion of agricultural machinery and equipment by importing and selling 4 wheel tractors (Massey Fergusson and Belarus), 2 wheel tractors, cultivators, pumping sets, rice hullers, seed drill, and reapers in the Tarai region (Adhikary 2010). Besides tractors, farm equipment like mould broad plough, harrow, cultivator, seed drill, planter, scraper, leveler, thresher, etc were added in the government farm.

During the decade 1970-1979, many farm implements and equipment were imported and introduced in the country at agricultural farms under the Department of Agriculture and from the support of USAID and technical consultant in farm development and machinery at Janakpur, Parwanipur, Rampur, Bhairhawa and Nepalgunj. The machinery then introduced were: Engine operated multi-crop thresher (rice/wheat), tractor drawn multi crop seed drill (rice/wheat), tractor drawn multi-crop planter (Maize, cotton, soybean, peas, etc), tractor drawn lawn mower, maize stock chopper, 65 hp tractor drawn scraper and land leveler. Besides the above mentioned machinery and equipment, other available machinery and equipment in the farms were tractor drawn implements which were mould board plough, disc plough, offset disc harrow, 9-tyre cultivator, ridger, puddler, chisel plough and boom sprayer (tractor operated). Among the animal drawn implement were: local plough, mould board plough, 3 tyre cultivator, and harrow. Because of the availability of above machinery and equipment, land preparation (grading, leveling, ploughing, harrowing, puddling, seeding, planting (rice, wheat, corn and cotton plant protection, spraying, dusting) ridging (maize and cotton), threshing (rice, wheat, maize) was possible completely using machinery and equipment. However, in Tarai farmers (small and medium farmers) ploughed their land using local plough, animal-drawn disc plough and 3-type cultivators. Threshing of rice was done by animal bullock trampling. But, big farmers ploughed their land with tractor drawn harrow and cultivator. Threshing of rice was done by tractor treading. In the hills, land preparation was done mostly manually and by bullock drawn local plough and threshing manually and by bullock trampling. In the mountain, all farming activities were mostly done manually. However, in some flat terraces and river basins, animal (*Chouri*) power was used for land preparation.

Status of ATIM use during 1980-1989

Total number of 4 wheel tractors and power tillers increased. AIRC was amalgamated into ATF that was later privatized and closed. It was a great setback for agricultural mechanization. Nepal joined RNAM as a ninth participating country. Use of ATIM was fairly increasing during 1980's. Total number of 4 wheel tractors was increased from 2514 in1980 to 6060 in1989, power tillers from 425 in 1980 to 1100 in 1989 and pump sets from 9986 in1980 to 23000 in 1989. Increased number of above machineries indicates that more number of four wheel tractors and power tillers were used in the fields than in the period between 1970 to1979. It shows that more hectares of land were irrigated in the Tarai as well as in the hills. In case of rice, de-husking/milling, few rice mills were established at places where micro hydro plants were the source of power. In the hills, increasing numbers of rice mills were observed due to the availability of electricity/micro hydro plant supply. Likewise, the number of rice mills established in Tarai was increasing.

Status of ATIM use during 1990-1999

NARC was established in 1991. National focal point of RNAM was shifted to AED/NARC by cabinet decision in 1994. Research and development division of ATF was handed back to AED, NARC in 1994 and renamed as AIRC (Manandhar 2010). During this period, number of tractor/4-wheel tractors and power tillers increased to 10974 in 1994/95, from 6060 four wheel tractors and 1100 power tillers in 1989. Use of power tillers for land preparation was becoming popular in the hills. Animal drawn harrow cum puddler was gaining popularity in the Tarai. In the hills, tractor drawn rice/wheat seed drills were introduced. Likewise, in the Tarai, manual drum seeders, which saved time and labor, were introduced. Zero tillage rice plant seed drills were also introduced in this period. These seed drills saved land preparation cost and water and increased the yield. Four row manual transplanters were also introduced in Bara and Parsa (Adhikary 2000). For harvesting rice, power tiller operated reapears were introduced in Khumaltar (Kathmandu), Ranighat (Parsa), Bhairhawa (Rupandehi) and other locations too. For threshing paddy in the mountains, manual and modified padal threshers were used in the hills (AED 1994). Besides manual and modified pedal thresher, power operated multi crop thresher were introduced and became popular. Likewise, in the Tarai, use of power operated multi crop thresher gained popularity. For seed cleaning and grading, number of seed cleaners and graders have been established in all three regions (mountain, hill, and Tarai). For de-husking and milling, number of rice mills is increased in all regions, where the source of power for running the mills is available. For cooking purpose, use of rice husk stoves are also increased in hill and Tarai regions.

Status of ATIM use during 2000-2009

Besides manual transplanters, power operated transplanters and engine power operated rice weeders were introduced in Morang and Sunsari districts. Powertill attached drill and zero till drill for dry seeded rice were introduced and became popular in Bara, Parsa and Rupandehi. Demand for power tiller operated reapers was increasing in the hill and Tarai regions. Due to shortage of labor, combined harvesters brought from India were also used on rent in Kailali, Kanchanpur, Rupandehi, and similar Tarai districts for harvesting rice. According to fiscal policy, farmers could import tractors and machinery with one percent custom duty. Establishment of Directorate of Agricultural Engineering (DoAE) was done in 2006 under the Department of Agriculture. Total numbers of tractors and power tillers increased from 10974 in 1994/95 to 34336 in 2004/05 (Adhikary 2007). During this period, transplanting, weeding, and harvesting were affected due to shortage of labor. In Tarai districts, multi crop threshers were also becoming popular.

Status of ATIM during 2010-2015

Agricultural Mechanization Promotion Policy (AMAP) 2014 has been approved by the Government (MoAD 2014). This policy is trying to address the problems of labor shortage in farm activities. Due to shortage of labor force in agriculture, demand for ATIM was very high and farmers' attraction towards ATIM increased. So, mechanization became the only option for farmers. Use of power rice transplanters and power weeders are increasing in Jhapa, Morang, and Sunsari. Likewise, combined harvesters are being used for harvesting rice in: Morang, Sunsari, Jhapa, Bara, Parsa, Rupandehi, Kapilbastu, Kailali and Kanchanpur districts (Nepal Krishi Company 2014). A farmer in Parsa district reported that he owns four combined harvesters, which are rented out to other farmers in harvesting seasons (AIRC Birgunj, personal communication 2016).

Shortage of labor, youth migration for foreign jobs, and high cost of cultivation have created demand for ATIM (in other words agricultural mechanization) for last couple of years. So, agricultural mechanization became the only one option for sustaining agriculture for farmers. Furthermore, ATIM supplemented by increasing rural road construction activities throughout the country helped to boost the import of tractors, power tillers, and mini tillers. This helped to increase the total number of tractors (4 wheels and 2 wheels) and power tillers from 34336 in 2005/06 to 106693 in 2014/15. Similarly, the number of pumpsets increased from 30 in 1965 to 109641in 2013. Mechanization for land preparation activities increased very fast. Even in the mountain region like: Rasuwa, Sankhuwasabha and Dolakha, the use of mini tillers has been started for land preparation. Farmers have been using power tillers and mini tillers for land preparation of rice field in Kathmandu Valley, Kavre Valley and Pokhara Valley for a long time. In Tarai, custom hiring of agricultural machinery like tiller, threshers, power weeders, and reapers are increasing. Harvesting of rice by combined harvesters taken on rent is being popular in: Kailali, Kanchanpur, Rupendehi, Nawalparasi, Bara, Parsa, Morang, and Sunsari districts. According to the farmers from Sunsari and Morang, harvesting of rice by using combined harvesters on rent is not only reducing harvesting costs but is also minimizing the post-harvest losses, ultimately reducing the cost of cultivation.

However, in hills and even in Tarai, large number of tractors, power tillers, and mini tillers are not possessed by farmers and are not used in agricultural works. As a result, their attachable equipment like seed drills, bund/furrow makers, threshers are becoming useless. Therefore, they need to be fully utilized for agricultural purposes.

Conclusion

The status of agricultural mechanization is improving. Mini tillers have been used for land preparation even in the mountainous districts like: Solukhumbu, Dolakha, Rasuwa, etc. Farmers are purchasing power tillers/mini tillers for land preparation and replacing bullocks in almost all hilly districts. Land preparation is done either by tractor or power tiller in Tarai. Those farmers who do not own tractors or power tillers get their land ploughed on contract basis (custom hiring) for transplanting rice. Manual transplanting of rice is common in mountain and hilly region, whereas in Tarai, power transplanters are being popular especially in Morang, Sunsari, Bara, Parsa, Chiwan and Rupandehi.

For rice weeding, manual weeding is a common practice in mountain and hilly regions, but power rice weeders are being used in Tarai, especially in Morang and Jhapa districts. For harvesting rice, manual sickles are the main tools in mountain and hilly regions. Reapers are also used in harvesting rice in Kathmandu and Kavre districts. Besides manual harvesting, combined harvesters are used in Tarai districts such as in Morang, Sunsari, Bara, Parsa, Rupandehi, Kapilbastu, Kailali, and Kanchanpur. Manual threshing as well as pedal threshers are used for threshing rice in mountain. Pedal threshers are used mostly in Kathmandu and Kavre districts. Power threshers are very popular in Tarai. The use of power threshers is very high in Chitwan. To some extent, threshing by animal trampling and tractor toddling are still prevalent. For rice cleaning and grading, in mountain and hill region, small size cleaner and graders are used, whereas in Tarai medium sized seed processing plants are also installed by farmers' cooperatives (eg Chitwan, Kailali and Kanchanpur) with the support of DoAE and several other organizations. There is lack of physical infrastructure and human resources for agricultural mechanization program both in AED/NARC and DOAE/DoA, which have major roles to perform for boosting up the use of ATIM in the country. Considering the growth of ATIM including combined harvester, a separate National Agriculture Mechanization Program should be established. Soft loan for farmers and supportive land use policy for unified farming (group farming) would be very helpful for the success of agricultural mechanization in the country.

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Soil, Fertilizer and Irrigation Management

(माटो, मलखाद एवम् सिँचाइ व्यवस्थापन)

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Tillage and Land Preparation System for Rice Production in Nepal

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सारांश

धान खेतीको लागि जमिनको तयारी सम्बन्धी लामो इतिहास छ । यो विश्वास छ कि धान खेतीको सुरुवात करिब ८,००० वि.सि. मा चिनको याञ्जे नदिको आसपासमा भएको थियो । भारतमा धान खेती ग्रिकहरूको समयभन्दा पहिले सुरु भयो । खनजोत गरी जमिन तयार पार्न धेरै उपायहरू अपनाइएको पाइन्छ । जमिन तयार गर्न सुरुमा हातले चलाउने ढुङ्गाको प्रयोग भयो र त्यस पछि काठले बनेको औजारहरू अनि जनावरले तान्ने धातुका औजारहरू र अहिले आधुनिक गह्रौ ट्रयाक्टरहरू प्रयोग भैरहेको छ । नेपालमा जमिन तयार गर्न पहिलो पटक ट्रयाक्टरको प्रयोग सन् १९२४ मा गरिएको थियो । धान रोप्न जमिनको तयारी पहिलो खनजोत (प्राइमेरी टिलेज) र दोस्रो खनजोत (सेकेन्डरी टिलेज) गरेर गर्ने चलन छ । पहिलो खनजोत खास गरेर वर्षा सुरु हुने बेला (अप्रिल-मे) मा गरिन्छ जुन बेला जमिन जोत्न चिस्यान प्रशस्त हुन्छ । यसले घाँस झारपात र पहिले लगाएका बालीका ठुसहरू माटोमा मिसाउन मद्दत गर्छ । दोश्रो खनजोत माटोको डल्ला फुटाउन, घाँस झारपातको नियन्त्रण गर्न, मललाई माटोमा मिलाउन, खेत साउन र जमिन सम्मयाउनको लागि गरिन्छ । आधुनिक २ पाङ्ग्रे ट्याक्टरमा मोल्ड वोर्ड, डिस्क र रोटोभेटरको प्रयोग गरी दोस्रो खनजोत गरिन्छ भने ४ पाङ्ग्रे ट्याक्टरमा टिन्ड् कल्टिभेटर्स्, ७-डिस्क प्लोज, अप्सेट डिस्क प्लोज र रोटोभेटरको प्रयोग गरी दोस्रो खनजोत गरिन्छ । घैया धान लगाइने क्षेत्रमा चिस्यान भएको बेला जमिन तयार गरिन्छ । यस लेखमा परम्परागत काठे हलो र फलामका औजारहरूको विभिन्न भागको नामहरू प्रस्तुत गरिएको छ जसको प्रयोग गरी नहिल्याइकन घैया धान खेती तथा पानी जमाई तराई, पहाड र काठमाण्डौं उपत्यकामा धान खेती गरिन्छ ।

Summary

Rice cultivation has a long history of extensive land preparation. It was believed that rice cultivation started along the Yangtze river in central China about 8,000 BC and was introduced in India before the time of Greeks. Tillage has gone through modifications from hand-operated stone to wooden tools to animal-drawn metal tools to modern heavy tractors. The use of tractor for land preparation in Nepal was first used as early as 1924. The land preparation for rice transplanting is done by primary and secondary tillage. Primary tillage is generally performed during pre-monsoon rain (April-May) when moisture is sufficient to plow the land. This helps to incorporate weed and crop residues in the soil. Secondary tillage is done after primary tillage for final land preparation for reducing clod size, weed control, incorporation of fertilizers, puddling and leveling soil surface. In modern 2-wheel tractor systems, the mold board, the disc and rotovator are used for secondary tillage, whereas in 4-wheel tractor systems, tined cultivators, seven-disc plows, offset disc plow and rotovator are most commonly for secondary cultivation. Upland tillage is performed in areas, where upland rice or aerobic rice is grown. Different parts of traditional wooden plow and iron tools used for upland and lowland rice cultivation both in Tarai and hills as well as in Kathmandu valley are discussed.

Keywords: Four wheel tractor system, Iron plow, Land preparation, Primary tillage, Rice, Secondary Tillage, Two wheel tractor system, Wooden plow

History, development and current practices of tillage

Tillage is the mechanical manipulation of soil aimed at improving soil conditions affecting crop production. From the crop production point of view, tillage is a process, in which human, animal and/or machine energy is applied for physical manipulation of soil to provide favorable soil environment for the growth and production of plants. Rice cultivation is widely believed to have emerged along the Yangtze River in Central China about 8,000 BC. How and when it spread eastward is unclear. One theory holds that immigrants fleeing the turmoil of China's Warring States Period, beginning about 450 BC, took the technology overland to present-day Korea, then across the relatively narrow Korea Strait to Japan's Kyushu Island. An alternative theory is that seafaring traders carried the technique to lands bordering the Yellow and East China seas around 1,000 BC or earlier. Rice has been cultivated in China since ancient times and was introduced in India before the time of Greeks.

In Japan, the spread of rice cultivation is one of the marks of the beginning of Yayo Period, which has been pegged to 500 to 400 BC, mostly from speculative analysis of evolving pottery techniques. Rice was common in West Africa by the end of 17^{th} century. It is thought that slaves from that area, who were transported to the Carolinas in the mid-18^{th} century introduced the complex agricultural technology thus playing a key part in the establishment of American rice cultivation.

Tillage practices started when man first planted seed in soil. In the process of evolution, tillage has gone through modifications, starting with manipulation of soil with simple hand-operated stone and wooden tools, through animals-drawn metal tools to modern heavy tractors and machines. It could be pulled by mule, ox, elephant, water buffalo, or similar sturdy animals. Horses are generally unsuitable, though breeds such as scyne could work. Soon after 1900, farm tractors were introduced, which eventually made modern large-scale agriculture possible. Rice cultivation has been carried out into all regions of the world having the necessary warmth and abundant moisture favorable for its growth, mainly subtropical rather than hot or cold.

Cattle or buffalo are generally used for land preparation in South and Southeast Asia, but manual tillage still prevails. In the transplanted rice areas, tillage begins after the rainy season starts and ample water is in the field. The plowing depth is between 5 and 10 cm. The plowing width is indefinite and sometimes leaves some unplowed soil. Plowing is followed by pudding with a knife or tooth harrow, or a wooden corrugated roller.

Use of agricultural machinery in Nepal is in early stage. The first appearance of a tractor in Nepal can be traced back to as early as 1924 (Shrestha 1997). The use of mechanical power in agriculture is considered not to have begun until the mid-sixties until the introduction of 64 tractors and 30 pump sets (Pudasaini 1976). In the seventies, five year plans promoted 4 –wheel tractors along with tube wells and pump sets. Since 1980, the number of 4-wheel tractors increased from about 2,500 to 17,000 in 1999. Over the same period, power tillers (2-wheel tractors) increased about 400 to 1,400 and irrigation pump sets from about 10,000 to 50,000 (Pariyar et al 2001).

Wooden plow with iron pearcer, *phali* was the only means of ploughing in Nepal until 1970. Then 2-wheel hand tractor in Kathmandu valley and 4-wheel tractor in Tarai were introduced (Biggs et al 2002). Now-a-days, 2-wheel tractors in Kathmandu, Pokhara and Chitwan valleys and 4-wheel tractors in different parts of Tarai are common for ploughing the land.

In 1974, the Japanese International Cooperation Agency (JICA) began an Integrated Agricultural Development Program with research, demonstration, and a series of loans to the Agricultural Development Bank and Agricultural Inputs Corporation to start a mechanization process in Nepal. Over a ten-year period nearly 1,000 Japanese power tillers were imported and sold mostly in Kathmandu and Chitwan valleys. The private sector was also encouraged and aided to import Japanese power tillers. The cost of spare parts of Japanese power tillers were very high. Therefore, power tillers did not spread on a large scale in Nepal in late 1970s and 1980s (Biggs et al 2002).

Biggs et al (2002) reported that during 1980s, Chinese power tillers gained popularity mainly in Kathmandu and Pokhara Valleys. About 1,000 were imported in this phase. Some observers estimated that about 30% -50% of these power tillers are still in use, mainly providing transport services for the construction industry in Kathmandu and Pokhara, and to a lesser extent in Kavre district. They also reported that from early 1980s and mid1980s, private businessmen recognized that the Korean power tillers were 25-30% cheaper than Japanese power tillers and about 200-400 were sold in Kathmandu and Chitwan valleys. Power tillers did not catch-on in the Tarai of Nepal in the late seventies and early eighties. Renting of 4-wheel tractors has started in Tarai for the last 10-12 years.

Land or field preparation system

Tillage is classified into primary or secondary tillage. Soil puddling can be classified as a secondary tillage and its primary purpose is to restrict water movement from the surface layers.

Primary tillage

It is the first soil tillage after the last harvest. It is normally conducted when the soil is wet enough to allow plowing and strong enough to give reasonable levels of traction. This can be immediately after the crop harvest or at the beginning of the next wet season. When there is sufficient power available some soil types are ploughed dry. In our context, primary tillage is carried out just after pre-monsoon as soil moisture is enough for primary tillage.

The objectives of the primary tillage are to:

- attain a reasonable depth (10-15 cm) of soft soil with varying clod sizes,
- kill weeds by burying or cutting and exposing the roots,
- maintain soil aeration and water accumulation depending on the soil type and the plough the soil will normally be inverted aerating the deep layers and trapping water during a rainfall event,
- chop and incorporate crop residues.

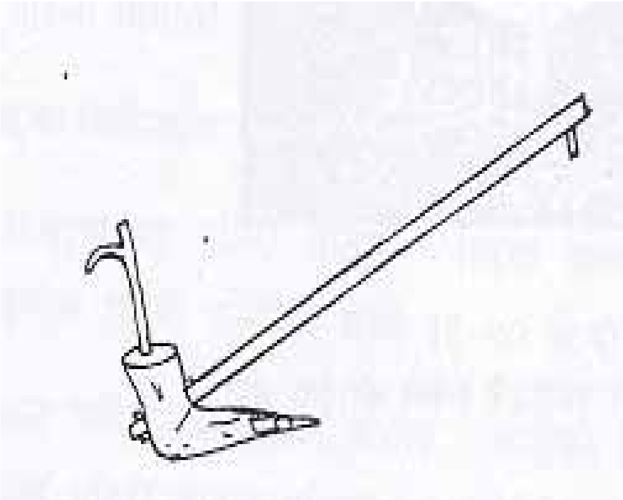
The most commonly used tiller with an animal powered system is the moldboard plows. In clay soils, the fields often are fully saturated before tillage can be undertaken at moisture levels below field capacity. In 2-wheel powered systems both moldboard and disc ploughs (one-way disc) are used. The disc is usually the preferred system as it takes less power and can handle obstacles much easier. In a 4-wheel tractor system, three discs, seven discs and upset ploughs are the most common. Tined plows are preferable in the upland systems but as yet not widely available in Asia.

Gap between primary tillage and secondary tillage

Primary tillage is generally done when there is pre-monsoon rain (April-May) and the moisture is sufficient to plough the land. Primary tillage helps to incorporate weed and crop residues in the soil. Then, the field is left for some time so that incorporated weeds and crop residues will be decomposed and soil becomes friable. Secondary tillage in the same field is done at the time of planting maize in uplands or rice in lowlands when there is sufficient moisture with either rain or irrigation.

Four-wheel tractor

Iron Plow used in Tarai



Wooden plow (kathe halo with iron pearcer Phali)

Bullocks drawn ploughing

Figure 1. Equipment and machines for tillage

Secondary tillage

Secondary tillage is any tillage completed after primary tillage and is undertaken for

- Reducing clod size
- Weed control
- Incorporation of fertilizers
- Puddling and
- Leveling soil surface

Secondary tillages are usually shallower and less aggressive than primary tillage. In the animal powered system, the second tillage is normally undertaken with the mold board plough when the field is fully saturated. The final tillage then is completed using peg tooth harrow that puddles the soil and leaves the surface level ready for planting.

In 2-wheel tractor systems, the moldboard, the disc and the rotovator are used for secondary tillage. In some instances, peg tooth harrow is also used if rotovators are not available. Cage wheels on the tractor are needed for traction in all soil types and these also help puddle the soil.

In 4-wheel tractor systems, tined cultivators, seven disc ploughs, offset disc ploughs and rotovators are the most commonly used equipment for secondary tillage. In this system, fields are either mechanically puddled with tractors using a rotovator and leveling board or by tractors fitted with large cage wheels and harrows. In 4-wheel tractors, there are different options to connect and plough the field ie tyned cultivators or seven-disc ploughs or offset disc ploughs or rotovators can be used depending on the convenience during ploughing of the field.

Normally, 1-2 secondary tillages are done after primary tillage and before planting but this will depend on: the cloddiness of the soil, the density of weeds, the need to incorporate fertilizer and the need for puddling. It is common in many countries for the first two tillages to be undertaken using tractors and the final working done by animals and harrows.

Puddling is the working of the soil in a totally flooded state to realign soil particles in a manner that will reduce the water penetration and leave the surface level for crop establishment. It is normally done using tractors and rotovators or animals and peg tooth harrows.

Before or after the secondary tillage and puddling, the strong bunds of the fields are made. The field corners, where ploughing cannot be done either with oxen or bullocks or tractors, are dug with spade (locally called *Kodali* or *Kodalo*) so that the rice field can be leveled and rice transplanting can be performed. For the control of water in the field, the drainage system of water (locally called *Sama*) is kept in each rice field terrace.

Lowland Ploughing *Lowland Levelling*

Figure 2. Secondary tillage in rice field

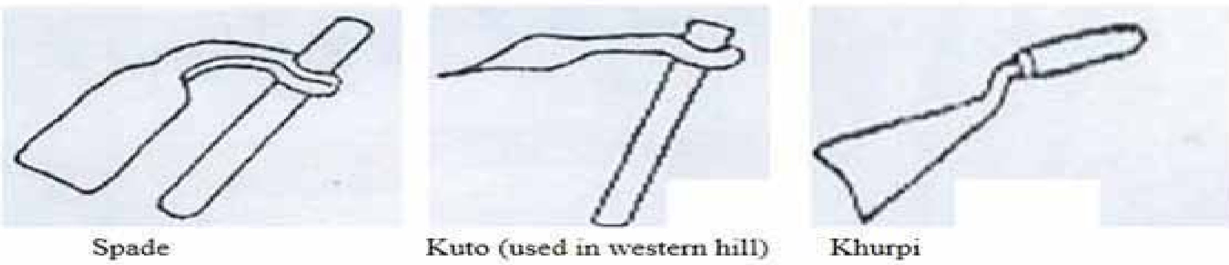
Upland tillage

Upland tillage is undertaken in locations, where upland rice is grown in aerobic soil conditions. This means that the soil is non-puddled and there is no freestanding water in the fields.

Upland Ploughing *Upland Levelling*

Figure 3. Upland tillage in rice field

Soil moisture levels are critical when ploughing in an upland-farming situation. If the soil is too dry, it will not till easily, the power requirement will increase and in clay soil large clods may cause problems when trying to decrease ped size to create a seedbed. If the soil is ploughed while very wet, near soil saturation, smearing and soil sealing can become problems during seedbed preparation.



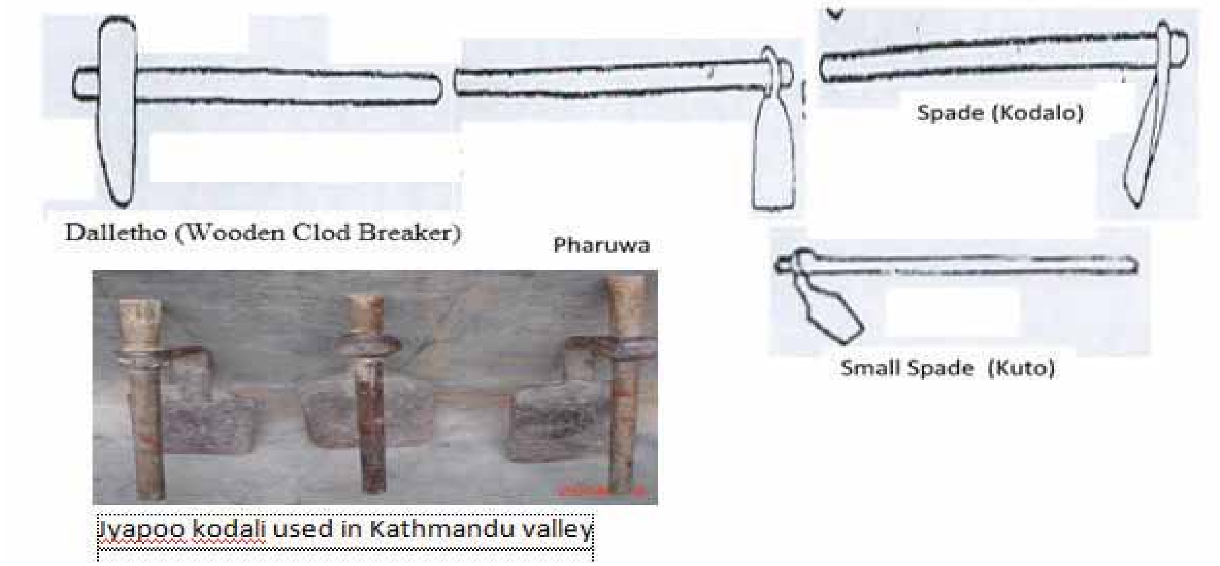
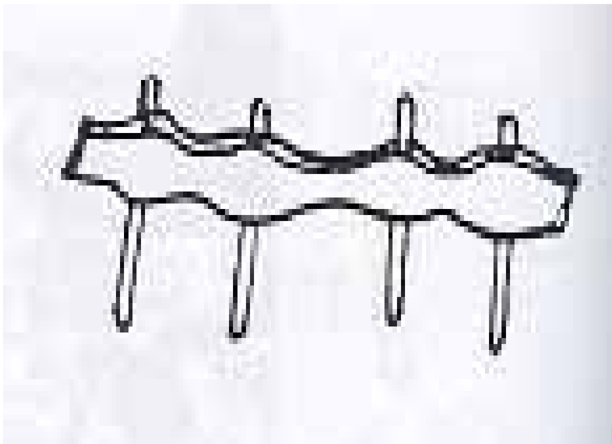


Figure 4. Traditional Iron tools with wooden handle



Juwa

Hallundo (Nara) to connect juwa and Harish

Land levelling with wooden plank

Jotaro rope (used to tie bullocks and juwa)

Figure 5. Different parts of plow and its composition

Tillage practices in upland condition in Nepal

The upland rice fields are ploughed by indigenous plow or tractor before or after the pre-monsoon rain when the land is fallow with sufficient moisture in the soil so that land can be tilled without any difficulty. In the river basin (*Tar*) and low hills of Nepal especially, Gorkha, Lamjung and Tanahun districts, rice seeds are broadcasted in previously ploughed fields and then again ploughed to cover the rice seed by turning the soil. This practice of rice cultivation is called “dry direct seeded rice cultivation”.

Tillage practices in irrigated condition in Nepal

In irrigated condition, the field is saturated with water and ploughed by local plow (wooden plough or iron plow) or tractor-drawn cultivator, double pass, followed by soil puddling. Then the field is leveled with a wooden planking to make the field ready for transplanting rice seedlings. Soil puddling reduces weed competition and water losses, but destroys soil structure and creates a hard pan at shallow depth and consumes a large quantity of water (Sharma et al 2002).

Field preparation practices for rice in hills

In the hills of Nepal, the rice terraces are small and narrow. The plot risers are cleaned and strong bunds are made to saturate soil and keep standing water in terraces. Then, local wooden plow and local oxen are used to till the barren land in saturated soil. The corners of the terraces, where local wooden plow cannot plough the field, are dug with locally made spade called *Kodali*. Finally, the land puddles get leveled with the locally made wooden plank called *Dande*. Then the fields are ready for transplanting rice seedling. In recent years, due to the scarcity of labors, hand tractors have been used in preparing the land for rice transplanting in the hills wherever possible.

Field preparation practices for rice in Tarai

In the flat land of Tarai farmers have been using bullocks for a long time to plough and puddle the field for rice transplanting. In recent years, the use of tractors for preparing land for transplanting rice is dominating, because of shortage of bullocks and labor. Now-a-days, young people do not stay in the village and the number of oxen or bullocks are decreasing. It has become expensive to feed the bullocks throughout the year because the plowing of the land is only for 2-3 months. The rice plots are ploughed by a tractor-drawn cultivator, double pass, followed by soil puddling and wooden planking so that the rice fields are leveled and rice seedlings are transplanted. In certain areas of Tarai, farmers have started growing direct seeded rice by preparing land with tractors and leveling the field with wooden planking.

Field preparation practices in Kathmandu valley

Most of the soil in Kathmandu valley is heavy clay type. Therefore, farmers have been using spade (locally called *Jyapu Kodali*) for digging and preparing the rice fields with raised beds on the onset of monsoon so that rainwater can be conserved. This is the reason that farmers of Kathmandu valley have not been using bullocks to plough their lands. There is no any religious reason to plough the land in Kathmandu valley. The risers of the field are cleaned with

Figure 6. Land preparation in Kathmandu Valley

spade and strong bunds are made for accumulating water in the rice terraces or fields. Farmers prepare and level the rice field with the help of spade. When the soil is just saturated with water, farmers level the land and transplant rice seedlings without any difficulty due to clayey (heavy) nature of soil.

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Management of Organic and Inorganic Fertilizer for Rice Production in Nepal

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सारांश

नेपालको माटोमा उर्वराशक्ति क्रमशः ह्रास हुँदै गइरहेको अवस्थाले गर्दा धान उत्पादकत्वमा अपेक्षाकृत प्रगति हासिल हुन सकेको छैन । देशको जनसंख्या वृद्धिदर अनुरूप पुग्दो अन्न बाली उत्पादन हुन नसकिरहेको स्थिति विद्यमान छ । माटोको उर्वराशक्ति घट्दै जानुको मुख्य कारण सतहको मलिलो माटो भूक्षय हुन गै रासायनिक, भौतिक तथा जैविक गुणमा ह्रास हुनुलाई मान्न सकिन्छ । जमिनमा मलखाद प्रयोग गर्दा सन्तुलित र बाली प्रणाली अनुरूप व्यवस्थित गर्ने कार्यको कमजोरी पक्षले गर्दा माटोको उर्वराशक्ति दिन-प्रतिदिन ह्रास हुँदै गै राखेको छ । नेपालको माटोमा मुख्य तवरले नाईट्रोजन तत्वको अत्याधिक कमी भएको पाइन्छ भने फोस्फोरस, म्याग्नेसियम, सल्फर (गन्धक) र केही सूक्ष्म तत्वहरू जस्तै–बोरन (स्वाग), जिङ्क (जस्ता) तथा मोलिब्डेनम तत्वहरू कमी भएको पाइन्छ । धान खेती गरिने नेपालको जमिनमा प्राङ्गारिक पदार्थ कमी रहेको विश्लेषणबाट देखिन्छ । धान खेतीको लागि आवश्यक खाद्यतत्व बढाउनका निमित्त एकदुई हप्ता अगावै प्राङ्गारिक मल प्रयोग गर्न सकेमा धान उत्पादनमा वृद्धि ल्याउन सकिने अवस्था रहेको छ । जमिनको उर्वराशक्ति व्यवस्थापनमा मुख्य तत्वहरू, सहायक तत्वहरू र सूक्ष्म तत्वहरू समावेश रासायनिक मलको सन्तुलित तवरले प्रयोग गर्न सके धानको उत्पादनमा वृद्धि ल्याउन सकिने अवस्था छ । गाईवस्तुको मल, कम्पोष्ट मल र हरियो मल प्रयोगमा ल्याउन सके माटोको रासायनिक, भौतिक तथा जैविक अवस्थाको सुधार हुन गै उर्वराशक्ति वृद्धि ल्याउन सकिने सम्भावना रहेको छ । माटोको उर्वराशक्ति कायम राख्न एकिकृत खाद्यतत्व व्यवस्थापन प्रणालीको ठूलो भूमिका रहको पाइन्छ । एकिकृत खाद्यतत्व व्यवस्थापनबाट धान बाली उत्पादन गर्न र दिर्घकालीन रूपमा माटोको उर्वराशक्ति कायम राख्न स्थानीय र बाह्यस्रोतको सन्तुलित र विवेकपूर्ण प्रयोग हुनु आवश्यक छ । रासायनिक र प्राङ्गारिक मलको प्रयोगमा सन्तुलित तथा अधिकतम उपयोग हुनेगरी प्रयोग गरिएको खण्डमा धान उत्पादनमा वृद्धि ल्याउन अवश्य नै सफल हुन सकिन्छ ।

Summary

Rice productivity in Nepal has not increased as expected because of declining fertility of soil over the years. Demand of growing population for rice has not been met by the domestic production. Loss of fertile layer of soil due to landslides have resulted in loss of chemical, physical and biological properties of soils. As farmers do not apply the doze of fertilizer and adopt the appropriate crop rotation, the fertility status of soil has gradually been degraded every day. Nitrogen is excessively used in Nepalese soil. Micronutrients like boron, zinc, molybdenum are always used less than the required quantity. Rice fields are generally found to contain low organic matter and thereby indicating the possibilities of increasing productivity through abundant supply of organic manure. Balanced application of primary and secondary nutrients and micronutrients can increase the rice yield. Use of compost, green manures can improve the chemical, physical and biological properties of the soil. Integrated Plant Nutrient Management System (IPNMS) and maintenance of soil fertility status requires balanced and judicious use of local and external sources of fertilizer. Balanced and optimum use of chemical and organic fertilizers can increase the yield of rice.

Keywords: Fertilizers, IPNS, Management, Productivity, Rice

Background

Inherent soil fertility, in general, is low in Nepalese soil. Nitrogen is the most limiting nutrient followed by phosphorus, potassium, magnesium, sulphur and some micronutrients (boron, zinc, and molybdenum). Inadequate plant nutrients supply and continuous soil nutrients mining through increased cropping intensity and leaching are important factors that have caused soil fertility decline. These factors in combination with increased population pressure are responsible for depletion of biomass and degradation of land and environment. Fertilizer is not available to farmers in required quantity, types, and time mainly due to:

inaccessibility, high cost, poverty, and dependence on foreign countries. The availability of organic sources of nutrients (FYM/compost) is decreasing due to depletion of forest base and low biomass production.

Initiation of chemical fertilizer use in Nepal

Mineral fertilizer was first introduced in Nepal in 1952 with the commissioning of the Sindhri plant in India (Pratap Narayan 1987). Fertilizer consumption was 100 tonnes in 1954, and increased to about 1500 tonnes by 1965. Organized supply of fertilizer began in 1965/66 with the establishment of Agriculture Inputs Corporation (AIC) then named as Agriculture Inputs Supply Corporation. The AIC started trading fertilizers with 3169 tonnes received as grant from India (2069 tonnes) and the USSR (1000 tonnes). Most of this (2500 tonnes) was ammonium sulphate (21%N). In 1965/66, an amount of 2069 tonnes fertilizer was sold. The sale of fertilizers at that time was mostly confined to the Central Development Region around Kathmandu Valley in the hills and Birgunj area of Bara and Parsa district in Tarai regions (AIC 1983). The consumption of mineral fertilizers has increased progressively since 1965/66 from a meager amount of 2069 tonnes (451 tonnes N, P_2O_5 and K_2O) to 185797 tonnes (90277 tonnes N, P_2O_5 and K_2O) in 1994/95. However, it has not yet taken-off as required. As a result, the maximum national average consumption of fertilizer nutrient was merely 35 kg/ha/year in 1994/95, which is the lowest after Bhutan in the SAARC region. The fertilizer consumption has actually declined against the plan of the country. The target in the eighth five-year plan (1992-097) was to raise the overall average fertilizer nutrients use from 31-83 kg/ha/year. But the published 1996-97 fertilizer nutrients consumption figure is around 28 kg/ha/year. Against this background, the APP (1995) target of achieving 150 kg/ha/year use of fertilizer nutrients by the year 2015 looks ambitious. The national average consumption of fertilizer nutrient reached about 92 kg/ha/year in 2015/16. It however, needs strong commitment from the government and private sectors involved in fertilizer use promotion.

The manufacturing industry of chemical fertilizers has not yet been established in Nepal. Few years ago fertilizer mixing and blending companies were established namely, Sagarmatha, Purbanchal, and Pathivara to produce fertilizers of 20:20:0 NPK and 20:20:10 NPK grade. These fertilizer blending companies could not sustain for a long period. These fertilizers blending companies have almost been closed now. Instead of blending plants, 33 commercial organic manure production industries have been registered in the MoAD. Among them, about 10 industries are producing organic manures.

The use of fertilizer in Nepal started with Ammonium Sulphate (21% N) in early 1950s. Therefore, the official fertilizer trade also started dominantly with Ammonium sulphate though small quantities of Ammonium Nitrate (26% N), Super phosphate (22% and 48% P_2O_5) and Murate of potash (60% K_2O) were introduced in mid-sixties from India with the objective of balanced supply of fertilizers to the crops. This was immediately followed by import of complex (20:20:0) and complete (15:15:15) fertilizer products by AIC from West Germany. Urea was introduced in the sixties (1968/69) followed by the introduction of various types of fertilizer grades in 1970s. Di-ammonium Phosphate (18:46:0) was introduced in 1981/82. Later on, introduction of fertilizer grade was the compound (19:19:10) with micronutrients (B and Mo) content in 1990/91 from Finland. There were a number of formulations: 20:20:10, single supper phosphate (16% P_2O_5), 23:23:0, 7:10:0, Calcium Ammonium Nitrate (26% N) etc, imported as Grant Aid fertilizer. Among the above mentioned fertilizer products, Urea (46% N), Ammonium Sulphate (21% N), Complexal (20:20:0), DAP (18:46:0) and Complete (15:15:15) were common over 95% of Nepalese fertilizer market.

Nutrient management for irrigated rice

Irrigated (wetland) rice soils vary very much in texture and nutrient status. However, they tend to have a low organic matter content and therefore provide a relatively small supply of nitrogen and phosphorus by mineralization; typically, rice crops obtain about 60 kg/ha of nitrogen from the soil. Paddy soils usually have a low base-exchange capacity and therefore small reserves of the nutrient cations: potassium and magnesium.

The nutrient status of rice soils can be improved by applying organic manure one or two weeks before transplanting. There is also considerable scope for biological nitrogen fixation in these soils by blue-green algae or the Azolla-Anabaena association, and this may supply 30-50 kg/ha or more nitrogen.

Nitrogen fertilizer management in rice

There is a close association between the amount of nitrogen fertilizer applied to rice and the yield level. Yield response of 20 kg or more of grain per kilogram of nitrogen is frequently obtained. Traditional tall rice varieties are prone to lodge from higher dose of nitrogen application, but improved varieties-short, high yielding, lodging and disease resistant, can benefit from a higher level of nitrogen supply. Whereas, traditional varieties could justify up to 50 kg/ha of nitrogen, but 160 kg/ha or more is recommended for improved varieties under good management and with good water supply. The season of planting also influences nitrogen requirement; the higher yielding, irrigated, dry season crops justify 30-40 kg/ha more nitrogen than rainy season rice crop.

In Nepal, farmers are using di-ammonium phosphate (DAP) as a basal doze and urea for top dressing. Most of the farmers of Nepal have not followed the method of three split application of nitrogenous fertilizers, but majority of farmers have adopted two split applications of nitrogenous fertilizer. The losses of nitrogen could be assumed very high in rice farming system of Nepal.

Majority of hill agriculture in Nepal is still compost based. Farmers are using various sources of organic manures to fertilize their rice fields since time immemorial. Nowadays, farmers are paying more attention to the use of nitrogenous fertilizer due to high nutrient content and responsive as a high yielding rice variety as well as unavailability of organic manures. As a result, there is adverse effect on soil health and sustainability of agriculture system due to haphazard use of nitrogenous fertilizer application in rice fields in the Tarai as compared to the hill rice farming systems. The practices of applying organic manure in the rice field of Tarai are found negligible. The farmers from the hills and the Tarai are using DAP and urea as a source of nitrogenous fertilizers. Farmers have not adopted the recommended dose of nitrogenous fertilizers.

Phosphorus fertilizer management in rice

Optimum rates of phosphorus vary with local conditions, but 40 kg/ha P_2O_5 will usually be enough for traditional (local) varieties and 60-80 kg/ha will be optimum for improved varieties. Phosphorus, or a combination of water and citrate soluble, is normally most efficient for rice production. Rock phosphate may be used on acidic soil but it is not in practice in Nepal.

In Nepal, unlike nitrogen, phosphorus is relatively immobile in the soil/plant system, but is nevertheless subjected to complex chemical reactions. The solubility of phosphorus ions in the soil solution is very much dependent on the pH level of the soil and is greatest at pH 6-7. Generally, the farmers from both regions of the hills and the Tarai have been applying phosphorus fertilizer as a basal dose in rice fields. Like nitrogen, phosphorus deficiency is also widely found in the hills where soil is strong to moderately acidic in nature.

Potassium fertilizer management in rice

For traditional varieties, application of 30-40 kg/ha of potassium is sufficient, but improved varieties justify an application of 60-120 kg/ha. It has been proved by the experiments in Chitwan and Kavre. Rice grain production was higher in the 75 kg/ha potassium fertilizer application treatment. On most soils, potassium fertilizer should be applied as a basal dressing, but on free-draining sandy soils where leaching may occur, half should be basal and half top-dressed.

Secondary and micronutrients management in rice

Sulphur deficiency is becoming more widespread in rice, because of the use of high yielding varieties, reduced use of organic matter, and use of sulphur-free fertilizers. Zinc, manganese and iron deficiencies occur fairly widely, especially on high pH soils. Because of the intensification of rice production, secondary and micronutrient deficiencies are becoming more common, and it is important to identify and correct them wherever they occur.

Rice is unusual in responding to application of silicon in the form of soluble silicates, and waste products containing this element are applied in some Asian countries.

Nutrient management for upland rice

The majority of rice growing areas are rainfed, which covers nearly 49% of the total cultivated areas. Rice cultivation in rainfed areas during wet season has been found riskier due to erratic rainfall. As a result, this rice domain has been characterized by poor and uneven production.

Because upland rice relies entirely on rainfall and soil moisture reserves, yields are lower than wetland rice. Since the soil is not flooded, soil nutrient behavior is akin to other cereal crops. Upland rice can justify 50 to perhaps 120 kg/ha of nitrogen, depending on yield potential, split between seedbed and top-dressing. Many upland rice soil is low in phosphorus and moderate fertilizer applications are usually required. Potassium fertilizer is important for high yielding rice varieties, particularly on sandy soils.

Soil Science Division has recommended 40:20:20 $N:P_2O_5:K_2O$ kg/ha for upland local paddy. Farmers are not applying the recommended level of nutrients for upland rice. Few farmers have started applying nitrogenous fertilizers only. Generally, farmers are even applying organic manure in insufficient quantity for upland rice. Upland rice requires small amount of nutrients as compared to improved and hybrid rice varieties. Rice in upland areas are adapted to erratic rainfall distribution, intense solar radiation, low N and P supply, blast incidence, and frequently acid soils.

Integrated plant nutrients management system (IPNMS)

The result of long-term soil fertility experiment conducted in different parts of the country under rice-rice-wheat and rice-wheat system has indicated that the productivity of the entire system decreases. The explanation for this may be a long term decline in the physical properties of the soil due to increased cropping intensity and reduced input of organic matter like FYM/compost.

Inorganic fertilizer use cannot be sharply increased due to its unavailability on time, inaccessibility, high prices and poor economy of the farmers in spite of good crop response and interest of farmers. As a result, nutrient consumption per hectare in Nepal is extremely low compared to other Asian countries. On the other hand, the quality of traditionally applied FYM is also decreasing due to depletion of forest base and biomass production. Under this situation, the IPNM approach, in addition to complementing the in organic fertilizer with the local natural resources, would help to increase nutrient efficiency and crop productivity through their synergistic effects. Thus, the losses of plant nutrients through leaching and volatilization will be reduced helping to optimize the resources used and keeping the environment safe. Experiments have shown that balanced use of organic and inorganic fertilizers increases yields by increasing the efficiency of applied fertilizer and maintaining the fertility status of soil.

Organic sources of plant nutrients for better soil quality

Organic sources of plant nutrients comprise of the residues of plants, animals and human beings. Some of the important sources of plant nutrients are: farmyard manure, compost, green manure and various animal wastes.

Farmyard manure (FYM)

In Nepal where housed livestock are important in agriculture, farmyard manure is the most important of the bulky organic manures. It is a decomposed mixture of dung and urine of cattle or other livestock with the straw and litter used as bedding and residues from the fodder fed to them.

Most of the farmers apply un-decomposed or partially-decomposed FYM on the surface for rice. Generally, rice fields are very far from the house. It is very difficult to carry FYM/compost to the rice fields. In this context, farmers apply more organic manures in *Bari* land (upland) compared to rice fields. Farmers carry FYM to the fields and keep it in heaps for a long time due to which N losses is higher. Farmers cannot spread out immediately to mix in the soil due to shortage of manpower. The soil analysis record has indicated that the *Bari* lands are more fertile than the rice fields (low land).

Compost

In general, farmers apply undecomposed or semi-decomposed compost to their field. In pit method composting is superior over the heap method in terms of nutrient content. Compost is usually carried in a *doko* (bamboo basket) to the fields in leisure time by women farmers. Compost is left in small heaps for 2-3 weeks till it rains and the farmers are ready for planting. Before ploughing the field, the heap of the compost is spread over the field uniformly and the land is ploughed. The nutrient of the compost is low due to nutrient loss by leaching and volatilization (evaporation) when it is left in heaps for few weeks.

Green manuring

Green manuring is another way of adding organic matter to the soil. A leafy crop, generally a legume is grown in the field itself or cut and brought from elsewhere, is incorporated in the soil prior to flowering. Leaves of bushes and trees may also be used for green manuring. Green manure crops can also be grown on bunds and waste lands. *Crotalaria juncea* (sunhemp), *Sesbania aculeate* (dhaincha), *S. speciosa*, *S. cannabiana*, *Astragalus sinicus* (milk vetch), *Vigna spp*. (cowpea) including other indigenous plants are some of the important green manuring plants.

Fertilizer research and recommendation

Introduction of fertilizer was followed by high-yielding rice, wheat and maize varieties, which performed well under high fertility management conditions. On the basis of results of limited number of fertilizer trials blanket doses of fertilizer nutrients at the rate of 100:60:40 kg/ha of N, P_2O_5 and $K_2O$for high yielding varieties and 60:40:30 kg/ha of N, P_2O_5 and K_2O for local varieties were recommended by the Soil Science Division in the 1960s.

In 1970s, the previous fertilizer recommendation was revised (**Table 1**) and extrapolated to individual districts based on accumulated experimental research and soil survey data (Joshy and Deo 1976). These recommendations were further extrapolated to district level based on soil test values. Based on this study and accumulated results of numerous other fertilizer trials then onwards, it has been established that high yielding varieties of cereal crops have responded highly to the application of nitrogenous fertilizers, moderately to phosphate and slightly to potassium fertilizers under Nepalese soil conditions (Pandey 1991). Moreover, after few years, deficiencies of P and K was frequently reported and cases of secondary (S) and micronutrients (B and Zn) deficiency were also increasingly observed. The research results on the efficient use of fertilizers under Nepalese soils, climatic, crop management and socio-economic condition are yet not sufficient to forecast the occurrence of nutritional disorder in Nepalese soil.

Table 1. Fertilizer recommendation dose by crops in term of nutrients

Name of crops	Compost fertilizer t/ha	Recommended fertilizer dose by nutrient (kg/ha)			NPK Ratio
		Nitrogen (N)	Phosphorus (P_2O_5)	Potassium (K_2O)	
Rice (irrigated)	6	100	30	30	3.3:1:1
Rice (unirrigated)	6	60	20	20	3:1:1
Maize winter	6	90	45	45	2:1:1
Maize yearly	6	60	30	30	2:1:1

Name of crops	Compost fertilizer t/ha	Recommended fertilizer dose by nutrient (kg/ha)			NPK Ratio
		Nitrogen (N)	Phosphorus (P_2O_5)	Potassium (K_2O)	
Wheat (irrigated)	6	100	50	25	2:1: 0.5
Wheat (unirrigated)	6	50	50	20	1:1:0.4

Source: Joshy and Deo 1976.

Green manuring technology adopted by farmers under rice based cropping system

At low altitude, locally available plant materials, *Ratosiris* (*Albizzi amollis*), *Asuro* (*Adhatoda vesica*) and *Khirria* (*Sapium insigne*) when green manured for rice at the rate of 10 t/ha, increase rice grain yields by 39% 37% and 27% respectively over the control (Sherchan and Gurung 1996). Green manuring technology has been well accepted as a low input technology especially for rice based systems. Farmers in developing countries, however, have rejected this technology. As the pressure of food production increases within the households and regions, farmers cannot afford to set aside portions of their land just for green manuring purpose. Negligible farmers of Tarai have been found to be adopting green manuring technology, in which Dhaincha (*Sesbania aculeata*) is a popular green manure in rice.

Fertilizer application method adopted by Nepalese farmers

In general, Nepalese soil is low in nitrogen content. Majority of farmers in Nepal have been following imbalanced and inefficient fertilizer application practices. The ratio of N: P: K recommendation varies with the type of crop, soil characteristics and physiographic situation. But, in general the average recommendation is 1N:0.5P:0.3K, whereas in practice, potassium application is extremely low, almost negligible in all crops. In terms of soil fertility difference due to land use, it was documented that irrigated paddy field (*Khet*) have the best fertility condition followed by rainfed agriculture (*Bari*), grazing land and forest.

The agriculture research has made general fertilizer recommendations for irrigated rice and unirrigated rice, 100:30:30 N: P_2O_5: K_2O kg/ha and 60:20:20 N: P_2O_5: K_2O kg/ha respectively, with 6 tonnes organic manure per hectare. Farmers have not adopted the recommended level of both organic and inorganic fertilizers. They are applying imbalanced chemical fertilizers such as DAP and Urea in rice fields. Generally farmers are avoiding potassic fertilizer for rice farming. Generally, they are using nitrogenous fertilizer as a basal dose in rice fields, which helps to enhance N losses aggravating environment pollution. Negligible numbers of farmers are applying nitrogenous fertilizers with 3 splits at different growth stages of rice plant. This is the perfect method of nitrogen application by which nitrogen efficiency enhances and reduces environment pollution. The imbalanced application of chemical fertilizers has been governed by three factors, such as unavailability of major nutrient fertilizers, lack of availability on time in the market, and farmers' poor economic condition.

Conclusion

A strong need for soil research and development has been felt by the scientists and development workers for increasing rice productivity in Nepal. The national level research and policy formulation institutions have also given strong emphasis on soil based research. There should be strong commitment and collaboration among the rice research institutions and Soil Science Division to increase soil productivity. The Division and National Rice Research Program must have strong coordination to generate technologies for the rice productivity. The problems of soil infertility from scientific viewpoints are: soil erosion or land degradation is seen as the most important problem in the hilly and mountainous regions of the country, which is needed to be resolved through innovation of appropriate technologies. The related research institutes should be able to develop an inventory of scientific information regarding soil types and their characteristics for the nutrient and water management of the rice crop. Farmers' awareness is necessary to alter their attitude on the imbalanced use of chemical fertilizers in rice based cropping systems. Concerned organizations might be able to provide scientific technologies on the compost and farm yard manure preparation and application methods in rice based farming systems. National program should be given the first priority on the soil acidity amelioration and balanced use of chemical fertilizers. Department of Agriculture should be reactivated for further reliable soil testing service. Increase in the farmers' adoption rates of appropriate technologies to enhance rice and soil productivity is necessary. Combination of organic and inorganic sources of plant nutrition management could have a positive role in sustaining the soil productivity of the rice based cropping systems. Organic sources have been the traditional sources of nutrition in farming system of Nepal, which maintained the soil fertility for a long run. The practice is still prevalent in the hilly region of Nepal. Thanks to the limited availability of organic manure, farmers have wisely diverted the manure meant for rainfed areas to more productive irrigated areas. This has led to a rapid decline of fertility of rain fed land. Green manuring technology has been well accepted as a low input technology especially for rice based systems. Farmers in Nepal have rejected this technology. As the pressure for food production increases within households and regions, farmer cannot afford to set aside portions of their land just for green manuring purpose. In this circumstance, there should be an alternative technology, in which *Dhaincha* (*Sesbania aculeata*) can be grown along with maize at the time of first and second hoeing and green manured for following rice crop. Through such practice, a total of 12.6 t/ha and 8.9 t/ha green bio-mass can be produced without reducing maize yields. The average increases in rice grain yield from *Dhaincha* green manuring could be obtained as 35% and 26% respectively over the non-green manured.

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Micronutrient Requirement of Rice and its Management in Nepal

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सारांश

नेपालीहरूको प्रमुख खाद्यान्न बालीको रूपमा रहेको धान बालीमा सूक्ष्म तत्वको न्यायपूर्ण र विवेकपूर्ण प्रयोगको उत्पादन र बालीको वृद्धिसँग सकारात्मक सम्बन्ध रहेको हुन्छ । प्रयोगशाला विश्लेषणको अभावमा नेपालमा सूक्ष्म तत्व बारेको अनुसन्धान केवल अध्ययन प्रयोजनमा नै सिमित हुन पुगेको छ । नेपालमा गरिएको अध्ययन अनुसार जस्ता, बोरोन र मोलिवडेनमको प्रयोगबाट धान बालीको उत्पादन वृद्धि भएको पाइएको छ । त्यसैगरी, फलाम र जस्ताको प्रयोगबाट नेपालको तराई क्षेत्रमा लगाइने धान बालीको उत्पादनमा ६ देखि १४ प्रतिशतले उत्पादन वृद्धि भएको पाइएको छ । नेपालका अधिकांश भूभागमा जिंक र केही भूभागमा सल्फरको कमी भएको पाइएको छ । पछिल्ला प्रतिवेदन अनुसार माटोको चिस्यान र पि.एच.को सूक्ष्म तत्व उपलब्धतासँग प्रत्यक्ष सम्बन्ध रहेको छ । साथै, एक अध्ययन अनुसार ओसिलो माटोमा रहेको पानीको मात्रालाई घटाउन सकेमा जिंकको मात्रलाई पुनः कायम राख्न सकिन्छ । त्यसैगरी, धान खेतमा प्रयोग गर्नुभन्दा नर्सरी अवस्थामा नै पातमा जिंक स्प्रे गर्दा प्रभावकारी पाइएको छ । बीउ प्राइमिङ र वायोफोर्टीफिकेसन धान बालीको उत्पादकत्व बढाउनका लागि र स्वास्थ्यका दृष्टिले दानामा सूक्ष्म तत्व कायम राख्न प्रभावकारी भएको पाइएको छ । नाइट्रोजन, फस्फोरस, पोटास र सल्फरको प्रयोगले उत्पादन वृद्धिका साथै धान बालीले सूक्ष्म तत्व ग्रहण गर्ने क्षमता वृद्धि गरेको पाइएको छ भने उच्च उत्पादन र जिंक ग्रहण क्षमता रासायनिक मल र कुखुराको मलको प्रयोगबाट भएको पाइएको छ । उत्पादकत्व वृद्धि एवम् मानव स्वास्थ्यका दृष्टिले धान बालीमा सूक्ष्म तत्व व्यवस्थापनको महत्वपूर्ण भूमिका हुँदा-हुँदै पनि फिल्डमा कार्यरत कृषि प्राविधिकहरूमा माटो र सूक्ष्म तत्व व्यवस्थापनमा ज्ञानको कमी, कमजोर पूर्वाधारहरू, औजार उपकरणहरूको अभाव, गुणस्तरीय माटो जाँच सेवामा कम पहुँच आदि कारणबाट नेपालमा सूक्ष्म तत्व व्यवस्थापन शिशु अवस्थामा नै छ । तसर्थ प्रयोगशाला पूर्वाधारको विकास गरी माटो र मलखाद व्यवस्थापनको क्षेत्रमा गहन अध्ययन नै विद्यमान अवस्थामा धानको उत्पादन र उत्पादकत्व वृद्धि गर्ने उत्तम उपाय हुन जाने देखिन्छ ।

Summary

Application of micronutrients has direct relationship with yield, growth and development of paddy. However, the study of micronutrient in soil and its recommendation for rice is very limited or confined to academic purpose in Nepal because of inadequate lab facilities. It has been revealed that rice yield is increased with the supplement of Zinc (Zn), Boron (B) and Molybdenum (Mo). 6-14% increase in yield was attributed in Tarai with the application of Iron (Fe) and Zn in comparison to control. Zn and sulphur deficiencies have often been reported in many parts of the country. Soil moisture level and pH have a direct effect on availability of micronutrients. Similarly, Zn deficiency in swampy soil may easily be recovered simply by draining water and creating favorable environment. In such soil, application of Zinc without draining water does not give good result. Similarly, application of Zn has increased the rice yield. Soil and foliar application of Zn in nursery bed was found to be more effective than application in rice fields in western Nepal. The technique of seed priming and biofortification are found to be effective not only for increasing crop yield but also for increasing the micronutrient contents in grain and edible part which is vital for human nutrition. Application of NPKS fertilizer is found to increase the yield as well as micronutrient uptake by rice plant. Combined use of chemical fertilizer with poultry manure has given the highest yield with maximum Zn uptake. Lack of technical know how at field level, absence of advanced lab equipment and less access to quality soil testing facility are some of the hindrances for managing micronutrients in rice field. Deep and detailed studies through development of necessary infrastructures, skilled manpower, are some of the urgent needs to increase the production and productivity of rice in Nepal.

Keywords: Analysis, Infrastructures, Micronutrient, NPKS, Productivity, Rice

Introduction

With the introduction of high yielding varieties and increasing cropping intensities, the rice yield had increased in the beginning but continuous cropping and unbalanced application of chemical fertilizer resulted in mining of soil nutrients and decline in soil fertility especially because of the decline in the amount of micronutrients. Reduction in yield of legumes and oilseed crops is an example of soil fertility decline. In recent days, deficiency of Zn and S is a common problem limiting rice yield.

Nutrient requirement of rice and soil testing facility in Nepal

Balanced application of manures and fertilizers depending on soil testing and crop requirement helps in higher and sustainable yield. But in Nepal there is lack of awareness among farmers and soil testing facility, balanced application of manure and fertilizer is not practiced. Moreover, use of high yielding varieties of rice and unbalanced application of manures and fertilizers has aggravated the problem of soil fertility decline and poor yield. The official soil testing practice in Nepal started with the establishment of the Soil Science Division in Khumaltar in the year 1958. The practice of making fertilizer recommendation in a blanket approach was avoided by making fertilizer recommendation on soil test basis and crop response and economics of fertilizer and crops produced in the year 1976.

Due to lack of updated information, soil and nutrient management practices are not very effective. With the commercialization of agriculture, farmers are looking for precision soil testing and nutrient recommendation services for higher and sustainable agricultural production, but the service delivered by the government laboratory are not only slow but also not very effective as expected by farmers.

In the past, there were no separate soil testing laboratories providing soil test services to farmers and the laboratories under the research stations were providing soil test service to farmers free of cost. After the establishment of Nepal Agricultural Research Council (NARC) in 1994, these laboratories focused on analysis of research samples and farmers had to pay a part of the total cost of chemicals and other consumables required for the soil testing, which repelled the subsistence farmers from soil testing. To address this problem, separate soil testing laboratories were established under the Department of Agriculture. In the beginning, one was established at center and five regional soil testing laboratories were established to provide soil test services to farmers. In the beginning, soil test service was free of cost but after 2001, the free soil test service policy was stopped and farmers have to pay a sum of Nepalese Rupee 66/sample for routine analysis (pH, OM, N, P, K, and texture). These laboratories also provide micronutrient analysis service but have to pay separately for it. In the year 2001, a separate soil testing laboratory was established in Surunga, Jhapa District for high value industrial crops like Tea, Cardamom, Coconut and Arecanut etc However, due to lack of manpower and poor infrastructure facility these laboratories are not able to give soil test services as expected by farmers. These seven laboratories can handle around 3000 soil samples in the laboratory and also provide soil test service to farmers in mobile soil test campaign. However, the soil test in soil test campaign is of qualitative nature and is not very useful for précised fertilizer recommendation. Moreover, since these laboratories are also mandated for fertilizer analysis for quality control, they are overburdened with the limited manpower. Therefore, these laboratories are not able to provide micronutrient testing service to farmers. Due to limited number of soil test laboratories and highly heterogeneous geographic terrain, it is very difficult for providing quality soil test service to farmers for précised soil and fertilizer management. To address the problem, policy for involvement of private sector in soil test service has been initiated, however it has not been implemented successfully due to high cost of private laboratories and inability of farmers to pay high service charge.

Micronutrient analysis and micronutrient use in rice

As described above, soil test service in Nepal has not paced as to cater to the need of time. In the past, micronutrient analysis was done by traditional method, mostly colorimetric and gravimetric analysis, but it was possible to handle only a few soil samples. Therefore, micronutrient analysis was done for research purpose only. Recently, with the advancement in laboratory tools and advanced micronutrient analysis method, the micronutrient analysis can be done very quickly. These tools and techniques, although very easy and quick are relatively costly and need well trained manpower and are used only in few government and private laboratories. Moreover, due to small land holding and subsistence level of farming, farmers are reluctant to use such high-tech and costly services and government is also not in a position to provide the service free of cost. This has not only limited the soil test service but it has also become a major problem diagnosis and management of micronutrient problem limiting the production and productivity of major crops including rice. The micronutrient analysis service is available in Soil Science Division (SSD) under NARC and Soil Management Directorate under the Department of Agriculture. Private sector laboratories also have micronutrient analysis facility, but they are more concentrated on industrial and environmental sector than agriculture and are out of reach for ordinary farmers due to high cost. Since the research on micronutrient analysis method and their correlation with crop response is very limited in Nepal, there is no uniformity in micronutrient analysis method and interpretation of result among these laboratories. Hence, there is doubt whether farmers really can benefit from the micronutrient analysis to address the problem of micronutrient deficiency.

Due to small land holding and highly heterogeneous geography, it is difficult to analyze soil samples for each individual farmer. Therefore, Soil Science Division of NARC started soil survey including soil physical as well as chemical parameters including micronutrient but could not complete the task. Perhaps the Land Resource Mapping Project was the mega project which helped to establish the inventory of soil resources in Nepal. But this project studied the major soil properties and did not include micronutrient status of the country. After the establishment of soil test laboratories under the Department of Agriculture, the soil fertility mapping was started by Soil Management Directorate. Soil fertility map prepared by SMD and Regional Soil Testing Laboratories include both major as well as micronutrient analysis. Since these maps include the available nutrients and active acidity only, they are useful for fertilizer management and cannot be used for predicting the long term soil fertility. In addition, due lack of knowledge of field technicians about soil fertility maps and its importance, these maps are not utilized effectively.

Micronutrient requirement of rice

Rice, as other crops, needs 16 essential elements to complete its life cycle. A study carried out in Philippines reported the requirement of different nutrient element as below.

Table 1. Nutrient requirement of high yielding rice variety

Plant Part	g/t yield of rice					kg/t of rice yield							
	Fe	Mn	Zn	Cu	B	Si*	Cl	N	P_2O_5	K_2O	MgO	CaO	S
Grain	150	310	20	2	16	41.9	5.5	7.6	1.1	28.4	2.3	3.80	0.34
Straw	20	60	20	25	16	9.8	4.2	14.6	6.0	3.2	1.7	0.14	0.60
Total	350	370	40	27	32	51.7	9.7	22.2	7.1	31.6	4.0	3.94	0.94

* *Beneficial element.*

Datta et al (1989) computed from the nutrient uptake data of rice variety IR36 at a yield level of 9.8 t/ha of grain and 8.3 ha of straw in Philippines.

Silicon is not an essential element of crop plant but plays an important role in rice plant which gives strength to plant and protects from lodging. It also helps to protect the plant from diseases and pests. A study conducted in Kathmandu and hills of Nepal reported increase in yield of rice with the supplement of Zn, B and Mo (Joshi 1997). Similarly, 6-14% increase in yield of rice was observed in Tarai region of Nepal with application of Fe and Zn compared to control (FAO 1990). Zinc deficiency is reported in rice crop in many parts of the country and in the recent days sulphur deficiency is also found in some areas. Therefore, analysis of soil for such elements and their management may help to increase production and productivity of rice.

Zinc requiremen t of rice and its management

Zinc is required for different biochemical processes in the rice plant; cytochrome and nucleotide synthesis, auxim metabolism, chlorophyll production, enzyme activation and the maintenance of membrane integrity. Zinc is required in early stage of the plant and its deficiency causes Khaira disease in rice.

Table 2. Critical stage and critical levels of Zn in plant tissue

Growth stage	Plant part	Optimum (mg/kg)	Critical level for deficiency (mg/kg)
Tillering	Y Leaf	25-50	<20
Tillering	Whole Plant	25-50	<10

Leaf Zinc concentration is a less reliable indicator of Zn deficiency, except in cases of extreme deficiency (leaf Zn<15 mg/kg). The relation of P:Zn and Fe:Zn in the shoot at tillering to the PI stage are good indicators of Zn status. Zn deficiency is possible when P:Zn >20-60:1 and Fe:Zn>5-7:1 in the shoot 6 weeks after planting. Low Zn availability in soil is the major reason for Zn deficiency in rice plant.

Causes of Zn deficiency

Sandy soil and soil with low organic matter are deficient in Zn. Susceptible rice varieties, high soil pH (≥7 under anaerobic conditions), and higher availability of Fe, Ca, Mg, Cu, Mn and P after flooding and excessive liming are some of the major reason for Zn deficiency in rice plant.

Management of Zn deficiency in rice plant

Zinc deficiency is most effectively controlled by Zn application and surface application of Zn is more effective in high pH soil. Recycling rice straw by composting or using FYM helps to increase Zn availability. Application of zinc sulphate in nursery bed and foliar application in nursery is found to be effective to control Zn deficiency in swampy areas. Seed priming before nursery establishment has also been tried and found effective to control Zn deficiency. Dipping rice seedling in Zinc Sulphate solution before transplanting is also found effective. In swampy areas, draining of field also helps to avoid Zn deficiency in rice. Due to high cropping intensity, Zn deficiency is common in most of the areas in Tarai and also in hills. Therefore, application of Zn is mandatory in the mega rice mission started in 2014/15.

Sulphur requirement of rice and management

Increasing cropping intensity, burning of crop residue, reduced use of FYM and use of chemical fertilizer not containing sulphur has resulted in sulphur deficiency in rice in recent days. Sulphur deficiency results in yellowing of the plant and is very often confused with nitrogen deficiency, but in sulphur deficiency leaves are pale yellow and cholorosis is more pronounced in young leaves and the tips may be necrotic. The author experienced recovery of yellowing rice plant in Chitwan in the year 2010/011 by applying zinc sulphate.

Table 3. Critical level of zinc deficiency in rice

Growth stage	Plant part	Optimum%	Critical level for deficiency%
Tillering	Y leaf		<0.16
TIllering	Shoot	0.15-0.30	<0.11
Flowering	Flag leaf	0.10-0.15	<0.1
Flowering	Shoot		<0.07
Maturity	Straw		<0.06

During vegetative growth, a shoot concentration of >0.15% indicates a response of applied sulphur is less likely. From tillering to flowering <0.10% sulphur and N:S ratio of >15-20 indicates sulphur deficiency. At maturity, a sulphur content of <0.06% or a N:S ratio of > 14 in straw or >26 in grain indicate sulphur deficiency. Soil test for sulphur is not very reliable but if it can include inorganic and mineralizable sulphur it can be more reliable.

Table 4. Critical soil levels for occurrence of S deficiency

Extraction method	S mg/kg
0.05 M HCl	<5
0.25 M KCl heated at 40^o C for 3 hours	<6
0.01 M Ca $(H_2PO_4)_2$	<9

Causes of sulphur deficiency

High cropping intensity, low organic matter recycling, stubble burning and low sulphur availability in soil are the major reasons of sulpur deficiency. Application of sulphur containing fertilizer is the most effective method of controlling sulphur deficiency. Organic matter recycling and use of manures/compost also helps in controlling sulphur deficiency in rice.

Status of micronutrient analysis and soil and fertilizer management in Nepal

Very little information is available about micronutrient status and management in Nepal. Most of the studies in the past have been carried out either for academic purpose or for research in a limited scale. Most of the studies are carried out on Boron and Zinc in different crops. Karki (2004) reviewed the past work on micronutrient in soil and management in various crops. Work has been carried out in field and greenhouse experiments on micronutrients' importance in agriculture such as: boron (B), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), and zinc (Zn). Most of this work concentrated on B and Zn, as deficiency of these two elements is significant in Nepalese soils; although chlorine (Cl) is equally important. However, since chlorine is supplied as potassium fertilizer in the form of murate of potash (KCl), its deficiency is not often observed. Silicon (Si), another important mineral element needed for plants and animals, is the second most abundant element next to oxygen and occurs in almost all minerals. Silicon is available through weathering of rocks and minerals, and its deficiency has not been noticed in plants. Micronutrients extracted by aquaregia in the top soil was found to have sufficient amount of Cu, Mn and Zn in top soil but the study did not report the availability of these elements (**Table 5**).

Table 5. Micronutrients extracted by aquaregia from Nepalese soil profiles (n= 20) (1994)

Soil depth (cm)	Micronutrients in ppm		
	Cu	Mn	Zn
0 – 30	35.5	628	105
30 – 60	9.1	222	62
60 – 90	7.9	207	40
0 – 90*	8.88-33.5	252-594	50-103
	* n = 60		

Source: SSD Khumaltar 1998.

In the High Himalayan region, diethylene triamine pentaacetic acid (DTPA) extracted soil contained greater amounts of Mn (4.36 mg/kg) and Zn (3.43 mg/kg), whereas Cu (0.28 mg/kg), Fe (8.86 mg/kg), and B (0.16 mg/kg) contents were low. In the mid hills of the Western region all of these elements were low except Fe, which was present in medium amounts. The central hills had similar characteristics. In the Kathmandu Valley, however, where soil is formed by lacustrine deposits, the content of trace elements varied. Zinc content ranged from 2.7 mg/kg to 26.8 mg/kg, Cu from 9.12 to 10.93 mg/kg, Fe from 290.9 to 1101.9 mg/kg, and Mn from 27.94 to 128.83 mg/kg. These elements in the Valley are categorized as being in the medium to high range. The higher content of these elements was due to the heavy application of compost formed from city waste. In contrast, B and Mo are low even in the valley soil and crops responded well to B and Mo applications. In the inner Tarai (Chitwan), B and Zn contents are low whereas Cu, Fe, Mn are high. In the Tarai, Cu, Zn, and Mn content are low to medium, but Fe content is high. All of these elements responded well to experiments in all five physiographic regions. In the eastern Tarai, boron has been found to create deficiencies in wheat. Karki (2004) reviewed and reported the micronutrient status of Nepalese soil to be very poor in micronutrients, especially Molybdenum, Boron and Zn.

Zn deficiency has come up as a major limiting factor in rice production especially in sandy and alkaline soil. It is reported that the highest crop yield was in treatment with Zinc Sulphate @20 kg/ha. It has been observed a positive response to applied micronutrients in rice crops in the central region. Positive response of micronutrients in rice-wheat cropping system has also been reported.

Mikko Sillanappa (1982) carried out extensive study on micronutrients in 30 different countries including Nepal and published a report. He concluded that Nepalese soil contains relatively good amount of Fe, Mn and Cu whereas Molybdenum is in the low range (one third) but for Boron (50%) and Zinc (lowest), deficiency is commonly expected.

Tuladhar (2001) analysed the micronutrients in Chitwan soils and reported that most of the samples were low in Boron (100% sample) and low to medium in Zn (95% samples), medium to high in Cu (98% samples) and Mn and Fe were found to be high (100% samples). Dhakal (2008) analysed Chitwan soil for Zn, Cu, Mn and Fe, and found almost similar report as above.

Studies in the past indicated increase in yield of different crops by micronutrient application, but Zn and B deficiency were commonly found. Khaira disease is commonly found in rice and this crop responds highly for Zinc application. Similarly, little leaf and rosette is also common in citrus growing area. Boron deficiency is common in cauliflower, other cole crops and oilseed crops. Considering the micronutrient problem, Soil Management Directorate has started analyzing micronutrient and preparation of micronutrient in soil fertility map. For eg, soil analysis report and fertility maps prepared by Soil Management Directorate also indicated the deficiency of Boron and Zinc in all sample districts namely: Makawanpur, Myagdi, Dailekh, Mustang and Palpa. The micronutrient status is found to be directly correlated to soil pH and micronutrient content in soil.

Micronutrient and human health

Although, plants absorb many elements from soil, it is established that 16 elements are essential for completion of plant life cycle. Although some elements are not directly involved in plant metabolic activities, they are found to be helpful for specific purposes like protecting plants from disease and pest attacks, making the cell wall and cuticle strong and preventing from lodging. Human beings require more than 50 elements and vitamins for a healthy life. Plants are the major source of human and animal nutrition, for eg: iodine, selenium, and fluoride although not required for plants, plays a vital role in human and animal nutrition. The essential micronutrient like Zn is not only important to plants but is also important to human beings. Therefore, micronutrient management in crop plants is not only important for higher crop production but also for human nutrition.

Hidden hunger, malnutrition due to the lack of micronutrients, is a major threat to human health in Nepal (RSTL 1998, Andersen 2007). Presently, the focus of national policy is on iodine (I), vitamin A, and iron (Fe) (RSTL 1998). Micronutrient deficiencies in the context of soil–crop relations are increasingly being recognized. Zn deficiency affects the immune system and develops resistance against diarrhea and other infectious diseases. There are no good indices of Zn deficiency in humans, but on the basis of food balance sheets, it was estimated that 95.4 ±2.1% of the South Asian population is at risk of low Zn intake. Stunting-height for-age being less than 2 standard deviations below the median—is a common measure of malnutrition. Among rural pre-school children in Nepal in 1996–1997, 56.3% were stunted. In Western Mountain region the figure was as high as 72.2% (RSTL 1998).

To mitigate the problem of micronutrient, mineral supplement is tried in health sector but is not very effective due to various reasons. Therefore, food based nutrition is given importance for micronutrient and vitamins through the intake of healthy diet. One of the examples is that nutrition is one of the components in Agriculture and Food Security Project where pregnant and lactating women are given message for food diversity. For this, Village Model Farm (VMF) and Home Nutrition Garden (HNG) are promoted for production of mineral and vitamin rich vegetables and dual purpose poultry and sannen goat are also supplied for egg, meat and milk production for improved nutrition of the farming community in selected VDCs of 19 districts in the Mid-West and Far-Western development regions.

Lately, plant breeders are trying to develop varieties that are efficient and useful for human nutrition. Golden rice project for high carotenoid content and high Fe containing rice in Philippines and orange fleshed sweet potato in Africa are some of the successful examples.

Supplement of some elements are found to increase the content of these elements in food grain. Scientists reported higher content of zinc, selenium and iodine in grains could be achieved by application of these elements as fertilizer. Application of urea containing 3% ZnSo4 not only increases the rice yield but also increases the Zn content in grain both in wheat and rice. Both soil as well as foliar application increases the grain Zn content even up to three times. Therefore, Zinc fertilization in rice can help Zn supplement in human nutrition.

Table 6. Micronutrients deficiency prevalence and major disorders (Bhandari and Rai 2015)

Micronutrients	Deficiency prevalence	Major deficiency disorders
Iron	35% of women (15–49 years of age) and 46% of children (under five years)	Iron deficiency anemia, reduced learning and work capacity, increased maternal and infant mortality, low birth weight, impaired human function at all stages of life
Iodine	22.0–27.9% (urinary iodine <100 μg/L)	Cretinism, goiter, impaired cognitive function, increased prenatal morbidity and mortality, reduced productivity
Zinc*	87.3% in children; 61.0% in pregnant women	Poor pregnancy outcome, impaired growth (stunting), genetic disorders, decreased resistance to infectious diseases
Folate*	6.2% in children; 12.0% in pregnant women	Neural tube and other birth defects, megaloblastic anemia, heart disease, stroke, impaired cognitive function, depression
Vitamin A*	8.5% in children; 7.0% in pregnant Women	Xerophthalmia (night blindness, Bitot's spot, corneal ulcer, keratomalacia, xerosis), increased risk of morbidity and mortality, increased risk of anemia
Vitamin D*	17.2% in children; 14.0% in pregnant women	Rickets, osteomalacia, osteoporosis, colorectal cancer
Vitamin E*	17.9% in children; 25.0% in pregnant women	Ataxia, peripheral neuropathy, muscle weakness, miscarriages, slow growth in children
Vitamin C*	Limited information	Scurvy (fatigue, hemorrhages, low resistance to infection, anemia)
Vitamin B1*	Limited information	Beriberi (cardiac and neurologic),Wernicke, and Korsakov syndromes (alcoholic confusion and paralysis)
Vitamin B2*	33.0% in pregnant women	Nonspecific (fatigue, eye changes, dermatitis, brain dysfunction, impaired iron absorption)
Vitamin B3*	Limited information	Pellagra (dermatitis, diarrhea, dementia, death)
Vitamin B6*	43.1% in children; 40.0% in pregnant women	Dermatitis, neurological disorders, convulsions, anemia, elevated plasma homocysteine
Vitamin B12*	18.1% in children; 28.0% in pregnant women	Megaloblastic anemia (associated with *Helicobacter pylori* induced gastric atrophy)
Calcium*	Limited information	Decreased bone mineralization, rickets, osteoporosis
Selenium*	59.0% in children	Cardiomyopathy and increased cancer and cardiovascular risk
Fluoride*	Limited information	Affects bone health including increased dental decay

**Lacking data from national survey*

Micronutrient management practice for rice crop in Nepal

The micronutrient study in Nepal is mainly done for academic purpose and is limited in geographical coverage and variety of crops. The reports indicate deficiency of Zn and Boron is very prominent. Tarai farmers and commercial vegetable growers are using Zn, B and other micronutrient containing fertilizers. Since the deficiency and toxicity range for micronutrients is very narrow, micronutrient fertilizer should be applied very carefully. Using micronutrient without soil and plant analysis may produce negative results. On the other hand, soil moisture level and pH has direct effect on availability of micronutrients. Hence careful attention is required before applying micronutrients. For example, Zn deficiency in swampy soil may easily be recovered simply by draining water and creating favorable environment. In such soil, application of Zinc without draining water does not give good result. In an experiment conducted in Khairenitar, Tanahun, application of Zn increased the rice yield. Soil and foliar applications of Zn in nursery bed were found to be more effective than application in the rice field (**Table 7** and **8**).

Table 7. Effect of Zinc in yield of rice*

Treatment	Jamune 1	Jamune 2	Khairenitar	Manpang	Chhang 1	Chhang 2	Average	Increae%
	2059/60 BS			2061/62 BS				
Farmer's Practice	2.54	1.86	1.99	2.5	1.9	3.2	2.33	0
NPK	3.23	2.88	2.16	2.7	2.1	3.4	2.75	17.73
NPK + Zn	4.2	3.63	2.97	3.1	2.3	3.6	3.30	41.53

Note: NPK- Recommended dose of, NPK+Zn- Recommended dose of NPK with Zinc

**Annual report of Regional Soil Testing Laboratory, Khairenitar 2002/03, 2004/05*

Table 8. Effects of different methods of Zn application in rice yield

Site	Treatment	Yield (t/ha)	% increase
Jamune Tanahun	T1 NPK	2.45	0.00
	T2 NPK+Zn in nursery	3.15	28.50
	T3 NPK + Zn in field	2.74	11.80
	T4 NPK+ Zn in both	4.52	43.60
Jamune Tanahun	T1 NPK	3.00	0.00
	T2 NPK+Zn in nursery	3.31	10.30
	T3 NPK + Zn in field	3.19	6.30
	T4 NPK+ Zn in both	3.55	18.30
Average	T1 NPK	2.72	0.00
	T2 NPK+Zn in nursery	3.23	19.40
	T3 NPK + Zn in field	2.96	9.05
	T4 NPK+ Zn in both	3.53	30.95

Micronutrient requirements of crop are very low. Under normal soil condition, the soil can supply required amount of micronutrients to crops. But in extreme soil condition like very high or low pH, the micronutrient availability is affected. High cropping intensity, use of high yielding varieties and low or no use of organic matter are the main reasons of micronutrient deficiency. Use of organic manure and fertilizer increases the micronutrient availability and crop yield too. Micronurients are relatively costly and not commonly available in the market. Very often, soil application of micronutrient is not effective and foliar application is time consuming which discourages farmers to use micronutrient fertilizer. Recently the technique of seed priming and biofortification are found to be effective not only for increasing crop yield but also for increasing the micronutrient content in grain and edible part which is vital for humane nutrition.

Table 9. Influence of zinc seed treatments on grain yield and grain enrichment

Source	Application mode	Application rate	Crop	Increase in grain yield over untreated Control (%)	Increase in Zn grain contents over untreated control (%)	References
Zinc sulphate	Seed Priming	1 g kg seed	Rice	14.57	-	Slaton et al 2001
		2.2 g/kg seed	Rice	17.92	-	
		4.7 g/kg seed	Rice	28.25	-	
		0.004 M 36 h	Rice	-	580	Johnson et al 2005
Zn-EDTA	Seed Priming	1.4 g/kg seed	Rice	20.73	-	Slaton et al 2001
		2.8 g/kg seed	Rice	26.50	-	
		5.7 g/kg seed	Rice	20.45	-	
ZnO-coated urea	Seed Coating	0.5% (w/w)	Rice	19.1	4.38	Shivay et al 2008
		1.0% (w/w)	Rice	10.63	16.50	
		1.5% (w/w)	Rice	18.48	30.98	
		2.0% (w/w)	Rice	27.59	40.07	
ZnSO4-coated urea	Seed Coating	0.5% (w/w)	Rice	6.84	12.79	
		1.0% (w/w)	Rice	13.16	27.61	
		1.5% (w/w)	Rice	20.25	36.03	
		2.0% (w/w)	Rice	29.62	48.15	

In an experiment, application of NPKS fertilizer increased the yield as well as micronutrient uptake by rice plant. The highest yield and Zn uptake was found in combined use of chemical fertilizer with poultry manure (70% NPKS + PM, NPKS- recommended dose of chemical fertilizers, RS- Rice straw@5 t/ha, DH-Dhaincha @15 t/ha, MBR-Mung @10 t/ha, CD- cow dung @5 t/ha, PM- Poultry manure @3 t/ha). The result suggests that increasing cropping intensity and use of chemical fertilizer with no or little supplement of micronutrient fertilizer result in mining of micronutrients from soil and decline in soil fertility as well as crop productivity

Micronutrient application does not always increase crop yield. It depends upon micronutrient availability in soil, the nutrient requirement of plants and ability of plants to uptake micronutrients from soil. For example, in a soil where khaira disease is found in rice plants may not necessarily show any symptoms of zinc deficiency in other crops. Even with the same species, one variety may suffer from deficiency of a particular nutrient but other varieties may do well in the same soil. Therefore, selection of efficient crop or variety may also help in managing the deficiency of a particular micronutrient in soil. Similarly, method and time of micronutrient fertilizer application affects the nutrient availability and deficiency of particular micronutrient. For example, in swampy land application of $ZnSO_4$ without draining the excess water does not help to correct Zn deficiency in rice plants.

In Nepal, rice farmers use Zinc Suplhate where the symptom of Zn deficiency was seen in past season. Zinc Sulphate, imported mainly from India, is available in agrovets. The data for micronutrient use is not available in Nepal. However, estimating the total rice area and the percentage of farmers using micronutrients (3% of rice farmers are using 15 kg/ha), it can be said that almost six to seven hundred tonnes of Zinc Sulphate is used every year.

Conclusion

In the last six decades, the production of rice increased by three times in Nepal. The production was increased mainly due to increase in area and cropping intensity, and use of high yielding varieties and chemical fertilizers. In recent days, farmers are unable to harvest the same yield as previous year using the same variety and same level of inputs. This is mainly due to little or no use of organic maure and unbalanced application of fertilizers leading to deficiency of one or more nutrients. The study of micronutrients in soil and its recommendation is very limited in Nepal. Limited number of studies was done in the past mainly for academic purposes.

Recommendation for micronutrient application was mainly based on the deficiency symptoms and the result of the limited research carried out in the past. Deficiency symptoms are seen in the extreme condition, therefore identifying the nutrient status beforehand could help in mitigating the hidden hunger and increasing the production and productivity of rice and increasing the profit per unit cost of production.

Laboratory facility for micronutrient analysis is not abundant in Nepal. Since, the modern equipments for micronutrient analysis are very costly, these laboratories are working with limited facilities. Moreover, due to the lack of skill development trainings to laboratory staffs, the existing facility in the laboratrory is not utilized to its full potential. Due to the lack of regular repair and maintenance of the laboratory equipment, the efficiency/accuracy of the laboratory report is also doubtful.

Due to limited research on micronutrients and technical booklets, the field technicians are not able to diagnose micronutrient deficiency in the field. There is very limited technical material on micronutrient management published for use by field technicians. The field technicians are not well acquainted of the laboratory report and are not able to interpret it for soil and micronutrient management. At present, the soil testing laboratories are not only providing the soil test service but also providing soil and nutrient management guidance to farmers.

The soil nutrient status changes over time and needs continuous study for effective soil and fertilizer management including micronutrients. Nepal Agricultural Research Council (NARC) is carrying out research on various aspects of soil and plant nutrient management, but the research on micronutrient in soil and its management in different crops are too little. The manpower in the field of soil and fertilizer research is also inadequate in comparison to the past and is the main reason for poor work in the field of micronutrient research.

Plant nutrient management is not only important for plant nutrition but is also equally important for human and animal nutrition. In the past, minerals and vitamins supplements have been tried with limited success in human nutrition. Recently the food and nutrition experts are of the opinion that food diversity and promotion of traditional nutritious food is more important and cost effective to address the micronutrient and vitamin deficiency. Finally, increasing crop production and productivity and improving the status of human and animal nutrition is almost impossible without due attention to micronutrient management backed up by soil and fertilizer management research through state of the art laboratory facility and competent technicians.

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Use of Leaf Color Chart in Rice Nutrient Management

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सारांश

लिफ कलर चार्टको प्रयोगले किसानहरूलाई कुनै निश्चित समयमा बिरुवाको लागि आवश्यक नाइट्रोजनको मात्रा अनुमान गरी मलखाद प्रयोगको उपयोगिता बढाउने तथा धानको उत्पादन बढी लिने अवसर श्रृजना गर्छ । बिरुवालाई आवश्यकता परेको बखतमा नाइट्रोजनयुक्त मलखादको प्रयोग गर्न र वातावरणमा हुने नाइट्रोजनको चुहावट कम गर्न लिफ कलर चार्टको प्रयोग एउटा राम्रो तरिका हो । बिरुवालाई आवश्यक हुने भन्दा थोरै नाइट्रोजन प्रयोग गर्न खोज्ने कम आम्दानी भएका किसानहरूको लागि लिफ कलर चार्ट प्रयोगको प्रभावकारिता कति हुन्छ भन्ने प्रश्न उठ्न सक्छ ।

Summary

Leaf color charts offer substantial opportunities for farmers to estimate plant nitrogen demand in real time for efficient fertilizer use and high rice yields. Leaf color chart is a good technique for farmers to save nitrogenous fertilizers by synchronizing the application with crop demand and to minimize nitrogen losses to the environment. A question may arise how effective the leaf color chart is for resource poor farmers, who tend to apply nitrogenous fertilizer less than the requirement of crops.

Keywords: Leaf color chart, Nitrogen demand, Resource poor farmers, Rice, Yield

Introduction

The national yield of rice was 3.39 t/ha in 2011/12 (ABPSD 2014). This is far below the attainable yield (Dey and Hossain 1995) and the yield obtained by other major rice growing countries in the world. Furthermore, present rice yield is insufficient to meet the national demand. It is estimated that about 1259 thousand tonnes of additional rice is required to be produced by 2030 and this volume is equivalent to an overall increase of 27.96% in the next 17 years (Prasad et al 2011, ABPSD 2014). Among various reasons for this low productivity, inefficient utilization of nitrogen is considered to be the most critical one, especially in South Asia including Nepal (Witt et al 2005).

In world-wide evaluation, fertilizer recovery efficiency was found around 30% in rice (Krupnik et al 2004). It is observed that more than 60% of applied nitrogen is lost from the soil plant system due to the lack of synchronization between nitrogen demand and supply (Yadav et al 2004). Most of the farmers rely on the age (days after transplanting) of rice seedlings, but not on nitrogen status of the crop (Alam et al 2005). The optimum use of nitrogen can be achieved by matching nitrogen supply with crop demand (Bijay et al 2002) This will result greater yield responses to nitrogen application in comparison to farmers' practice (Witt et al 2005).

The direct measurement of leaf nitrogen concentration by laboratory procedure is laborious, time consuming, and costly (Nachimuthu et al 2007). A simple and quick method for estimating plant nitrogen demand is the use of leaf color chart (LCC) (Hussain et al 2000). Soil plant analysis development (SPAD) is another alternative, which can estimate leaf chlorophyll content in a nondestructive manner (Dwyer et al 1991) through an indirect assessment of leaf N status (Blackmer and Schepers 1994). The costly SPAD meter is not suitable as an on-farm tool while LCC is easy to use and is an inexpensive diagnostic tool for monitoring the relative greenness of a rice leaf as an indicator for the plant nitrogen status (Balasubramanian et al 2003). The LCC technique offers substantial opportunities to farmers for the detection of time and amount of N to be applied for efficient nitrogen use and high rice yield. Thus, LCC becomes useful in avoiding under or above fertilization besides maintaining the supply of nitrogen at appropriate time (Budhar 2005).

Significance of leaf color chart

The LCC is a simple tool to monitor the relative greenness of rice leaves (Witt et al 2005). The leaf nitrogen content of a cereal crop is closely related to photosynthetic rate (Yoshida and Coronel 1976), biomass production (Kroff et al 1993), and it can serve as an indicator of nitrogen demand by the crop during the growing season. A standardized plastic LCC with six plastic panels ranging from yellowish green to dark green in color (**Figure 1**) has been developed and promoted across Asia (IRRI 2010). The LCC was originally developed to use in rice, but it can be used for fine tuning the application of nitrogenous fertilizer in wheat (Alam et al 2006) and maize (Witt et al 2009).

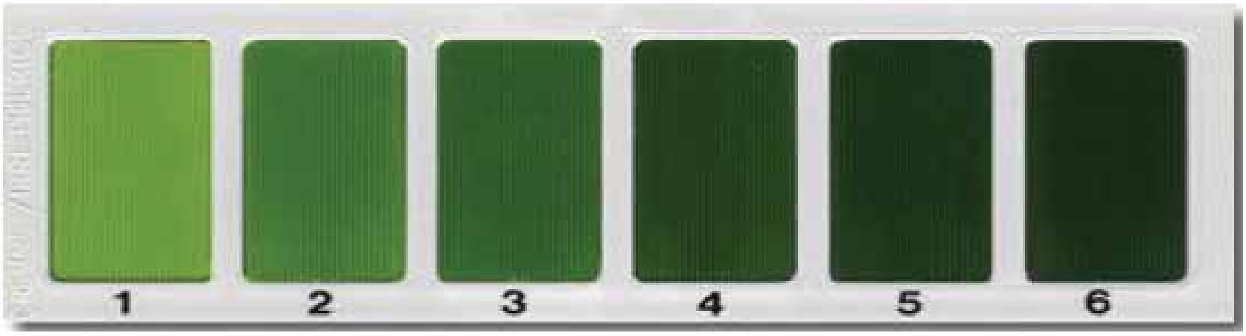

Figure 1. Leaf color chart

Based on the LCC, nitrogen application could be skipped off if a reading of four or above is obtained. The critical leaf color reading for nitrogen top dressing ranges from three for varieties with light green foliage (eg scented to aromatic rice varieties) to four for other improved varieties and hybrids. Similarly, the critical LCC level is four for transplanted rice and three for direct wet seeded rice under Philippine conditions. The same level can also be used in case of Nepal. Crops showing a leaf color below the critical values suffer from nitrogen deficiency and require immediate application of nitrogenous fertilizer to prevent yield losses. For locally important varieties and crop establishment methods, the critical LCC values can be redefined after one or two test seasons. The following are the significance of LCC.

The LCC helps to monitor the crop nitrogen status in-situ and to determine the right time of nitrogen application to rice crop based on crop need.

The LCC promotes timely and efficient use of nitrogen in rice, minimizes nitrogen loss and hence reduces the pollution of water resources from fertilizers.

Procedure and guidelines for LCC measurement

Randomly select 10 healthy plants in the field where plant distribution is uniform. The topmost fully expanded leaf is chosen for leaf color measurement as it is highly correlated to the N status of rice plants. Different sets of 10 leaves should be used for reading every week.

The color of a single leaf is measured by holding the LCC vertically and placing the middle part of the leaf in front of a color strip for comparison. If the color of a rice leaf seems to fall between two color shades, take the mean of the two values as the reading. The leaf in which reading to be recorded should be shielded with our body as the leaf color chart reading is affected by sun's angle and sunlight intensity. If possible, same person should take color measurement at the same time of the day.

Readings are taken between 8-10 am when there is not much glare from the sun. Readings should not be taken early in the morning since dew drops can make reading difficult.

Readings are taken from ten leaves at random from each plot and then the average score is compared to determine the need for nitrogen top dressing (**Table 1**).

The LCC readings are taken once in every 7-10 days, starting from 14 days after transplanting for transplanted rice and 21 days after seeding for wet seeded rice and ending with flowering. Continue taking readings at 7-10 days intervals until first flowering.

If the area is heterogeneous (with different soil nitrogen status), the area should be divided into several plots of similar characteristics. Then LCC readings of 10 representative plants should be taken from each plot.

Fertilizer recommendation on the basis of leaf color chart

At least 40 kg P_2O_5/ha and 30 kg K_2O/ha should be applied in the field during final land preparation. A basal application of 25 kg ZnSO4/ha is also recommended. The recommended doses of N fertilizer to be applied at different growth stages for semi- dwarf *indica* varieties is given in **Table 1**.

Table 1. The amount of N to be applied at different growth stages for semi-dwarf *indica* varieties

Types of rice farming	Dry season	Wet season
Transplanted rice		
Early growth stage (14-28 DAT)	30 kg N/ha	20 kg N/ha
Rapid growth stage (29-48 DAT)	45 kg N/ha	30 kg N/ha
Late growth stage (49 DAT to Flowering)	30 kg N/ha	20 kg N/ha
Direct Seeded rice		
Early growth stage (21-34 DAS)	30 kg N/ha	20 kg N/ha
Rapid growth stage (35-55 DAS)	45 kg N/ha	30 kg N/ha
Late growth stage (56 DAS to Flowering)	30 kg N/ha	20 kg N/ha

Performance of LCC based nitrogen management

Performance of nitrogen application on the basis of LCC on grain yield and nitrogen economy

The application of nitrogenous fertilizers over a fixed duration on the basis of LCC contributed in increasing rice yield and saving nitrogen in comparison to the blanket recommendation. Nitrogen management through LCC saved 7.88% of nitrogen along with yield advantage of 4.93% but varied with varieties, establishment methods, locations, and years (**Table 2**).

Table 2. Evaluation of leaf color chart (LCC) based real time nitrogen management versus blanket nitrogen recommendations in transplanted rice in different experiments in Nepal

SN	LCC based N management		N application as per blanket recommendation		References
	Grain yield (t/ha)	Nitrogen applied (kg/ha)	Grain yield (t/ha)	Nitrogen applied (kg/ha)	
1	4.76	90.00	4.60	100.00	Adhikari 2006
2	3.75	95.00	3.71	100.00	Poudel 2007
3	4.70	95.00	5.05	100.00	Adhikari 2006
4	4.11	92.33	3.74	100.00	Marahatta 2008
5	4.89	100.00	4.34	120.00	Subedi 2014
6	3.82	98.33	3.16	100.00	Lama 2014
7	5.54	101.75	5.44	100.00	Devkota 2007
8	3.76	83.00	3.63	100.00	NARC, Annual report, Ranighat 2004

Yield response to LCC managed nitrogen (at critical level 4) and total nitrogen requirement was significantly influenced by the varieties (**Figure 2**). Client oriented rice variety Super-3004 gave higher yield than Sabitri and Barkhe-2024 along with the saving of 2 kg N/ha (Marahatta 2008). Subedi (2014) observed the highest yield of US-312 followed by Sukkha-5. The nitrogen requirement for US 312, a hybrid variety, was 37.5 kg/ha more than Radha-4, an inbred variety, while Sukkha-5 gave higher yield than Radha 4 with saving of 7.5 kg N/ha in LCC based nitrogen application.

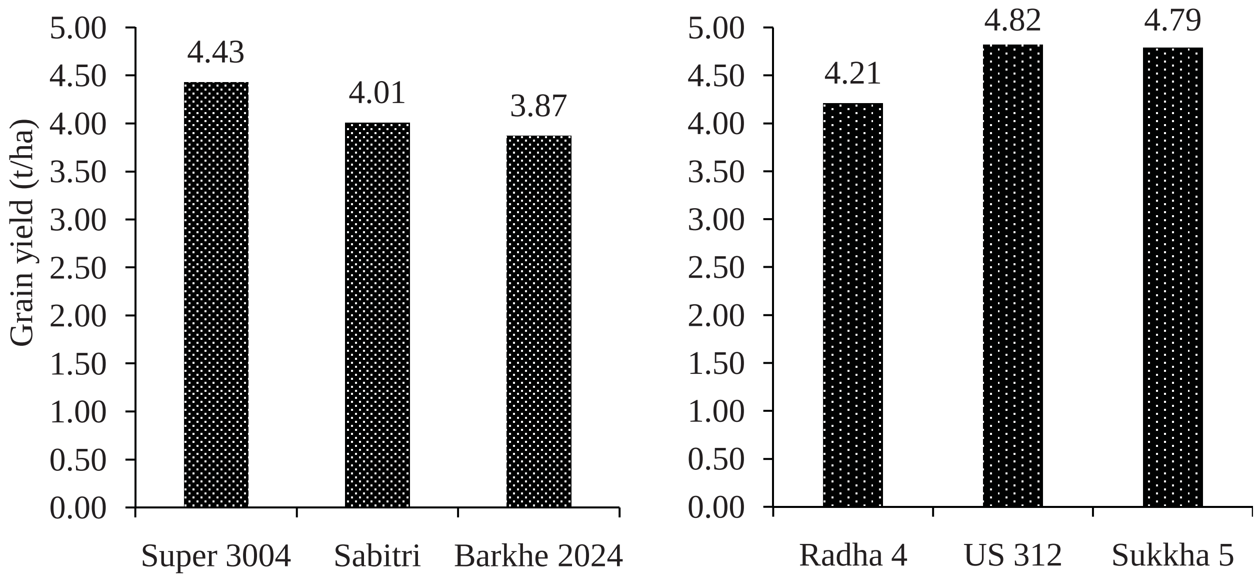

Figure 2. Grain yield (t/ha) as influenced by varieties at LCC based nitrogen management with critical value 4 for: (A) transplanted rice and (B) direct seeded rice

Subedi (2014) examined the adjustment of basal nitrogen in LCC based application for direct seeded rice. In recommended practice, 120 kg N/ha was applied while the total N applied in LCC based treatments ranged from 100 to 130 kg/ha irrespective of varieties. Nitrogen saving in LCC based treatments over the recommended practice ranged from 7.5 to 30 kg/ha in Radha-4 and 7.5 to 37.5 kg/ha in Sukkha-5 while hybrid varieties required additional 7.5 to 37.5 kg/ha. So, there was no N saving in case of US 312. Similarly, grain yield was found significantly higher in LCC based treatments than in recommended practice, in which nitrogenous fertilizers were applied in three split doses (**Table 3**). Grain yield was found 287 to 483 kg/ha (3.88 to 16.98%) higher in LCC based treatments as compared to recommended practice of three split application (**Table 3**).

Table 3. Effect of nitrogen management practices and varieties on the amount of total N applied and grain yield for dry direct seeded rice in Chitwan, 2014

Nitrogen management practices	Nitrogen application (kg/ha)			Grain yield (t/ha)		
	Radha 4	US 312	Sukkha 5	Radha 4	US 312	Sukkha 5
Recommended practice (120 kg N/ha)	120	120	120	4.03	4.51	4.47
30 kg N at basal + LCC based N application	120 (0.00)	157.5 (-37.50)	112.5 (+7.50)	4.21 (+4.37)	4.82 (+6.91)	4.79 (+7.12)
30 kg N at 15 DAS + LCC based N application	112.5 (+7.50)	157.5 (-37.50)	105 (+15.00)	4.43 (+9.95)	5.06 (+12.27)	4.73 (+5.82)
Pure LCC based N application	90 (+30.00)	127.5 (-7.50)	82.5 (+37.50)	4.72 (+16.98)	5.10 (+13.04)	4.64 (+3.88)

Note: Nitrogen applied on LCC was 30 kg/ha at critical level ≤ 4. Figures in parentheses indicate N saving (+) or excess (-) in kg/ha and yield advantage in percentage (+) and reduction in percentage (-) as compared to recommended practice.

Source: Subedi 2014.

Nitrogen requirement through LCC based management also differed according to the establishment methods (Lama, 2014). Nitrogen requirement to conventionally tilled direct seeded rice and unpuddled transplanted rice under LCC based application was 27.12% and 6.78% higher in comparison to puddled transplanted rice and 25.00% and 5.00% higher in comparison to recommended practice (100 kg N/ha). However in case of puddled transplanted rice, nitrogen saving under LCC based management was negligible in comparison to recommended practice (**Table 4**).

Table 4. Nitrogen application and yield in LCC based nitrogen application in real time and blanket application in fixed time in rice, 2014

Establishment methods	Recommended practice		LCC based N management	
	Grain yield (t/ha)	Nitrogen applied (kg/ha)	Grain yield (t/ha)	Nitrogen applied (kg/ha)
Puddled TPR	3.18	100.00	3.71 (+16.80)	98.33 (+1.67)
Unpuddled TPR	2.65	100.00	3.68 (+38.81)	105.00 (-5.00)
Conventional till DSR	3.16	100.00	3.82 (+20.96)	125.00 (-25.00)

Source: Lama 2014.

Note: Nitrogen applied on LCC was 30 kg/ha at critical level ≤ 4. Figures in the parentheses indicate N saving in percentage (+) or excess in percentage (-) in kg/ha and yield advantage in percentage (+) and reduce in percentage (-) as compared with recommended practice.

Duxbury (2002) analyzed 22 comparisons of LCC (using a critical value of 4) versus farmers' practice. These comparisons were undertaken during the rice season in 2002. The purpose of these comparisons was to popularize and evaluate the LCC approach amongst farmers in the mid-hills of Nepal (**Figure 3**). Yields from LCC plots were 3-34% higher than the farmer practice. The overall average yield from LCC plots was 12% higher than the plots following farmers' practice. Farmers using 100 kg N/ha at Bageswori were able to save 20 kg N/ha with LCC management; while at Katunje, LCC saved 30-40 kg N/ha relative to the farmer practice of 150 kg N/ha. The variation in the yield between the LCC management and farmers' practice on farms may be due to incorrect critical levels for the varieties and environmental conditions of the mid-hills.

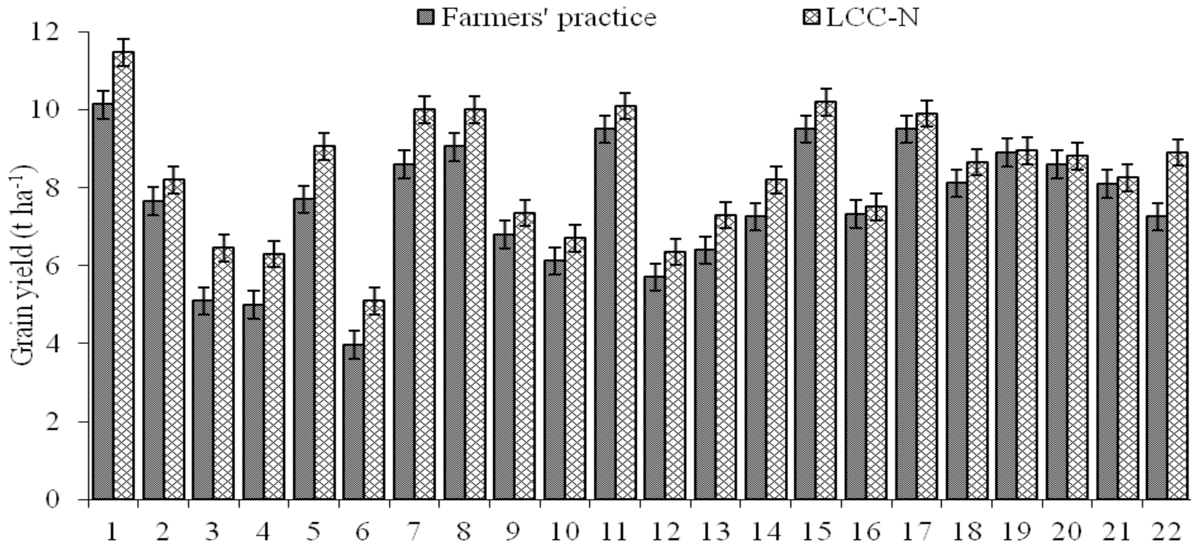

Figure 3. Response in rice yields managed with LCC tool versus farmer practice at Katunje and Bageswori villages of Kathmandu valley in 2002

The calibration of LCC carried out in 2001 and 2002 for different varieties of rice in the Kathmandu Valley indicated different LCC critical levels. The critical levels for adding nitrogen according to LCC for Chainung 242, NR 10291 and Khumal 4 came out at 4 while NR 10375 yielded better at a LCC value of 5 (**Figure 4**).

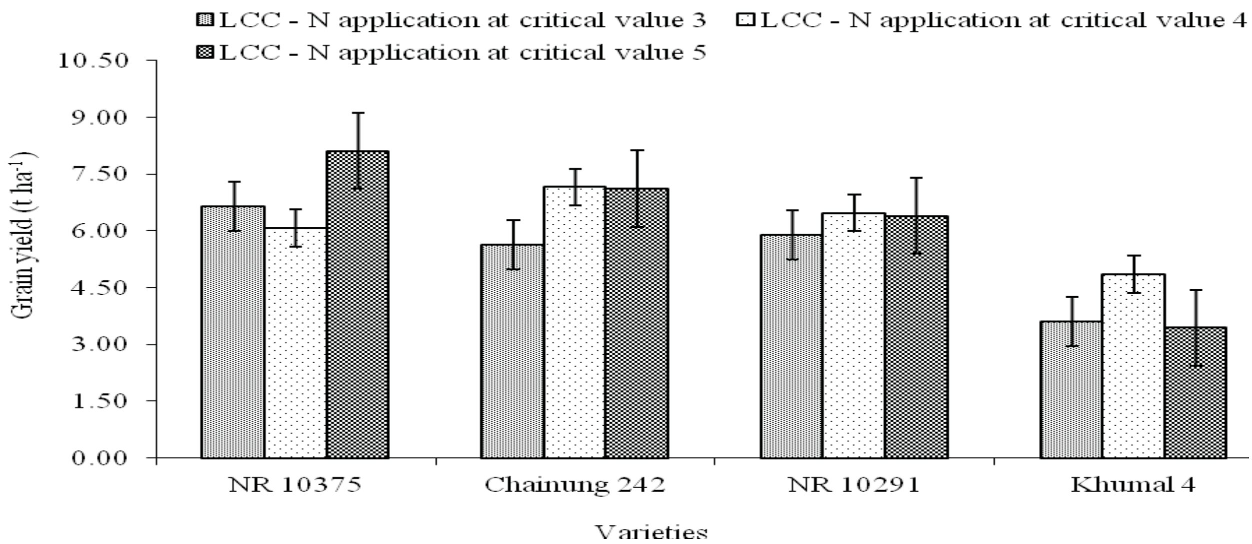

Figure 4. LCC critical value calibration study results for different rice varieties at Kathmandu Valley

Performance of LCC based nitrogen management on nitrogen uptake and use efficiency

The application of nitrogenous fertilizers using LCC resulted in higher nutrient uptake, higher nitrogen use efficiency and higher profits than fixed scheduling of nitrogen (Adhikari 2006, Poudel 2007, Nepal 2006). Adhikari (2006) reported lower agronomic efficiency of nitrogen under LCC based management (8.72 kg grain/kg of nitrogen) than recommended application (10.75 kg grain/kg of nitrogen), while the result is just opposite to the recovery efficiency (51.10 and 49.90% respectively). Poudel (2007) recorded higher nitrogen uptake under LCC based nitrogen management (147.90 kg/ha) even lowering the nitrogen application (5%) over recommended application (141.20 kg/ha). Nepal (2006) did not find any difference in nitrogen uptake under LCC based nitrogen application.

Merits and demerits of LCC based nitrogen management

LCC is an inexpensive, simple and easy to use tool for farmers to assess the leaf nitrogen status and to determine the time of nitrogen top dressing in rice. This tool does not require collecting samples, processing them and sending them to a laboratory for analysis.

At the same time, LCC has some demerits. LCC cannot indicate smaller differences in leaf greenness if the color shades fall in between two shades. In such cases, the mean of the two scores is calculated to find out the critical level and this may not give accurate result. There are possibilities of occurrence of personal variations due to diurnal differences, varieties and seasons. To minimize such variations, calibration is required before applying the tool. The relative accuracy of LCC to assess the leaf nitrogen status can be determined only when it is compared and correlated with chlorophyll meter readings and calibrated properly with the cultivar groups (semi dwarf, local tall, and hybrid). The LCC is used only to fine tune nitrogen top dressing, but the amount of basal nitrogen application cannot be decided. The LCC can be more successful in integrated site-specific nutrient management strategy, in which the availability of other nutrients, such as P, K, S, and Zn must not be limiting to achieve optimum response of nitrogenous fertilizers. Phosphorus or potassium deficiencies may cause darker leaf color, which leads to erroneous LCC readings, but SPAD meter is less affected by these deficiencies.

Conclusion

Blanket or package fertilizer recommendations over larger areas are not efficient because the supply of nutrient elements from other sources varies widely among rice fields. The LCC based nitrogen management will significantly benefit farmers by adjusting nitrogen input to actual crop conditions and nutrient requirements.

The LCC is a tool that provides certain guidelines for finding out the amount of nitrogen required for top dressing and synchronizing the application of nitrogenous fertilizer with actual crop demand and adds more returns to the farming community.

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Site Specific Nutrient Management in Rice

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सारांश

नेपालमा धानको लागि सिफारिस गरिएको मलखादको मात्रा स्थान विशेषको उत्पादन क्षमता र माटोको उर्वराशक्तिसँग सम्बन्धित नभई प्राय सबैतिरको लागि एउटै र एकदमै सामान्य खालको छ । स्थान विशेष खाद्यतत्व व्यवस्थापनको रणनीतिले स्थान र मौसम अनुसार बालीको खाद्यतत्वको आवश्यकता तथा पहिलेदेखि नै माटोमा भएको खाद्यतत्वको आधारमा उत्पादन बढाउन खाद्यतत्व व्यवस्थापन गर्नु पर्ने कुरालाई समावेश गर्छ । सामान्य अवस्थामा कृषकले प्रयोगमा ल्याइरहेको मलखाद व्यवस्थापनबाट भन्दा स्थान विशेष खाद्यतत्व व्यवस्थापन रणनीतिको कार्यान्वयनबाट बिरुवाले खाद्यतत्व बढी मात्रामा लिन सक्ने तथा नाइट्रोजन मल प्रयोगको बढी उपयोग हुने भएकाले धानको उत्पादन बढी लिन सकिन्छ । स्थान विशेष खाद्यतत्व व्यवस्थापन भित्र अन्तरनिहित सिद्धान्तहरूले कृषि पर्यावरणका लागि प्रमुख खाद्यतत्वको आवश्यक मात्राको पहिचान र मूल्याङ्कन गर्नु जरूरी ठान्दछ । यस दृष्टिकोणलाई यसका सफलताका महत्वपूर्ण अंशहरू नगुमाई कृषक समुदाय समक्ष सरल रूपमा पुऱ्याउन व्यापक मात्रामा प्रसार र अनुकूलन गर्नु नै अहिलेको मुख्य चुनौती रहेको छ ।

Summary

Fertilizer recommendation in Nepal, even for rice cultivation, is presently too generalized and insufficiently related to the site-specific yield potential and soil fertility status. Site Specific Nutrient Management (SSNM) strategies include site and season specific knowledge of crop nutrient requirements and indigenous nutrient supplies that increase rice yield over farmers' practice of fertility management and recommended dose of fertilizer application along with higher nutrient uptake and better N use efficiency. The underlying principles of SSNM need to be carefully identified and evaluated for each macronutrient for each specific agro-ecology. A major challenge is to simplify the approach for wider scale dissemination and adaptation to farming communities without losing components that are crucial to its success.

Keywords: Adaptation, Fertilizer, Macronutrient, SSNM, Yield

Introduction

The present national yield of rice ie 3.39 t/ha (ABPSD 2014) is far below the potential yield of 9.08 t/ha (Regmi 2003). Among various reasons, imbalanced use and inefficient utilization of plant nutrients is considered to be the most critical for this low productivity especially in South Asia including Nepal (Shukla et al 2004). Fertilizer recommendations by government agencies and research stations are based on blanket recommendations for a region or district without considering the site specific soil and weather variations. As a result, there is under fertilization in some areas and over fertilization in others. In most cases, there is low use of all nutrients while in some cases there is relatively high use of nitrogen and phosphorus and low use of potassium, secondary nutrient elements and micro-nutrients (Timisina et al http://nrn.org.au/). Such imbalanced and inadequate use of nutrients can decrease the nutrient use efficiency and profitability and may increase environmental risks associated with loss of unutilized nutrients through emissions or leaching. However, an opportunity exists to enhance yield, profitability and nutrient use efficiency of crops through the application of fertilizers when necessary and based on the crops' nutritional status, which is basically determined by the indigenous supply of nutrients.

Several studies have demonstrated that soil fertility, fertilizer use, and crop response to nutrient inputs may vary widely among rice fields within smaller irrigated and rainfed environments and also from season to season in the same field (Olk et al 1999, Adhikari et al 1999). However, fertilizer recommendations are given only for larger areas, with little differentiation for major agro-ecological zones, soil types, and cropping systems. A new concept of Site Specific Nutrient Management (SSNM) has been developed (Dobermann and White 1999) for rice based systems which overcomes the current mismatch of fertilizer levels and crop nutrient demand in irrigated rice environments (Dobermann and Cassman 2002). The SSNM captures the spatial and temporal variability in soil fertility in small-holder production systems and provides an approach to "feeding" crops with all required nutrients based on crop needs and thus can improve NUE, crop yield, and farmers' income (Dobermann et al 1996). The SSNM is a low-tech, plant need-based approach for optimally applying major nutrients: N, P, and K to the crop (IRRI 2006). The SSNM enables farmers to adjust fertilizer use dynamically to fulfill the nutrient deficit of a high-yielding crop (Pampolino et al 2007). It does not specifically aim to reduce or increase fertilizer use (Buresh et al 2005). In addition to soil variability and nutrient management practices, crop management has a significant role in the utilization of inherent and applied nutrients. This article summarizes current efforts to refine and simplify the underlying principles of SSNM into tools and guidelines for improved nutrient management in irrigated rice systems.

Principles of site specific nutrient management

The SSNM provides an approach for feeding crops with nutrients as and when needed. This approach advocates optimal use of existing indigenous nutrient sources, including crop residues and manures, and timely application of fertilizers at optimal rates to meet the deficit between the nutrient needs of a high-yielding crop and the indigenous nutrient supply.

- Principle 1: Grain yield and fertilizer requirements
- Principle 2: Use of omission plots for estimating soil nutrient supply
- Principle 3: Need based N management (Location specific N fertilizer splitting schedules either preventive N management or combine with LCC, real time corrective N management)
- Principle 4: Sustainable crop and soil based P and K management
- Principle 5: Increasing profitability

Calculation of the site specific nutrient management

Site specific N, P, and K fertilizer recommendations are calculated in five key steps. The following procedure is based on the author's experiment entitled "Conservation agriculture and site specific nutrient management for an intensive rice based cropping system in western foot hills of Nepal" conducted during 2011-2013. The experiment was conducted at Sunawal VDC of Nawalparasi district in Radha-4, which is a popular improved variety of Nepal.

Target yield or yield goal

The grain yield limited by climate and genotype is the potential yield with all other factors not limiting the crop growth, but it may fluctuate among the sites, farms and years because of climatic variability and change in available water during growing season (Dobermann et al 2004). The mean simulated potential yield (Y_{max}) of improved varieties of rice grown in inner Tarai of Nepal is in the range of 8.87-9.47 t/ha with a mean of 9.08 t/ha in the main season (Regmi 2003). Potential yield can be determined by using crop simulation models or estimated from the highest yield recorded at a particular site in an experiment with near optimal conditions for crop growth. The target yield or yield goals are usually set around 75 to 80% of the potential yield (Witt et al 1999) for several reasons including: (a) internal nutrient use efficiencies decrease at very high yields near to Y_{max}, (b) practical experience has shown that the best farmers can achieve yields of about 80% of Y_{max} under normal field conditions and (c) at a yield level of 75 to 80% Y_{max}, financial returns are greatest under open market conditions. Thus, 6.81 to 7.26 t/ha is considered the target yield during main season rice in Tarai, inner Tarai, foot hills, and low lying areas of mid hills but it is high for hybrids and even for the early season rice.

Estimation of crop nutrient requirements

The nutrient uptake requirements of a crop depend on target yield or yield goal. Nutrient requirements in SSNM are estimated using the Quantitative Evaluation of the Fertility of Tropical Soils (QUEFTS) model (Janssen et al 1990), which we have adapted for rice. The model provides a generic approach for estimating crop nutrient requirements for a specified yield goal, taking into account the climate adjusted, season-specific yield potential. Provided rice plant growth is limited solely by nutrient supply, the optimal nutritional balance is achieved with an uptake of about 14.70 kg N, 5.95 kg P_2O_5, and 17.46 kg K_2O per ton of grain yield in inner Tarai and foothills of Nepal (Author research). Plant nutrient requirements for a particular yield goal may be smaller in high yielding season than in low yielding one. For example, 80 kg plant N would be required to support a yield goal of 5.5 t/ha at an Y_{max} of 10 t/ha, but 100 kg plant N would be required for the same yield goal at an Y_{max} of 6 t/ha (Witt and Dobermann, 2002). The model also provides a useful tool for identifying optimal yield goals based on the relationship between grain yield and nutrient uptake.

Estimation of indigenous nutrient supplies

An important step in the calculation of site-specific fertilizer requirements is the estimation of the indigenous nutrient supply (INS) of primary nutrients. The INS of N, P, and K is defined as the total amount of a particular nutrient that is available to the crop from soil without the application of nutrients during a cropping cycle, when other nutrients are non-limiting. The INS is derived from soil, incorporated crop residues, water, and atmospheric deposition. This is estimated by measuring plant nutrient uptake in an omission plot. For example, the indigenous N supply can be measured as plant N uptake at harvest in a small 0-N plot located in a farmer field, where P, K, and other nutrients are supplied in sufficient amount so that plant growth is limited only by the indigenous N supply.

A potential disadvantage is that the estimate is variety-specific (due to differences in root distribution, for example) and is affected by factors inherent in a particular variety that control nutrient uptake. To obtain reliable plant-based estimates of indigenous nutrient supplies using omission plots, the following points should be considered: use certified (treated) seed; manage the omission plot with proper crop care (water, weed, pest, and disease control); take measurements in a season with favorable climatic conditions and low pest pressure to minimize the effect of yield-limiting factors other than the nutrient under test.

Author conducted the nutrient (N, P and K) omission plot experiments in Radha-4 to observe the indigenous supply of 36 farmers' field in 2011 and 2012 during monsoon season and estimated the indigenous supply as 53.37 kg N, 28.63 kg P_2O_5 and 84.19 kg K_2O/ha (**Table 1**).

Table 1. Indigenous nutrient supply (INS) for N, P_2O_5 and K_2O of rice soil at Sunawal, Nawalparasi, Nepal in 2011 and 2012

Indigenous nutrient supply capacity (INS) (kg/ha)	Year	Mean	SD	Min	Max	CV,%
	2011 (n=17)	51.56	10.78	31.56	74.46	20.91
Indigenous nitrogen supply	2012 (n=19)	54.99	13.00	32.76	74.14	23.64
	Av. (n=36)	53.37	11.96	31.56	74.46	22.41
	2011 (n=17)	28.41	5.35	15.48	39.48	18.83
Indigenous phosphorus supply	2012 (n=19)	28.82	4.27	22.62	36.31	14.82
	Av. (n=36)	28.63	4.74	15.48	39.48	16.57
	2011 (n=17)	81.85	13.37	53.93	109.44	16.33
Indigenous potassium supply	2012 (n=19)	86.29	11.19	68.23	107.03	12.97
	Av. (n=36)	84.19	12.29	53.93	109.44	14.60

CV, Coefficient of variation; SD, Standard deviation; Min, Minimum; Max, Maximum

Calculation of fertilizer rates

Site specific N, P, and K fertilizer recommendations are calculated on the basis of plant nutrient requirement for selected grain yield goal (**Section 3.1** and **3.2**), an estimate of the indigenous nutrient supply (**Section 3.3**), and the expected fertilizer recovery efficiency (RE, kg fertilizer nutrient taken up per kg applied) by the plant.

Fertilizer rate (FR) = $\frac{Nu \quad - \quad (N_{SS} \quad + \quad N_{SO})Nu \quad - \quad (N_{SS} \quad + \quad N_{SO})}{RE \qquad\qquad\qquad RE}$

Where, N_u = amount of nutrient needed to get target yield (kg/ha)

N_{ss} = amount of indigenous nutrient soils (kg/ha)

N_{so} = amount of nutrient come from other sources (kg/ha)

RE = fertilizer recovery of applied fertilizer N (kg/ha)

The recovery efficiency ranged from 40 to 60% for N, 20 to 30% for P, and 40 to 50% for K (Witt and Dobermann, 2002). Nitrogen recovery efficiency was assumed to be 50% when proper plant-based N management strategies are used and that for phosphorus and potassium were 30 and 50% respectively. The SSNM fertilizer recommendation for the Radha 4 grown in the main season was 95.82 kg N/ha, 42.98 kg $P_2O_{5/}$ha and 72.00 kg K_2O/ha with the use of indigenous nutrient supply as presented in **Table 1**.

Dynamic adjustment of fertilizer N applications

The total requirement for fertilizer N calculated earlier provided a rough estimate of the amount of N required to reach the target yield under average climatic conditions in a particular season. Basic plans were then developed for splitting and timing N applications in relation to crop growth stages. Strategies differed from site to site depending on climatic season, variety and crop duration, crop establishment method, water management, and possible pest problems. The strategy for N management evolved at each site as we gained experience. General principles include the following (Dobermann and Fairhurst 2000):

- Decide on the requirement for pre-plant N application. Basal incorporation was generally carried out at sites where the plant density was low or in these sites where the indigenous N supply was less than 40 kg/ha.
- Apply the remaining N fertilizer in two to three splits at critical growth stages, depending on plant growth and N requirement of a growth stage, season, growth duration, and variety.
- Apply a late season application of N to improve grain filling if the crop stand at that time is in good condition and there are few pest problems.
- Adjust the amount of each fertilizer N top-dressing based on actual plant N status determined with SPAD or LCC. Threshold levels were set for each crop establishment method.

Yield, nutrient requirement and nutrient uptake under SSNM

Significant increases in grain yield, nutrient uptake and nutrient use efficiency due to SSNM were observed in most of the experiments. The reduction in N rate during the early vegetative stage is considerable because indigenous N supply of rice soils provides sufficient N for the early vegetative growth.

Application of LCC-N + SSNM-P and K had produced significantly higher grain yield (6.66 t/ha resulting 5.33% yield gap with attainable yield and improved yield by 41.34% over farmers' practice) than other nutrient management practices except SSNM during an experiment conducted by the author for Radha 4 variety in 2013 at Sunawal VDC of Nawalparasi district. The higher grain yield was obtained due to higher nutrient uptake. The standard three split application of SSNM amount of fertilizers or its' 25% reduction or LCC based N application on SSNM significantly decreased the amount of nitrogenous and phosphorus requirement and more potassium required as compared to the recommended fertilizer application.

Table 2. Effect of nutrient management practices on nutrient requirement (kg/ha), grain yield (t/ha) and nutrient uptake (kg/ha) of main season rice at Sunawal, Nawalparasi district, Nepal in 2013

Treatments	Nutrient applied (kg/ha)			Grain yield (t/ha)	Nutrient uptake (kg/ha)		
	N	P_2O_5	K_2O		N	P_2O_5	K_2O
SSNM - 3 standard split of N	95.82	42.98	72.00	6.25^{ab}	113.62^{a}	26.57^{ab}	122.14^{ab}
75% SSNM - 3 standard split of N	71.87	32.24	54.00	5.94^{bc}	101.25^{b}	25.67^{bc}	108.69^{b}
LCC-N and SSNM-P & K	97.14	42.98	72.00	6.53^{a}	117.28^{a}	28.55^{a}	130.09^{a}
FFP	52.50	25.91	8.27	4.62^{d}	74.54^{c}	20.49^{d}	74.58^{c}
Rec. K and FFP N & P	52.50	25.91	40.00	5.38^{c}	94.09^{b}	23.65^{c}	103.48^{b}
Rec. NPK	120.00	60.00	40.00	5.61^{bc}	101.61^{b}	26.33^{ab}	113.92^{ab}
SEm (±)				0.16	3.47	0.81	6.16
LSD (=0.05)				0.48	10.03	2.33	17.78
CV,%				7.50	9.15	8.43	14.97
Grand mean				5.80	100.40	25.21	108.82

Note: SSNM, site specific nutrient management; LCC, leaf color chart; FFP, farmers fertility management practice, Rec., Recommended. Treatment means in the column followed by the same letter(s) are not significant different by DMRT at 0.05 level of significance.

Regmi and Ladha (2006) conducted research in Tarai of Nepal during 2000 and 2001 on rice to test the SSNM and integrated crop management (ICM) over the farmers' practices of fertilizer management. Improved nutrient and crop management had a significant positive effect on the grain yield of rice (**Figure 1**). ICM produced 6.4% higher rice yield than SSNM because of better crop management, especially in terms of plant density and weed management. SSNM produced a 40% higher rice yield than FP, showing a lack of nutrient input in farmer's practice. Farmers generally apply only nitrogenous fertilizers. Some farmers apply only a small amount of phosphorus fertilizers; even fewer farmers apply still smaller amounts of K to the rice crop. The higher yield under ICM and SSNM was due to higher nutrient uptake (**Table 3**).

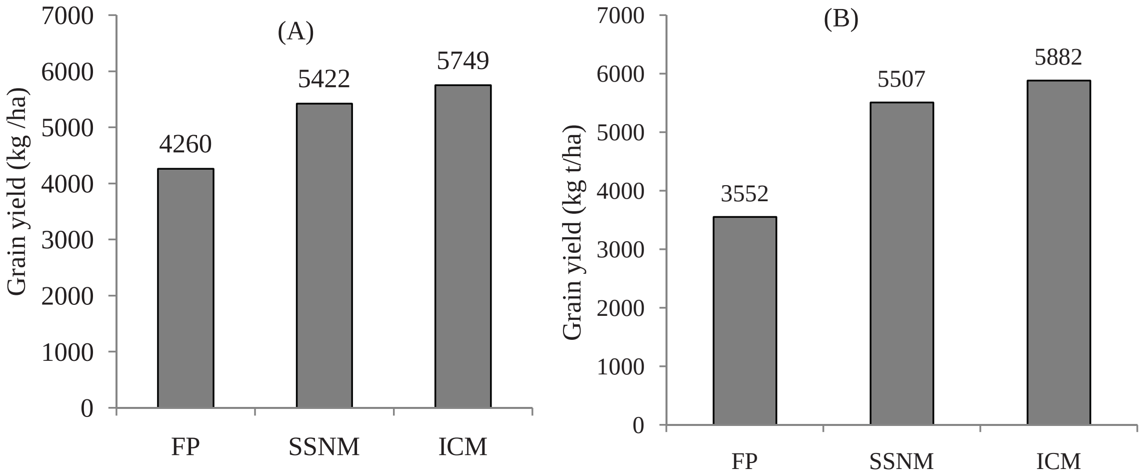

Figure 1. Grain yield (kg/ha) of rice site-specific nutrient management (SSNM), integrated crop management (ICM) and farmers fertility management practice (FP) in Bara and Parsa districts, Nepal during (A) 2000 and (B) 2001

Note: F probability is <0.001

Source: Regmi and Ladha 2006.

The SSNM and ICM approaches resulted significant increase in N-use efficiency in rice compared with FP (**Table 3**). Average agronomic efficiency of N (AEN) of SSNM was 13.65 kg grain kg N, and recovery efficiency of N (REN) was 0.48 kg N kg N, which were higher by 96.90% and 93.18%, respectively, than corresponding values observed under FP in the same season. There was an increase of 17.95% and 11.76% in AEN and REN in ICM over SSNM on an average of two years.

Table 3. Nutrient uptake and nutrient use efficiencies of rice under site-specific nutrient management (SSNM), integrated crop management (ICM) and farmers' fertility management practice (FP) in Bara and Parsa districts, Nepal during 2000-2001

Measured parameters	Year	Treatment			Probability
		FP	SSNM	ICM	
Plant N uptake (kg/ha)	Year 1	71.40	102.30	109.30	< 0.001
	Year 2	70.70	127.70	134.10	< 0.001
Plant P uptake (kg/ha)	Year 1	14.60	14.90	17.10	< 0.001
	Year 2	12.30	21.80	22.90	< 0.001
Plant K uptake (kg/ha)	Year 1	99.90	118.90	131.10	< 0.001
	Year 2	83.60	97.30	144.00	< 0.001
Agronomic efficiency of N	Year 1	8.70	13.10	15.60	< 0.001
(kg grain/kg N)	Year 2	NA[a]	14.20	16.60	< 0.001
Recovery efficiency of N	Year 1	0.22	0.34	0.40	< 0.001
(kg N/ha N)	Year 2	NA	0.51	0.55	< 0.001

[a] Not available; FP, Farmers' fertility management practice; SSNM, site specific nutrient management, ICM, integrated crop management.

Source: Regmi and Ladha 2006.

The international plant nutrition institute (IPNI) developed a model, which is based on the principles of site-specific nutrient management called Nutrient Expert (NE). The NE is a new, computer-based decision support tool developed to assist local experts to quickly formulate fertilizer guidelines for irrigated and rainfed rice based on the principles of SSNM described by Witt et al (2009). The model is tested by different organizations and personnel to validate in the context of Nepal.

Table 4. Effect of different nutrient management practices on grain yield and economics of rice in mid-hills of Nepal, 2014

Treatments	Grain yield (t/ha)	Gross revenues (NRs/ha)	Net revenues (NRs/ha)	B:C ratio
NE-H	7.362[a] (+54.4%)	285080[a]	211326.9[a] (+102.05%)	2.864[a]
NE-I	5.864[b] (+24.31%)	204000[bc]	148186.3[b] (+41.68%)	2.031[b]
GR-H	5.462[b] (+14.57%)	242000[b]	151135.3[b] (+44.50%)	2.054[b]
GR-I	4.705[b] (-1.3%%)	181000[c]	107703.0[c] (+2.97%)	1.473[c]
FFP	4.767[b]	173000[c]	104590.5c	1.523[bc]
SEm (±)	0.270	9098	994.472	0.0666
LSD (=0.05)	0.801	28033.8	28802.2	0.3967
CV %	18.7	14.9	22..3	22.1

Note: NE-H, Nutrient expert for hybrid; NE-I, Nutrient expert for improved; GR-H, government recommendation for hybrid; GR-I, government recommendation for improved and FFP, farmers' fertility management practice. Figures in the parentheses indicate yield and revenue advantage in percentage (+) or loss in percentage (-) as compared to farmers' fertility management practice.

The result of research conducted in the mid hills of Nepal for evaluating the performance of NE on grain yield, revenues, and B: C ratio is presented in **Table 4**. The highest yield of 7.36 t/ha was noticed in NE hybrid followed by NE improved (5.86 t/ha), and government recommendation for hybrids (5.46 t/ha). The lowest yield of 4.71 t/ha was obtained from government recommendation for improved. The yield of 4.77 t/ha was observed in farmer's fertilizer management practice (Amagain 2014, personal communication). Similarly in the eastern Tarai of Nepal, the highest yield (5.26 t/ha) was obtained from NE field, which was followed by government recommendation (4.53 t/ha) and farmers' fertility management practice (4.08 t/ha) as presented in **Table 5** (Amagain 2014, personal communication).

Table 5. Effect of different nutrient management practices on grain yield and economics of rice in eastern-Tarai of Nepal, 2014

Treatment	Grain yield (t/ha)	Gross revenues (NRs/ha)	Net revenues (NRs/ha)	B:C ratio
NE dose	5.26 (+28.92)	185201	136854[a] (+25.7)	2.836[a]
Government recommendation	4.53 (+11.08)	162413	116432[b] (+6.94)	2.536[b]
Farmers fertility practice	4.08	148925	108869[c]	2.716[c]
SEm (±)	0.073	3157.6	3109.6	0.067
LSD (=0.05)	0.2	8978.5	8842.9	0.190
CV,%	12.8	11.8	16.4	17

Note: NE, Nutrient expert. Figures in the parentheses indicate N saving in percentage (+) or excess in percentage (-) in kg/ha and yield advantage in percentage (+) and reduce in percentage (-) as compared with recommended practice. Figures in the parentheses indicate yield and revenue advantage in percentage (+) or loss in percentage (-) as compared with farmers' fertility management practice

The net revenues were found highest in NE treatment followed by GR treatment and FPP treatment both in the mid-hills and eastern Tarai of Nepal. In the mid hills, NE for hybrid had highest B:C ratio while NE for improved had the similar B: C ratio to the farmers' practice.

Conclusion

There is too general fertilizer recommendation for rice fields in Nepal. Most of the research works have demonstrated limitations of the current approach of fixed rate, fixed time (blanket) fertilizer recommendation for large areas. Such blanket recommendation does not consider the significant variability in the nutrient supply, biotic and abiotic conditions that influence the crop growth and yield. Thus, SSNM strategies included site and season specific knowledge of crop nutrient requirements and indigenous nutrient supplies increase rice yield, improve nutrient uptake and efficiencies and optimize the profit. A major challenge is to simplify the approach for wider scale dissemination and adaptation to the relatively uneducated and small holder farming communities without losing components that are crucial to its success.

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Status of Chemical Fertilizer Use for Rice in Nepal

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सारांश

धानको उत्पादन र उत्पादकत्व वृद्धिको लागि रासायनिक मलले महत्वपूर्ण भूमिका खेलेको हुन्छ । रासायनिक मलको बिक्री एवम् खपतको अवस्थाको सिंहावलोकन गर्दा हालसम्म धान बालीमा यसको बिक्री बढिरहेको पाइन्छ । नेपालमा कृषि सामाग्री कम्पनी लिमिटेड र साल्ट ट्रेडिङ्ग कर्पोरेसन लिमिटेड रासायनिक मलको आपूर्ति र बिक्रि वितरणमा संलग्न निकायहरू हुन् । आ.व. २०१४/१५ मा वितरण भएको कूल २९८,६७७ मेटन अनुदानित रासायनिक मलमध्ये कृषि सामाग्री कम्पनी लिमिटेडबाट वितरण भएको अनुदानित मलको हिस्सा ६७ प्रतिशत रहेको पाईयो । क्षेत्रगत रूपमा अध्ययन गर्दा सबैभन्दा बढी नाइट्रोजन, फस्फोरस र पोटासको प्रयोग मध्यमाञ्चल विकास क्षेत्रमा (६१:३६:१५केजी प्रति हेक्टर) र सबैभन्दा कम सुदूर पश्चिमाञ्चल विकास क्षेत्रमा (२९:१३:०४ केजी प्रति हेक्टर) रहेको पाइयो । यसैगरी सबैभन्दा बढी रासायनिक मल तराई क्षेत्रमा (७०:३८:१५ केजी प्रति हेक्टर) र सबैभन्दा कम उच्च पहाडी क्षेत्रमा (२४:१६:०३ केजी प्रति हेक्टर) प्रयोग गरेको पाइयो । नेपालमा धानखेतीमा औषतमा ४६:२६:१० केजी प्रति हेक्टर नाइट्रोजन, फस्फोरस र पोटास प्रयोग गरिएको पाइयो । यस अध्ययनबाट नेपालमा धान बालीमा रासायनिक मलको प्रयोगमा मुख्य गरी नाइट्रोजन सबभन्दा बढी, त्यसपछि फस्फोरस र पोटासको मात्रा बढी प्रयोग भएको पाइयो । रासायनिक मलको प्रयोगको अवस्था असन्तुलित रहेको र अम्लीयपनको समस्या व्याप्त रहेको पाईयो ।

Summary

Fertilizer plays a key role in increasing production and productivity of rice. Sale of chemical fertilizer had been increasing since FY 2010/11 till date. Agriculture Input Corporation Limited (AICL) and Salt Trading Corporation Limited (STCL) are institutions currently involved in import and trade of chemical fertilizer (Urea, DAP and Potash) under the subsidy program of Government of Nepal. A total of 298,677 tonnes of subsidized chemical fertilizer was sold throughout the country in year 2014/15, of which AICL sold 67%. The trend of sale of chemical fertilizer in different development regions of the country for N: P: K kg per hectare was maximum in Central development region (61:36:15) and the lowest in Far-western development region (29:13:04). The maximum amount of chemical fertilizer for N: P: K kg per hectare in rice was used in Tarai (70:38:15) and minimum in Mountain (24:16:03). Under normal supply of chemical fertilizer 46:26:10 kg/ha NPK was used in Nepal. The study revealed that the use of chemical fertilizer was not balanced in the sense that mostly macro nutrient of NPK was used and as a result there was problem of acidity throughout the country.

Keywords: Chemical fertilizer, NPK, Rice, Subsidy, Supply

Introduction

Fertilizer is a key input for agriculture production. Use of chemical fertilizer has been increasing with the advancement of modern agriculture (Shrestha 2010). APP has envisaged an increase in fertilizer usage from 31 kg nutrient/hectare of the base year 1995 to 131 kg nutrient/hectare by 2017. Based on field survey, use of 58 kg nutrient per hectare (102 kg per fertilizer per hectare) had been reported and 18.2% annual growth of fertilizer demand in Nepal had been estimated (ANZDEC 2002, Thapa 2006). In a study conducted by

Oxford Policy Management (OPM), UK in 2001-2002 for MoAD also estimated average application rate of 56 kg nutrient/hectare and 100.4 kg/household (Shrestha 2010, OPM 2003). In cereals, average use of chemical fertilizer per household in the country was 79.7 kg where that of Tarai was 137.5 kg, which was much higher than Hill (21.3 kg). However, use of nutrient per unit land needs to be increased for cereals to meet ever increasing demand of cereals in the country.

Rice is an important cereal crop of Nepal in terms of area and production. Rice is grown in 1425346 ha with average productivity 3.36t/ha (MoAD 2015). On an average, rice crop absorbs an average of 20 kg N, 11 kg P_2O_5 and 30 kg K_2O per ton of rough grain production (Roy et al 2006). For improved varieties of rice recommended dose of NPK is 108:52:36kg/ha for eastern region, 99:45:35kg/ha for central region and 102:46:34kg/ha for western region (FPOS 2012, FRIP 1990). Broad recommendation of fertilizer for rice is 100:30:30 kg/ha for irrigated rice and 60:20:20 kg NPK kg/ha for rainfed rice (AICC 2016). Among the cereals crops, maximum amount of fertilizers is used in rice. However, studies conducted on the use of chemical fertilizer in rice in Nepal showed an inadequate use of chemical fertilizer. Therefore, this study attempts to review literature on the use of chemical fertilizer on rice in Nepal.

Methodology

Data were collected from primary and secondary sources. Primary data was collected from 56 randomly selected District Agriculture Development Offices (DADOs) out of 75 districts. Of these randomly selected districts, seven represented mountainous region, 29 represented hill and 20 represented Tarai region. Individual interview with the farmers, subject matter specialists of the DADOs was conducted using semi-structured questionnaire developed by the Crop Development Directorate (CDD), DoA, Harihar Bhawan, Nepal. Secondary data regarding the fertilizer sales and distribution was collected from publications of Ministry of Agricultural Development and Department of Agriculture. The collected primary and secondary data were analyzed using MS Excel.

Fertilizer policy in Nepal

Use of chemical fertilizer in rice and any other crops depend on the quality, quantity, time of availability, which are greatly influenced by government policies. Fertilizer policy and distribution strategy has changed from time to time since the beginning of fertilizer import. Fertilizer was introduced in Nepal in early fifties with some private traders which imported some small quantity of Ammonium Sulphate $(NH_4)_2$ So_4 (21%N) from India. Fertilizer transactions were officially started with the establishment of the Agriculture Input Corporation (AIC) in 1966. Demand and use of fertilizer started to increase since then. Until 1972, purchasing cost plus storage, transportation and other costs involved were adopted for fixing prices of chemical fertilizer. With the increase in price in international market, the policy was slightly altered to adopt uniform pricing system. With the rise in the price of fertilizers in the international market, the government decided to introduce price subsidy and transport subsidy in selected high hills and mid-hills districts in 1973/74. The subsidy policy was brought in order to encourage farmers to use fertilizers by providing relatively low price and discourage outflow of fertilizers from Nepal to India by keeping price 15-20% higher than that of India. However, with the increase in price of fertilizer in international market, price was not adjusted in the country which made difficulties to satisfy increasing demand of fertilizer in country. In Nepal, dissemination and use of chemical fertilizer was made through fertilizer grant from Germany, Canada, Finland, Japan and many other countries for major crops. Once farmers were habituated to using chemical fertilizers to these crops following assistance from donor countries the use of fertilizer increased after 1991/92. As such, the government could not make provision of adequate subsidy to meet the growing demand of higher priced fertilizer for these crops as well. Subsequently, import and supply of fertilizers declined adversely affecting agriculture production. The government started deregulating the fertilizer trade in November 1997 with complete removal of subsidy in Diammonium Phosphate (DAP) and Murate of Potash (MoP), and with the phase-wise removal of subsidy in Urea. The subsidy was completely removed after November 1999. This led private traders to stand at equal footing with AIC. In order to institutionalize the deregulation policy, and to regulate the business under the policy, the government promulgated Fertilizer Control

Order, 1999 as per Essential Commodity (Control) Act, 1996. In line with the deregulation policy, National Fertilizer Policy, 2002 was formulated (Shrestha 2010). Following the deregulation of the fertilizer sector in 1999, there have been concerns that the supply of chemical fertilizers has not improved. Due to the excessive rise in the price of fertilizers, farmers could not afford to buy fertilizers of good quality. They were forced to use lower priced fertilizers of unknown quality that were available in the free market. In 2009, the government reintroduced the subsidy on chemical fertilizers (Raut and Sitaula 2012).

Sales of chemical fertilizer in Nepal

Urea, DAP and Potash are the major chemical fertilizers imported and used mainly for rice in Nepal. Sale of chemical fertilizer (formal source) varied widely from 2001/02 to 2014/15. This variation was mainly influenced by the budget allocated to supply subsidized chemical fertilizer by MoAD and participation of private sector in chemical fertilizer business. Sale of chemical fertilizer from private sector decreased gradually since FY 2003/04 and no import and sale records were available from FY 2009/10 onwards. Total sale of chemical fertilizer was the least in the country in FY 2009/10. Sale of urea drastically reduced in FY 2007/08 but is gradually increasing till date. This was mainly to address global food crisis scenario in Nepal to increase food production. Until the food crisis of 2008, priority for use of chemical fertilizer for crops including rice had been decreased. In Nepal also this trend in fertilizer use for rice was observed. As a result, sale of DAP reduced abruptly in FY 2007/08 and no sale have been recorded in following year, after that sale of DAP is increasing gradually. Sale of potash reduced sharply in FY 2005/06 and no sale have been recorded in following three years. Meanwhile, sale of complex fertilizers was noticed in FY 2006/07 and that continued for four years. Thus, supply of chemical fertilizer suffered during 2006/07 to 2009/10. To address issue of food crisis after 2008 in Nepal there was increase in fertilizer sale in 2010/11. It was reported that there was significant increment of fertilizers supply in the country through informal or unofficial sources. The Agricultural Sector Performance Review reports 65.8% of fertilizers used were supplied through the channels of informal imports. ANZEDC reported that in year 1999/2000, the share of informal supplies on actual progress was: N (51.4%), P (78.8%), K (84.9%), and total nutrient 63.8%. The use of chemical NPK fertilizer in Nepal in 2011/12 was 422,547 tonnes of which only about 25% imported was officially declared to customs and the other 75% was imported informally (ADS 2014, Hoyum 2012)

In 2008/09 government reintroduced fertilizer subsidy on cost sharing basis. This might have discouraged private sectors in fertilizer trade. Annual budget for fertilizer subsidy has increased over the years, thereby leading to increase in import and sales quantity of chemical fertilizers under government subsidy program.

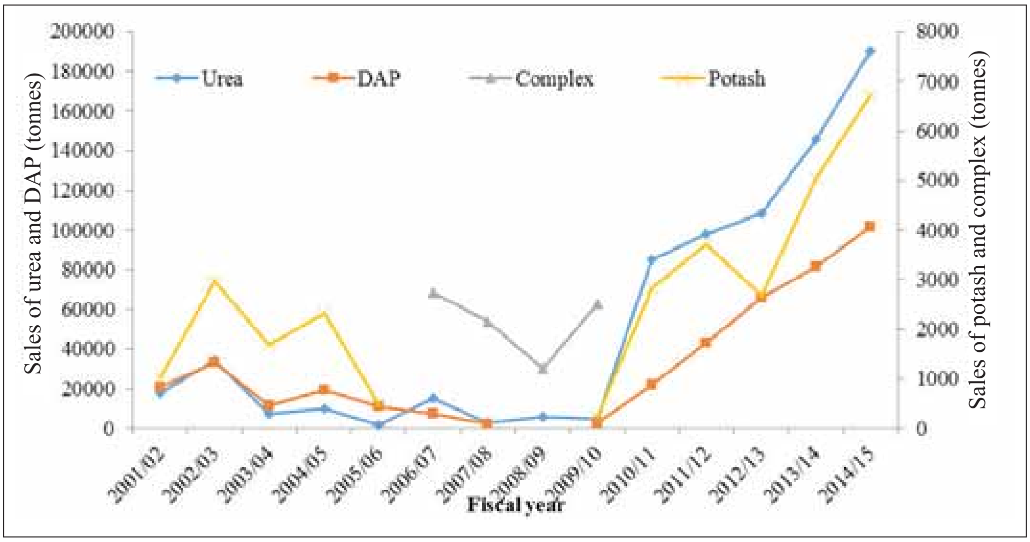

Figure 1. Sale of different chemical fertilizer during FY 2001/02 to FY 2014/15

Source: MoAD 2015.

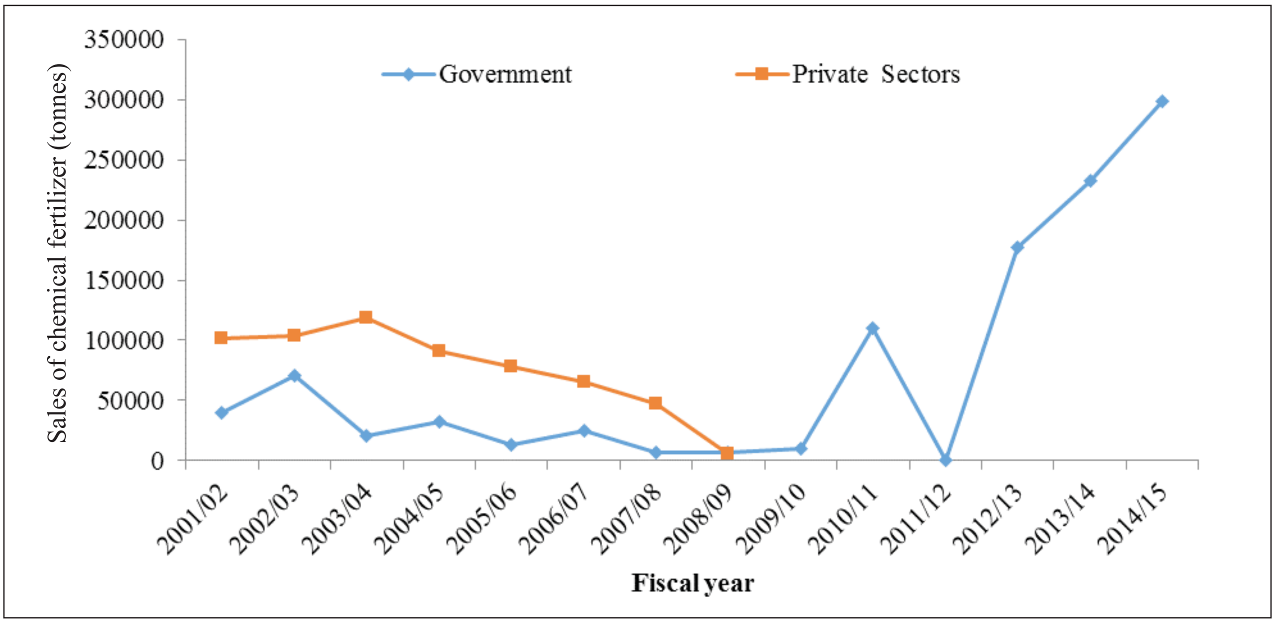

Figure 2. Sale of different chemical fertilizer by government and private sector during FY 2001/02 to FY 2014/15.
Source: MoAD 2015.

Agriculture Input Company Limited (AICL) and Salt Trading Company Limited (SALT) are public organizations currently involved in import and trade of chemical fertilizer (Urea, DAP and Potash) in Nepal. A total of 298,677 ton chemical fertilizer was sold throughout the country in year 2014/15 of which the share of AICL was 67%.

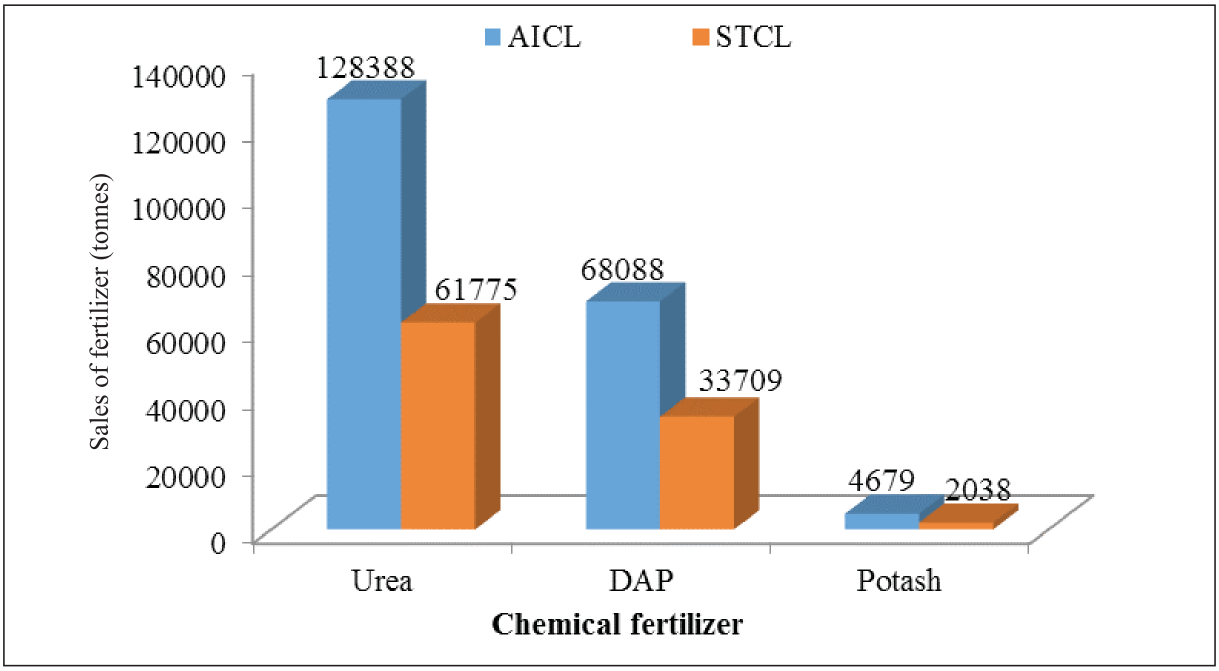

Figure 3. Sales of chemical fertilizers by different supplier organizations of Nepal in FY 2014/15
Source: MoAD 2015.

Further, 63.7% of total sale is urea followed by DAP (34.1%). Sale of Potash is only 2.2% of total sale of chemical fertilizer (MoAD 2015). Sale of chemical fertilizer in different ecological zone shows the maximum amount of fertilizer sale in central region followed by eastern, western and mid-western region. The least amount of fertilizer sold in far western region.

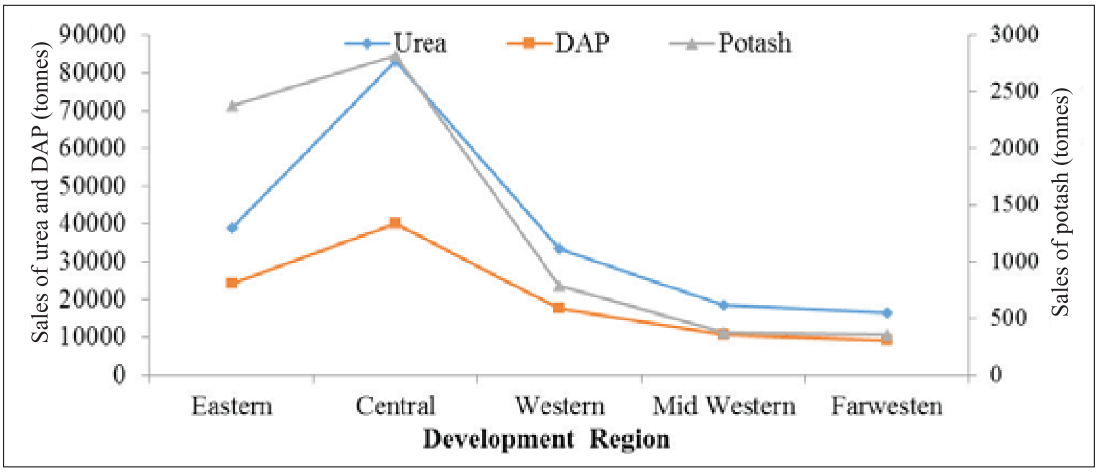

Figure 4. Sales of chemical fertilizers in different development regions of Nepal

Source: MoAD 2015.

Fertilizer use for rice in different development regions of Nepal

Data reveals the maximum amount of fertilizer used in Central Development Region followed by Eastern Development region. The least amount of fertilizer was used in Far Western Region. These might be because of easy access to chemical fertilizer and commercialization of rice farming in central and eastern part of country. Similar is the trend of Diammonium Phosphate (DAP) and Murate of Potash (MoP) use in the country.

Table 1. Fertilizer use in different development regions in Nepal (Kg/ha)

Development region	Urea	DAP	Potash
Eastern	79	58	18
Central	102	77	25
Western	75	48	12
Mid-western	59	40	10
Far-western	52	27	7

Source: Survey 2016.

Urea and DAP are major synthetic fertilizer as a source of Nitrogen in rice crop in Nepal. The maximum amount of chemical N-fertilization (61 kg per hectare) was applied in central development region of the country, which is only 61% of general recommendation for irrigated rice in Nepal. The average Phosphorus and Potash use was maximum in the central region (36 kg per hectare and 15 Kg/ha respectively) and their use was minimum in the far western development region (13 and 4 kg/ha respectively). Average use of NPK decreased with the progress of development regions towards west from central development region.

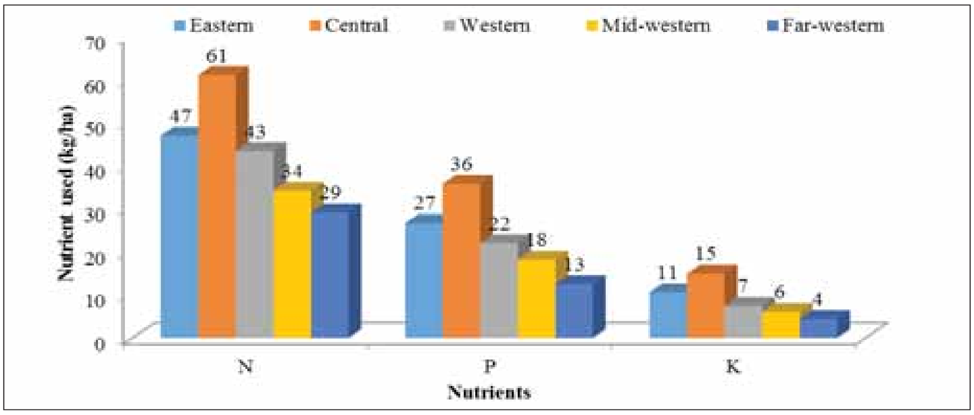

Figure 5. Nutrient use in different development regions of Nepal

Source: Survey 2016.

Fertilizer use for rice in different ecological zones of Nepal

The maximum amount of urea (121 kg per hectare), DAP (82 kg per hectare) and Potash (25 kg per hectare) fertilizer was applied for rice in Tarai region. Higher use of chemical fertilizers in Tarai compared to other agro-ecological regions could be because of ease of access, proximity to India, lower fertilizer prices that suggest the use of fertilizer is likely to increase with improvements in access to fertilizer (IDL Group 2006; Shrestha 2010). Commercialization of agriculture and awareness on the importance of chemical fertilizers were other reasons for higher use of chemical fertilizer in Tarai region. Urea used in Tarai was 3.1 times higher than that of Mountain and 2 times higher than that of Hill. Similarly, DAP used in Tarai was 2.4 times and 1.9 times greater than Mountain and Hill respectively. The least amount MoP (5 kg per hectare) used in Mountain region followed by hill region (13 kg per hectare).

Similarly, Use of N:P:K in Tarai region was 70:38:15kg/ha which was higher than that of Hill (35:18:08 kg/ha) and Mountain (24:16:3kg/ha). However, even in Tarai, use of nutrient is lower than recommended dose for irrigated rice ie 100:30:30kg/ha NPK (AICC 2016). Unavailability of required amount of fertilizer in time, lack of knowledge on use of chemical fertilizer and lower purchasing capacity were some of the causes for low fertilizer use in Mountain region.

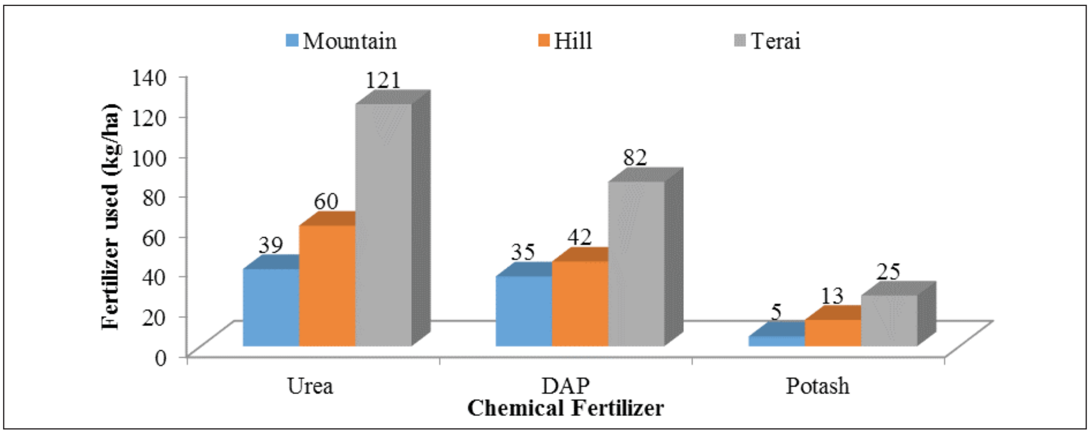

Figure 6. Fertilizer use in rice in different ecological zones of Nepal

Source: Survey 2016.

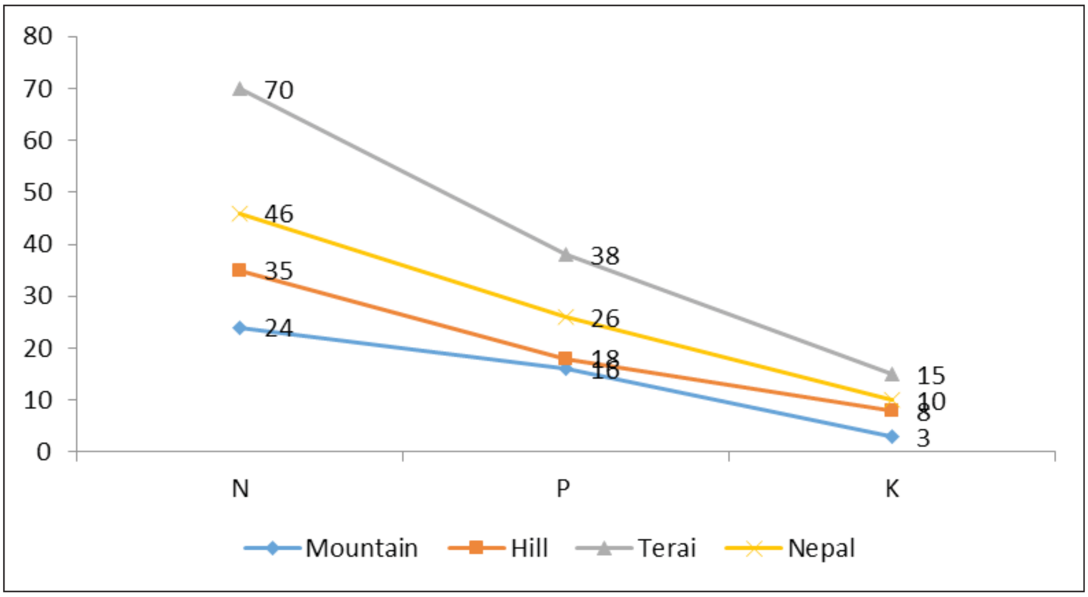

Figure 7. Nutrient use in rice in different ecological zones of Nepal

Source: Survey 2016.

Average use of chemical fertilizer in rice farming in Nepal

Data revealed the average use of: 79 kg urea, 56 kg DAP and 17 kg potash equivalent to 46:26:10kg/ha NPK in rice throughout the country. General recommended dose of nutrient in rice in Nepal is 100:30:30 kg/ha NPK which was equivalent to 191.9 kg urea $Co(NH_2)$, 265.22 kg DAP (contained 16% N and 48% $P_2 0_5$) and 50 kg MoP (contained 60% K_2O) for irrigated rice and 60:20:20 kg/ha NPK (which is 113.4 kg urea, 43.48 kg DAP and 33.33kg MoP equivalent) for rainfed rice crop. On an average, use of NPK throughout the country is lower than recommended dose for irrigated rice. Average use of Nitrogen and Potassium is even lower than that of recommended dose for non-irrigated rice. This showed the imbalanced use of chemical fertilizers across the geographical domains in the country. On the other hand, use of chemical fertilizer by farmer varies in different year as amount of import also varies.

Fertilizer use in rice and soil pH

Soil Management Directorate and its soil testing laboratories used to collect soil samples for testing from farmers' field throughout the country. Review of the results of soil test showed the maximum proportion of soil acidity (67%) in central development region and the minimum (26%) in far western region. Central Development Region is found to use the maximum amount of urea in rice and whereas it was minimum in far western development region. This might have influenced the soil acidity in these regions. Soil acidity could be the result of imbalanced use of urea and N fertilizers only for rice field.

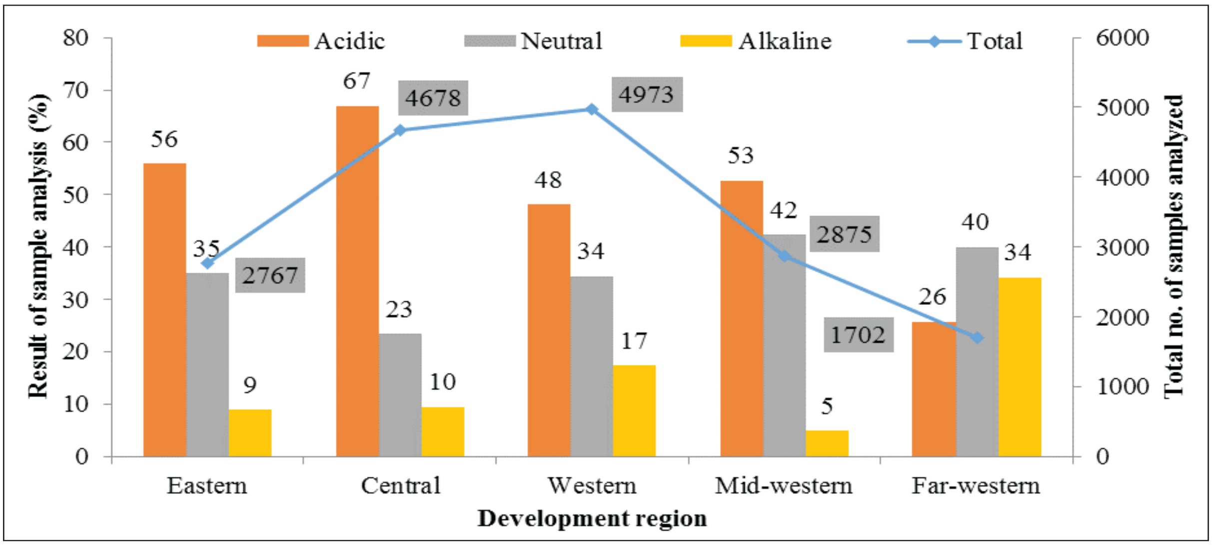

Figure 8. Soil reaction in different development regions of Nepal

Source: Dawadi and Thapa 2015.

Conclusion

Use of chemical fertilizer has been increasing with the gradual advancement of modern agriculture in Nepal. The average use of nutrient per hectare in Nepal is relatively lower in comparison to neighbouring countries. Imbalance and irrational use of chemical fertilizer is major concern at present. This has ultimately resulted problem of soil acidity in Nepalese soil. Thus, government should focus in creating awareness for balanced and judicious use of chemical fertilizer and promoting organic and bio-fertilizers.

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Annex 1. Use of chemical fertilizers in sampled districts

SN	District	Fertilizer per Hectare			Fertilizer per Hectare		
		Urea	DAP	Potash	N	P	K
1	Taplejung	35.76	9.40	10.00	18.14	4.33	6.00
2	Panchthar	45.50	60.00	15.00	31.73	27.60	9.00
3	Ilam	60.00	40.00	14.00	34.80	18.40	8.40
4	Jhapa	120.00	80.00	25.00	69.60	36.80	15.00
5	Sankhuwasabha	52.00	27.07	7.82	28.79	12.45	4.69
6	Dhankuta	50.00	60.00	21.52	33.80	27.60	12.91
7	Bhojpur	48.00	50.73	21.00	31.21	23.34	12.60
8	Morang	120.00	85.00	25.00	70.50	39.10	15.00
9	Sunsari	125.00	90.00	25.00	73.70	41.40	15.00
10	Khotang	67.84	38.54	7.35	38.14	17.73	4.41
11	Udaypur	60.00	40.00	15.00	34.80	18.40	9.00
12	Saptari	130.00	78.00	26.00	73.84	35.88	15.60
13	Siraha	115.00	95.00	17.00	70.00	43.70	10.20
14	Dolakha	50.90	43.62	6.00	31.26	20.06	3.60
15	Sindhuli	73.08	61.51	24.63	44.69	28.30	14.78
16	Dhanusha	149.53	112.00	38.00	88.94	51.52	22.80
17	Mahottari	140.00	110.00	40.00	84.20	50.60	24.00
18	Sarlahi	145.00	108.00	42.00	86.14	49.68	25.20
19	Rasuwa	40.00	90.00	2.00	34.60	41.40	1.20
20	Dhading	4.00	30.00	0.50	7.24	13.80	0.30
21	Sindhupalchok	41.76	48.71	8.53	27.98	22.41	5.12
22	Kavrepalanchok	68.33	51.83	12.50	40.76	23.84	7.50
23	Kathmandu	128.90	67.24	25.25	71.39	30.93	15.15
24	Bhaktapur	135.00	95.00	32.02	79.20	43.70	19.21
25	Lalitpur	120.00	70.00	21.00	67.80	32.20	12.60
26	Chitwan	140.00	75.00	30.00	77.90	34.50	18.00
27	Makwanpur	89.09	69.82	17.32	53.55	32.12	10.39
28	Parsa	141.00	93.69	35.00	81.72	43.10	21.00
29	Bara	148.00	95.00	55.00	85.18	43.70	33.00
30	Rautahat	123.16	94.70	34.00	73.70	43.56	20.40
31	Gorkha	78.03	48.60	24.89	44.64	22.35	14.93
32	Tanahun	70.78	49.41	12.06	41.45	22.73	7.24
33	Kaski	53.92	52.87	18.53	34.32	24.32	11.12
34	Syangja	55.16	41.25	10.77	32.80	18.97	6.46
35	Parbat	41.92	31.06	11.92	24.87	14.29	7.15
36	Baglung	25.00	13.03	2.22	13.84	5.99	1.33
37	Gulmi	40.00	25.00	5.51	22.90	11.50	3.30
38	Arghakhanchi	65.00	35.00	9.00	36.20	16.10	5.40
39	Nawalparasi	130.00	47.94	2.46	68.43	22.05	1.48
40	Rupandehi	140.00	85.00	25.60	79.70	39.10	15.36
41	Kapilbastu	128.00	97.54	13.25	76.44	44.87	7.95
42	Rolpa	46.46	33.05	5.11	27.32	15.20	3.07
43	Salyan	66.00	35.00	19.00	36.66	16.10	11.40
44	Dang	74.00	64.00	23.00	45.56	29.44	13.80
45	Dailekh	28.31	15.43	2.71	15.80	7.10	1.63
46	Jajarkot	70.00	32.76	7.62	38.10	15.07	4.57
47	Surkhet	47.00	41.00	8.87	29.00	18.86	5.32
48	Banke	92.00	58.00	13.00	52.76	26.68	7.80

SN	District	Fertilizer per Hectare			Fertilizer per Hectare		
		Urea	DAP	Potash	N	P	K
49	Bardiya	78.00	63.66	11.81	47.34	29.29	7.09
50	Kalikot	25.00	13.00	0.00	13.84	5.98	0.00
51	Bajura	24.57	12.84	0.00	13.61	5.91	0.00
52	Doti	31.40	11.95	6.90	16.60	5.50	4.14
53	Achham	29.10	8.50	3.00	14.92	3.91	1.80
54	Kailali	85.00	50.43	14.00	48.18	23.20	8.40
55	Baitadi	49.00	19.57	7.75	26.06	9.00	4.65
56	Kanchanpur	95.00	60.00	12.26	54.50	27.60	7.35

Annex 2. Use of chemical fertilizers in different development regions of Nepal

Development Region	Urea	DAP	Potash	N	P	K
Eastern	79	58	18	47	27	11
Central	102	77	25	61	36	15
Western	75	48	12	43	22	7
Mid-western	59	40	10	34	18	6
Far-western	52	27	7	29	13	4

Annex 3. Use of chemical fertilizer in different Agro-ecological zones of Nepal

Agro-ecological zone	Urea	DAP	Potash	N	P	K
Mountain	38.57	34.95	4.91	24.03	16.08	2.94
Hill	60.23	42.35	13.20	35.33	19.48	7.92
Tarai	120.93	82.15	25.37	70.42	37.79	15.22

Annex 4. Fertilizer recommendations for improved crop varieties

Crop	Plant Nutrient Dosage (kg/ha)								
	Eastern Region			Central Region			Western Region		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Wheat	117	50	45	88	45	43	90	49	42
Rice	108	52	36	99	45	35	102	46	34
Maize	105	57	32	89	50	36	86	52	33
Potato	88	45	90	80	38	78	68	35	68

Source: FAO Nepal Fertilizer Program (FRIP) Report 1990, NFOS 2012.

Annex 5. Growth rate of chemical fertilizer

Year	Chemical Fertilizer		
	Nitrogen	Phosphorous	Potash
1980/81-1989/90	11.7	15.0	5.6
1990/91-1999/2000	-8.7	-6.4	-11.2
2000/01-2009/10	-9.1	-18.5	44.11

Source: NFOS 2012.

Annex 6. The region wise, crop-wise fertilizer use in Nepal

Regions	Cereals	Cash crops	Pulses	Fruits	Vegetables	Total
Hills	21.3	11.8	0.1	0.0	2.7	35.9
Tarai	137.5	14.7	6.2	2.0	3.9	164.3
Average	79.7	13.3	3.2	1.0	3.3	100.4

Source: Fertilizer use study, OPM 2003; Shrestha, 2010; FPOS, 2012.

Irrigation Development for Rice Cultivation in Nepal

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सारांश

बाली उत्पादन वृद्धिका लागि सिँचाइको भूमिका महत्वपूर्ण हुन्छ । परापूर्वकालदेखि नै कृषकहरूले आधुनिक सिँचाइ प्रणालीको विकास हुनु अगाडि पनि धान उत्पादनका लागि यो सिँचाइ प्रणालीको विकास गर्दै आएको पाइन्छ । धान रोप्ने संस्कृतिको सुरुवातसँगै सिँचाइको पूर्वाधार निर्माण गर्ने क्रममा कृषकहरूले स-साना खोला तथा पानीका स्रोतबाट अस्थायी बाँध बाँधी पानीको प्रयोग गर्ने गरेको पाईन्छ । आफ्नै स्रोत, साधन, सीप तथा परम्परागत प्रविधिहरू अवलम्बन गर्नुको साथै कृषक समूहबाट ठूला प्रकृतिका सिँचाइका संरचनाहरू निर्माणको सुरुवात गरेको पाईन्छ । औपचारिक सिँचाइ योजना चरणको शुरूवात अगावै काठमाण्डौं उपत्यकामा राजकुलोहरू तथा पहाड र तराईमा कृषकद्वारा व्यवस्थित सिँचाइ प्रणालीको सामान्य विकास भैसकेको देखिन्छ । वि.सं. १९५६ मा औपचारिक रूपमा सिँचाइको विकासको थालनी, नेपाल सरकारको स्रोत साधनको प्रयोगबाट वि.सं. १९७९ बाट सिँचाइ विकासको सुरुवात तथा वि.सं. १९८५ मा चन्द्रनहरको निर्माणसँगै आधुनिक सिँचाइ प्रविधिको प्रयोग हुँदै वि.सं. २०१३ पछि मात्र नीति, योजना तथा कार्यक्रम आदिको तयारी गरी चरणबद्ध रूपमा सिँचाइको विकास भएको पाइन्छ । विगतमा सरकारी तथा गैर सरकारी संस्थाहरू, जल उपभोक्ता समितिहरू एवम् कृषकहरूको नीजि प्रयासबाट नेपालमा सिँचाइसँग सम्बन्धित क्षमता विकास, भौतिक पूर्वाधार, मानवीय तथा संस्थागत विकास भएको देखिन्छ । जसको फलस्वरूप तेह्रौं योजना (आ.व. ०७०/७१-०७२/७३) को दोस्रो वर्षको अन्त्यसम्म नेपालमा १३,६८,९१४ हेक्टर क्षेत्रफलमा सिँचाइको सुविधा प्राप्त भएको र आ.व. २०७२/७३ को अन्त्यसम्म ४७७ वटा डीप ट्यूबवेल र ५३,६७७ वटा स्यालो ट्यूबवेल जडान भएको अवस्था रहेको छ । विगतमा सिँचाइ विभागले आफ्ना कार्यक्रमहरू मार्फत् विशेष गरी सिँचाइ सम्बन्धी भौतिक पूर्वाधारहरू निर्माणमा जोड दिने गरेको भएता पनि पछिल्लो समयमा कृषि विभागसँगको सहकार्यमा कृषि प्रसारका गतिविधिलाई पनि महत्वका साथ अगाडि बढाउँदै सिँचाइका कार्यक्रमहरू मार्फत् धान उत्पादनमा जोड दिइएको छ ।

Summary

Irrigation is primary factor to boost up crop production. From the very beginning before the formal interventions, farmers themselves initiated the construction of irrigation canals for rice production. They diverted water from streams and small rivers to their farm lands with temporary headwork and introduced a rice-based culture and later on, they started to develop and manage a large number of irrigation facilities from their own resource, skill and techniques. The Raj kulo (royal canal) in Kathmandu valley and other FMISs in hills and Tarai were common before formal planning phase. From the start of formal irrigation development in 1900, irrigation sector development was promoted for increasing agricultural production primarily focused on rice. Government of Nepal started irrigation development only after 1923. Modern irrigation technology was developed after the construction of Chandra Canal in 1929. Planned irrigation development with the availability of timely policy, plans and programs was started only after 1957. Due to past efforts and practices, there is increased capacity development in irrigation related techniques, physical infrastructures, human resources and institutional development of governmental and non-governmental organizations. As a result, the total irrigated area reached to 13,68,914 hectares till the end of second year of the thirteenth plan (2013/14-2015/16) and the total deep tube wells and shallow tube wells installed till date reached to about 477 and 53,677 respectively. In the past, Department of Irrigation focused mainly on developing the physical infrastructures for irrigation development and these days, the need of joint efforts together with the Department of Agriculture for agricultural extension activities has been realized. Also, realized is the fact that rice is the major food security crop and primary focus is on irrigation for rice production.

Keywords: Food security, Infrastructures, Irrigation, Policy, Rice

Introduction

Irrigation is the artificial application of water to soil for crop production. Irrigation is supplied to supplement the water available from rainfall and the contribution to soil moisture from ground water. In Nepal, like many countries of the world, the amount and timing of rainfall are not adequate to meet the moisture requirement of crops and irrigation is essential. The role of irrigation in increasing the agricultural production has been identified to be crucial. The development of irrigation sector from ancient time is increasing the agricultural production basically for rice followed by winter crops. In recent years, there is an increasing trend of using the cultivated and cultivable agricultural land for non-agricultural use due to which ancient minor irrigation infrastructures such as *Raj kulo*, and other channels are disturbed in Kathmandu valley, hills and Tarai regions. The Government of Nepal has approved the Land Use Policy in 2012 for the protection of cultivable land as well as irrigation system. However, it has not been effectively applied due to the lack of Land Use Act in the country. Some of the I/NGOs are involved for the small irrigation development especially for income generating activities of small holding farmers, eg irrigating vegetables with treadle pump which is popular in eastern Tarai districts of Nepal. The productivity trend of rice during last 50 years seems to be increasing, it is basically due to availability of water for rice cultivation from irrigation system even during the rainfall deficit period.

Historical background

The historical evidences suggest that irrigation development and management in Nepal began before the 6th century BC. In Kathmandu Valley, the *Litchhivis,* during the first half of the 5th century, constructed water control structures on the *Dhobi Khola* and *Tukucha Khola* for irrigation. In the 17th century, a number of *Raj kulo* (royal canals) were built with state initiative and financial support (Poudel 2000). The *Raj kulo* were the most important and indigenous design in the valley's water supply system. In hills and mountains, irrigation systems were developed following the introduction of a rice-based culture during the 12th century, which replaced a predominantly pastoral economy with cropping practices (Bista 1967). Terraces were built and reshaped over time for paddy cultivation and irrigation systems were developed by the community to irrigate these terraces, locally called as '*khet*' (Shah SG and A Friend1992).

During the 16th century or even earlier, farmers diverted water from streams and small rivers to their farm lands after constructing temporary headwork, such as earthen dams of stones and logs, simple canals and distribution channels within their financial and technical capacities. Small to large groups of water users were involved in constructing irrigation facilities they required and managed them with their own social rules, regulations, norms and codes tested over time.

Farmers developed a large number of irrigation facilities with local resources and initiative as they expanded the areas under rice cultivation between the 19th and the first half of the 20th century. These systems are simple run-of-the-river diversions providing supplementary irrigation to the rice crop during the monsoon season. However, where perennial water sources are available, year-round irrigation is practiced. Some medium to large farmers have developed irrigation facilities using underground water and have been managing them privately.

The government, for the first time, initiated irrigation development in the Tarai flatlands only after 1920s (eg the Chandra canal irrigation system-Saptari). Later, in 1930s-1940s, more public sector irrigation schemes were launched. Planned economic development in Nepal began in 1956. During past 5 decades, government agencies constructed and managed numerous small to large surface and groundwater irrigation schemes and also rehabilitated a few farmer-owned and managed irrigation schemes, using public resources and grant and, loan assistance from bilateral and multilateral agencies. For the past 1.5 decades, a few INGOs have also been contributing to irrigation development. The public sector irrigation schemes, termed as 'Agency-Managed Irrigation Systems (AMIS), are managed by government agencies with formal rules and regulations. The most common feature of both Farmer Managed Irrigation System (FMIS) and surface AMIS is the run-of-the-river diversion providing supplementary irrigation to the rice during monsoon.

At present, the Department of Irrigation (DoI) is the main implementing agency involved in irrigation development in the country. The other agencies involved in this sector are: the Ministry of Federal Affairs and Local Development (MoFALD), Department of Agriculture (DoA), Agriculture Development Bank-Nepal (ADBN) and a few INGOs, such as CARE Nepal, International Development Enterprises (IDE), the Netherlands Development Organization (SNV) etc. The formal and informal water users' associations (WUAs) or water users' committees (WUCs) are directly involved in operation and management of small to medium scale irrigation schemes.

Different phases of irrigation development

Based on the history, there are two phases of irrigation development in the country and the different programs during each of these phases are described here:

The early or pre-planning phase (Until 1956)

Farmer Managed Irrigation Systems (FMIS) are irrigation systems managed through informal community groups developed rules, norms or codes and assigned the rights and responsibilities among themselves. They also developed numerous irrigation facilities using their resources and technical capabilities, particularly in the 19^{th} and up to the first half of the 20^{th} century, following the expansion of rice cultivation in both hills and Tarai. Besides *Raj kulo* in the Kathmandu valley, there are hundreds of ancient canals that are still providing irrigation facilities to large areas in the western Nepal such as: Rani-Jamara-Kulariya (Kailali), Aargali (Palpa), Chhattish Mauja (Rupandehi) and Rajapur (Bardiya). These irrigation systems are mostly used for supplementing irrigation of rice, during the monsoon season, and in a few cases where water source is perennial, year-round irrigation is practiced. It is estimated that such irrigation facilities have provided irrigation to about 636000 hectares of land (Irrigation yearly book 2015). These farmer-developed irrigation infrastructures, particularly headwork and canals, need regular maintenance.

The government's involvement in irrigation development began in the early 1920s. Chandra canal irrigation system (Triyuga River, Saptari district) is the first AMIS constructed during 1922-1928 with state fund and under the design and supervision of British engineers. This scheme provided irrigation to an area of about 6,300 hectares during monsoon season in the eastern Tarai. It has now been rehabilitated and upgraded to cover a net command an area of 10,000 hectares. Later, during 1932-45, several public sector irrigation schemes were initiated in the central and western Nepal. Some of these are: Juddha canal (Manusmara) in the central Tarai (Sarlahi 1943-46), Jagadispur reservoir (Banaganga) in the western Tarai (Kapilvastu) and Pardi (Phewa Lake) in Pokhara valley (Kaski). Two bilateral agreements were signed with India during the early phase of irrigation development. The first bilateral agreement was the Sharada project agreement (signed with British India in 1920) which was for using the Mahakali river to provide irrigation and hydropower benefits to India and supply of 11.3-28.3 m^3/s of water (depending on season) to Nepal for irrigation.

The Planning Phase (after 1956)

Infrastructure development phase (1956-70)

The Sharada project agreement led to the development of Mahakali irrigation project (Kanchanpur district) with a planned net command area of 11,600 hectares which was started in 1971 and completed in 1998. India diverted the maximum water (up to $400m^3/s$) in 1993 to irrigate about 1 million hectares of land (UNDESD/UNDP, 1993). The treaty on the integrated development of Mahakali River, signed in February 1996, replaced the 1922 Sharada project agreement.

Similarly, Nepal and India signed the Koshi Project Agreement in April 1954, and slightly amended it in December 1966. In accordance with that agreement, the Government of India built a barrage on the Nepal-India border and related works upstream of the barrage, supplying irrigation water to 2.2 million hectares of land in India and developed the Chatara canal irrigation scheme (Sunsari and Morang districts) on the Eastern Koshi (with a command area of 66,000 hectares) and western Koshi (with a command area of 21,000 hectares) irrigation systems in Nepal. Nepal retained the right to further use of water of Koshi basin as may be required from time to time while India was given the right to regulate all the remaining water supply on the Koshi River at the barrage site for irrigation and electricity generation. The construction of the Chatara canal (later renamed as Sunsari-Morang irrigation project -SMIP), with net command area of 41,500 hectares, was started with a bilateral grant in 1964. The Western Koshi irrigation system was completed in 1978-1990.

Nepal and India also signed the *Gandak* agreement in December, 1959 and amended in April 1964. That agreement permitted India to construct the Gandak barrage, canal head regulators and other related works on the Narayani river at the Nepal-India border with provision to construct at India's cost: a) Eastern Nepal canal and associated distributaries system, providing sufficient water for irrigating approximately 42,000 hectares of land. b) Western Nepal canal and associated distributaries system for irrigating approximately 16,000 hectares of land, and c) 15MW of hydropower generation.

Run-of-the-river diversion with a gravity distribution system mainly providing supplementary irrigation during monsoon seasons, an approach followed by farmers in the last couple of centuries, was the mode of irrigation development. This mode focused on 'extensive development' of irrigation systems with provision of basic infrastructures such as diversion weirs and major canal systems, such as those in Chatara canal, East and West Gandak, and the Kamala Irrigation Project (Dhanusha and Siraha districts). During this phase, emphasis was given on the construction of government-financed medium and large projects and several projects in the hills and Tarai, which was constructed under Indian and American grant assistance. The Kamala Irrigation Project with a gross command area of 25,000 hectares started in 1959 but it was temporarily abandoned in 1966 after about NRs 20 million had been spent.

Many of the projects developed under the Indian aid mission and USAID grant were left incomplete due to lack of adequate tertiary and on-farm distribution facilities. As a result, the actual area irrigated was far less than the declared command area of the project. The major construction works started in the hills were: Tika Bhairav-I (Lalitpur), Mahadev Khola (Dhading), Bijayapur (Kaski), Gokarna (Kathmandu), Phewa (Kaski), Kotkhu (Lalitpur), Bosan (with a net command area of 3,370 hectares) and Sirsia, Dudhaura, Tilawe, Jhaj, Dundwa, Manusmara, Hardinath, Chatara Canal, Eastern and Western Gandak (Chitwan and Nawalparasi) with a net command area of 122,030 hectares (Poudel 1992). During this period, irrigation facilities were developed covering an area of 59,050 hectares against a target of 103,983 hectares.

Intensive development phase (1970-85)

Intensive development of command area and comprehensive approach to irrigated agriculture were the focus of agriculture development in 1970s. This included: a) expansion of irrigation infrastructures developed earlier with HMG/bilateral/grant assistance to farm-level water management, and b) financial and technical assistance to rehabilitate and improve farmer-owned irrigation infrastructures.

The policies during the earlier plan periods concentrated on infrastructure development to achieve high economic growth rates, and only after the Fifth plan (1975-80), the emphasis shifted from investments in infrastructures development to directly productive sectors. Thus, the national policies of the Fifth Plan, emphasizing infrastructures development directly benefiting the productive sectors, and the Sixth Plan (1980-85), emphasizing poverty alleviation through increased farm production were the guidelines for developing intensive irrigation systems. This intensive irrigation system included development of tertiary canals and service blocks, development of irrigation command area, rehabilitation of FMIS and introduction of appropriate agricultural technologies in irrigated areas.

There was a Command Area Development (CAD) scheme with the provision for lower-end channels to permit water distribution to smaller blocks (typically 3-5 ha) that focus on farm-level water management. Specifically, CAD projects are Manusmara (Sarlahi), Western Gandaki and Banganga (Kapilvastu).

Project implementation: projects with grant assistance: Bilateral assistance started decreasing after the completion of physical infrastructure works in the Chatara canal (Koshi) and the Nepal eastern canal (Gandaki), while the Western Koshi project was ongoing, all with Indian grant assistance, according to the

Koshi and Gandak agreements. The United Nations Development Program (UNDP) and the United Nations Capital Development Fund (UNCDF) provided technical assistance as a grant for the implementation of the Marchawar Lift Irrigation Project (1981-99) in Rupandehi and Kapilvastu districts.

The Indian government started the construction of the Chatara Canal Project in 1964 and handed it over to Nepal in 1976. Similarly, the construction of the Nepal eastern canal was completed and the canal was handed over to Nepal in 1976. However, the construction work of the West Koshi canal, which started in 1978, was delayed and the canal was handed over to Nepal in 1990 after completion. Nepal-India agreements (such as Koshi and Gandak) guided the construction works, which included only basic infrastructures such as diversion weirs; main and secondary canals categorized as extensive development. All these projects were later completed with loan assistance from the World Bank and the Asian Development Bank (ADB).

CARE Nepal irrigation project: CARE Nepal has been involved in improving the technical and management efficiency of FMISs since 1983. It rehabilitated 33 FMISs during 1983-88 in those areas where ADB Nepal had launched the Small Farmer Development Program. Many subprojects undertaken by CARE-Nepal have included rehabilitation of FMISs. Till 1994, CARE-Nepal had supported 131 FMISs, covering 8,105ha of land and benefiting 11,133 households (Gurung 1996).

Project with government resources: Government explored the irrigation development potential of the Babai area (Bardiya district) in 1964. A feasibility study identified the irrigation potential to be 40,000 hectares on the assumption that $35m^3/s$ water would be diverted from the Bheri to the Babai River. Since there was no loan assistance available for the implementation of this project, the government started the construction of this project in 1993 with its own resources. The construction work has been temporarily abandoned since late 2000. Small irrigation program and Cooperative based small irrigation scheme program (Funded under the KR2 program of the Japanese government at the beginning and, later on, it has been funded by the Nepalese government) is one of the regular programs of government that started since 1999/2000 to increase the irrigated areas and also to maintain the existing irrigation structures.

Project with loan assistance: During the intensive development phase: Kankai Irrigation Project, Sunsari-Morang Irrigation Project, Kamala Irrigation Project, Bagmati Irrigation Project, Narayani Irrigation Project, Chitwan/Narayani Lift Irrigation Project, CAD Project, Bhairahawa-Lumbini Groundwater Irrigation Project, Mahakali Irrigation Project, Hill Irrigation Project, etc were the projects with loan assistance.

The Integrated Development Phase (1985-Present)

Integrated irrigation development approach: The Seventh Five-Year Plan (1985-90) made a major change in the irrigation development approach by emphasizing:

- Renovation, reconstruction and expansion of FMISs,
- Participation of beneficiaries in development and management of irrigation infrastructures,
- Development of groundwater irrigation in areas where surface irrigation is limited to year-round irrigation,
- Involvement of NGOs in irrigation development and
- Use of improved and appropriate agricultural technology and materials in irrigated farmlands to maximize outputs.

The Basic Needs Program (1985-90) was given the foremost priority for attainment of the minimum basic needs of the people by the end of the century (Irrigation Master Plan 1990). This program promoted integrated efforts such as agricultural technology and intensive development of irrigation to attain the goal of almost doubling the cereal grain production from 4.39 million tonnes in 1984 to 8.65 million tonnes by the year 2000. The Eighth Five Year Plan (1992-97) placed emphasis on enhanced reliability of irrigation and agricultural technologies. Priorities were given to:

- conjunctive use of groundwater for the year round irrigation in areas where surface irrigation is not

available in dry seasons;
- rehabilitation and expansion of irrigation schemes that are defunct and
- Initiation of multi-purpose projects.

Agriculture Perspective Plan (APP), a 20–year plan, placed high emphasis on ground water harvesting for the year round water supplies. The Ninth Plan (1997-2002) continued the emphasis of the earlier periodic plans of this phase on development of groundwater irrigation, rehabilitation of FMISs, development of integrated irrigation and multi-purpose large reservoir-based irrigation projects. This plan adopted the irrigation development strategies contemplated by the APP. However, it deviated from the APP by gradually reducing the subsidy on the installation of shallow tube-wells (STWs). The subsidy program eventually terminated in 1999 and greatly affected the installation of STWs.

Agency developed irrigation systems: Mechi Hill Irrigation, SINKALAMA irrigation program, Irrigation Line of Credit Program, Irrigation Sector Project (ISP), Irrigation Sector Support Project, Nepal Irrigation Sector Project, Nepal Irrigation Sector Support Project, Second Irrigation Sector Project and Irrigation Development Project-Mid Western Region and Chanda-Mohana Irrigation Project are some of irrigation projects managed by DoI.

Project implemented in collaboration between DoI and DoA: Recently, Irrigation and Water Resource Management Project (IWRMP) and Community Managed Irrigated Agriculture Sector Project (CMIASP) have been jointly been conducted by Department of Agriculture and Department of Irrigation.

Groundwater irrigation development

Groundwater resources: Broad assessment by geologists indicate the availability of about 12 billion cubic meters (BCM) of groundwater in Nepal. Of this quantity, about 6 BCM can be safely extracted annually for irrigation and other purposes, and this is rechargeable. The water resources sector diagnostic and program formulation study estimated about 10,500 million cubic meters (MCM) of groundwater recharge in shallow 'phreatic' (zone of saturation) aquifers spread over Tarai and inner Tarai regions (UNDESD/UNDP 1993). An assessment by the National Planning Commission in Tarai region in 1997 confirmed the availability of considerable amount of groundwater. The potential command area of STWs in Tarai is estimated to be 1.53 million hectares and area of DTWs is 0.35 million hectares on the basis of recharge in the *Bhabar* region, the total recharge being 11,662 MCM. The rivers and rivulets flowing into Tarai through the *Siwalik* hill range recharge the groundwater, the recharge mostly taking place in the Bhabar zone, the southern foothills of the *Siwaliks* adjoining the Tarai flatlands. The Siwalik range is highly susceptible to soil erosion, and about one-third of the *Siwalik* has been experiencing diminishing land productivity and disturbances in soil mantle and channels (Forestry Master Plan 1988).

Groundwater irrigation development: The groundwater irrigation development started in mid 1970s, and the area coverage significantly increased since the seventh Five-Year Plan period (1985-90). Since 1985 the government has been giving the highest priority to groundwater irrigation in areas where surface irrigation is limited, not easily accessible and would take a long time, requiring river diversion projects to feed the southern rivers or implementation of multipurpose projects. Many groundwater projects were proposed and implemented between 1992 and 1997. The Irrigation Policy, 1992 made provision for 90% subsidy on surface irrigation and DTWs, 60% on community STWs and 30% on private STWs, which encouraged farmers to install STWs. The APP focused on year-round irrigation as a key input for achieving the desired output of agricultural production, emphasizing more on groundwater irrigation (HMG 1995). The 9th Plan (1997-2002) emphasized ground water irrigation, which can be developed in a short period of time with moderately low expenses and under the control of farmers themselves.

The major groundwater irrigation projects implemented between 1975 and 2000 are: Bhairawa-Lumbini groundwater irrigation project, Kailali-Kanchanpur groundwater irrigation project, Mahottari DTW, Sunsari-

Morang DTW, Birgunj groundwater, Community tube well program, groundwater irrigation component of the Janakpur Agriculture Development Project (JADP), Sagarmatha Integrated Rural Development Project (IRDP) and ILC/NISP, Rapti and Mahakali IRDPs also had a groundwater irrigation component. The ADBN and DoI are the main agencies involved in the development of groundwater irrigation. In the past, Farm Irrigation and Water Utilization Division (FIWUD) under the DoA, Ministry of Panchayat & Local Development and a few INGOs were also involved in STW irrigation works on a small scale. Among the INGOs, IDE emerged as a leading agency in STW irrigation development, having installed about 23,000 treadle pumps and having covered about 5,700 hectares between 1986 and 2000 (IDE 2001).

Shallow tube wells: ADBN has been involved in the installation of STWs since 1981, providing loans and technical assistance and channelizing government subsidies to farmers. The installation of STWs gradually accelerated between 1981 and 1990, their number peaked in 1992 and then it consistently decreased from 5,164 in 1992/93 to 1,250 in 1998/99 (Koirala and Gautam 1998, DoI 2000). The department of irrigation has reported the installation of 47,355 STWs in the country until the FY 2012/13 whereas Janakpur Agriculture Development Project (JADP) installed 6,322 STWs until the FY 2015/16. In spite of high amount of subsidy (75%) and low cost per hectare of installation, farmers are reluctant to install community STWs due to their fragmented and scattered land holdings, and many farmers whose plots are adjacent to each other find it very difficult to organize in groups. Moreover, those group members whose land lie at the tail end of the system face difficulties, resulting in more operating cost per unit of area. Only about 4% of the total STWs installed was operated and managed by the community (Koirala and Gautam 1998).

Deep tube wells: There have been considerable increases in cropping intensity, particularly in DTW areas, while the yields of paddy and wheat have increased up to 3.5 t/ha and 2.1 t/ha, respectively. There are institutional problems in community-managed DTWs, such as lack of a sense of ownership, and some farmers have installed STWs, which further reduces the command area for irrigation and makes the operation and maintenance more expensive. Most of the DTWs are under-utilized; the average annual operation hours of DTWs in Kailali district and in Bhairawa-Lumbini sites are reported to be in the range of 200-490 hours per year, which is very low compared to the anticipated 2,000 average operation hours per annum (MDC/New ERA 1996, Regmee et al 2000). Thus, limited use of water is mainly due to the high cost (due to higher operating charges of DTWs) of pumped water compared to surface water as well as poor technological and marketing initiatives to use this high-cost water for diversified and commercial farming. The use of water is limited to traditional agricultural cropping system, which is less diversified and mostly includes cereal crops. Farming needs to be diversified and commercial crops grown to make economical use of the currently under-utilized groundwater and significantly increase the operating hours to nearly 2,000 hours per year, as planned. Farmers need timely government policy interventions so that they can reduce the production cost and compete with the Indian farmers across the border where agricultural inputs are highly subsidized. The Department of Irrigation (DoI) has reports of installation of 184 DTWs in the country until the FY 2012/013 whereas JADP has installed 293 DTWs until the FY 2015/16.

Conclusion

Irrigation practice on agriculture development is not a recent phenomenon in Nepal. It has been practiced from ancient time. Rice being the major cereal crop of our country and irrigation is one of the major inputs; it provides an opportunity for the large quantity of production on the limited land. For that Nepalese government has emphasized the development of irrigation systems in different stages of planning process and development phases to raise the agricultural productivity**.** The irrigation facilities are available in various forms such as canal, well, tube-well, lift and so on.

Acknowledgements

The author would like to thank and appreciate the immense efforts of Mr. Dila Ram Bhandari, Director General of Department of Agriculture for his initiation in publishing this historical document. The author also take this opportunity to thank Department of Irrigation for providing necessary information during preparation of this article.

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Water Management Practices for Rice Production in Nepal

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सारांश

नेपालमा धान खेती सामान्यतया लामो समयसम्म पानीको उपलब्धता हुने जग्गामा गरिन्छ । धानको अर्धजलीय गुणको कारणले गर्दा यो सुख्खामा अत्यन्तै संवेदनशील हुन्छ । औसतमा धान उत्पादन क्षेत्रहरूमा धान बालीलाई एक किलो उत्पादन गर्न १४३२ लिटर पानीको आवश्यकता पर्दछ । धानले बाली अवधिभर माटोको बनावट अनुसार चिम्ट्याइलो माटोमा ४०० देखि बलौटे माटोमा २००० लिटरसम्म पानीको उपभोग गर्दछ । धानको गुणस्तर र उत्पादनमा प्रमुखतः सिँचाइ गरिने पानीको गुणस्तर, सिँचाइ व्यवस्थापनको समय, बालीको महत्वपूर्ण चरणमा सिँचाइको उपलब्धता तथा प्रयोगले प्रभावित पार्दछ । त्यसैले कम पानी आपूर्ति गरी खेती गर्न हामीले पानीको प्रयोगमा दक्षता ल्याई पानी खपतको आर्थिक, प्राविधिक र वातावरणीय प्रदर्शन सुधारका प्रविधि अपनाई सिँचाइ विधिको विविधिकरण तथा सिँचाइ संरचना प्रणालीमा परिवर्तन गर्नुपर्छ । तसर्थ, यो लेखमा धान बालीको उत्पादन बढाउन पानीको गुणस्तर र बालीको आवश्यकतालाई ध्यान दिई सिँचाइ गर्नुपर्ने विषयमा उल्लेख गरिएको छ ।

Summary

Rice is typically grown in bunded fields that are continuously flooded up to 7-10 days before harvest. Due to its semi-aquatic characteristics, rice is extremely sensitive to drought. On an average, it takes 1,432 liters of water to produce 1 kg of rice in an irrigated lowland production system. Total seasonal water input to rice fields varies from as little as 400 mm in heavy clay soils with shallow groundwater tables to more than 2000 mm in coarse-textured (sandy or loamy) soils with deep groundwater tables. The quality and yield of rice is influenced by the quality of irrigation water, frequency and timing of irrigation, water management at critical stages and irrigation scheduling as per crops need and availability. Different techniques of maximizing water use efficiency should be followed such as diversification of production and cropping patterns, changing in management systems of irrigation structures, etc. This paper focuses on water saving ideas for paddy production focusing on water quality and need of crop.

Keywords: Critical stages, Irrigation, Irrigation scheduling, Ground water, Rice, Water quality

Introduction

Rice was grown on an area of 1.42 million hectares with only 64% area is under irrigation (MoAD 2015). It is unique among the major food crops in its ability to grow in a wide range of hydrological situations, soil types, and climates. It is the only cereal that can grow in wetland conditions. Rice being a semi-aquatic crop is suffered by a long dry spell (Adhikari et al 2007a). The water balance of a rice field consists of inflows by irrigation, rainfall, and capillary rise, and outflows by transpiration, evaporation, over bund flow, seepage, and percolation. The nursery, field puddling and transplanting requires large quantity of water. Rice could be grown with much less water by only saturating the field instead of ponding water throughout the growing period (Adhikari et al 1998).

Flooding rice fields continuously throughout cropping season does not necessarily increase the yield. Draining the rice field for every 7 to 14 days at tillering stage saves irrigation water. Saturating the field during the crop cycle used 3000 liters of water to produce 1 kg of rice grain. The water utilization efficiency for rice is 0.7 to 1.1 kg grains/1000 liters of water (Dorenboss 1979; Dedatta and William 1968). Water is the single most important component for sustainable rice production, especially in the traditional rice growing areas of Nepal. The depletion of water resource is an increasingly worrying aspect of rice production in Nepal, particularly for irrigated rice. The need to produce more rice for more people on less land with less water is a challenge for science and technology, as well as for the rice-farming community. The limiting factor in Nepal affecting rice yield is erratic precipitation as it has only 1368914 hectare area under irrigation. The general water duty for rice being used by Nepalese farmers is 5 liters/sec/ha, which is very high (Adhikari et al 2007b).

Sources of irrigation for rice production in Nepal

In Nepal, about 57% of the total holdings with irrigation reported "canal (seasonal)" as the source of irrigation water (http://cbs.gov.np/image/data/Agriculture/Agriculture%20Monograph%20contents/Chapter08.pdf). In Tarai, tubewell/bore ranked second as the source of irrigation compared with canal (permanent) for the Hill belt and Mountain belt. In Hill and Mountain belts, almost all of the irrigated land holdings depend on seasonal as well as permanent canals as their source of irrigation water. Most of the irrigation systems are thus fed by medium or small rivers, which almost entirely depend on the rain.

Methods of irrigation adopted by Nepalese farmers

In Nepal, majority of irrigation system rely on surface irrigation - in fact furrow irrigation has operated successfully for generations. In this method, water is allowed to flow by gravity to respective areas and water use efficiency of the system is around 40-50% only. Basin irrigation is also followed during field preparation. Trapping water and humus through irrigation canals to farm is also an important function in different areas of Nepal, where farmers broadcast rice on irrigated land and transplant rice seedlings incase of lack of irrigation water. Wild flooding practice is adopted in smooth fields. Similarly solar pumping system and no energy pumps are also used for drawing irrigation water for paddy in Nepal.

Key challenges for irrigation development in Nepal

Old infrastructure and poor performances of the existing irrigation systems, poor system efficiency and under-utilization of canal water, weak participation of water users associations (WUAs), weak institutional capacity, weak linkages between agriculture and irrigation, continuation of subsistence agriculture practices in command area, etc are some of the key challenges facing by Nepalese irrigation sector.

Water requirement of rice crop at different growth stages

Nursery establishment

Average water requirement in this period is 50-60 mm which is about 5% of total water required by crop throughout its growing period (Agropedia 2016). Summer ploughing minimizes water requirement for land preparation.

Puddling

The fields are usually first flooded. A few days after flooding, the field is ploughed. Flooding makes ploughing easier. After ploughing, 200-250 mm of water is required during puddling which is about 20% of the total water requirement of the rice culture (Adhikari et al 2007a). Puddling reduces the permeability of the soil and therefore also reduces the percolation losses. Large quantity of FYM should be applied in the field since its application increases water holding capacity of light textured soils and thus saving of water.

Transplanting

Seedling transplantation should be done when there is shallow depth of water (2-3 cm) in the field. After transplanting, water levels should be around 3 cm initially, and gradually increase to 5-10 cm with increasing plant height and remain there until the field is drained 7-10 days before harvest. For direct wet seeded rice, field should be flooded only once the plants are large enough to withstand shallow flooding (3-4 leaf stage) (http://www.knowledgebank.irri.org/step-by-step production/growth/water-management).

Weed management

Continuous flooding helps ensure sufficient water and control weeds. Proper water management is necessary for the formation of chemical treated soil layer to ensure sufficient time for weeds to absorb. Shallow depth of water should be maintained at the time of application and this water should be kept for a certain length of time (5-7 days). Normally, it is recommended to keep water standing for at least one week after chemical application. Draining of water or overflowing after application should be avoided.

Table 1. Water requirement of rice crop at different growth stages

Stages of growth	Average water requirement (mm)	% of total water requirement (approx.)
Nursery	50-60	5
Main field preparation	200-250	20
Planting to panicle initiation (PI)	400-550	40
PI to flowering	400-450	30
Flowering to maturity	100-150	5
Total	1200-1460	100.0

Moisture stress during rooting and tillering stage cause poor root growth leading to poor crop establishment and low yield and thus irrigating the crop up to 5 cm height is recommended. During booting and maturity stages continuous inundation of 5 cm and above leads to advancement in root decay and leaf senescence, delay in heading and reduction in the number of filled grains per panicle and poor harvest index. Similarly, continuous submergence lowers weed dry matter production and increase rice yield (Singh 1988).

Table 2. Estimation of water requirement of rice, Central Dept. of Hydrology and Meteorology

Months	No of days	Crop water requirement mm/day	Total crop water required mm
June	8	0.87	6.96
July	31	2.10	62.31
August	31	5.28	163.68
September	30	15.95	478.5
Total			711.45

Source: Aryal S 2016.

The variation in the crop water requirement of with the advancement in the development stage of the rice plants is reflected in the experiment conducted by Aryal (2016) (**Table 2**). There is increase in the average daily crop water need of rice in the successive months. This suggests that during the growing and developing period crops need large quantity of water for various physiological functions and sensitiveness of crop to moisture requirement changes with different growing and developing period.

Frequency and depth of irrigation water

The season, climate, duration, variety, and soil condition decide the frequency of irrigation in rice. Usually 9 to 15 irrigations are required. The depth of irrigation may vary from 5-10 cm depending upon soil condition and stages of crop. Heavier irrigations are applied in heavier soils where percolation of water is slow. Frequent irrigation is needed in lighter soils and at flowering and grain filling stages. It is recommended to apply smaller quantities of water at closer intervals then applying larger quantities at longer intervals. On average about 40% of water is assumed to be taken by plants from the upper quarter of the rooting depth, 30% from the second quarter, 20% from the third quarter, and 10% from the lowest quarter (Reddy 2011).

Critical stages of water requirement

Critical stage refers to a stage when water scarcity or deficit of water causes comparatively greater reduction in yields which cannot be made by favorable water supply at earlier or later stages. Hence, water deficit during these stages should be avoided. Following are the important critical crop growth stages for water stress in rice plant.

Tillering: Allow the water to aerate the soil and stimulate root penetration, tiller production, firm root anchorage, correction of micronutrient imbalances, and removal of toxic substances from the soil.

- Panicle initiation: Maintain 2-5 cm flood water to avoid drought stress.
- Heading/panicle emergence
- Flowering/anthesis (reproductive phase)

About 70% loss in grain yield is due to the stress at reproductive stage, after flowering there is great decrease in water requirement (Rao 1951). The moisture stress reduces the number of grains panicle and thus the yield is reduced. To facilitate uniform maturity and harvesting of the crop, irrigation should be stopped after grain hardening stage. A study showed that termination of irrigation 14 to 17 days before the harvest resulted to a uniform maturity of the crop and economized 16 cm of irrigation water, while suspension of irrigation 3 weeks before the harvest saved 22 cm of water. In later case, there was marginal decrease of only 200 kg grains per hectare (Sandhu et al 1982).

Role of irrigated water in insect and disease management

Irrigated water has positive role in disease and insect management in rice crop. Continuous flooding and poor drainage encourage the hopper population. Regulation of irrigation water is to be modified in line with pest control. Intermittent flooding and draining the field frequently during mid season, lowers the brown plant hopper build up to a significant extent. Similarly, different diseases of rice could be controlled with wise use of water. In order to control the Bacterial leaf blight of rice, good drainage should be provided to field. To control stem rot disease of rice, fields should be drained and soil should be allowed to crack before re-irrigating the field. Rodents' activity in the field could be checked by flooding the rice field.

Drainage needs of rice

Excessive irrigation leads to water logging. Water logging also occurs due to excessive rainfall, floods, rise of ground water level etc. Continuous stagnation of water leads to accumulation of toxic biochemical's substance and silt deposition. In different places the problem of excess water is associated with the salinity and alkalinity problems. Certain stages of growth like early flowering have been reported to be more susceptible to water logged conditions than other stages of crop growth (CRRI 1980). Thus drainage is imperative and should be synchronies with the period just following tillering and flowering (Sahu 1967). Even 4 days complete submergence at flowering is more detrimental than 8 days of submergence at seedling establishment and 12 days of submergence during the late vegetative phase. The drainage period could last from 3-7 days depending upon the type of soil (Prasad 1999).

Scheduling of irrigation

Irrigation scheduling is the process used by irrigation system managers to determine the correct frequency and duration of watering. Precipitation rate of irrigating equipment, distribution uniformity, soil infiltration rate, soil topography, soil available water, effecting rooting depth, allowable moisture stress and timing of irrigation should be taken into consideration during irrigation scheduling. The goal for irrigation scheduling is to apply enough water to fully wet the plant's root zone while minimizing overwatering and then allows the soil to dry out in between watering, to allow air to enter the soil and encourage root development, but not so much that the plant is stressed beyond what is allowable. Number of irrigation may be decided depending upon the receipt of rain and available moisture content. The irrigation schedule for the rice crop is presented below in table.

Table 3. Scheduling of irrigation in rice crop

Short duration variety			Medium duration variety			Long duration variety		
Days	No. of irrigation	Water level (cm)	Days	No. of irrigation	Water level (cm)	Days	No. of irrigation	Water level (cm)
1-25	5-7	2-3	1-30	5-7	2-3	1-35	6-8	2-3
25	-	Thin film of water	30	-	Thin film of water	35	-	Thin film of water
28	-	Life irrigation	33	-	Life irrigation	38	-	Life irrigation
29-50	6	2-5	34-65	6-8	2-5	39-90 or 95	12-15	2-5
51-70	5-6	2-5	66-95	8-10	2-5	96-125	7-9	2-5
71-105	5-6	2-5	96-125	6-8	2-5	126-150	5-6	2-5

Source: Agropedia 2016.

Water saving

It has been estimated that a 10% decrease in the water use for irrigated rice could lead to water saving of approximately 150,000 million m^3, almost one-fourth of all the fresh water used world-wide for non-agricultural activities. Several studies have indicated that irrigated rice can be easily cultivated using 8,000-10,000 m^3/ha, which is approximately 50% of current use, without affecting yield. The main difficulty with saving water is that the water is not priced properly, especially in schemes where they charge the user by irrigated area and not by volume of water used. With such schemes, there is no economic incentive to save water. There are several ways to reduce irrigated rice water consumption including: limiting rice cultivation to only the rainy season, using and developing more water efficient varieties (C_4 type plants), promoting upland rice, developing drought tolerant rice varieties, modifying the planting date and making more effective use of rainfall, changing rice planting practices, etc. Wet seeding of rice uses about 20-25% less water than in traditionally transplanted rice and drastically reduces labor for establishing the crop from 30-person days per hectare to 1-2 person days. Other techniques include replacing transplanting by direct seeding, intermittent flooding, maintaining the soil in sub-saturated condition, alternate wetting and drying, supplementary irrigation either for crop establishment or at critical growth stages, water recycling and conjunctive use to enable farmers to reuse seepage, percolation losses from canals and fields using alternatives to flooding techniques as overhead sprinklers, furrows, etc with newly developed aerobic varieties, adopting simple conservation that is, maintaining only supersaturated soil conditions during cultivation of the crop, significantly reducing land preparation (puddling) water and keeping water within the field by reducing outflow discharges. The farmer's acceptance to the above practices depends on economic and other factors. Farmers will need technical support in upgrading irrigation systems for efficient water distribution and agricultural support in adapting agricultural practices such as modified irrigation methods, using new varieties and new water management practices.

Precautions for irrigation

Water is consumed during the production processes of rice crop, yet large range of climates generate a variety of hydrological regimes and an uneven distribution of water resources and water use conditions. The rule of thumb to adopt water scarcity is to consume less water, followed by modify water demands, maximize efficiency in water use, and improve the economic, technical and environmental performance of water consumption, together with diversification of production and cropping patterns, changes in management systems and structures, and financial sustainability (Facon 1999). During irrigating the rice crop, withholding of water should be done for few days till seedlings establishment. Field to field irrigation system should be avoided. The water should be drained from the field for about 2 days prior to the application of fertilizers. In order to avoid leakages of water through main bunds, small bund may be formed parallel to the main bund of the field at a distance of 30-45 cm within the field. The depth of water should be maintained at 5 cm or less in the field to minimize percolation loss. In water logged conditions open drains of about 60 cm depth and 45 cm width across the field should be constructed. In case of the areas where irrigation facilities are not available, all the rain water in paddy fields should be stored by making 25-30 cm raised bunds. Water should be drained off completely for 5 to 7 days following tillering and flowering stages. This helps to remove the toxic substances like sulphides and regulates oxygen supply to roots.

Conclusion

Water for food production is increasingly becoming scarce with increased demand from other sectors such as domestic, industrial and environmental uses. Thus farming community shall use the water in wise way. Water saving techniques has to be introduced to meet the competitive demand. More research has to be conducted to produce more with the less water use.

Acknowledgements

The authors would like to express their sincere gratitude to Mr. Dila Ram Bhandri, Director General of Department of Agriculture, Hariharvawan, for providing an opportunity for preparing this manuscript. Sincere thanks goes to staffs of DoI who contributed positively with valuable suggestions and comments during preparation of this article.

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Seed Sector Development
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Seed Sector Development in Nepal Focusing on Rice

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सारांश

सन् १९५० भन्दा अगाडि नेपालमा धानको बीउ आपूर्ति अनौपचारिक प्रणाली अनुसार हुने गर्दथ्यो, जुन अहिलेको अवस्थामा पनि ८५% भन्दा बढी बीउको कारोबार सोही अनुसार हुने गर्दछ । नेपालमा धान बीउ उत्पादन तथा वितरणको औपचारिक संस्थागत सुरुवात कृषि सामग्री संस्थानबाट राष्ट्रिय बीउ बिजन कम्पनी लिमिटेडको स्थापना भए पश्चात् हुँदै आएको छ । त्यसैगरी राष्ट्रिय बीउ बिजन नीति (१९९९), बीउ बिजन ऐन (१९८८), नियमावली (२०१३), बीउ बिजनको दीर्घकालीन राष्ट्रिय सोच (सन् २०१३-२०२५) आदि धान बीउ प्रणालीलाई सुदृढ पार्न लागु गरिएका नीतिगत व्यवस्थाहरू हुन् । हाल नेपालमा धान बीउको आपूर्ति सरकारी र निजी क्षेत्र दुवैबाट हुँदै आएको छ भने केही वैदेशिक सहायतामा संचालित परियोजनाहरूले समेत धान बीउ उत्पादन तथा बजारीकरणसँग सम्बन्धित गतिबिधिहरू संचालन गरिरहेका छन् । नेपाल कृषि अनुसन्धान परिषद्ले प्रजनन बीउको आपूर्ति गर्ने गरेको छ भने परिषद्का अतिरिक्त केही बीउ बिजन कम्पनीहरूले मूल बीउ उत्पादन गरी वितरण गरिरहेको अवस्था विद्यमान रहेको छ । हाल नेपालमा १३ वटा बीउ परीक्षण प्रयोगशाला र भण्डारणका लागि १६० संरचनाहरू रहेका छन् । धान बीउ बिजनको आपूर्ति हेर्दा राष्ट्रिय बीउ बिजन कम्पनीबाट आपूर्ति हुने बीउको परिमाण निजी क्षेत्रबाट हुने आपूर्तिभन्दा निकै कम रहेको छ । जिल्लास्तरीय बीउ बिजन आत्मनिर्भर कार्यक्रम (डिस्प्रो), सामुदायिक बीउ बैंक, जिल्ला बीउ बिजन समन्वय समिति आदि संरचनाहरू धान बीउ प्रणालीलाई सरकारी तवरबाट सुदृढ पार्ने हेतुले स्थापना एवम् गठन भएका छन् । यसरी धान बीउ प्रणालीलाई व्यवस्थित गर्न निकै प्रयासहरू भएता पनि धानको बीउ प्रतिस्थापन दर (१३.४%) अपेक्षाकृत रूपमा बढ्न सकेको छैन । तसर्थ, धान बीउ प्रणालीलाई प्रभावकारी एवम् दिगो बनाउन यससँग सम्बन्धित सरोकारवाला निकायहरू बीच प्रभावकारी तथा अर्थपूर्ण समन्वयको टड्कारो आवश्यकता महसुस गरिएको छ ।

Summary

Before 1950s, Nepalese seed sector was based on informal seed supply system which still for accounts more than 85% in Nepal. Transformation of Agricultural Input Corporation (AIC) into National Seed Company Limited (NSCL) was a major event in formal development of seed sector in Nepal. National Seed Policy (1999), Seed Act (1988), Seed Regulation (2013), National Seed Vision (2013-2025), etc are some of the policy frameworks to strengthen rice seed system in Nepal. Currently, rice seed supply is made through both public and private sector. Moreover, seed sector in Nepal has been receiving substantial foreign assistance in the name of various projects to cover a wide range of seed activities. Supply of breeder seed is made by Nepal Agricultural Research Council (NARC) and foundation seed is generally supplied through NARC and fewer private companies. There are 13 seed labs and 160 seed storage structures to effectively manage rice seed system in Nepal. The rice seed supplied by private sector is in higher quantity than that supplied by public sector. District Level Seed Self Sufficiency Program (DISSPRO), Community Seed Banks (CSB), District Seed Coordination Committee (DSCC) are some of the institutional arrangements to strengthen rice seed system at district level through government sector in Nepal. Quality control is formally controlled by the National Seed Board (NSB), Seed Quality Control Centre (SQCC) and Regional Seed Testing Laboratory (RSTL). Despite various institutional arrangements in supply of rice seed in Nepal, the Seed Replacement Rate (SRR) of rice is still very low (13.4%). Thus, effective and meaningful coordination among the various stakeholders engaged in rice seed system is an urgent need to make rice seed system viable, sustainable and efficient.

Keywords: NSCL, Rice, Seed, SRR

Background

Seed is the basic input of agriculture production that sets the limit to all other production technologies. It is the basis of food security, biodiversity conservation and vital agriculture input (Gauchan 2015). Seed is the ultimate technology which encapsulates a package of disease resistance, quality and yield potential. Sustained increase in agriculture production and productivity necessarily requires continuous development of new and improved varieties of crops and efficient system of production and supply of seeds to farmers (Joshi 2015). Therefore, an effective and sustainable seed systems can help improve the livelihoods of small farmers and benefit consumers as well, serving as an important element in strategies for agricultural development and poverty reduction (Minot 2006). The following headings in this paper tries to assess the overall seed system of Nepal with special focus on rice.

Informal seed management system (farmer's seed system) before formal intervention

Before the 1950s, almost all rice areas in the country were covered by the local varieties. The rice crop was cultivated under traditional crop management condition (Shrestha and Lal 1990). Informal seed system is that in which, farmers plant, select, store, consume, sell and exchange seed of farmer preferred cultivars over generations for their livelihood. Most traditional varieties or landraces are the products of such local selection and maintenance process. Farmers' seed systems depend on the free exchange of seeds either through small gifts, barter/exchange and for both monetary and non-monetary value. The stability of the varieties within the community is based on taste and nutrition that give the additional value. It is the total of seed production activities of farmers, mostly small-scale farmers. Generally, the seeds are cheaper and easily available under informal seed system. This traditional transaction of seed is still more than 85% for rice crop to date. Both informal and formal seed systems are important channels for delivering cereal seeds to Nepalese farmers. Currently the distribution system of seed can be classified into two ie formal and informal categories (**Figure 1**).

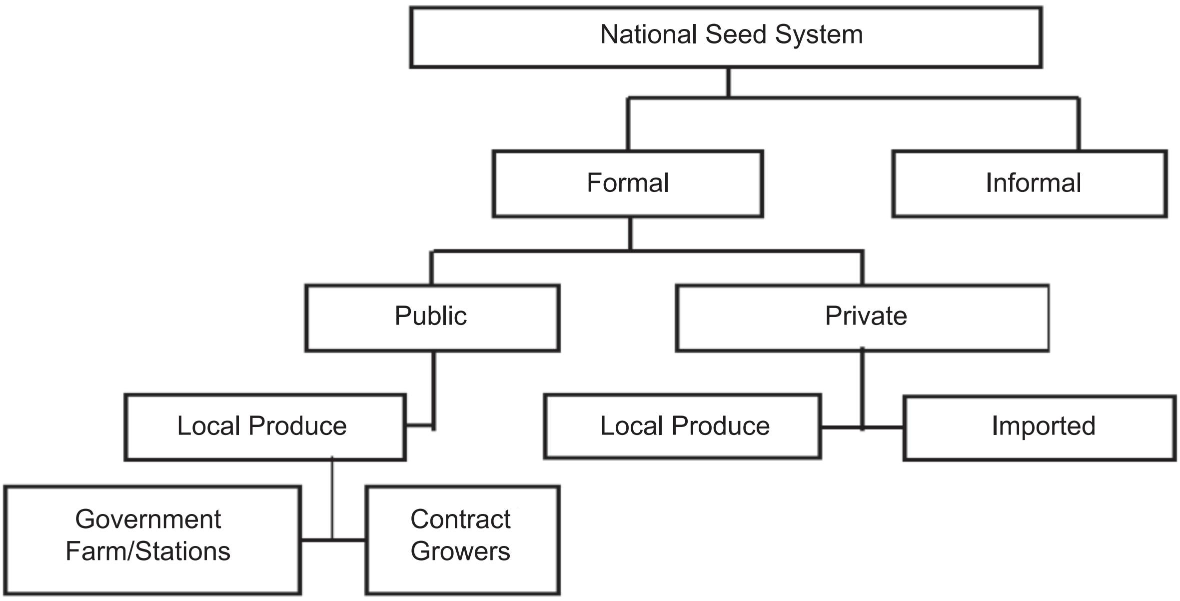

Figure 1. Formal and informal seed supply system in Nepal

Formal seed production and distribution system initiatives in Nepal

This is characterized by a vertically organized production and distribution of released/registered varieties by public and private organizations (**Figure 1**). The spread of new agriclutural technology in food grains started with the introduction of high yielding varieties of crops (Thapa et al 2001). The formal seed supply systems cover seed production and supply mechanisms using agreed quality control mechanism. It comprises different phases of seed cycle: breeder, foundation, certified and improved seeds. Formal seed production and distribution in Nepal was initiated during 1950s-1960s decade with the introduction of wheat varieties, Lerma Rojo-52 and Lerma Rojo-64 and a maize variety *Amarilo de Blanco*. During this period, new varieties of Rice like Taichung Native-1 and IR-8 were also introduced in the country. In 1957, China-45 (CH-45) originated in China was introduced from India along with other varieties (Shrestha and Lal 1990). It is also said that Japanese and Columbian improved rice and wheat varieties were produced at agricultural farms located at Singhdurbar, Kathmandu and then distributed. During that period seeds produced at government farms and centers were provided to the farmers through extension. However, organized seed production began in Nepal during the 1970s.

Formal institutional development process

During the third five-year plan under the Corporation Act 2021 BS (1964 AD), a state owned institution named Agricultural Supply Corporation (ASC), the first of its kind was established in 1965 under government's liability for the supply of agriculture production inputs. ASC was actively involved either in procurement of improved seeds from government farms or import from various sources. In 1972, ASC was replaced by the Agriculture Marketing Corporation (AMC) with the continuation of ASC program. The rice seed produced by government farms and research stations did not meet the increasing demand. As a result, AMC procured locally available seeds and also imported and distributed large qualities of wheat seeds (30 tonnes) from the Tarai Development Corporation, Pantanagar or from National Seeds Corporation, India (Pant and Jain 1979). For the food supply in the country, Food Management Corporation (FMC) was established in 1972. Again, By merging AMC and FMC, a new Agriculture Buying and Selling Corporation (ABSC) was brought into action in 1973 with the aim of supporting agricultural development through the supply of agricultural inputs like fertilizer, machineries, improved seeds, insecticides, etc. This institution supplied food as well as agricultural inputs together. Meanwhile, based on Corporation Act 2021 BS, ABSC was renamed as Agricultural Input Corporation (AIC) and a separate Nepal Food Corporation (NFC) was established for food trade on December 2, 1974. At that time, a small unit of Seed Division was also established within the AIC. The main objective of AIC was to supply chemical fertilizer. Imported seeds were very expensive and they did not reach the farmers' hand in time. Quality and reliability of imported seeds were not up to the mark. This necessitated the production of improved seeds inside the country and the then AIC was entrusted with the production and marketing of seeds in addition to other ongoing activities. Since 1973, AIC has started seed production in organized way in the farmers' field under its technical supervision (Pradhan and Sinha 1990). The program was basically conducted in the Tarai. Wheat is continuously the predominant crop for seed production followed by maize and rice. However, rice seed was initially produced only in government farm. AIC also started producing rice seed in farmers' field in 1983 to meet an increasing demand (Hada and Dawadi 2001).

During 1974-75, the UNDP assisted Nepal in multiplication of improved seeds of rice, maize and wheat in Narayani zone where a seed processing plant was installed for selection and treatment of certified seeds obtained from registered seed growers. The Hetaunda Seed Processing Plant was established around 1976. Then organized seed production and extension program was regularized. The AIC was procuring seeds from contracted seed growers, research farms and stations, and made available quality seeds to farmers through purposively created network distribution system in the country. Seed processing plants of varying capacities were established at Hetaunda with FAO/UNDP assistance and in Itahari, Janakpur, Bhairahawa, and Nepalgunj with German assistance. Similarly, under the joint assistance of GTZ and USAID, storage structure and transportation means were made available to AIC. Mini seed houses were created in 20 hill districts by USAID assisted SPIS project (Upadhyaya and Bhattarai 1990). Major institutions like AIC, DoA and NARC received substantial support from the donors, mainly USAID, FAO and GTZ for the seed sector development including infrastructure, human resource and implementation activities.

Public sector led the organized seed production and supply in Nepal during 1960's, 70's and 80's (Bharati et al. 2008). Until 1990, public sector (AIC) continued to play a key role in production and supply of seeds in Nepal.

Despite the past 30 years of seed development initiatives unavailability of good quality seeds in sufficient amount at the right time and place is the main constraint for improving seed replacement in the farmers' field. The supply of seed from this organization could not cover more than 3% Seed Replacement Rate (SRR). None of the private sector was involved in cereal seed business till 90's due to high volume and low price.

National Seed Company Limited

With the aim of making effective working efficiency regarding the agricultural inputs supply following the then HMG decision in the 8th May,1998 according to Company Act 2053(1996), AIC was divided into two public limited named as Agriculture Input Company Limited (AICL) for chemical fertilizer supply and National Seed Company Limited (NSCL), for seed supply. Accordingly NSCL has been working only on the seeds from the time of its establishment. Government established NSCL for seed business on 8th May, 2002. Now NSCL is the public sector responsible for seed distribution in the country. The NSCL is supported by NARC in supply of breeder and foundation seeds for seed multiplication. The status of seed supplied by NSCL over the five decades with price of improved rice seed is presented in **Table 1**, which shows that the annual sale increased from 40mt in 1966/67 to 3714 tonnes in 2014/015 with frequent ups and downs in sale during that period. The average selling price of improved seed increased from NRs15.86/kg in 2001/02 to NRs 52.49/kg in 2014/15.

Table 1. Selling of improved paddy seed by NSCL from 1966/67 to 2014/15

FY	Selling paddy seed (tonnes)	Selling price NRs/kg Seed	FY	Selling paddy seed (tonnes)	Selling price NRs/kg Seed
1966/67	40.00*	na	1991/92	276.52	na
1967/68	232.00*	na	1992/93	211.43	na
1968/69	253.00*	na	1993/94	242.16	na
1969/70	210.00*	na	1994/95	316.58	na
1970/71	102.00*	na	1995/96	250.35	na
1971/72	265.00*	na	1996/97	371.78	na
1972/73	160.00*	na	1997/98	177.87	na
1973/74	414.00*	na	1998/99	308.00	na
1974/75	328.00*	na	1999/00	326.00	na
1975/76	124.00*	3.0**	2000/01	231.00	na
1976/77	359.00*	3.0**	2001/02	208.03	15.86
1977/78	299.00*	3.0**	2002/03	352.26	17.92
1978/79	255.00*	3.0**	2003/04	493.51	18.72
1979/80	305.00*	na	2004/05	559.75	20.5
1980/81	204.36	na	2005/06	643.57	21.62
1981/82	243.93	1.50	2006/07	661.48	22.59
1982/83	691.10	3.50	2007/08	885.94	24.18
1983/84	317.93	5.22	2008/09	931.27	26.62
1984/85	237.89	na	2009/10	850.10	28.18
1985/86	153.85	na	2010/11	1209.08	35.79
1986/87	140.98	na	2011/12	1200.46	33.72
1987/88	211.93	na	2012/13	773.85	34.82
1988/89	212.58	na	2013/14	2079.59	41.48
1989/90	145.52	na	2014/15	3714.32	52.49
1990/91	156.02	na	2015/16		

*Source: NARC 1997, *Parajuli et al 1990, **Mallick 1981, MoAD 2015, na= not available.*

Source seed (BS and FS) production and distribution program under NARC

NARC, a public sector agency, is playing major role in breeder and foundation seed production of rice at different farms/stations and commodity programs. It supplies breeder and foundation seed to commercial actors: such as DoA, private seed companies and community organizations involved in seed production, processing and distribution in the country. However, FS is also produced by NSCL and 16 registered authorized private seed companies. The production trend of BS and FS from NARC is presented in **Table 2**, which shows significant ups and downs over the years. The production of BS and FS increased from 0.20 and 35.49 tonne in 1974/075 to 12.27 and 430.93 tonne in 2014/15, respectively.

Table 2. Production of BS and FS of rice by NARC from 1966/67 to 2014/15

Year	Breeder seed (tonne)	Foundation seed (tonne)	Year	Breeder seed (tonne)	Foundation seed (tonne)
1966/67	na	na	1991/92	3.19	49.09
1967/68	na	na	1992/93	2.40	38.52
1968/69	na	na	1993/94	3.51	50.83
1969/70	na	na	1994/95	4.22	47.93
1970/71	na	na	1995/96	3.97	45.10
1971/72	na	na	1996/97	na	na
1972/73	na	na	1997/98	4.19	79.80
1973/74	na	na	1998/99	2.57	50.13
1974/75	0.20	35.49	1999/00	7.01	52.82
1975/76	0.37	42.82	2000/01	6.38	62.58
1976/77	0.50	38.80	2001/02	5.54	55.68
1977/78	na	na	2002/03	25.42	400.00
1978/79	0.60	51.40	2003/04	7.57	446.00
1979/80	0.60	50.38	2004/05	11.24	408.00
1980/81	0.60	52.20	2005/06	7.84	295.200
1981/82	0.33	0.55	2006/07	5.09	254.02
1982/83	0.33	53.04	2007/08	7.70	309.8
1983/84	na	na	2008/09	15.23	451.70
1984/85	na	na	2009/10	8.60	253.00
1985/86	na	na	2010/11	15.40	270.00
1986/87	na	na	2011/12	20.57	348.00
1987/88	na	na	2012/13	30.00	364.00
1988/89	2.30	51.22	2013/14	24.00	438.00
1989/90	3.92	51.03	2014/15	12.27	430.93
1990/91	2.57	50.13			

Source: NARC 1997, Parajuli et al 1990, Mallick 1981, MR Bhatta and J Bajracharya 2008. The Proceedings of Fourth National Seed seminar, MoAD 2015, na= not available.

Strengthening seed production and distribution program under DoA

The amount of seed procured by AIC was far more inadequate based on farmers' demand on the one hand while on the other, AIC had to bury substantial quantities of seed every year as waste. In this case, DADOs were blaming DoA for not coordinating centrally on systemic seed supply for the district requirement, while NARC used to blame AIC and DoA for not disseminating newly developed varieties. DoA was also blaming AIC for inadequate and inefficient delivery system of seed. For the improvement of this situation, a new approach, DISSPRO for ensuring cereal seed supply was initiated from Crop Development Directorate (CDD) under DoA complementarily for AIC program and as endorsed in the Ninth Plan.

District Level Seed Self-sufficiency Program (DISSPRO) 1998

DISSPRO is the seed multiplication directive and was approved from DoA in 1998 (CDD 1998). The objectives of the DISSPRO are: to produce good quality seed and make it available to the growers at desired time, at the right place and affordable price, faster dissemination of newly released variety, farmer to farmer spread of good quality seed, create awareness on quality seeds among farmers, promote farmers' group into seed entrepreneurs and ultimately make the district self sufficient in major cereal seeds.

Implementation procedure

From the FY 1997/98 fifteen districts, three from each development region (two belonging to Tarai and one from hill) have been producing certified first generation (C_1) seed from the FS procured from NARC stations and farms. These source districts have been instrumental in serving the neighboring farmers in the production of C_2 seed. DISSPRO farmers are given source seed at 25% subsidy besides 100% transport subsidy up to their respective Service Centre and other subsidies like 25% on sprayers and metal bins as well as small grant support for construction of storage structures, threshing floor, and other equipment. There is provision of revolving fund of NRs 5000/farmers' group. This program coordinates and provides necessary technical support and quality management support in producing, processing, storing and distributing seeds.

Impact of DISSPRO

Within 2-3 years of DISSPRO implementation, quality seed security at farmers' level was drastically improved. The SRR of rice improved from 3 to 4.45% (Bhandari and Devkota 2001). Farmers group became gradually developed as seed entrepreneurs and converted into seed cooperatives finally transferred into seed companies. The specialty of the DISSPRO was its formulation and implementation from core government budget and our own knowledge without donor support. The great impact of DISSPRO is the involvement of private sector in cereal seed business in the country. It is currently being implemented in more than 63 districts by District Agriculture Development Offices (DADO) within 15 years of initiation.

Community Seed Banks (CSB)

The CSB Guidelines (2009) provide establishment and management of CSB where seeds produced in the community are processed, stored and sold locally under the leadership of community. Surplus seeds are sold outside the community. CSB can collaborate with local NGOs, DADOs and financial institutions. The seed production, supply and distribution are localized within a cluster of villages where the overall control is by the farmers. Basically this model strengthens the capacities of farmers and their institutions to achieve self-sufficiency in quality seed production. CSB objective is to conserve and promote traditional varieties of all crops. This model helped many growers to get access to good quality seeds (genuinely labeled) at affordable prices at right time. For the first time in the country, policy allows farmers to procure own seed in their own village and get the subsidy for the same. Currently CSB program is launched in 9 districts namely: Gulmi, Jumla, Jajarkot, Dadeldhura, Sankhuwasabha, Okhaldhunga, Sindhupalchowk, Dhading and Doti under CDD. Similarly, Li-Bird has also been working for conservation and seed production of various types of crops and varieties through establishment of community seed bank. Till 2015, LI-BIRD has facilitated establishment of 17 community seed banks in 14 districts (Bara, Bardia, Kailali, Kanchanpur, Jhapa, Sankhuwasabha, Nawalparasi, Tahanun, Doti, Dang, Dhanding, Jumla, Siraha and Udayapur) and additional 4 community seed banks in: Humla, Jumla, Lamjung and Dolakha are in process of establishment within 2016.

Project based supports in seed sector (1980-2000)

Investment in the seed sector in Nepal is primarily done through the project-based support. Over the decades, seed development program in Nepal has been receiving substantial foreign assistance to cover a wide range of seed activities. The number of projects in seed development sector during this period is briefly discussed below.

Seed Production and Input Storage Project (SPISP) 1980-1987

The SPIS project was launched in the beginning of 1980 under AIC to assist in establishing a system of local seed production in mid hill areas of Nepal. The project grants agreement between HMG of Nepal and the Government of USA was reached on August 31, 1987. This project life covered 67 months only. The project focused on the production and improvement of cereal seeds (rice, maize and wheat) in the hills and it was implemented by AIC with the financial assistance from USAID. This project provided high amount of subsidy for infrastructure development and their operation throughout the project duration. Seed production and distribution in the hills was initiated by AIC to reduce the pressure on subsidy in transporting seed from Tarai to hills. However, the AIC continued contracting farmers in the Tarai for producing seeds and supplying them in the hills to fulfill the demand. Farmers were encouraged by DADOs to save their seed for use in the following years under this project. Metal bins were distributed to farmers either in clusters in a locality or at random with 25% price subsidy and free transport up to the district headquarters. The subsidy was borne by FAO and Rural Save Grain Project.

Hill Seed Programme (1983)

This seed programme was supported by Seed Production and Marketing Project (SPMP) funded by GTZ in Salyan, Pyuthan and Rolpa of Rapti Zone and later in Arghakanchhi and Accham districts. It helped to develop a mechanism for production and marketing of improved cereal seeds locally. There was involvement of DADO, AIC, DoA and GTZ development partners in this programme. The project became successful in introducing new varieties of rice. However, due to heavy investment in operational and infrastructural costs through the project, it lost continuity upon withdrawal of the support from the project.

Koshi Hills Agriculture Project/KHAP (Seed Component 1987-1992)

The project aimed at developing cereal and vegetable seed production and supply system in hill districts of Koshi (Dhankuta, Terhathum, Sankhuwasabha and Bhojpur) and was implemented at the ASC level. The major commodities were: rice, maize and wheat under seed production program. The DADO and concerned line agencies in the districts were held responsible for project operation. Sajhas were actively involved in seed procurement, storage and marketing.

Rural Development Project (1988-1990)

There were some rural development projects like Mechi Hills Project, Dhading Development Projects, etc which included seed activities. These activities encouraged seed production of cereals and vegetable crops at the village level for income generation and increased the availability of improved seeds. These projects were successful in raising awareness among farmers for the use of good quality seeds.

Private Producer Seller Program (ARPP-1986)

With the support of Agriculture Research and Production Project (ARPP) funded by USAID, the seed production and management program was started in 1985 in: Parbat, Baglung, Myagdi and Gulmi. It aimed at increasing access to quality seeds of new varieties of rice, maize and wheat for farmers in the hilly region at affordable prices to achieve self sufficiency in foods by increasing the production of cereal grains. These projects focused more on the seed distribution and consumption rather than establishment and strengthening of sustained quality seed production mechanism and infrastructures.

Project based supports in seed sector (2000-2016)

In recent years, the project-based supports through Social Safety Nets Project (SSNP), Project for Agricultural Commercialization and Trade (PACT), Raising Incomes of Small and Medium Farmers Project (RISMFP), High Value Agriculture Project (HVAP) and Kisanka lagi Unnat Biubijan Karyakram - Improved Seeds for Farmers Program (KUBK-ISFP) have increased in seed business on the basis of merit of the proposals by the proponents. The nature, commodity value chains and amount of such supports vary and are guided by the respective project objectives. In this period, the project-based supports on seed sectors are as follows:

Social Safety Nets Project (SSNP)

The World Bank approved the SSNP to be implemented between May 2010 and September 2013 in Nepal. The objective of the seed component was to increase the use of certified/improved seeds of cereals by involving concerned stakeholders in seed production and supply, and by creating awareness on the importance of producing and using improved seeds. The project was implemented under the leadership of Seed Science and Technology Division (SSTD), NARC.

Research into Use Program (RIU)

The RIU is implemented under the leadership of FORWARD, LIBIRD, CEAPRED and Support Foundation in partnership with DOA, NARC, SEAN and Centre for Advanced Research in Agricultural Development (CARIAD), UK in 50 Community Based Seed Production (CBSP) groups of 20 Tarai districts. Since 2001, RIU is supporting seed production of mainly cereals, pulses and oilseeds. The CBSP groups are supported to enhance their managerial and marketing skills as well.

Project for Agricultural Commercialization and Trade (PACT)

PACT is implemented by MoAD since 2009/10 with the assistance of World Bank for expediting agricultural commercialization in Nepal. The project period is up to 30th June, 2018. PACT's overall goal is to improve the competitiveness of project supported to smallholder farmers, cooperatives, producer associations, processors and traders within a selected value chain. PACT primarily supports on cereal seed (rice, maize and wheat) business by demand driven investment proposals through competitive matching grants.

Raising Incomes of Small and Medium Farmers Project (RISMFP)

The Asian Development Bank has approved the RISMFP with grant support. The Government of Nepal and ADB reached an agreement on this project on March 16, 2011 to implement it in 10 districts namely: Dang, Banke, Bardiya, Surkhet and Dailakh from Mid-western Development Region and Kailali, Dadeldhura, Doti, Baitadi and Darchula from Far-western Development Region of Nepal for 6 years (14 June 2011 to 30 June 2018). It is implemented under DoA. The aim of this project is to promote agribusiness on vegetables, pulses, honey, mushroom, MAPS and cereals seeds (rice, wheat and maize) in the project area. RISMFP considered supporting the cooperatives and farms that require setting up seed processing facility to enhance seed quality and improve market linkage with seed traders.

Kisanka lagi Unnat Biubijan Karyakram - Improved Seeds for Farmers Program (KUBK-ISFP)

MoAD, with the financial assistance of the International Fund for Agriculture Development (IFAD), is implementing KUBK in Rukum, Rolpa, Pyuthan, Gulmi, Argakhanchhi and Jajarkot districts. The Program aims to support on improvement of certified seeds (cereals and vegetables) through formal seed sector. The Program has provisioned investment funds for grant schemes focusing on formal seed business. There is provision of strengthening role and capacity of NARC and DOA farms, SQCC and RSTL to produce required foundation seed and perform adequate seed quality control mechanism. Moreover, as per the KUBK designed document, the program can support NSB and SQCC for implementation of Seed Policy, Seed Act, Regulations and National Seed Vision (2013-2025).

Seed policy and legislation framework in Nepal

Nepal's advantage in seed sector includes favorable policy and regulatory environment. With the promulgation of seed act, policy and regulations, the whole seed industry stands on solid foundation in Nepal. The Seed Act 1988 (with amendment in 2008), Seed Policy 1999, Seed Regulation 2013, National Vision 2013-2025 support in various aspects of the seed sector development. NSB under MoAD has been constituted to implement seed act and advice government in all the matters concerning the development of a viable seed industry in the country and also to make ensure the availability of good quality seeds through regular production, processing and marketing.

Stakeholders involved in formal sector

In the present context of Nepal, formal seed system comprises seed production by farms and stations of NARC and DoA, NSCL, Salt Trading Corporation (STC), Non Governmental Organizations like

CEAPRED, LIBIRD, FORWARD, etc. We have about 100 seed cooperatives and more than 1,000 CBSP groups involved in cereal seed production and marketing of OPVs. There are about 16 registered seed companies and 2,600 agro-vets in the private sector handling hybrids, OPVs and inbred seeds in Nepal (SQCC 2016). From the very beginning, some other NGOs like Action-Aid, Care Nepal, etc have been involved in production and distribution of cereals seeds.

Physical infrastructure development in seed sector

Physical facilities have been developed for the operation of a good seed system in the country. There are 13 seed testing laboratories available in public and private sector. The first seed testing laboratory at Khumaltar was set up in 1962 (Rajbhandari et al 1990). The NSCL has 6 seed processing plants and 6 seed storage with the capacity of up to 11,100 tonnes SEAN Service Centre has a processing plant in Thankot, Kathmandu and two cooperatives in Chitwan district possess two processing plants. Currently, 16 registered seed companies have some physical seed processing facilities. In addition, several mini-processing plants have been established with other seed producing groups and cooperatives under DISSPRO and CBSP programs. The detail inventory of physical infrastructure is mentioned in Table 3, which shows altogether 13 seed labs, 160 seed storage structures with the storage capacity of 20,045mt in Nepal.

Table 3. Physical facilities for the seed management in various organization from 1965 to 2016 in Nepal

Organizations	Seed testing Laboratories (N)	Seed storage (N)	Seed storage capacity (tonne)	Processing plant (N)
SQCC/DoA	6	0	0	0
DoLS	1	0	0	0
NARC	3	25	655	11
NSCL	0	6	11,100	6
STC	0	1	950	1
Private seed companies	3	18	3190	18
Cooperatives	0	59	2000	56
Farmers group	0	51	2150	51
Total	13	160	20,045	143

Source: SQCC, CDD, NARC, DADO (Through communication)

Seed quality assurance mechanism in Nepal

NSB, SQCC, CDD and RSTL are involved for the implementation of seed quality control mechanism formally. The NSB has introduced a set of quality standards for various types of seeds. SQCC has a Central Seed Testing Laboratory along with 5 RSTLs under CDD. SQCC is mandated to monitor these standards in all seeds produced in the country by public, private and community sectors. The Seed Act (2008 amendment) and Seed Rules, 2013 have focused the quality control system by making provision for the establishment of private seed testing laboratory and selling of truthfully labeled (TL) seeds. Seed certification in Nepal is voluntary, but truthful labeling for containers of notified crop varieties offered for sale in market is compulsory (Thapa et al. 2008). The crop inspectors, seed samplers and seed analysts are to be engaged in seed quality monitoring and testing from field to lab. The RSTL, one in each Development Region serves important function in both regulating and providing technical services to the seed entrepreneurs. NSCL has internal quality control setup with small laboratory facilities as well. Quality control services include field inspection, seed testing, seed certification, seed storage inspection, and post certification inspection. The trend of rice seed samples tested in central and regional laboratories are presented in the **Table 4**, which shows the annual rice seed samples tested in different seed testing laboratories of Nepal increased from 33 in FY 1993/94 to 2530 in 2015/16 with ups and down.

Table 4. Annual rice seed samples tested in different seed laboratories from 1993/94 to 2015/16

SN	Year	CSTL	Jhumka	Hetauda	Bhairhawa	Khajura	Sundarpur	Total
1	1993/94	na	na	na	na	33	Na	33
2	1994/95	na	na	na	na	53	Na	53
3	1995/96	na	na	na	na	78	Na	78
4	1996/97	49	144	na	207	45	Na	445
5	1997/98	na	91	na	413	52	Na	556
6	1998/99	105	62	na	na	16	Na	183
7	1999/20	58	150	na	na	106	Na	314
8	2000/01	76	113	na	na	285	Na	474
9	2001/02	228	146	na	na	118	na	492
10	2002/03	210	160	na	na	60	na	430
11	2003/04	127	109	na	na	98	na	334
12	2004/05	229	128	na	207	141	na	705
13	2005/06	182	122	na	413	130	na	847
14	2006/07	251	127	na	426	158	na	1442
15	2007/08	322	132	626	525	154	42	1801
16	2008/09	262	150	678	477	173	93	1833
17	2009/10	309	299	896	620	180	106	2410
18	2010/11	330	302	891	814	339	139	2815
19	2011/12	332	354	817	736	310	209	2758
20	2012/13	176	344	822	595	281	147	2365
21	2013/14	140	510	698	690	334	238	2610
22	2014/15	223	305	466	691	225	327	2237
23	2015/16	494	138	505	734	343	316	2530

Source: SQCC and 5 RSTLs 2016.

Seed Replacement Rate (SRR) on Rice

SRR of rice over the years shows slightly increasing trend. However, the rate of increment is not so satisfactory to achieve the target set by National Seed Vision (2013-2025).

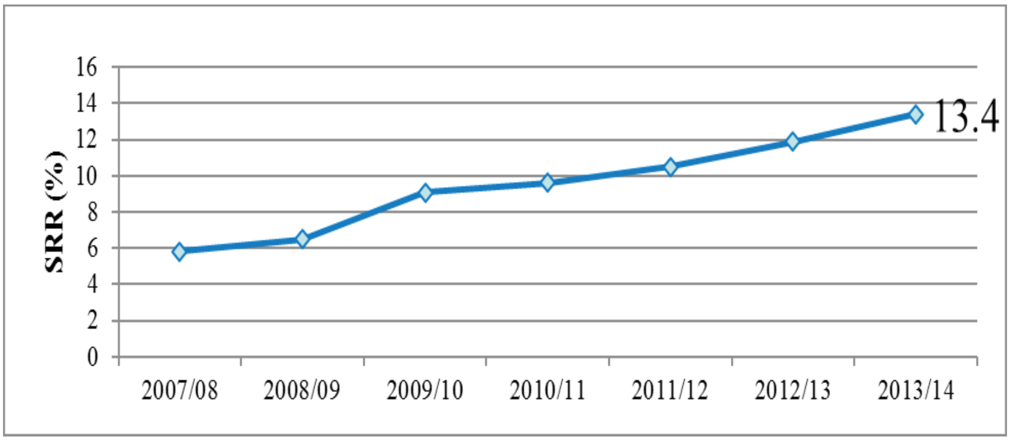

Figure 2. SRR of Paddy

Seed distribution mechanism in the district level

There are formal and informal seed distribution networks prevalent in the country comprising of public, private and community institutions. In case of rice (open pollinated), the main channels of seed marketing are the dealers, cooperatives, retailers, individual trader and farmers themselves. Seed companies sell through agro-vets, their own dealers, and retail shops. Cooperatives also have dealers, retail shops and their own members as buyers. Some NGOs and DADO also are their buyers.

In recent days, system of running seed business at district level has started through DSCC. Similarly, the distribution of subsidized seeds of rice and other cereals is done through District Level Seed Supply Committee, headed by the Chief District Officer (CDO). The government of Nepal has appointed a Crop Inspector at the DADO, who is the responsible person for regulating seed business in the district. The subject matter specialists in crop, horticulture and agricultural extension based on their availability in the district in that order are assigned as Crop Inspectors. Agricultural cooperatives are involved in: distributing agricultural inputs, organizing seed production, processing and linking with traders within and out of district periphery. Agro-vets supply most of the agricultural inputs like: seeds, fertilizer, pesticides and herbicides. Both formal and informal seed systems are complementary of each other for production, maintenance and supply of preferred crop varieties.

Conclusion

Seed is one of the most important factor of production in agriculture. Quality of seed has always remained a major part among various issues in Nepalese Agriculture. Rice seed sector is also a part of seed system in Nepal. Quality seed of paddy ensures the higher productivity and thus the enhanced state of food security in Nepal. Most of distribution of paddy seeds in Nepal is informal. Despite of continual efforts through various plans, policies, programs and project for rice seed system development in Nepal, the SRR has not been improved as expected. Effective and meaningful coordination among the various stakeholders engaged in rice seed system is an urgent need to make rice seed system viable, sustainable and efficient.

Acknowledgements

The authors would like to express sincere gratitude to Mrs. Kamalesh Lata Rajhandari, Devaki Shrestha, Mahesh Nath Shrestha, for their immense contribution for seed sector development in Nepal. The authors acknowledge Mr. Hari Bhandari, Govinda Prasad Pandey, Sachet Bahadur Nepali (Ghimire), Krishna Kumar Shrestha for their support in developing seed system in Nepal.

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Classification of Rice Seed and Seed Certification System in Nepal

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सारांश

धानको बीउको गुणस्तर खेत निरीक्षण तथा बीउलाई प्रयोगशालामा परीक्षण गरी निर्धारण एवम् सुनिश्चित गर्ने गरिन्छ । हाल नेपालमा मुलुक भरिनै बीउ बिजन ऐन २०४५ लागु भैसकेको छ । बीउ उत्पादक एवम् बीउ व्यवसायीलाई धानको बीउ बिजन बिक्री वितरण गर्न बीउ प्रमाणीकरण गराउन नै पर्ने बाध्यता भने नेपालको बीउ बिजन सम्बन्धी कानूनले गरेको छैन तर बजारमा धानको बीउ बिक्री वितरण गर्दा अनिवार्य रूपमा यथार्थ संकेतपत्र लगाई नेपाल सरकारले तोकेको गुणस्तर मापदण्ड पुरा गरेको बीउ बिजन मात्र बिक्री गर्न पाइने व्यवस्था बीउ बिजन ऐन २०४५ ले गरेको छ । यथार्थ संकेतपत्र पद्धतिबाट कमभन्दा कम सरकारी स्रोत र साधनको प्रयोगबाट पनि तोकिएको गुणस्तर मापदण्ड पुरा गरेको धानको बीउ बिजन आपूर्ति गर्न सकिने र यस पद्धतिमा बीउ उत्पादक एवम् बीउ बिक्रेता स्वयम् नै आफूले बिक्री वितरण गर्ने बीउ बिजनको जिम्मेवार हुने भएकोले बीउ बिजनको गुणस्तर नियन्त्रणमा निजी क्षेत्रलाई समेत सहभागी गराउन सहयोग पुग्दछ । बीउ बिजन प्रमाणीकरण गर्ने तथा मूल बीउ एवम् प्रमाणित बीउमा प्रमाणीकरण प्रमाणपत्र जारी गर्ने अख्तियारी बीउ बिजन ऐन २०४५ ले बीउ बिजन गुणस्तर नियन्त्रण केन्द्र तथा क्षेत्रीय बीउ बिजन प्रयोगशालाहरूलाई मात्र प्रदान गरेको छ । प्रजनन् बीउ उत्पादन गर्ने, त्यसको गुणस्तर कायम गर्ने तथा प्रजनन बीउमा ट्याग लगाउने जिम्मेवारी भने धान बाली अनुसन्धान कार्यक्रमको सम्बन्धित प्रजनकलाई नै रहेको छ । राष्ट्रिय बीउ बिजन समितिले अनुमोदन, उन्मोचन गरी सिफारिस गरिएको धानको जात मात्र प्रमाणीकरणमा लान सकिन्छ भने यथार्थ संकेतपत्र लगाएर पञ्जीकृत मात्र भएको धानको बीउ पनि सामान्य रूपमा बिक्री वितरणमा लान सकिन्छ । प्रमाणीकरणको लागि धानको बीउ एवम् बीउ बालीले राष्ट्रिय बीउ बिजन समितिले तोकेको खेतको स्तर, बालीको स्तर तथा बीउको गुणस्तरको न्यूनतम मापदण्ड भने पूरा गरेको हुनु पर्दछ ।

Summary

Quality parameters of rice seeds are ensured through field inspections and laboratory tests. At present, Seed Act, 1988 is implemented throughout the country and seed certification is voluntary whereas truthful labeling of notified varieties of rice offered for sale in the market is compulsory for seed business. Truthful labeling is not only suitable to make available prescribed quality seed in market with very less government efforts and resources but also makes seed producers responsible over their own seeds. Seed Quality Control Centre, Hariharbhawn, Lalitpur and Regional Seed Testing Laboratories are authorized agencies to perform seed certification works in Nepal and are accountable to issue certification tags for foundation and certified seeds. Rice breeders of Nepal Agricultural Research Council (NARC) are responsible to produce, maintain and issue tags for breeder seeds. Only rice varieties released by National Seed Board are eligible for seed certification where as truthful labeling can be done in even registered varieties for seed business. Seed certification standards viz field standards, crop standards and seed standards prescribed by National Seed Board, shall be met for seed certification of rice seeds and to issue the certification tags.

Keywords: Certification tags, Filed inspection, Seed certification, Truthful labeling

Background

Rice belongs to the genus *Oryza* and family *Poaceae* (syn. *Gramineae*). The two cultivated species of rice are *Oryza sativa* and *Oryza glaberrima*. Rice seed is a grain or caryopsis with 5-12mm long and 2-3mm thick. It is found in a variety of colors: white, brown, black, purple and red. Rice varieties can be distinguished from each other based on their size, shape, color and awns. Seed Act (1988) defined seed as a mature ovule or caryopsis containing embryonic plant, food reserves and protective covering which can be propagated by sexual or asexual means and used for sowing or planting purpose for increasing production and productivity of different crops. Rice grain is commonly known as seed, but in true sense of botany, it is fruit that develops from ovary during seed formation. It is monocot seed with modified part of single cotyledon.

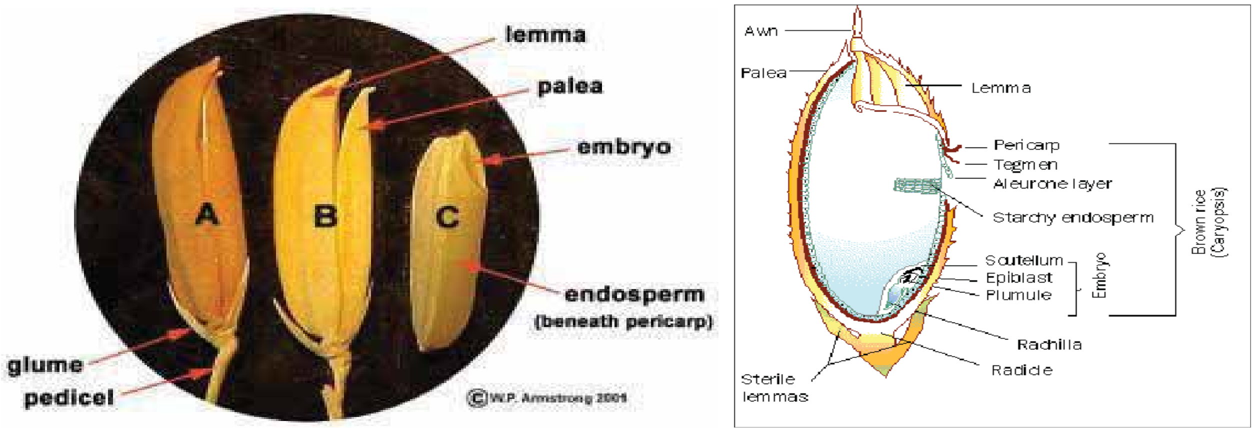

Figure 1. Parts of rice seed

The mature grain consists of single caryopsis which is enclosed by lemma and palea as in harvested unit. Embryo is situated in one end of caryopsis. Scutellum remains in close contact with endosperm which acts as food reserves. Endosperm contains starch, protein, fats and mineral etc that contain 80% starch. Nutrient available in endosperm is sufficient for germinating seedling until seedling is capable to start photosynthesis. Sound and bold seeds of rice have good food reserves that can supply sufficient nutrients to young growing seedlings during germination (ISTA 2015). Hence, it is recommended to select good and bold seeds of rice by salt water treatment before sowing on seedbed. The scutellum is the part of embryo attached near to the center of the embryo axis, which consists of radicle, protected by thin sheath, the coleorhiza and the plumule, also surrounded by a protective sheath, the coleoptiles (ISTA 2015).

Classification of seeds

Seed Regulation, 2069 has specified the following different seed classes.

Nucleus seed

The first lot of seed that is produced by the breeder is called nucleus seed. A portion of this will be kept in long term storage and the balance is used to produce breeder's seed. This seed is the basis of a variety and is known as the nucleus stock. This nucleus stock must be managed with great care so that all seed produced by it remains true to the new variety. It is produced by the breeder in very little quantity and is genetically pure. Plant breeder use it to develop breeder seed (SQCC 2012).

Breeder seed

Breeder seed is seed whose production is personally supervised by a qualified plant breeder and provides the source for the initial and recurring increase of foundation seed. Breeder seed should be genetically pure to guarantee that in the subsequent generation ie foundation seed shall confirm the prescribed standards of genetic purity (Tunwar and Singh 1988). Breeder or breeding institution is responsible to maintain the quality and labeling of breeder seed with prescribed standards.

Foundation seed

Foundation seed is produced from breeder seed and is supplied to seed production farms and different seed companies as source seed for production of certified seed. Authorized quality control agency is responsible to maintain the quality of foundation seed and confirms to the prescribed seed certification standards with white colour tags. Genetic purity of foundation seed shall be the minimum of 99%. In case of no seed certification, if seed producer themselves maintain the quality of the progeny of breeder seed with their own internal quality control (field inspection and seed testing) facilities and issue the truthful label then it is termed as source seed. The minimum seed standards of source seed shall be equal to that of foundation seed. It is decentralized system of source seed production where seed producers and seed companies do not need to rely on quality control agencies for source seed production.

Certified seed

It is produced from the foundation seed. It is provided to farmers and seed producers to produce improved seed. If seed multiplication ratio of particular species is very low then certified seed is also used to produce certified seed second generation to solve the possible problem of source for seed production. However, certified seed-II is not produced in rice seed because the seed multiplication ratio of rice seed is high. Authorized quality control agency is responsible to maintain the quality of certified seed and genetic purity of certified seed shall be the minimum of 98%. Certification tag shall be of white in colour with blue stripe for certified seed. Seed produced from foundation seed with truthful labelling, is equivalent to certified seed, through internal quality control facilities, is termed as labelled seed.

Improved seed

It is produced from certified seeds or from labelled seed. Quality control agencies are not involved to maintain the quality of improved seed but seed producers themselves are responsible to maintain the minimum prescribed seed quality standards with truthful labelling. The truthful label tags shall be of yellowish colour. Minimum seed quality standards and labelling process of all classes of seed is monitored by official seed sampler through seed law enforcement program during inspection of marketed seed.

Quality parameters of rice seeds

Different quality parameters of rice seeds such as seed uniformity and lusture, analytical (physical) purity, germination, moisture, thousand seed weight (seed boldness), seed vigor, seed health (freedom from disease and pest) and genetic/varietal purity (true to type) should be maintained while handling the seed business. Among these quality parameters, genetic/varietal purity and seed health are assured through field inspection while others are ensured through laboratory tests (Rana 1997).

Uniformity of seed

Good quality seed shall be uniform in size and should have its original colour and lustre. Uniform seeds can produce sound seedlings which may give good crop yield. All undersized, oversized, shrivelled, immature, broken and light seeds and chaffs can be removed by seed processing to make uniform seed size. Recommended drying temperature for rice seeds is 110^{o}F that helps to maintain the seed quality and seed lustre (Agrawal 1997).

Weight

Weight determination of seed indicates the seed boldness and well filled grain quality of seed. It has also significant effect on seed quality especially on seed germination and vigour. Bold and well filled grains have enough food reserves that can produce vigorous seedlings which ultimately affect on good crop stand and yield. Weight determination of rice seed in laboratory is performed by calculating 1000 seed weight either by counting whole working sample of pure seed fraction or counting eight replicates of 100 seeds after purity analysis. Thousand seed weight of each rice variety is determined and prescribed by plant breeder during release of the particular variety. Hence, quality seed should have always prescribed 1000 seed weight that is used for seed and crop production so that it can produce sound and healthy seedling for better production. In rice seed, bold and well filled grain can be selected by using salt water treatment.

Physical purity (analytical purity)

Farmers are buying seeds and paying for seeds not for admixtures. Rice seed should be free from other crop seed, weed seed and inert matters such as: broken seeds, broken caryopsis, dust, soil, sand, stone, weed and plant debris, flower, broken awn, stalks, chaff, husk, live and dead insects and all other non-seed matters. It is quite impossible to make seeds completely free from admixture. Hence, even though admixture is present in seeds, it shall not be more than permissible standard. It is therefore, rice seed sample in seed testing laboratory is analyzed and divided into four components such as: pure seed, other crop seeds, weed seeds and inert matter with the help of different apparatus and equipment and its percentage is determined by its weight. Farmers, consumers and seeds sellers can use physical purity analysis results to determine the percentage of pure seeds, the types and quantity of physical contaminant present in seed lot, which finally assist farmers and consumers for decision making to purchase the seeds. The minimum physical purity shall be 98% for both foundation and certified seeds of rice.

In rice seed, physical purity analysis is conducted in small quantity of working sample ie slightly more than 70g, in which significant impurities may be missed in laboratory and it only provides information about pure seed and admixtures (other crop seed, weed seed and inert matter). It does not provide information about other distinguishable varieties (ODV) and noxious and undesirable species present in rice seeds. For complete information about impurities of rice seeds, it is therefore necessary to perform physical purity analysis test and the determination of other seeds by number test, simultaneously or at the same time in laboratory.

Germination

Germination is defined as emergence and development of seedlings to a stage where the aspect of its essential structures indicates whether or not it is able to develop further into satisfactory seedlings under favorable condition in the field (ISTA 2015). Among the seed quality attributes, germination is one of the most important and prime quality of the seed. Even though seed lots have good analytical purity, appropriate moisture, free from disease and pest and high genetic identity, it will be worthless if it does not have good germination. Rice seeds shall have minimum 80% germination and germination test can be performed in laboratory by standard methods as prescribed in current ISTA (International Seed Testing Association) rules. The main objective of germination test is to determine maximum germination potentiality of the seed lot, which can then in turn be used to compare the quality of different seed lots and ultimately useful to estimate field planting value. Seed germination is directly related to plant stand which ultimately affect on yield of rice. Hence, bold and sound seeds shall be used in seedbed to produce strong and healthy seedlings which can easily establish in the field condition.

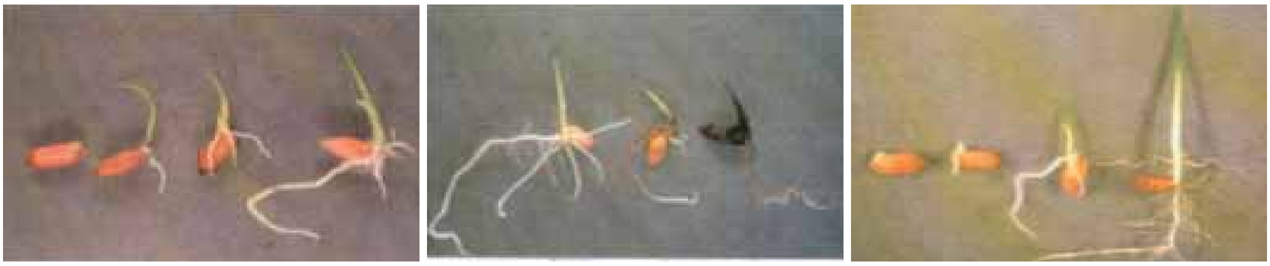

Figure 2. Stage of germination with different types of normal and abnormal seedlings

Seed moisture

Seed moisture is one of the critical factors in rice seeds which influences the seed quality with respects to viability, vigor, storability, insect/pest infestation and so on. Since the life span of a seed largely revolves around the moisture content of seeds, it is necessary to dry the rice seeds at safe moisture level ie less than 13%. It is important to note that very low moisture level (below 4%) is also harmful and damage the seeds due to extreme desiccation. If the seeds are kept at moisture content higher than 13%, the losses could be very rapid due to growth of mold on and in the seed. The higher the moisture content of the seeds, the more rapidly are seeds affected by adverse conditions such as: temperature, mold growth and insect infestation in seed storage.

As an orthodox seed, rice seeds can be safely stored in low moisture content. Harrington thumb rule says that, one percent decreases in seed moisture content nearly doubles the storage life of the seed. It is therefore, very essential to determine seed moisture content at different operations like: harvesting, threshing, processing, drying, seed treatment, packaging and storage to maintain the quality of seed (Agrawal 1997). Moisture determination of rice seeds can be done by either moisture meters or from oven method.

Seed vigour

Germination is taken as one of the most important seed quality parameters in our condition. However, standard germination test is conducted in the seed testing laboratories under favorable environmental conditions (such as appropriate moisture, temperature and light), which are seldom available in the fields. Thus, the test is inadequate to express the relative performance of the seed lot. It has often been observed that two seed lots belonging to a particular variety or cultivar having the same germination percentage behave differently under field conditions; one resulting into a good crop stand while the other fails to do so. This differential behavior may be attributed to the stamina of the seed, which is mainly expressed under sub-optimal condition. Hence, vigor test is conducted in laboratory by providing stress condition to the seed to determine its ability to produce normal seedlings in abnormal condition.

The term seed vigor must be differentiated from viability. Viability is synonymous to germination and indicates the status of aliveness of the seed. On the other hand, vigor indicates the degree of aliveness in a seed (ISTA 1995). Hence, in developed countries, farmers and consumers prefer vigour test results instead of germination for assured good crop stand in the field. Seed vigor is the sum of the properties that determines the activity and performance of seed lot of acceptable germination in wide range of environments.

Seed health

Seed health refers to the presence and absence of disease causing organism such as: fungi, bacteria and viruses, and animal pest such as eelworm and insects. Seed borne diseases can affect seed during germination and seedling emergence and up to its maturation time as well. Along with this, insect damage and infested seed also cannot produce good seedling during germination. Unhealthy seed cannot germinate, if germinated it will give poor yield with low quality seeds. Hence, seed should be free from diseases, insects and pests. Proper crop rotation, isolation distance, seed treatment are the effective ways to produce healthy seeds (Rajbhandari 1996). Sowing rice seeds without testing seed borne disease always keep the chance to infestation of diseases in the field. If seed health test is conducted prior to sowing of rice seeds, presence or absence of disease causing organism such as fungi and bacteria can be identified and proper seed treatment can be done to control the diseases. Systemic fungicide Bavistin @2-2.5 g per kg of seed is used to control seed borne diseases of rice.

Genetic purity

Genetic purity means true to type of the seed lot. It is important to assure the genetic identity of rice variety which makes cultivars distinct as well as maintains the yielding ability of the variety. Genetic purity of rice can be best assured through a field inspection and protecting the harvest from mechanical mixing during harvesting and threshing. Rice is self-pollinated crop, thus maintaining 3 meters of isolation distance from the field of other varieties or from same variety not conforming varietal purity is simple and effective method to maintain genetic purity of the rice variety. Eelectrophoresis and some other molecular techniques are also in practice to assess genetic/varietal purity of seeds in some of advanced laboratories of developed countries. Yet, generally these tests are not performed in laboratory and genuineness of variety is guaranteed only through field inspection. However, determination of other seed by number test can be conducted in our laboratory to identify the other distinguishable varieties present in seed sample on the basis of length, colour and seed appendages (ie awn/awnless or length of awn) of rice seeds. This test and procedure assist to improve genetic purity of the rice variety as well as to determine the presence of undesirable and noxious seeds in rice seed for international trade.

Rice seed certification system in Nepal

Quality control is an essential component of a viable and dependable seed development program. Quality seed is ensured and guaranteed through checks, ie field inspections to establish genetic/varietal purity and laboratory tests to record: physical purity, germination, vigor, moisture content and seed health (Rana 1997). In Nepal, Seed Act was enacted in 1988 and new Seed Regulation was enforced in 2013, by which seed certification is voluntary where as truthful labeling of notified varieties offered for sale in the market is compulsory in Nepal. National Seed Board has already developed and published the minimum field and seed standards for certification and truthful labeling in Nepal *Rajpatra* (gazette paper). As per provision of Seed Act, 1988 Nepal is adopting two types of quality control systems ie Seed Certification and Truthful labeling.

Seed certification

The purpose of seed certification is to make high quality seed available to farmers with high physical and genetic identity to increase production and productivity of crops. Seed certification is a comprehensive quality control system, in which quality control agency is responsible for monitoring and supervision of different agricultural activities related to seed production for maintaining quality of seed from sowing to marketing. This is accomplished through field inspections and laboratory testing by the staff of an authorized seed certification agency such as: field inspection, harvesting, threshing and storage inspection, seed sampling and testing, processing, treating, bagging and issuing of certificates to suitable seed lots, and testing of seed lots before marketing. Seed certification system needs high-level government resources in terms of equipment, infrastructural facilities and trained manpower (Rana and Raut 1997). For developing countries like Nepal, where quality control wing is suffering from enough resources and manpower crunch, truthful labeling is one the most practical and cost effective quality control systems to ensure the good quality seed for seed market.

In truthful labeling, seed producers are free to produce and sell their seed by their own quality control mechanism through field inspection and laboratory testing. However, seed producers/traders are responsible for maintaining minimum quality standards of seed and are also compelled for labeling of container to bring the seeds in market. Notified seed sampler will draw the enforcement samples and if the seed offered for sale could not meet minimum seed standard then seed producers or sellers are liable for punishment as per the provision of Seed Act, 1988 (Rana and Raut 1997). This system is suitable for developing and poor countries to produce and supply the quality seed throughout the country. It does not need large regulatory bureaucracy and needs very limited involvement of government agency as well as resources as compare to seed certification (Thapa 2006). Seed Quality control Centre, Hariharbhawn, Lalitpur and Regional Seed Testing Laboratories are authorized government agencies to perform seed certification works in Nepal. To fulfill above objective and to ensure the seed quality, seed certification standards have been already developed by National Seed Board and it is subdivided into two broad categories viz. general and specific seed certification standards.

Seed certification standards

General seed certification standard describes verification of seed source, seed class, validity period of seed, and minimum area of seed crop for certification, eligible varieties, and seed certification sequence. Specific seed certification standards include minimum field standards, minimum crop standards and minimum seed standards of produced seed to maintain the high physical and genetic integrity of the rice seed.

General seed certification standards

Verification of source seed and seed classes

Rice seed producers should apply for seed certification with prescribed format to the certification agency along with relevant evidences about the source seed, such as certification tags/or tags issued by commodity program for breeder seed. Such evidences are necessary to conform that source used for seed production is obtained from the source approved by seed certification agency and from research station in case of breeder seeds. If such evidences are not supplied during the application period, then those must be made available in first field inspection time (Rana 1997).

Validity period of seed certification

According to Seed Regulation 2013, if seed is properly and safely stored, the validity period of seed remains for six months. However, validity period can be extended continuously for six more months as long as it meets minimum prescribed seed standards during revalidation tests. With this rule, validity period of certified rice seed also remains for six months and it can be extended following revalidation.

Minimum area and eligible varieties for seed certification

Minimum area of rice crop shall be at least one hectare in Tarai and five ropani in hills for seed certification. This area may of one farmer or group of farmers. Only rice varieties released from National Seed Board are eligible for seed certification but seed of registered rice varieties can be produced with truthful labeling for seed business.

Figure 3. Tags and labels of different classes of rice seeds

Seed certification sequence

Receipt and scrutiny of application.

- Verification of seed source, class and other requirements of seed, used for raising seed crop.
- To verify land requirement whether it meets seed certification standards or not.
- Field inspection to verify the isolation distance and minimum prescribed field standard.
- Supervision of harvesting and threshing to avoid mechanical mixing.
- Inspection and sampling of seed lot as prescribed procedure.
- Analysis of seed sample in laboratory to verify the prescribe seed standards.
- Supervision of processing, treating, bagging and sealing of seed lot.
- Issuing of certification tags to suitable seed lot.

Sampling and testing of seed lot again to verify the minimum prescribed seed standard before marketing of seed (Rana, 1997).

Specific seed certification standard

Minimum field Standard

Land requirement: Land to be used for seed production of paddy shall be free from volunteer plants. ***Isolation distance:*** Rice is self-pollinated crop so rice field producing foundation and certified seeds shall be isolated by at least 3m from the field of other rice variety or field of same variety but not conforming varietal purity. If it is difficult to maintain isolation distance with neighboring field then it is recommended to discard 3 meters of seed crop from all sides of field (Tunwar and Singh 1998).

Field inspection standard

To assure minimum crop standards, field inspection is carried out at different crop stages to determine the extent of off type plants, other crop plants, weed plants (general and designated both) and diseased plants in field, which shall be responsible to deteriorate the quality of the rice seed. Farmers should remove these contaminants before the visit of crop inspector through the process of rouging. Rouging can be done several times as far as possible to remove the contaminants and other doubtful and dissimilar plants from the field. However, a minimum two times rouging, one in pre-flowering stage and another in before maturity of the crop, is necessary to maintain the varietal as well as physical purity of the rice seed. During pre-flowering stage, rouging should be done on the basis of growth and tillering habit of the plant to remove plants of early or late maturing varieties. All off-types and objectionable weed plants (weed plants that produce the seeds which are similar in shape and size of crop seed and it is very difficult to remove through economical way of processing) should be removed before second or final inspection.

At first inspection during flowering stage, source seed used for seed production and isolation distance are verified. Suggestions about rouging, weed control and other required operations for improving quality of seed crop are given to seed producer in prescribed format during first inspection time. The second inspection is performed during maturity of the crop. During this time, critical factors, such as off type plants, weed plants, especially designated weed viz. wild or weedy rice: *Oryza sativa* var. fatua Prain (Syn. *O. sativa* form *spontanea* Rosch.) and diseased plants (especially seed borne disease such as neck blast), that influence the seed quality of produced seed, are recorded. These contaminants are completely removed from the field before final inspection. If present, contaminants are to be within prescribed standard. However, if recorded contaminants are above than prescribe standards, then opportunity for maximum one re-inspection can be provided to seed producer due to self-pollinated nature of rice crop. Contaminants can be recorded by taking actual counts in field from different random places. Minimum thousand plants/ear heads are taken in each count and number of counts depends on area of seed crop as follows.

Area of seed crop	number of minimum counts
Up to 2 ha.	5
Above 2 to up to 4 ha	6
Above 4 to up to 6 ha	7
Above 6 to up to 8 ha	8
Above 8 to up to 10 ha	9
More than 10 ha	10

Count taking method in the field

Arms span and foot step method is used for taking count. The numbers of plants/ear heads come under each arms span after one foot step are counted from different random places of field to determine average number of plants/ear heads in each step. Then, walking towards the different directions for taking counts to represent the whole field by following arms span and foot step method is done. Contaminants that are encountered during walking are recorded but those contaminants far from crop inspector or the contaminants out of walking path are not to be recorded during field inspection. After performing required number of counts, contaminants of specific categories are added, and average number of contaminants is calculated to determine the percentage of specific contaminants by its number. Field count results are compared with the field certification standards prescribed by NSB and decision is made whether to certify the seed crop or not. Standards for off-types, designated diseased plants and objectionable weed plants are met during final inspection. Crop inspector shall provide final inspection report to farmers in prescribed format (Rana 1997). The minimum crop standards are as follows:

Contaminants	Foundation seed	Certified seed	Remarks
% off-type plant (maximum)	0.05	0.20	
% designated diseased plant (maximum)	0.20	0.50	Neck blast
% objectionable weed plants (maximum)	0.05	0.10	Wild rice

Seed standards

Standard of rice seed is verified by routine test (physical purity as well as other seed determination by number test, germination and moisture tests) in laboratory before seed certification. The minimum seed standards for rice seed is as follows:

Components	Foundation seed	Certified seed
Pure seed (minimum)	98%	98%
Inert matter (maximum)	2%	2%
Other crop seeds (maximum)	10/kg	20/kg
Other distinguishable variety seeds (maximum)	10/kg	20/kg
Objectionable weed seeds (maximum)	2/kg	5/kg
Total weed seed (maximum)**	10/kg	20/kg
Germination (minimum)	80%	80%
Moisture (maximum)	13%	13%

Seed production field and/or seed lot not meeting the crop standard and seed standard shall not be qualified for certification of rice seed.

**Not mentioned in seed standard of Nepal. Only objectionable weed seed is mentioned in the standard but how many weed seeds (in total) are permissible in seed sample is not specified by minimum seed standards of Nepal. Hence, it is necessary to revise the seed standards of rice seed and seed standard for "Total weed seed (max.)" must be included.

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Private Sector in Rice Seed Business in Nepal

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सारांश

धानको बीउ व्यवसायका सन्दर्भमा निजी क्षेत्रको संलग्नताको इतिहास तरकारी बीउ जस्तो पुरानो नरहेकाले निजी क्षेत्रका लागि धान बीउ व्यवसाय अझै पनि शिशु अवस्थामै रहेको छ । तर पनि ६० को दशकको सुरुवातका वर्षहरूबाट विभिन्न बीउ कम्पनी, कृषक समूह र सहकारीहरू धान बीउ व्यवसायमा संलग्न हुँदै आएका छन् । वर्तमान अवस्थामा जिल्ला बीउ उत्पादन समन्वय समिति, राष्ट्रिय बीउ उत्पादक संघ र सियान नेपालसँगको सहकार्य र समन्वयमा धान बीउ सम्बन्धी कारोबार भइरहेको छ । बीउ र जातको प्रतिस्थापन दर बढाउने, गुणस्तरीय बीउको परिमाण वृद्धि गर्ने र बीउ बिजन क्षेत्रमा समेत यान्त्रिकीकरणलाई बढावा दिई प्रयोग गर्ने मुख्य जिम्मेवारी निजी क्षेत्रको रही आएको छ । हाल निजी क्षेत्रले कूल ७२३१.५ मे. ट बीउ वार्षिक रूपमा उत्पादन गर्दै आइरहेको छ जुन अनुदान प्राप्त गर्ने सरकारी निकाय राष्ट्रिय बीउ बिजन कम्पनी लि. को भन्दा निकै बढी हो । धान बीउ व्यवसायमा निजी क्षेत्रको संलग्नता पश्चात् खुल्ला परागसेचन हुने धानका बीउको आयात गर्नु नपर्ने अवस्था रहेको छ तथापि अनौपचारीक रूपमा केही, उच्च उत्पादन दिने धानका जातहरू जस्तै सर्जु-५२, गोल्डेन मसुली र रन्जित आदि भारतबाट समेत भित्रिएको अवस्था भने विद्यमान रहेको छ । सुलभ ऋणमा पहुँच, विद्युत र भन्सारमा सहुलियत, धान बीउ बीमा, बीउको मूल्य निर्धारणका लागि कानुनी संरचना, बीउमा संलग्न निकायहरूको क्षमता अभिवृद्धि, निजी क्षेत्रलाई समेत पैत्रिक लाइनको उपलब्धता, पञ्जीकरण प्रक्रियामा सहजता, राष्ट्रिय र अन्तर्राष्ट्रिय स्तरमा बीउ बजारीकरणको लागि संजालको स्थापना, धान बीउसँग सम्बन्धित सुविधा तथा सहुलियत बाँडफाँडका लागि एकद्वार प्रणाली अवलम्बन आदि धान बीउ व्यवसायलाई व्यवस्थित एवम् दिगो बनाउन निजी क्षेत्रले गरेका अपेक्षाहरू रहेका छन् ।

Summary

The history of private sector's involvement in rice seed business is not as old as vegetable seed business in Nepal. Rice seed business through private sector is still at embryonic stage. However, various private seed companies, farmers groups and cooperatives have been involved in rice seed business since early 1960s in Nepal. Seed production and marketing activities in Nepal has currently been facilitated by District Seed Production Coordination Committee, National Seed Production Association of Nepal and SEAN-Nepal. Increasing Seed Replacement Rate (SRR) and Varietal Replacement Rate (VRR), increasing the volume of rice seed, promotion of mechanization in seed sector are some of the major roles of private sector in rice seed business. Currently, private seed companies have become able to produce 7231.5 tonnes of rice seed which is more than produced by government owned institution ie National Seed Company Limited (NSCL), which receives the sub sidy for seed transactions. After the involvement of private sector in producing rice seed, the import of open pollinated (OP) varieties has been restricted except for unofficial import of some Indian varieties like Sarju-52, Golden Mansuli and Ranjeet. Access to soft loan, subsidies on electricity and custom taxes, seed insurance, formulation of legally valid floor for price fixation system of raw and final seed, capacity build up for hybridization, access to inbred lines to produce F_1 seeds, easy mechanism for registration, establishment of network at national and international levels for seed marketing, one umbrella policy in distributing facilities related to rice seeds are some of the expectations of private sector engaged in rice seed business for making rice seed business sustainable.

Keywords: Marketing, Private sector, Production, Rice, Seed

Introduction

Before 2000, private seed sector was in embryonic stage in Nepal. In the earlier stage of seed business in Nepal, most of the private seed companies were engaged in vegetable seeds in easily accessible areas only. In earlier 1960s the private seed sector started the business of cereal seed in Nepal. More than 30 seed companies and cooperatives are producing and marketing more than 7000 metric tonnes of rice seeds annually. In recent days, the private sector seed companies are involved in government's activities for seed production and marketing.

The production of rice grain for the seed purpose in large quantity started from 2001/02 by the private seed company of Rupandehi. Nowadays, seed production activities have been promoted by formation of District Seed Production Coordination Committee and National Seed Production Association of Nepal and SEAN-Nepal, through quality control, production and marketing. These insinuations have also been playing significant role in policy advocacy, exchange experiences and ideas, transfer of technologies.

Role of private sector in seed business in Nepal

The prime role of private sector in seed business is to supply the quality seed of rice in time with appropriate price throughout the country. The role also rests on exporting of quality seed to third country as well through bulk production of seeds of OP (open pollinated) and hybrid varieties. Increment in the seed replacement rate (SRR), productivity and overall national production of rice in Nepal are some of the roles of private seed sector in Nepal.

Strategies for promotion of rice seed business through private sector in Nepal

Strategies to promote the rice seed business in Nepal can be looked through two perspectives ie government and private sectors perspectives.

Expectation of private seed sector from Government of Nepal

The government of Nepal plays a regulatory and facilitating role in seed business. Provision to produce BS (Breeder Seed) by supplying nucleus seed, making arrangements to supply the inbreed line to produce the F_1 seed, creation of linkage with the international organizations for the collaboration of R&D activities by applying fast track research, human resource management like plant breeders, exploration of the potential national and international market for rice seed, making arrangement to formulate legally valid floor for price fixation of raw and final seeds, rectifying and implementation of the most convenient way of registration of new improved and renowned varieties and subsidy support for electricity, seed insurance etc are some of the expectations of private sector to make the seed business competitive in Nepal.

Strategies of private seed sector

Private sector, in turn, can play several roles to promote rice seed business in Nepal. Government of Nepal also has certain expectations from the private sectors to make rice seed business more competitive in Nepal. Quality assurance, seed production program in mass scale, creation of national and international rice seed marketing network, coordinating with research for post-harvest technologies of rice seeds, are some of the expectations of government from the private sector.

Activities of private sector to promote rice seed business in Nepal

After the involvement of private sector in seed business in early 1960s, various seed producing companies, farmers' groups and cooperatives have started seed production and marketing activities in Nepal. The private sector started providing quality seed to the government of Nepal from the fiscal year of 2012/13. The import of OP varieties from third countries was totally substituted through seed production program by private sector. However, some of the promising and high yielding varieties of paddy like: Radha-4, Sarju-52, BPT-5204, Golden Mansuli and Ranjeet entered Nepal through the porous Indian boarder. Awareness regarding the quality, standards and label of seeds of different crops and their varieties as explained in seed act of Nepal, has been raised among seed producing groups and cooperatives. Private sector has produced the bulk volume of paddy seed to increase the area under improved and quality seeds of paddy. Private sector has tried to develop necessary infrastructures like: modern seed godown, modern seed processing machines, modern seed lab, etc for post-harvest management of rice seed. Private sector has seriously been working to meet the national target of achieving SRR (Seed Replacement Rate) of rice as mentioned in National Seed Vision 2013-2025. Private sector has started coordinating with various institutions like NARC, IAAS, IRRI, CIMMYT, and USAID in order to promote the program of R&D by applying fast track research system.

Expectation of private sector for rice seed business governance

Private sector has played a significant role for promotion of rice seed business in Nepal. However, there are some bottle necks to be overcome to make viable environment for private sector in rice seed business. Some of the expectations of private sector to improve the governance of rice seed business in Nepal are Establishment of sustainable seed marketing system via: formation of national seed marketing network and creating linkage with international marketing system; and price fixation of raw and final seed via appropriate pricing system to make seed business sustainable (as seed price has been found to increase by 80-100% after performing the post-harvest technologies in final seed production, appropriate price fixation mechanism is felt urgent).

Achievements of private sector in seed business

There are few results in the field of seed business after the activation of private sector. The production of quality seed of rice by private sector from the fiscal year 2012/13 to 2015/16 has increased from 3353 to 7231.5 tonnes respectively. The details of seed production are presented in **Table 1**.

Table 1. Rice seed production by private sector and their share percentage

Production year	Private sector		Government and NSCL		Total
	Tonnes	Share%	Tonnes	Share%	Tonnes
2012/13	3353	80.7	800	19.3	4153
2013/14	4358	78.4	1200	21.6	5558
2014/15	5328	76.9	1600	23.1	6928
2015/16	7231.5	77.5	2100	22.5	9331.5

Source: NSCL 2016.

Farmer groups, co-operatives and seed companies are gradually transforming themselves from seed producers to seed industrialists. All the seed value chain actors are aware about all the packages of seed business. Private seed companies are qualitatively cheaper and quick source of seed suppliers as compared to government organizations. Few private seed companies started to work on R&D with fast track research. Farmers are also aware and have become conscious about the quality of seed, its label, seed production packages and price of the seeds.

Government subsidy program

The government of Nepal has initiated seed subsidy program since 2011/012. By then, the share of seeds supplied by private sector seed companies has been increasing whereas the share of public sector institution, National Seed Company Limited was in decreasing trend. The government subsidy program in rice seed subsidy program has remained very effective for private sector seed companies and seed traders, because it ensures the market of seeds produced by them (MoAD 2011). Private sector is getting better opportunity than the other sectors involved in seed production in the country. Presently, more than 1,850 seed entrepreneurs and 830 traders are directly or indirectly involved in the seed business in the country and most of them have very low annual transactions. The infrastructure like seed processing, storage and skilled manpower required for seed production and supply are urgent need to make rice seed business sustainable in Nepal.

Conclusion and suggestion

Private sector in Nepal has continuously been contributing on meeting the rice seed demand of Nepalese farmers. The national interest of expanding the area under improved quality rice seed has been supplemented by the seed production activities of private sector. However, the seed business environment has not been favorable as expected by private seed companies. There are some bottlenecks related to: price, marketing, infrastructure, varietal development, appropriate policy, act and regulations which need to be addressed by government. In order to make rice seed business by private sector sustainable, efficient and effective the following suggestions should be considered.

- Implementation of R&D with fast track research.
- Establishment of marketing channel and connect it at national and international levels.
- Establish and implement the carryover stock management of high value rice seeds.
- Rectify the seed subsidies program and also provide subsidies on source seed from the government of Nepal.
- Mechanization on seed to seed process in the seed industries by providing the grants.
- Need to provide soft loan facility, insurance, customs subsidies, subsidy in electricity for private sector
- Increase government financial support to private sector to make rice seed business sustainable in Nepal

References

MoAD. 2011. *Guidelines for seed subsidy on improved seeds*. Ministry of Agricultural Development, Kathmandu, Nepal.

NSCL. 2016. *Annual progress report.* National Seed Company limited, Kathmandu.

Weed Seed Identification in Rice in Seed Testing

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सारांश

धानको बीउको गुणस्तर बीउको भौतिक शुद्धता, उमारशक्ति, चिस्यान, ओजस तथा बीउ स्वास्थ्यको आधारमा मापन गरिन्छ । गुणस्तरीय बीउको प्रयोगशाला परीक्षणमा यी पक्षहरूलाई मात्र प्राथमिकताका साथ हेरिने गरिन्छ तर बीउमा रहने झारपातका बीउहरूको पहिचानमा खासै ध्यान दिइदैंन । साथै, बीउ विश्लेषकको बीउमा रहने झारपातका बीउहरूको पहिचान गरी हटाउने क्षमताको कमिका कारण बीउका उपभोक्तालाई बीउ परीक्षण प्रतिवेदन अपूर्ण हुन जाने देखिन्छ । भौतिक शुद्धता, उमारशक्ति र चिस्यान परीक्षण बीउ बिजन प्रयोगशालामा हुने नियमित परीक्षणहरू हुन् । तर, प्रयोगशालामा गरिने धानको बीउको भौतिक शुद्धता परीक्षणमा निकै थोरै परिमाणको नमुना (७० ग्राम भन्दा केही बढी) प्रयोग गरिने हुँदा बीउ परीक्षणका दौरान झारपातका बीउहरू तथा अन्य मिसावटहरू नमुनामा नसमेटिन सक्ने सम्भावना देखिन्छ । त्यसैले बीउ परीक्षण गर्दा भौतिक शुद्धता परीक्षणका साथै अन्य झारपातका बीउको पहिचान समेत नियमित परीक्षण गरी धान बीउमा रहेको मिसावट र झारपातका बीउ हटाउने कार्यलाई प्राथमिकता दिइनु आवश्यक छ । बीउ परीक्षण प्रतिवेदनमा सामान्यतया झारपातका बीउको विस्तृत पहिचान नै नगरी झारपातका बीउको संख्यामात्र उल्लेख गरिने भएकाले उक्त प्रतिवेदन बीउ उपभोक्ताको तर्फबाट हेर्दा प्रभावकारी एवम् उपयोगी देखिदैन । पहिचान गरिएका झारपातका बीउको विस्तृत विवरण सहितको प्रतिवेदनले मात्र बीउ उपभोक्तालाई झारपातका बीउ हटाउने उपयुक्त प्रविधि अपनाउन र बाहिरबाट त्यस किसिमका हानिकारक झारपातका बीउ आयात गर्नबाट रोक्न सहयोग पुर्‍याउने देखिन्छ । तसर्थ, विद्यमान प्रयोगशालाहरूमा झारपातका बीउको विस्तृत विवरण तयार गर्ने क्षमताको विकास गर्नु जरूरी छ । प्रस्तुत लेखमा बीउ विश्लेषक, बीउ नमुना संकलक, बाली निरीक्षक, क्वारेन्टिन र बाली संरक्षण अधिकृत, खाद्य विज्ञहरूका लागि बीउको गुणस्तर नियमन गर्न सहयोग पुगोस् भन्ने उद्धेश्यका साथ केही धानका बीउमा देखिने झारपातका बीउहरूको रंगीन तस्बिरहरू समावेश गरिएको छ ।

Summary

Rice seed quality is judged in terms of physical purity, germination, moisture, vigor and seed health. All the seed quality attributes are getting importance during quality test in laboratory but retrieval and identification of weed seeds are overlooked during seed analysis due to lack of identification ability of seed analyst, which ultimately makes test report unworthy for customers. Physical purity, germination and moisture test are the routine test of seed testing laboratory. However, physical purity analysis in rice seed is conducted in small quantity of working sample ie (slightly more than 70 g), from where significant impurities, such as noxious and undesirable weed seeds, may be missed in seed analysis. It is therefore necessary to include determination of other seeds by number test in routine test of seed testing laboratory and perform both tests (ie physical purity and determination of other seeds by number test) simultaneously at same time to retrieve and identify the noxious and undesirable weed species with weed seed identification tool ie color weed seed images. It is commonly observed that most of the laboratories report the number of weed seeds in their test report but as unidentified weed seeds, which makes the test report unworthy and useless for customer and seeds men. Seed testing report with identified weed seeds and their detail shall help to customer and seeds men to select appropriate screen and apparatus to remove the weed seeds during processing as well as to check the import of noxious and harmful weed seed infested seed lots in the country for quarantine people. Laboratories must have capacity to identify the weed seeds present in rice seed sample at least at genus level and report its scientific and common name in their test reports to make test reports useful and worthy for the customers. Hence, here some colorful images of rice weed seeds have been included to enrich knowledge and skill of seed analyst, seed samplers, crop inspectors, quarantine and plant protection officers, food technologist and agriculturist for regularizing the production, testing and certification of rice seeds/food for quality control and seed law enforcement in Nepal.

Seed images of broad and narrow leaf weed seeds of Rice and their other species of same genus

Broad leaf weeds

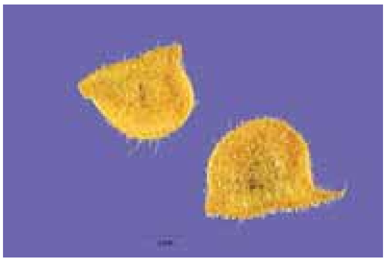
Aeschynomene americana L.
Shyleaf

Aeschynomene elaphroxylon
(Guill. & Perr.) Taubert ambatch

Aeschynomene indica L.
Indian jointvetch

Aeschynomene rudis Benth.
zigzag jointvetch

Aeschynomene virginica (L.) Britton,
Sterns & Poggenb. - Virginia



Aeschynomene viscidula Michx.
sticky jointvetch

Alternanthera sessilis (L.) R. Br. ex DC.
sessile joyweed

Commelina benghalensis L
Day flower /Kane

Commelina communis L.
Asiatic dayflower

Commelina diffusa Burm.f.
Day flower/Kane

Eclipta alba (L) Hassk
false daisy/Bhangraiyo

Ecliptaprostrata (L.) L.
false daisy/Bhringraj


Eichhornia crassipes (Mart.) Solms
common water hyacinth/Jal kumbi


Ipomoea alba L.
tropical white morning glory/Swamp cabbage/Karmaiya


Ipomoea aquatica Forssk.
swamp morning-glory

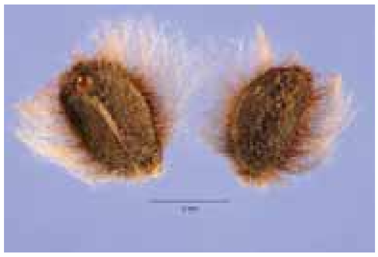

Ipomoea cairica (L.) Sweet
mile a minute vine


Ipomoea carnea Jacq.
Bush morning glory


Ipomoea hederacea Jacq.
ivyleaf morning-glory


Ipomoea horsfalliae Hook.
Lady Doorly's morning-glory


Ipomoea leptophylla Torr.
bush morning-glory


Ipomoea pandurata (L.) G. Mey.
man of the earth


Ipomoea pes-tigridis L.
morningglory


Ipomoea setosa Ker Gawl.
Brazilian morning-glory


Lemna aoukikusa Beppu et Murata


Lindernia anagallidea (Michx.) Pennell


Lindernia dubia (L.) Pennell
yellowseed false pimpernel


Lippia nodiflora Michx.
Toad stool/Kurkur

Ludwigia octovalvis (Jacq.) P.H. Raven
Mexican primrose-willow

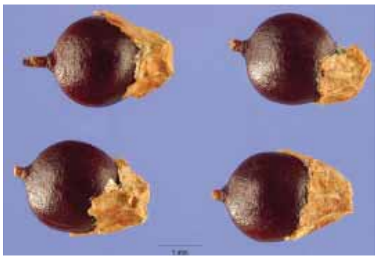
Ludwigia repens J.R. Forst.
Creeping primrose-willow

Monochoria hastata (L.) Solms
[excluded] arrowleaf falsepickerelweed

Monochoria vaginalis (Burm. f.) C. Presl ex Kunth
heart shape false pickerelweed

Pistia stratiotes L.
water lettuce

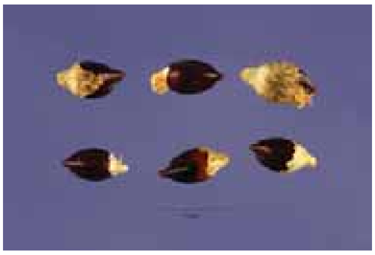
Pistia stratiotes L.
water lettuce



Polygonum amphibium L.
water knotweed

Polygonum aviculare L.
prostrate knotweed

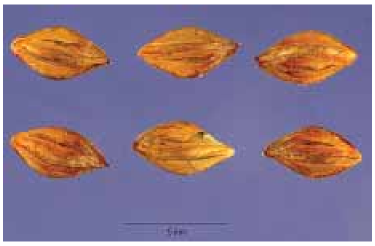
Polygonum bistorta L.
meadow bistort



Polygonum capitatum Buch.-Ham. ex D. Don

Polygonum convolvulus L.
black bindweed/wild buckwheat

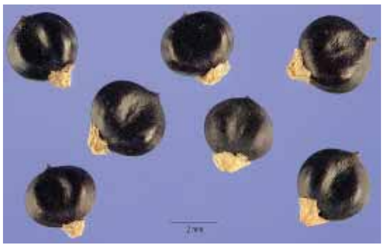
Polygonum convolvulus L.
black bindweed/wild buckwheat



Polygonum douglasii Greene
Douglas' knotweed

Polygonum hydropiper L.
marshpepper knotweed/pire

Polygonum lapathifolium L.
curlytop knotweed



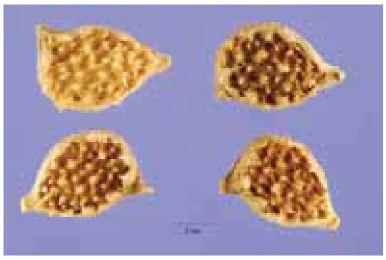
Polygonum orientale L.
kiss me over the garden gate

Polygonum pensylvanicum L.
Pennsylvania smartweed

Potamogetonepihydrus Raf.
ribbonleaf pondweed

Potamogeton natans L.
floating pondweed

Ranunculus acris L.
tall buttercup



Ranunculus arvensis L.
corn buttercup

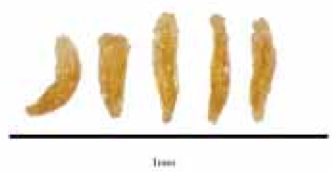
Ranunculus sceleratus L.
cursed buttercup/ cursed

Rotala indica （Willd.) Koehne
var. uliginosa (Miq.) Koehne

Rotala leptopetala (Blume)
Koehne var. littorea (Miq.)

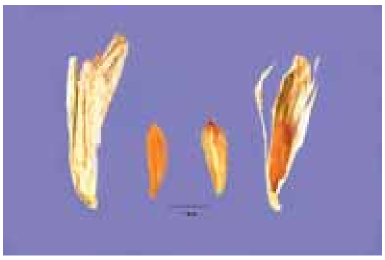
Sagittaria longiloba Engelm. ex J.G. Sm.
longbarb arrowhead

Sagittaria sagittifolia L. [excluded]
arrowhead



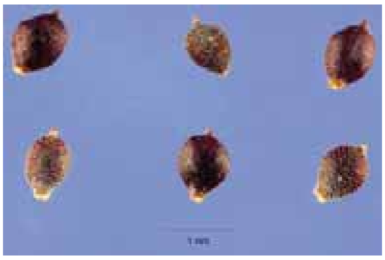
Sphenoclea zeylanica Gaertn.
chickenspike

Cyperus difformis L.
variable flatsedge



Cyperus echinatus (L.) Alph.
Wood

Cyperus erythrorhizos Muhl.
redroot flatsedge



Cyperus flavescens L.
yellow flatsedge

Cyperus iria L.
Flat sedge

Cyperus rotundus L.
Red nut sedge

Echinochloa colona (L.) Link
jungle rice.

Echinochloa crus-galli (L.) P. Beauv.
barnyardgrass

Echinochloa frumentacea Link
Billion-dollar grass/White panic/
Barnyard Millet (cultivated species)

Echinochloa haploclada (Stapf) Stapf
cockspur

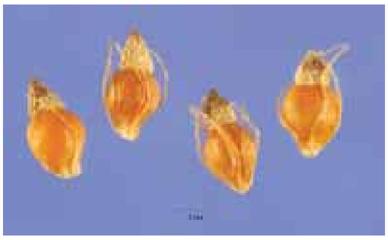
Echinochloa pyramidalis (Lam.) Hitchc. & Chase
antelope grass

Echinochloa stagnina (Retz.) P. Beauv.
hippo grass

Eleocharis acuta R.br.
Common spike rush

Eleocharis congesta D. Don
Spikerush

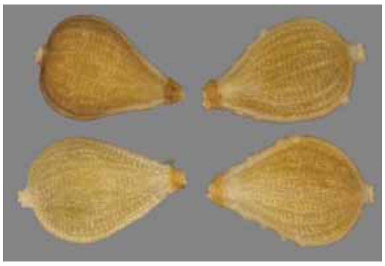
Eleocharis obtusa (Willd.) Schult.
blunt spikerush

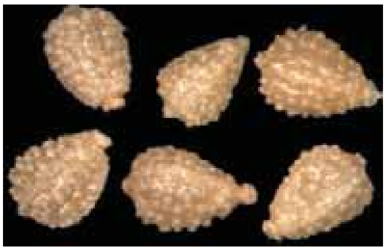


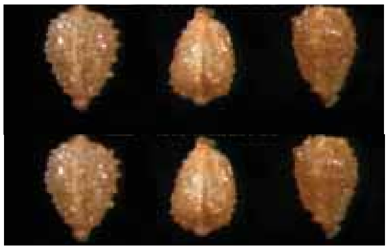
Eleocharis palustris (L.) Roem. & Schult.
common spikerush

Eleocharis quadrangulata (Michx.) Roem. & Schult.
squarestem spikerush

Fimbristylis aestivalis (Retz.) Vahl
Summer fimbry

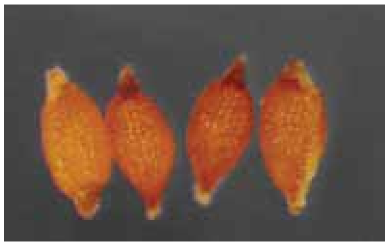

Fimbristylis dichotoma (L.) Vahl
forked fimbry


Fimbristylis littoralis Gaudich.
fimbry


Fimbristylis miliacea (L.) Vahl
grass like fimbry


Ischaemum indicum (Houtt.) Merr.
Indian murainagrass


Ischaemum rugosum Salisb.
ribbed murainagrass


Juncus acuminatus Michx.
tapertip rush


Juncus biflorus Elliott
bog rush


Juncus canadensis J. Gay ex
Laharpe


Panicum antidotale Retz.
blue panicum (cultivated species)


Panicum miliaceum L.
proso millet (cultivated species)


Paspalum dilatatum Poir.
dallisgrass


Paspalum scrobiculatum L.
kodomillet (cultivated species)


Scirpus atrovirens Willd.
green bulrush


Scirpus fluviatus (Torr.) A. Gray
River bulrush


Typha angustifolia L.
Narrowleaf cattail

Source: SQCC 2007 (Weed seed identification mannual 2007, Central Seed Testing Laboratory, Hariharbhawan)

Crop Protection
(बाली संरक्षण)

Rice Science and Technology in Nepal (MN Paudel, DR Bhandari, MP Khanal, BK Joshi, P Acharya and KH Ghimire, eds).
Crop Development Directorate (CDD), Hariharbhawan and Agronomy Society of Nepal (ASoN), Khumaltar.

Insects and their Management in Rice Production of Nepal

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सारांश

धान बालीलाई खेतबारी एवम् भण्डारणमा विभिन्न किसिमका किराहरूले नोक्सान पुऱ्याउँछन् । नेपालको तराईदेखि उच्च हिमाली क्षेत्रसम्मको कुनै पनि धान बाली कुनै न कुनै किराहरूको प्रकोपबाट मुक्त छैन । हिमाली क्षेत्रमा खेती गरिने जुम्ली मार्सी, चन्दननाथ-१ र ३ मा गबारो र पतेरोको प्रकोप देखिएको छ, जुन तराई र तल्लो पहाडको पनि मुख्य समस्या हो । औसत अनुमानित उत्पादन क्षतिको आधारमा पतेरो, गबारोहरू, हिस्पा, फड्के किरा र फौजी किरा नेपालको धान बालीमा देखिने प्रमुख किराहरू हुन् । एकिकृत तरिकाले सावधानी पूर्वक यी किराहरूको व्यवस्थापन गरी खडा अवस्थाको धान बली तथा भण्डारणमा हुने क्षति न्यूनिकरण गर्न सकिन्छ । यस लेखमा धान बालीमा लाग्ने केही प्रमुख किराहरूको क्षतिका लक्षणहरू तथा तिनको व्यवस्थापनको बारेमा छोटो जानकारी समावेश गरिएको छ ।

Summary

Rice as a crop in field and as a post harvest grain commodity is equally ravaged by different types of insect pests. With some specialization in environment, rice crop in both the Tarai and mountain regimes are prone to insect pests. Even the high mountain, temperate region, rice varieties, Jumli Marshi, Chandannath-1 and Chandananth-3 in Jumla district are found attacked by insects like rice stem borer and rice seed bug which are very common pests in rice crop in the Tarai and foot-hill. Based on the weighted average yield loss estimates, seed bug, stem borer, rice hispa, brown plant hopper and rice armyworm major rice insects in Nepal. Judicious management of these insects could be done in an integrated approach. Brief information of damage symptoms of rice insect pests with their management has been included in this article.

Keywords: Damage symptoms, Insect pest, Judicious management, Post-harvest, Rice

Introduction

Rice is equally damaged by different types of insect pests right from the field to the storage. General surveillance and pest risk analysis (PRA) of rice pests (insects and mites) conducted in Nepal revealed 158 rice pests (156 insects and 2 mites) in pre- and post-harvest rice commodity (Joshi 2005 and Joshi 2013); 99 insect pests of them are preserved as reference insects (Joshi and Manandhar 2001) in Entomology Division Insect Museum, Khumaltar, Lalitpur. Rice crop in both the Tarai and mountain regimes are prone to insect pests. Even the high mountain, temperate region, rice varieties, Jumli Marshi, Chandannath-1 and Chandananth-3 in Jumla district are found attacked by insects like rice stem borer, *Chilo partellus* (Swinhoe) and rice seed bug, *Leptocorisa* sp.which are very common pests in rice crop in the Tarai and foot-hill (Paudel 2011). A very comprehensive rice yield losses from major insect pests in Nepal has been detailed in Upadhyay 1996. Estimated average rice production losses (extension workers' views) in Nepal due to pestilence of stem borers (*Chilo suppressalis, Scirpophaga incertulas, S. innotata, C. polychrysus* and *Sesamia inferens*), leaffolder (*Cnaphalocrocis medinalis*), brown plant hopper (*Nilaparvata lugens*), green leafhoppers (*Nephotettix virescens* and *N. nigropictus*), seed bugs (*Leptocorisa acuta, L. oratorius* and *L. chinensis*), and rice hispa (*Dicladispa armigera*), respectively, are 110, 42, 34, 41, 20 and 89 kg/ha (Ramasamy and Jatileksono 1996). Based on the weighted average yield loss estimates, Upadhyay 1996 indicated seed bug, stem borer and rice hispa being three important rice insects in Nepal. But in the present scenario of rice insect outbreak occurrences, further two insects, brown plant hopper and rice armyworm (*Mythimna separata*) could be added with seed bug, stem borer and rice hispa.

Seed-bed beetle (*Heteronychus lioderes* Redtenbacher)[Coleoptera: Scarabaeidae]

Seed-Bed Beetle, locally called *Ritthe kira*, is reported for the first time from Kathmandu in 1962 (DoAER 1966). It is considered a minor rice pest, and is recorded only from upland rice (*Ghaiya*) field in the hills. As recorded in the Entomology Division, in 1966, upland rice plants in Sundarijal, Nayapati, Sunkhani and Dharmasthali were completely devastated by this pest that needed second planting of *ghaiya*. The subsequent rice planting was also damaged to a tune of 30% (DoAER 1967).

Damage symptoms

Both beetle and grub inflict harm to rice plants typically at a water scarcity state in field. Beetles are very much attracted to upland rice and dry bed nursery with no standing water in rice field. Wilted tiller due to beetle feeding on roots and collar region is the main damage symptom. Damaged tiller could be easily pulled out. Tattered rice stem at immediate under soil line is due to beetle's chewing on it. Grubs chew roots of rice plant. Beetles burrow underground damaging many rice plants at a time, and with a repercussion patches of dead plants are seen in an affected rice field. Sometimes they are, also, found damaging rice plants in the irrigated fields.

Management

- Maintaining standing water in the rice field.
- Light trap collection and destruction of seed-bed beetles.
- In an anticipation of beetle damage based on past experience, nursery seed-bed and/or main field before rice transplantation should be soil treated with chlorpyriphos-10G @10 kg/ha or chlorpyrifos-4G @15 kg/ha (AICC 2016).

Rice mealybug (*Brevennia rehi* Lindinger) [Hemiptera: Pseudococcidae]

Rice Mealybug (RMB) is reported for the first time from Janakpur in 1964. Its occurrence is regular but in patches in limited rice area in Sarlahi in 1966, 1967 and 1968 as observed during rice insect pest surveillances from Entomology Division when more than 80% vegetative rice plants in certain localized areas were devastated in 1968 (DoAER 1969). Now it has become a common pest in Tarai rice belt where Sarlahi, Bara, Parsa, Rautahat and Dhanusha districts have been branded RMB hot pockets where rice yield lost from 95-100% depending on mealybug severity. RMB occurred in rice plants, for the first time, in National Rice Improvement Program, Parwanipur in large number during drought in May-July, 1980 where an average (4 plots each of 1250 hills) 1250 rice hills found infested to a tune of 72.5-63.2%. Durga and Laxmi were very much susceptible to mealybug during its natural occurrence in research plots. Including sugarcane, grasses, namely *Echinochloa crusgalli, E. colonum, Cyprus difformis, C. rotandus, C. iria, Cynodon dactylon, Phalaris minor, Fimbristylis littoralis, Leptochloa chinensis, Setaria* sp., and *Eleusine* sp. were found alternative host plants for this mealybug (Pradhan 1981). Early planted rice crop is very much prone to mealybug attack compared to the late planted ones (Pradhan 1983).

Figure 1. (a) patches of stunting and yellowing of infected field; (b) wilted plants in field (http://zipcodezoo.com)

Damage symptoms (Figure 1a, b)

- Stunted and yellow plants.
- Plants with yellowed and curled leaves.
- Wilting plants in severe mealybug infestation.
- Colonized hard waxy masses of mealybugs between leaf sheath and stems.

- Severe infested rice plants with no panicles; even if present no exertion.
- Frequently visiting ants in sick plants.

Management

- Trace RMB before rice cultivation, in grasses around rice plot and destroying them.
- Alternative hosts around rice fields should be removed and destroyed.
- Use resistant varieties if available. Bindeswari, Chandina, CH-45 and Malika are tolerant or resistant to RMB (Pradhan 1983).
- Remove and destroy infested rice hills transplanted in field.
- Encourage rice field environment to conserve lady beetles, the natural enemies of RMB.
- Early planting and continuous irrigation up to 5 cm depth throughout the growing period.
- Mealybug transportation from infested to healthy rice field foundmainly through field tools. Make tools clean every time before using them.
- Least nitrogen fertilizer and ample farmyard manure help check mealybug explosion in field.
- For soil water treatment with following granular formulated insecticides (AICC 2016).
- Carbofuran 3 GR @1.25 kg/ropani orcartap hydrochloride 4 GR @1.25 kg/ropani or Fipronil 0.3 GR @1.25 kg/ropani orchlorantraniliprole @750 g/ropani

Rice stem gall midge (*Orseolia oryzae* Wood-Mason)[Diptera, Cecidomyiidae]

Chaughada and Hathia near Hethauda, Makawanpur are known as hot pockets for rice stem gall midge occurrences in Nepal but its economic impact on yield was not known until the main rice season in 1971 when, for the first time, galls encountered in the rice plants in the localities. Coinciding with this incidence, similar events were observed in an entire Tarai. Experiment conducted during this period in Parwanipur, indicated every percent increase in the gall incidence depleted the rice yield by 0.85%. Rice varieties, IR 8 (20.5% plants with galls), and Kaoshuing-24 and IR-154-123-1-1 (each 6.9% plants with galls), found moderately susceptible and moderately resistance to this insect. Also, *Platygaster oryzae* (Hymenoptera, Platygasteridae) found to be a natural enemy against the grubs of midges inside galls (Joshi 1986).

Figure 2. O. oryzae larva induced silver shoots in rice hill (http://agropedia.iitk.ac.in)

Damage symptoms

Potential rice tillers are converted to tubular galls due to larval feeding stimulant on the growing primordia of developing tillers that resemble onion leaves (**Figure 2**). These galls are also called silver shoots which never produce panicles.

Management

- Cultivate resistance or tolerant rice varieties if available,such as CH-45 (IRRI 1980); Laxmi and Masuli (Pradhan 1982b); Chandina and Bindeshwari (Shahi 1982); Hardinath-1 (Adhikari et al 2011) are resistant and Makawanpur-1 (Khatiwada and Upreti 2008) are moderately resistant.
- Removal of graminaceous weeds (*Leersia hexandra* and *Echinochloa crus-galli*) and wild rice (*Oryza nivara*, *O. rufipogon, O. granulata* and *O. officinalis*).
- Delaying wet season planting of photoperiod-sensitive varieties and planting photoperiod-insensitive varieties as early as possible after the beginning of wet season.
- Use of moderate amounts of N fertilizer and split applications over three growth stages.
- Dip the root of seedling before transplanting in solution of chlorpyriphos 20EC. @0.02% + 4% urea (0.5 L chlorpyriphos in 25 L of water) for 3-4 hours.
- Apply carbofuran 3G @25 kg/ha at the root zone of plants maintaining standing water level in the field when rice stem gall midges found attracted in light.

Rice leaf folder (*Cnaphalocrocis medinalis* Guenée) [Lepidoptera: Crambidae]

Until an outbreak of rice leaffolder (RLF) in the main season in Dhanusa, Jaleswor, Sarlahi, Bara and Parsa in 1977, its status was unknown in Nepal. Virtually, it was placed in major rice pest in national rice insect pest inventory of Nepal, 1977. Immediately after a year, different rice pockets in the Kathmandu valley, Godavari, Bandegaon, Pashupati and Pharphing area experienced the pressure of this insect in rice crop (Pradhan 1977). Again, in 1978, RLF was observed in large areas in Janakpur, Bara, Parsa and some hilly areas around Kathmandu valley. Similarly, high intensity of RLF infestations was observed in Parwanipur and its surrounding areas and in Janakpur, Kankai, Bara and Parsa districts in 1980 (Pradhan and Shahi 1983).

Figure 3. (a) beginning leaf folding (http://www.rkmp.co.in); (b) on the way to folding (http://rysw.cn/); (c) folded leaf (arrowed) (www.rkmp.co.in); (d) progressing damaging leaves (www.crida.in); (e) highly infested rice field

Damage symptoms

- Rolled leaf by longitudinally folding with sticky substance (**Figure 3a-c**).
- Membranous, whitish leaves (**Figure 3d**).
- Many folded leaves and a scorched appearance of leaf blades (**Figure 3e**)

Management

- Keep the rice field and surrounding weed free particularly *Echinochloa colona* (*Sama ghans*) and *Leersia hexandra* (*Nabo dhan*).
- Use optimum nitrogenous fertilizer dose and split it in growing crop.
- Practice applying potassium fertilizer alone in the growing crop.
- Maintain wider spacing (22.5 x 20 cm and 30 x 20 cm) in rice planting.
- Conserve natural enemies (crickets, damselflies, ants, beetles and spiders) of RLFs.
- Spray commercial *Bt* formulation @3 g/litre water against freshly hatched larvae.
- In case of severe damage, treat the crop with any of the following insecticides (AICC 2016).
- Chlorpyrifos 20 EC @1.25 ml/litre water or
- Carbosulfan 25 EC @1 ml/litre water or
- Lambda-Cyhalothrin 5 EC @0.5 ml/litre water or
- Azadirachtin 0.5 EC @3-5 ml/litre water.

Rice hispa (*Dicladispa armigera* Olivier) [Coleoptera: Chrysomellidae]

Rice hispa (RH) (*Dicladispa armigera* (Olivier) was collected for the first time in rice plant in Kathmandu in June 1962 (Joshi and Manandhar, 2001). It is considered a major rice insect pest in the Tarai belt, and a first instance of its population built up was experienced in Sunsari and Morang districts in 1970, and later in 1971 its population observed extended to Bara, Sarlahi, Dhanusha, Mahottari and Jhapa (Manandhar 1976). There are instances of its outbreak in the Tarai rice crop in Bara and Parsa districts in 1972 (ravaged ca 500 hectares rice crop fetching 10-20% yield loss) (Sharma 1972), in Parsa district in 1973, in Bara (ca 2000 hectares and Rautahat (ca 200 hectares) in 1975 (Manandhar 1976, KC 1975). Its severe infestation in rice crop was also recorded in the hill rice crop in Lalitpur district during the 3 rd week of July, 1982 (Pradhan 1982a). At the maximum rice hispa population density of 64 adults per sq m of rice plants, the potential yield rice losses of 4.48, 3.13, 2.18 and 2.16 kg/ha per day resulted in 22.1, 19.6, 19.6 and 27.5% loss during booting, tillering, flowering and milk stages, respectively (Gyawali 1998).

Damage symptoms

- Scraping on the upper surface of the leaf blade.
- White streaks parallel to the midrib on the lower epidermis of the leaf blade.
- Irregular translucent white patches parallel to the leaf veins; wither off leaves in plants.
- Whitish and membranous leaves in rice plants.
- Impression of scorched crop field in severe RH infestation (**Figure 4**).

Figure 4. Scorched crop field in severe hispa infestation (www.celkau.in)

Management

- Keep the rice field and surrounding grassy weeds free.
- Early planting with the onset of monsoon; maintain close plant spacing in crop field.
- Clipping seedling leaf tips at the time of transplanting; avoid over fertilizing the field.
- Removing damaged leaves until the crop booting; sweeping and destruction of adults.
- Treating rice canopy with diluted kerosene aqueous solution (a mixture of 1 part kerosene and 1 part water) by means of solution soaked a piece of rope.
- In case of managing the pest with chemical pesticide, treat the crop using any one of the following insecticides (AICC 2016).
- Chlorpyrifos 20 EC @1.25 ml/litre water or
- Lambda-Cyhalothrin 5 EC @0.5 ml/litre water or
- Malathion 50 EC @1.5 ml/litre water.

Rice stem borers (5 species)

Five stem borers, namely rice striped borer (RSB) *Chilo suppressalis* Walker, rice yellow stem borer (RYSB) *Scirpophaga incertulas* Walker, rice white stem borer (RWSB) *Scirpophaga innotata* Walker, dark-headed stem borer (DHSB) *Chilo polychrysus* Meyrick and pink stem borer (PSB) *Sesamia inferens* Walker are among the major pests of rice in Nepal. RSB is reported for the first time from Kathmandu valley in 1965 (DoAER 1966); RYSB is reported for the first time from Parwanipur in 1969 and Kathmandu in 1970; RWSB is first reported from Bhaktapur in 1960; DHSB is reported for the first time from Kathmandu in 1982; and PSB is first reported from Kathmandu in 1967 (Joshi and Manandhar 2001). Unprotected main season rice crop from borer infestation can deplete the yield to 2.6% in Khumaltar condition. Every one percent increase in borer infestation in rice crop may reduce 135 kg yield per hectare (Joshi 1977). Recently, an outbreak of stem borer in rice is experienced in 7000 hectares of Rajapur area in Bardia (Panthi 2016). *S. inferens* is the most important pest among the stem borers in the hill rice (Pandey et al 1995). *C. suppressalis* is found most abundant in temperate region rice crop.

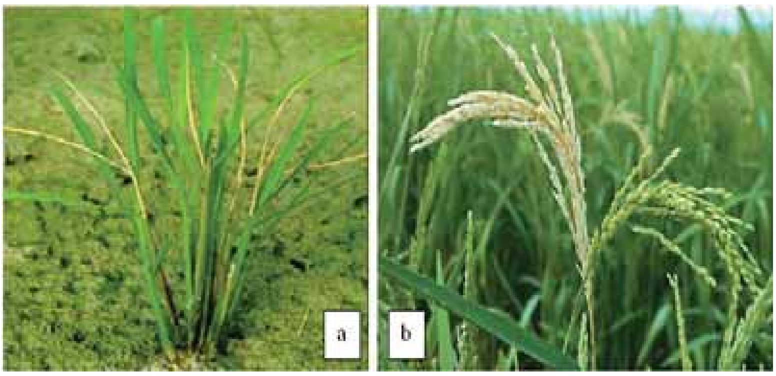

Figure 5. (a) Deadheart (http://agropedia.iitk.ac.in); and (b) White head in rice plant (www.celkau.in) due to stem borer

Damage symptoms

Central leaves of a young tiller turn brown due to larval feeding which is called dead heart (**Figure 5a**). Damaging inner portion of a tiller at the time of spikelet formation results in white panicles bearing no grains, which is called whitehead (**Figure 5b**). Whitehead can easily be pulled where larva with excreta can be seen.

Management

- Cultivate resistance or tolerant rice varieties if available; plant early maturing rice varieties. Mithila is resistant to rice stem borers (Adhikari et al 2011).
- Clean cultivation; straw removal and ground level cutting of stubbles.
- Tip cutting of seedlings before transplanting help remove eggs of some species of borers.
- Splitting nitrogen fertilizers applications; planting soybean in ridges around rice plot.
- Light trapping and destroying of moths; conserving natural enemies of rice stem borers.
- Freshly hatched stem borer larvae on rice plants should be treated with any commercial formulation of *Bacillus thuringiensis* @3 g/litre water.
- Soil water treatment using carbofuran 3 GR @1.25 kg/ropani or, cartap hydrochloride 4 GR @1.25 kg/ropani or fipronil 0.3 GR @1.25 kg/ropani or chlorantraniliprole @750 g/*ropani* (AICC 2016).

Rice grass hopper (*Hieroglyphus banian* Fabricius) [Orthoptera: Acrididae]

Rice grasshopper (RGH) *Hieroglyphus banian* is reported for the first time from rice crop in Kathmandu in 1968 (Joshi and Manandhar 2001). Grasshopper is one of the serious pests in the mid and far-western region of Nepal as decided by farmers and Regional Agriculture Technical Working Group (Ghimire et al 2016). Its pestilence in major status in rice crop was not known until the rice crop devastation of RGHs in Surkhet in 2004.

Damage symptoms

- Irregularly cut leaf margins in rice plant foliage due to nymphs and adults of RGH.
- Cut out areas on leaves, typically, from margin inward or upward.
- Leaves defoliation remaining only midrib and stalk.
- White ears due to nibbling of tender florets or gnawing into the stalk base.
- Damaging boot leaf and emerging panicle; cut-off panicles

Management

- Scraping rice plot bunds to a depth of about 15 cm and reformed.
- Conserving natural enemies; sweep net trapping of grasshoppers and destroying.
- Treating rice foliage with lambda-cyhalothrin 5 EC @0.5 ml/litre water or chlorpyrifos 20 EC @1.25 ml/litre water or carbaryl 50 WP @1 ml/litre water (Merchant 2016).

Rice armyworm *(Mythimna separata* Walker*)*[Lepidoptera: Noctuidae]

Rice armyworm was first collected from maize plant in Trisuli, June 1973 (Joshi and Manandhar 2001). It ravaged rice crop in Kailali and Kanchanpurin 3000 and 770 hectares, respectively, in August, 1974 where an estimated crop loss was 30% (Gyawali 1974). Massive attack was observed in Chitwan, Dang and Baglung in Nov-Dec, 1977 where about 15% rice yield loss was estimated in Chitwan (Neupane 1979). A latest outbreak was observed in Chitwan in Oct, 2013 when an average 34-38 larvae/m^2 was recorded in Piple (Mainali et al 2014).

Damage symptoms

- Cutting seedlings at seed-bed.
- Massive defoliation at vegetative stage of rice plant.
- Rice plant devoid of lemma and palea in developing grains, and anthers of flower due larval feeding on them at flowering time.
- Basal cutting of panicles, hanging half-cut panicles, messing field with severed panicles with grains.

Figure 6. Armyworm damaging pattern in rice crop: leaf damage (left), spiklet damage (centre) and ravaged rice crop (right)

Management

- Keeping nursery site free of weeds; deep ploughing; early rice sowing, clean cultivation.
- Light trapping and mass killing of moths, conserving and maintaining spiders' population.
- Flooding rice field in case of suspecting armyworms harboring in field.
- In outbreak, armyworms move in rows in crop field. Trench trapped armyworms should be collected and destroyed. Trenches may be treated with dust formulated insecticide like malathion 5% dust or chlorpyrifos 1.5% dust.
- In an unavoidable situation, spray either emamectin benzoate 5 SG @0.3 g/litre or fenevaletate 25 EC @1 ml/litre or cypermethrin 25 EC @1 ml/litre of water (Mainali et al 2014).

Rice whitefly (*Aleurocybotus occiduus* Russell) [Hemiptera: Aleyrodidae]

Whitefly was never reported an insect pest of rice crop until an outbreak occurred in the main rice season in Chitwan in 2005 where the crop grown in Ratananagar, Parbatipur, and Bharatpur was seriously hit by numerous whitefly populations. A maximum of 1000 whitefly nymphs per rice tiller was observed. A total rice area in Chitwan under the grip of whiteflies was estimated about 20561 hectares, and an estimated yield loss thereby was 9448 tonnes. Population build up of whiteflies but not of alarming status was also reported from Tanahun, Lamjung, Gorkha and Kaski coinciding with the outbreak in Chitwan. The whitefly was identified *Aleurocybotus occiduus* which is yet to be verified to its authenticity (Pokhrel and Thapa 2011).

Damage symptoms

- General symptoms of wilting, chlorosis and stunting in plants due to cell sap sucking of adults and nymphs.
- Premature leaf drop, or premature death, in severe infestations.
- In an outbreak, rice field turns reddish-yellow (**Figure 7a, b**)
- Honeydew on leaf surface with sooty mould.

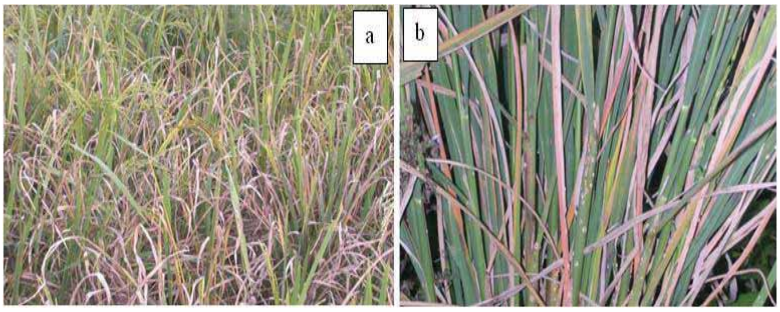

Figure 7. Severe infestation by whitefly in Chitwan; b. whitefly nymphs on tillers (Pokhrel and Thapa, 2011)

Management

- Grow Kanchhi masuli and Masuli until whitefly resistant rice varieties are developed.
- Discourage rice-rice pattern; practice crop rotation; split fertilizer application.
- Keep away the alternative hosts, *Echinocloa, Cyperus, Cyanodon,* sugarcane, sorghum etc from the periphery of rice field (Vejar-Cota et al 2009).
- Conserving natural enemy *Encarsia* sp. (Hymenoptera: Aphelinidae) in nature near around the presence of whiteflies.
- In an unavoidable situation, treat the crop against whiteflies using one of the insecticides followed (Pokhrel and Thapa 2011).

  Imidacloprid (eg Anumida) 17.8 SL @1 ml/litre water or
  Dimethoate (eg Rogor) 40 EC @1.5 ml/litre water or
  Carbofuran (eg Furadon) 3G @1 kg ai/ha.

Brown plant hopper (*Nilaparvata lugens* Stal)[Hemiptera, Homoptera, Delphacidae]

Brown plant hopper (BPH), apparently causing no serious rice damage, isreported for the first time in Nepal from Kathmandu valley in 1965 (DoAER 1966) and Biratnagar in 1968 (Joshi and Manandhar 2001). First record of its field status changing from minor to major pest was evident at Chandradangi, Jhapa in 1977 and 1978 when a population density of 200-400 per hill, was observed (Manandhar et al 1978, Manandhar and Dhungana 1984). Presently, this insect is one of the key pests in rice cultivation from Tarai-inner Tarai. Intensive rice cultivation with high nitrogenous fertilizer and improper insecticides applications induced them a regular visitor in an epidemic mode in every 2-3 years. Exemplary epidemic of BPH could be noted of 1996 in the early rice crop at Kumroj and Kathar areas of Chitwan when 3304 tonnes rice yield in 1033 hectares was BPH ravaged with an estimated monetary loss of NRs 23.13 million (Shivakoti 1996). Research at Parwanipur indicated *N. lugens* in this area being a new biotype different from biotypes 1, 2 and 3 generally existed in the Asian rice crops (Shrestha and Adhikary 1987). BPH is a potential vector of the grassy stunt and the ragged stunt diseases in rice plant but these are not yet reported in Nepal (Amatya and Manandhar 1986, Shrestha et al 1994).

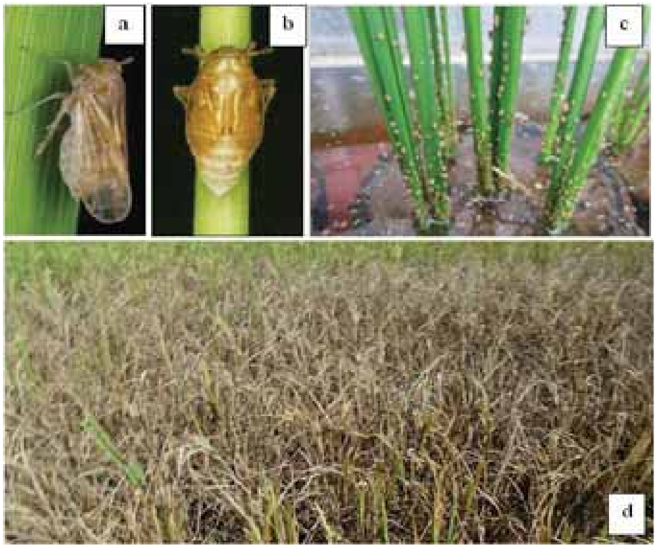

Figure 8. long-winged (Macroterous) and short-winged adult BPH (Brachypterous); nymphs and adults on lower part of plants (www.irri.org);hopper burn (Sudeep Paudel)

Damage symptoms

- Active tillering and booting are the most vulnerable stages for BPH damaging rice crop.
- Hopper burn in the field rice plants is an evidential symptom of BPH infestation due to plant sap draining from phloem cells and the blockage of vessels from the feeding tube sheaths (**Figure 8d**).
- Extensive hopper burn in susceptible rice varieties is a commonplace symptom in an outbreak of BPH.
- BPH infested areas at the base of rice hill shows the presence of honeydew and sooty moulds.

Management

- Summer ploughing; clipping leaf tips of seedlings before transplanting to avoid BPH eggs.
- Growing BPH tolerant rice varieties (if available); growing early maturing cultivars (94-103 days) to escape BPH population buildup (Heinrichs et al 1986).
- Synchronizing rice planting in neighborhood; at least within a period of 2-3 weeks.
- No volunteer plants around, rotating rice with other crops (if possible).
- In circumstances of the early stage of BPH infestation, draining rice crop field for 3-4 days.
- Optimum dose of N at three-split-applications.
- Letting weeds flowering at bunds and between fields to attract natural enemies of BPH.
- Encouraging natural control activities of BPH from *Anagrus* sp., *Gonatocerus* sp., *Oligosita* spp., *Paracentrobia* sp. (egg parasitoids), *Pseudogonatopus* sp. (nymphal parasitoid) and predators like *Cyttorhinus lividipennis*, *Microvelia douglasi atrolineata*, *Paederus fuscipes*, *Limnogonus* sp., *Micraspis* sp., *Metioche vittaticollis*, *Anaxipha longipennis*, *Conocephalus longipennis*, and spiders, *Lycosa* sp., *Oxyopes* sp., *Callitrichia* sp., *Argiope* sp., *Tetragnatha* sp., and *Araneus* sp. (NARC 1990) in rice field.
- Treat the infested rice crop with insecticide only in the situation when BPH per rice stem is an average of more than one. While spraying, nozzle should be directed at the basal portion of the plants. Followings are recommended insecticides and their doses (AICC 2016).
- Acephate 75% SP @3g/4 litres water or Buprofezin 25 SC @1.5 ml/4 litres water or Fipronil 5 SC @2-3 ml/4 litres water or Imidacloprid 17.8 SL @1 ml/litre water or Carbosulfan25 EC @1 litre/litre water or Azadirachtin 0.03% @2 ml/litre water.
- In condition of repetition of insecticide treatment after a time period, use other than last treated insecticide.
- Discourage rice plant resprout and continue growing after harvest.
- Remove stubbles to letting no chance to BPH to survive on.

Whitebacked plant hopper (*Sogatella furcifera* Horváth) [Hemiptera: Delphacidae]

White backed plant hopper (WBPH) was collected for the first time from Kathmandu in Sep, 1964 (Joshi and Manandhar 2001). It is always considered a minor pest but sometime it appears in an outbreak mode, and such event was experienced in the main rice season in Kathmandu valley in 1982 when more than 3000 hectares rice field was under its grip with infestation ranging from 50-90%. Its pressure in rice crop was easily lessened using a spray of methyl parathion (0.05%) (Pradhan et al 1983, Gyawali 1983).

Damage symptoms

- Dwarfing, dis-colouring and wilting rice plants, honey dew and sooty mould on leaf surface.
- Infested rice plants' leaves turning orange-yellow to brown and drying (Hopper burn).
- Symptoms of ragged stunt and grassy stunt diseases in infested rice crop.

Management

- Growing WBPH resistant varieties (if available); IRRI evaluated Nepalese genotype Latighawar and found resistant in International Rice WBPH Nursery (Singh 1986).
- Follow management practice as mentioned in BPH.

Green rice leaf hopper (*Nephotettix nigropictus* Stal; *N. virescens* Distant) [Hemiptera, Homoptera, Cicadellidae]

Two species of green leafhopper (GLH) *Nephotettix virescens* Distant and *N. nigropictus* Stal are commonly observed in rice crop in Nepal; *N. virescens* only occurs in the Tarai and inner Tarai rice fields (< 500 m) while *N. nigropictus* occurs in both Tarai and mountain but its occurrence tendency is more in high altitude (> 1000 m). *N. nigropictus* is first collected from Kathmandu in 1962 (Joshi and Manandhar 2001) while John et al 1979 reported *N. virescens* for the first time in rice from Parwanipur and confirmed virus disease tungro in rice based on high population prevalence of *N. virescens* in this area, and also indicated the prevailing rice cultivars cultivated in the area were susceptible to tungro virus. Similarly, *N. nigropictus* found vectoring dwarf disease in rice variety Taichung-176 in Khumaltar (John et al 1979). An outbreak of combination of WBPH and BPH in 1568 hectares of early rice in Chitwan in 1996 caused an estimated yield loss of 4262 tonnes worth NRs 30 million (Pokhrel et al 1998).

Damage symptoms

- Stunted plant growth with reduced vigor; yellowing leaves in sickly plants (tungro virus disease transmitted by green leafhoppers); reduced number of productive tillers.
- Withering or complete drying of the crop plants progresses with an access of green leafhopper population; sticky, whitish honeydew on leaf surface.

Management

- Apply neem cake @80 g/5m^2 nursery as basal dose; growing GLH resistant varieties (if available), Radha-9 shows the lowest tungro virus infection.
- Early planting with synchronizing rice planting in neighborhood; at least within a period of 2-3 weeks; transplanting older seedlings (>3 weeks old); optimum dosage of fertilizer application; light trapping green leafhoppers (GLH); discourage re-sprouting after harvest.
- Encouraging natural control activities of GLH from *Anagrus*, *Gonatocerus*, *Oligosita*, *Paracentrobia* (egg parasitoids), *Pseudogonatopus* (nymphal parasitoid) and predators like *Cyttorhinus lividipennis*, *Microvelia douglasi atrolineata*, *Paederus fuscipes*, *Limnogonus*, *Micraspis*, *Metioche vittaticollis*, *Anaxipha longipennis*, *Conocephalus longipennis*, spiders, *Lycosa*, *Oxyopes*, *Callitrichia*, *Argiope*, *Tetragnatha* and *Araneus* (NARC 1990).
- Acephate 75% SP @3 g/4 litres water or buprofezin 25 SC @1.5 ml/4 litres water or fipronil 5 SC @2-3 ml/4 litres water or imidacloprid 17.8 SL @1 ml/litre water or azadirachtin 0.03% @2 ml/litre water. If repeated treatment needed, use different insecticide than previous (AICC 2016).

Rice seed bug (*Leptocorisa acuta* Thunberg, *Leptocorisa oratorius* Fabricius and *Leptocorisa chinensis* Dallas) [Hemiptera: Alydidae]

Rice seed bugs (RSBs) were reported for the first time in 1962 (Kathmandu),1963 (Parwanipur), 1972 (Janakpur) and 1996 (Bhairahawa) (Joshi and Manandhar 2001, DoAER 1967). RSBs are called "*dhanko patero*" in Nepali. Serious RSB occurrence in 235 hectares rice crop in the new settlement area of Rapti Madi, Chitwan was the first record on RSB pestilence in rice in Nepal when a mixture of methyl demeton (Metasystox 25 EC) and Ethyl parathion (Folidol E 605) was used to suppress RSB successfully in rice crop (DoAER 1966). RSB is one of the major insect pests of rice in Nepal. No milk stage rice crop in Tarai belt and some foot-hill areas are safe of this insect (Neupane 1979). An investigation showed the highest RSB damage in rice ear, 1.15% in the Tarai early rice crop in 1996 (Gyawali 1997).

Damage symptoms

- Small and/or shriveled rice grains
- Deformed rice grains (**Figure 9b**)
- Partially filled and dis-coloured grains or pecky rice, empty grains, erect panicles, dark husk (**Figure 9a**)
- Mark of stylet on husk (**Figure 9c**)
- RSB pestilence is very serious in the early rice varieties.

Figure 9. (a) Dark grain husk; (b) Deformed and spotty grains; (c) RSB secreted stylet sheath (www.lucidcentral.org)

Management

- Cultivating late maturing varieties to escape attack of RSBs; removing grassy weeds in rice field and around; synchronizing rice planting; trapping and destroying RSBs hanging around rice plants particularly in the early morning or late afternoon.
- Protecting natural enemies of like spiders, wasps, long-horn grasshoppers and tiger beetles.
- Before the flowering of the main rice crop, practice to collecting and destroying RSBs hanging around trap crops of grasses or early-planted rice.
- Shaking-off nymphs infested heads into pans with kerosene + water; collecting and destroying RSBs trapped into decomposing meat(decaying meat serves attractant to RSBs); keeping population of RSBs in low level organizing campaign against RSBs in village.
- RSBs may be managed with insecticide application. Use insecticide only ifone bug/hill is observed; malathion 50 EC @2 ml/litre water or cypermethrin 25 EC @1 ml/2L water or fenvalerate 20 EC @1 ml/2L water.

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Rice Diseases and Management in Nepal

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सारांश

सन् १९६३ मा कृषि विभाग अन्तर्गत बाली रोग विज्ञान शाखा स्थापना भएपश्चात् धान बालीमा लाग्ने रोगहरू सम्बन्धी अनुसन्धान कार्यको सुरुआत भएको थियो । तत्पश्चात् धेरै संख्यामा रोगका कारक तत्वहरू र बीउबाट सर्ने जीवाणुहरूको पहिचान भएका छन् । तिनीहरूमध्ये मरूवा/ब्लाष्ट (पाइरिकुलारिया ओराइजी), खैरो थोप्ले/ब्राउन स्पट (बाइपोलारिस ओराइजी), पातेफेद डढुवा/सिथ ब्लाइट (राइजोक्टानिया सोलानी), फेद कुहिने/फुट रट्/बकाने (फ्युजारियम प्रोलिफराटम्), कालोपोके/फल्स स्मट (अस्टिलागिन्वाइडिया भाइरेन्स्), डढुवा/ब्याक्टेरियल ब्लाइट (ज्यान्थोमोनास ओराइजी प्याथोभार ओराइजी), र खैरा (जिंक तत्वको कमी) मुख्य रोगहरू हुन् । पाते फेद कुहिने/सिथ रट् (सारोक्लाडियम ओराइजी) र पाते फेद खैरो कुहिने/सिथ ब्राउन रट् (स्युडोमोनास फुस्कोभाजिनी) क्रमशः गर्मी र चिसो क्षेत्रमा प्रमुखरूपमा देखा पर्न थालेका रोगहरू हुन् । डाँठ कुहिने/स्टेम रट (स्क्लेरोसियम ओराइजी) र ब्याक्टेरियल लिफ् स्ट्रिक (ज्यान्थोमोनास् ओराइजी प्याथोभार ओराइजीकोला) महत्वपूर्ण रोग भएता पनि यिनीहरूबाट खासै क्षति हुने गरेका छैनन् । सानो थोप्ले रोग/न्यारो ब्राउन लिफ् स्पट (सर्कोस्पोरा ओराइजी), बेर्ना डढुवा/सिडलिङ् ब्लाइट (स्क्लेरोसियम रोल्फ्सी), दागी दाना/ग्रेन डिस्कलरेसन (विभिन्न जीवाणुहरू), दाना डढुवा/ग्लुम ब्लाइट (फोमा सोरघिना), ब्याक्टेरियल स्ट्राइप (एसिडोभोराक्स एभिनी सब स्पेसिस एभिनी), बेर्ना तथा दाना कुहिने/सिडलिङ एण्ड ग्रेन रट् (बुरखोल्डेरिया ग्लुमी) सामान्यतया देखा परिरहने रोगहरू हुन् । सिंकेधुप रोग/उडबट्टा (इफेलिस ओराइजी) नेपालको लागि नयाँ भएता पनि यसको प्रकोप बढिरहेको छ । विगतमा जुकाजनक सेतो टुप्पो/ह्वाइट टिप नेमाटोड (एफेलिन्कोइड्स बेसियी) महत्वपूर्ण मानिन्थ्यो भने अहिले जरामा लाग्ने जुका (हिर्समानिएला ओराइजी र हिर्समानिएला म्युक्रोनाटा) र जरामा गाँठा बनाउने जुका (मेल्वाइडोगाइन ग्रामिनिकोला) प्रमुख रूपमा देखा परेका छन् । पुड्के/राइस ड्वार्फ र खिइने/राइस टुंग्रो भाइरस रोगहरूको पहिचान भएता पनि उल्लेखनीयरूपमा क्षति पुग्ने गरी देखा परेका छैनन् । धान बाली सम्बन्धी भइरहेका अनुसन्धान कार्यलाई नियमित र विशेष (डिग्री हासिल गर्ने शोधकार्यसहित) गरी दुई किसिममा विभाजन गर्न सकिन्छ । रोग अवरोधक जातहरूको छनौट तथा विकास कार्य ब्लाष्ट र ब्याक्टेरियल ब्लाइट रोगहरूमा केन्द्रित छन् भने सिथ ब्लाइटमा केही काम हुने गरेका छन् । अन्य महत्वपूर्ण रोगहरूमा यसतर्फ काम हुन बाँकी नै छ । खासगरी ब्लाष्ट रोग व्यवस्थापनका लागि रासायनिक, जैविक नियन्त्रण आदि विधितर्फ काम भएका छन् भने ब्राउन स्पट, सिथ ब्लाइटमा केही काम भएका छन् । केही समन्वयात्मक परियोजनाहरूमार्फत् ब्लाष्ट, ब्याक्टेरियल ब्लाइट र रूट नट् नेमाटोडमा केही विस्तृत काम भएका छन् ।

Summary

Investigation on rice diseases was initiated in 1963 with the establishment of Plant Pathology Section under the Department of Agriculture. Since then a large number of disease causing agents, including various seed borne organisms have been reported. Of them, blast (*Pyricularia oryzae*), brown spot (*Bipolaris oryzae*), sheath blight (*Rhizoctonia solani*), foot rot/bakanae (*Fusarium proliferatum*), false smut (*Ustilaginoidea virens*), bacterial blight (*Xanthomonas oryzae pv. oryzae*) and khaira (zinc deficiency) are the major diseases. Sheath rot (*Sarocladium oryzae*) and sheath brown rot (*Pseudomonas fuscovaginae*) in the warm and cool areas, respectively are becoming major diseases. Stem rot (*Sclerotium oryzae*) and bacterial leaf streak (*X. c. pv. oryzicola*) are important diseases but not found causing significant damage in general. Narrow brown leaf spot (*Cercospora oryzae*), seedling blight (*Sclerotium rolfsii*), grain discoloration (*several pathogens*), glume blight (*Phoma sorghina*), bacterial stripe (*Acidovorax avenae subsp. avenae*), seedling and grain rot (*Burkholderia glumae*) are commonly occurring diseases. Though udbatta (*Ephelis oryzae*) is a relatively new disease in Nepal its incidence is increasing. Earlier, white tip nematode (*Aphelenchoides besseyi*) was considered important and now rice root nematodes (*Hirschmanniella oryzae and H. mucronata*) and rice root-knot nematode (*Meloidogyne graminicola*) are becoming important. Rice dwarf and rice tungro virus diseases have been identified but not found affecting the crop significantly. Researches on rice diseases can be divided into two types, regular and special, including MSc and PhD studies. Management of rice diseases through host resistance has been largely concentrated on two major diseases, blast and bacterial blight, and to some extent on sheath blight. Other major and important diseases have yet to receive attention in this aspect. Works on other management practices, including chemical and biological control, especially for blast and to some extent for sheath blight and brown spot have been made. Some detailed studies on blast, bacterial blight and root-knot pathogens have been made through collaborative projects.

Keywords: Diseases, Management, Nematode, Rice, Virus

Introduction

Investigation on rice diseases was initiated at Minbhawan in Kathmandu in 1963 when the Plant Pathology Section, established in 1954 under the Department of Agriculture, became functional. However, rice research in Nepal was started in 1951 (Mallick 1981). Historically, the first annual report of the Department of Agricultural Education and Research included three diseases of rice as major ones (DAER 1966). They are blast, bacterial blight and false smut. A preliminary list of pathogens causing rice diseases by Khadka and Shah (1967) included *Cladosporium herbarum, Cochliobolus miyabeanus, Khuskia oryzae, Leptosphaerulina trifolli, Pyricularia oryzae,* and *Ustilaginoidea virens*. A supplementary list (Khadka et al 1968) added *Curvularia verrulosa, Phyllosticta miurai, Trichoconis padwickii* (now *Alternaria padwickii), Sclerotium* sp., and *Xanthomonas oryzae* (now *X. oryzae* pv. *oryzae)*. Since then many other rice pathogens, including nematodes and viruses have been reported.

Researches on rice diseases can be divided into two major types: (1) regular researches, and (2) special researches, including MSc and PhD studies. Regular researches have been mainly concentrated on disease survey (in the past), screening varieties and breeding lines against some major diseases, efficacy of chemical pesticides and other disease management practices. These researches have led to the release of varieties resistant to diseases, mainly blast and bacterial blight; and recommendation of chemical pesticides and cultural practices for the management of diseases. Special researches have attempted some in-depth investigations mostly in collaboration with universities and international organizations. These researches have contributed to the development of control strategies and the generation of some information of practical value.

Some of the special projects include Bacterial Blight Project at the Institute of Agriculture and Animal Science, Nepal in collaboration with IRRI and Kansas State University, USA; Collaborative Research Support Project in collaboration with Cornell University and National Institutions in Nepal, Bangladesh and India; Rice-Wheat System Research Consortium with CIMMYT and NARC, including Soil Health and Sustainability of the Rice-Wheat Systems of the Indo-Gangetic Plains; Capacity Enhancement Project on Seed Pathology at NARC in collaboration with Danish Seed Health Center, Denmark.

There are two publications which have dealt with overall diseases of rice, a brief review by John et al (1980) and a book by Manandhar (1987). A miniature of the rice book in Nepali for extension workers and farmers (Manandhar 1990) is also available. A brief overview of accomplishments on major rice diseases is included in the 25 Years of Rice Research in Nepal (NRRP 1997). A proceedings of the First National Rice Blast Workshop is available (Sah 1988) but the workshop could not be continued. Over a dozen of MSc and PhD thesis researches on rice diseases have been made in the country and abroad. This review is organized in six major headings of diseases caused by respective group of pathogens, including seed-borne organisms. The seed-borne organisms are treated as a separate heading because the topic has been extensively studied.

Seed borne organisms

For the first time, Shrestha (1971-76) reported 13 fungi in seeds of local rice cultivars - *Alternaria longissima, Cercospora oryzae, Curvularia lunata, Drechslera oryzae* (syn. *Helminthosporium oryzae,* now *Bipolaris oryzae), Epicoccum purpurescens, Fusarium dimerum* (now *Microdochium dimerum*)*, F. moniliforme* (now mostly *F. proliferatum), F. semitectum* (now *F. pallidoroseum), Nigrospora oryzae, Phoma* sp.*, Pyricularia oryzae, Stemphylium* sp.*, and Trichoconis padwickii (*now *Alternaria padwickii).* In 1977, Shrestha compiled a list of seed-borne organisms including the ones reported earlier, the others were *Alternaria tenuis* (now *A.*

alternata), Botrytis cinerea, Cephalosporium sp. (now *Acromonium* sp.), *Curvularia clavata, C. dieghtonii, C. eragrostidis, C. intermedia, C. oryzae, C. tuberculata, Drechslera bicolor* (now *Bipolaris bicolor*), *Drechslera halodes, D. hawaiiensis* (now *B. hawaiiensis*), *D. longirostrata, D. rostrata, D. sorokiniana* (now *B. sorokiniana*), *D. tetramera, Fusarium culmorum, F. equiseti, F. longipes, Myrothecium verrucaria, Pestalotia* sp., *Phaeotrichoconis crotolariae, Phoma glumarum, Ustilaginoidea virens, and Xanthomonas oryzae* (now *X. oryzae* pv. *oryzae).* A supplementary list added *Aspergillus flavus, A. niger, Cercospora oryzae, Curvularia pallescens, C. inaequalis, and Penicillium* spp. (Shrestha 1984). Also, Desjardins et al (2000) added *Fusarium acuminatum, F. avenaceum, F. chlamydosporum, F. graminearum, F. oxysporum,* and one rare species *F. anguioides* as new records on rice seeds from Nepal.

Of the above listed seed-borne organisms, all except the bacterium *X. oryzae* pv. *oryzae*, are fungi. Later, some other bacteria were reported in rice seeds. They are *Pseudomonas avenae* (now *Acidovorax avenae*) (Shakya et al 1985), and *P. glumae* (now *Burkholderia glumae*) (Shakya 1989), *Pseudomonas fuscovaginae* (Mortensen et al 1992, Shakya and Manandhar 1992), *P. marginalis* and *Erwinia* sp. (Mortensen et al 1992). A nematode, *Aphelenchoides besseyi*, has been frequently isolated from rice seeds.

Mathur and Manandhar (2003) in their book 'Fungi in Seeds' have presented the results of seed health tests of 467 Nepalese seed samples. The results, based on the test done at the Institute of Seed Pathology (DGISP) in Denmark during 1967-2002, included range of infections by major pathogens. The organisms, not included in the above list but recorded at DGISP are: *Bipolaris setariae, Exserohilum rostratum, Fusarium culmorum, F. solani, F. subglutinans, Macrophomina phaseolina, Melanospora zamiae, Myrothecium* spp., *Nakataea sigmoidea, Phoma jolyana, Phoma sorghina, Pyrenochaeta* spp., *Tilletia barclayana* (now *Neovossia horrida*). These are pathogens or non host pathogens recorded in very low incidence. Also, saprophytic and weak parasitic organisms such as *Bipolaris spicifera, Chaetomium* spp., *Cladosporium* spp., *Curvularia geniculata, C. maculans, C. protuberata, C. trifolii, Graphium* sp., *Rhizopus* spp., *Trichoderma* spp., *Ulocladium* spp., *Verticillium tenerum* were recorded.

Infection of rice grains with *Fusarium* can cause contamination with mycotoxins that affect human and animal health. To determine the potential for mycotoxin contamination *Fusarium* species were isolated from samples of rice seeds collected in 1997 on farms in the foothills of Nepal. The *Fusarium* species isolated were species of the *Gibberella fujikuroi* complex, including *G. fujikuroi* mating population (MP) A (anamorph *Fusarium verticillioides*), *G. fujikuroi* MP-C (*F. fujikuroi*) and *G. fujikuroi* MP-D (*F. proliferatum*). Other common species were *G. zeae* (*F. graminearum*) and *F. semitectum*, with *F. acuminatum*, *F. anguioides*, *F. avenaceum*, *F. chlamydosporum*, *F. equiseti* and *F. oxysporum* occasionally present. Strains of MP-C produced beauvericin, moniliformin and gibberelic acid, but little or no fumonisin, whereas strains of MP-D produced beauvericin, fumonisin, and usually moniliformin, but no gibberelic acid. Some strains of *G. zeae* produced the 8-ketotrichothecene nivalenol, whereas others produce deoxynivalenol. Despite the occurrence of fumonisin- and of 8-ketotrichothecene-producing strains of *G. zeae*, tested rice showed no detectable contamination with these mycotoxins. Effective traditional practices for grain drying and storage may prevent contamination of Nepalese rice with *Fusarium* mycotoxins (Desjardins et al 2000).

Fungal diseases

Blast

Blast, caused by *Pyricularia oryzae* Cavara [also called *P. grisea* (Cooke) Sacc. for several years], teleomorph, *Magnaporthe oryzae* Barr (Couch and Kohn), [also called *M. grisea* (T.T. Hebert) Yaegashi and Udagawa for several years], is the most destructive rice disease in Nepal. The disease was first recorded in 1964 from Thimi in Bhaktapur (Bhatta 1966). As the name of the fungus has been disputed for many years, Manandhar (2000) suggested *P. oryzae* as the proper name for the rice blast fungus.

Occurrence and economic importance

Blast occurs in all rice growing areas from lowland (60 masl) to the high hills (3050 masl) and often appeared in epidemic form (Adhikari and Shrestha 1986, Sah 1989). Its incidence and severity used to be very high until a few years back especially in inner Tarai and foot hills where one of the most popular varieties Masuli was cultivated, and in valleys of mid hills growing Taichung-176 and Chainan-242. Reduction in grain yield was estimated between 21 and 51 kg/ha with 1% increase in neck blast under mid hill conditions (Manandhar et al 1985). In lower altitude, 38.5 and 76.1 kg/ha of grain yield reduction in Masuli and Radha-17, respectively, with 1% increase in neck blast has been reported (Chaudhary 1999).

Jumli Marshi, the most common traditional variety of Jumla, is highly susceptible to blast. In recent years, many farmers have been forced to abandon the variety because of blast. In 2011, blast destroyed 80% Jumli Marshi in the Tila valley. Likewise, in Palung area of Makawanpur district, the local rice variety 'Phalame' was almost wiped out because of its susceptibility to blast. A rice variety Khumal-4 which was released in 1987 as blast resistant is now susceptible. A few years back there was heavy blast appearance in Manjushree variety in Kathmandu, and in Radha-17 in Makawanpur. Recently, there was an epidemic of blast on hybrid rice (DY-69) grown in Kathmandu valley and surroundings. Blast often causes seedling loss in the seedbed resulting in shortage of seedlings for transplanting (Chaudhary and Sah 1997). Studies have shown seed transmission of the blast fungus when grown with light or no covering of seeds and also detected latent infection at low temperature (Manandhar et al 1998c) and survival in different parts of seeds (Puri et al 2007). The other host reported in Nepal is *Brachiaria mutica* (Khadka and Shah 1967) and by cross inoculation are *Eleusine coracana, E. indica,Panicum* sp., and *Setaria* sp. (Khadka et al 2012).

Pathogenic variability

The blast fungus is highly variable. Based on international differentials the race group prevalent in Khumaltar (mid hill) conditions belongs to 'IC' (Thapa and Manandhar 1985) and in Parawanipur (Tarai) conditions belongs to 'IA' (John et al 1980). It is claimed that the race group of Khumaltar is identical to that prevailing in eastern Asia (Korea and Taiwan), whereas the race group of Parawanipur is one of the most virulent in the world. Chaudhary et al (2004) evaluated 25 blast isolates from the plain to hilly areas, which resulted in 15 pathotypes. The pyramid BL121 with Pi-1+Pi-2 showed complementary resistance, conferring resistance to 80% of isolates. All tested isolates were incompatible to Laxmi and thus this variety could be a potential donor in breeding for blast resistance. This author could divide 33 monoconidial isolates of the fungus into 24 pathotypes (results not published).

Hermaphroditic isolates of both mating types were identified from Nepal and some provinces of China (Guzhou, Hubei, Hunan and Zhejiang) using SCAR markers. Some isolates from Nepal, China and Vietnam were identical (Shen et al 2004). Also, some Nepalese isolates were studied for determining diversity and mating types (Yaegashi and Yamada 1986, Saleh et al 2014).

Jumli Marshi, believed to have introduced by Baba Chandan Nath, has been grown in Jumla since time immemorial. The variety is the most popular despite its susceptibility to blast because of other qualities, including long durability after eating '*aadilo*' (meaning one does not get hungry soon). Since late 1990s there have been often epidemics of the disease. Two improved varieties Chandannath-1 and Chandannath-3 resistant to blast were released for Jumla valley and similar climates. Still farmers prefer Jumli Marshi. But for some years farmers could not harvest the crop at all. Therefore, they were forced to grow the improved varieties. Thus, Jumli Marshi's cultivation decreased significantly for couple of years and obviously the disease problem also minimized. Then after farmers again started growing Jumli Marshi and the disease pressure was minimal for one or two years. When the area under Jumli Marshi increased again then the epidemic of blast reoccurred. It could simply be a case of decreasing the populations of blast fungus by growing only resistant varieties for at least two years and then growing of Jumli Marshi relatively safely for one or two years (when the pathogen population is low). This may fit the concept of rotation of monogenes for disease control (Crill and Khush 1979).

Host resistance

Continuous attempts have been made for host resistance against blast through national and international rice blast nurseries (earlier called International Uniform Blast Nursery) every year at different locations in the country. The National Rice Blast Nursery was started in 1978. Resistance to blast has been identified both in some local (Adhikari et al 1995a) and exotic germplasm. Germplasm from hills had higher frequency (80.3%) of resistant entries than those from plains (56.7%) (Upadhyay 1982). Though leaf and neck blast are positively correlated not all leaf blast resistant varieties are resistant to neck blast. Leaf blast resistant Himali and Khumal-3 were severely attacked by neck blast (Thapa and Manandhar 1986).Works have been concentrated on selection for partial resistance to blast. So far cultivars like Kanchan, Khumal-2, Khumal-4, Khumal-8, Khumal-10, Khumal-12 for the hill conditions; Palung-2, Macchpuchhre-3, Chandannath-1, Chandannath-3, Lekali-1 and Lekali-2 for the high hills; Sabitri, Laxmi, Janaki, Ram Dhan, Mithila, Rampur Masuli, Loktantra, Hardinath-1, Chaite-2, Tarahara-1 Sugandhit Dhan-1, Radha-4, Radha-7, Radha-12, Radha-13 and Radha-14, Sukhadhan-1, Sukhadhan-2, Sukhadhan-3, Sukhadhan-4, Sukhadhan-5 and Sukhadhan-6 have been recommended for Tarai and inner Tarai conditions. Very recently, Lekali-1 was found heavily infected by leaf blast in Dolkha.

In the course of varietal development and its use Sabitri replaced Masuli in the Tarai, inner Tarai and lower altitudes of the hills; Hardinath-1 replaced CH-45 in lower altitudes of the hills and river basin; Khumal-4 replaced Taichung-176 and Chainung-242 in the mid hills, including Kathmandu valley; and Chandannath-1 and Chandannath-3 replaced Jumli Marshi in Jumla valley and Palung-2 replaced Phalame in high hills of Makawanpur. All the replaced varieties were most popular, but susceptible to blast.

Inheritance of blast resistance using microsatellite marker analysis confirmed that blast resistance in rice variety 'Laxmi' is governed by a single dominant gene located on chromosome 8 (Sharma et al 2007). At least 40 genes conferring resistance to blast isolates with multiple alleles based on DNA markers were identified, in which both dominant and recessive resistance alleles were found in many rice landraces (Joshi et al 2014).

Chemical control

Historically, the first annual report of the Department of Agricultural Education and Research of 1966 (DAER 1966) reported that 'At Maharajgunj, Dithane Z-78 (zineb) was sprayed on paddy already infested with blast disease and the yield was as follows – Dithane Z-78: 1420 lbs/acre, control (no spraying) – all plants killed (no harvest).'

A number of chemicals, including benomyl (Benlate), captan (Captaf), copper oxychloride+zineb (Blitane), carbendazim (Bavistin), ediphenphos (Hinosan), IBP (Kitazin), kasugamycin (Kasumin), leptophos (Phosvel), mancozeb (Dithane M-45), probenazole (Oryzemate), pyroquilon (CGA 49104), thiophanate methyl (Topsin M), thiram (Hexathir), zineb (Dithane Z-78), ziram (Ziride) were evaluated. Of them, Thapa (1975) and Manandhar et al (1985) found Hinosan and Kasumin, respectively as the most effective against blast for foliar spray. Kitazin and Oryzemate were effective for soil drench (Thapa 1983, Manandhar et al 1985). For seed treatment Benlate (Upadhyay 1983), Topsin M (Manandhar et al 1987b), Bavistin (Manandhar 1984, Sah and Karki 1988) were found effective at least for seedbed stage. Later, tricyclazole (Beam) was found effective as seed treatment and foliar spray (Chaudhary and Sah 1998). Hinosan remained for a long period as the recommended and widely used fungicide for the control of rice blast (till mid 2000s). Because of its high toxicity its use has now been discouraged and kasugamycin, tricyclazole and hexaconazole are in use. Recently, Magar et al (2015) reported tricyclazole 22% + hexaconazole 3% SC was found to be the most effective.

Soil drench or foliar application of non-fungicidal chemicals ferric chloride, di-potassium phosphate and salicylic acid has also been demonstrated for rice blast control, suggesting induced resistance (Manandhar et al 1998a, Manandhar et al 2000).

Biological control

Pre-inoculation with avirulent isolates of *Pyricularia oryzae* and non-rice pathogen *Bipolaris sorokiniana* was effective as foliar spray in reducing leaf blast and neck blast (Manandhar et al 1998b) and the mechanism behind the control was associated with induced resistance (Manandhar et al 1999, 2000). Seed treatment with *Trichoderma harzianum* reduces leaf blast in Sub1 and non-Sub1 rice genotypes (Chaudhary et al 2014).

Cultural control

Use of wet seedbeds for raising rice seedlings minimizes rice leaf blast in the seedbed (Sah 1989b and 1993). Rice seedlings can be saved from leaf blast by using lower doses of nitrogen (Shrestha and Bhardwaj 1985, Sah 1993). Submergence mediates leaf blast resistance in Sub1 and non-Sub1 rice genotypes (Chaudhary et al 2015a). Use of salt-sorted seeds (15% salt solution) removes diseased and lighter seeds, and brings significant impact on both raising healthy seedlings and direct seeded rice (Manandhar et al 2006).

Brown spot

Brown spot, caused by *Bipolaris oryzae* (Breda de Haan) Shoemaker [syns. *Drechslera oryzae* (Breda de Haan) Subramanian and P.C. Jain and *Helminthosporium oryzae* [Breda de Haan], teleomorph *Cochliobolus miyabeanus* (Ito and Kuribayashi in Ito) Drechs. ex Dastur, was first recorded in 1964 from Thimi in Bhaktapur (Bhatta 1966).

Occurrence and economic importance

The disease occurs in all rice growing areas of the country, especially under poor management conditions and is predominant in inner Tarai and Tarai regions (Manandhar 1987). According to Shah (1975) the introduction of improved variety IR-5 greatly enhanced the disease. In 1987, 1.3 hectares of B44b rice variety at Kaptanganj in Sunsari was found heavily infected by the disease (Manandhar 1987).

The disease may cause seedling rot/blight, but usually appears in heading stage. Shrestha (1979) reported rotten un-germinated seeds and seedlings due to this fungus. Seed infection up to 73% in var. Nantunii and 99% in IR-528-1-32 from Parawanipur were reported (Manandhar 1987). At heading stage, moderate to severe infection of brown spot on IR-26, IR-29, IR-30, IR-34, IR-44, Himali, Masuli and Janaki at Parawanipur (Bara) were reported (Manandhar 1987). The yield reduction due to the disease ranges from 3 to 20% (Manandhar et al 1992).

For the last few years with the less epidemics of blast both the incidence and severity of the brown spot have increased in the inner Tarai and Tarai areas. Sharma et al (2002) reported brown spot along with sheath blight as the major disease under rice-wheat system in the Tarai (Bara, Parsa and Rautahat). They observed significantly higher root necrosis in minimum tillage and higher total fungal count in conventionally-tilled rice. Pradhanang et al (1991) observed that the outbreak of brown spot was confined every year to low lands where drainage was a problem, but not in the neighboring free-draining fields. In 2015 main rice season at Rampur in Chitwan this author observed severely infected panicles in several experiments at the research fields of Agriculture and Forestry University. Wild rice species from Nepalgunj area were reported to be infected by brown spot fungus producing typical symptom (Manandhar 1987).

Host resistance

Despite the economical importance and increasing incidence of brown spot the disease has not received attention from national research system for host resistance and other management practices. Thus, no commercial varieties are known to be resistant to the disease. However, a few breeding lines and Pokhreli Masino were found moderately resistant to the disease based on the observations in a blast nursery where brown spot had appeared instead of blast (Manandhar 1987). Such occurrences also took place when students planned for research on blast, but turned to brown spot.

Panth (2015) found rice cultivar Sankharika most susceptible with AUDPC 340 followed by Radha-4 (108) and Sabitri least affected (80.36) under Hardinath (Tarai) conditions. Magar (2015) found only HJ-G1 and HJ-G2 moderately resistant among the tested genotypes.

Chemical control

Several chemicals, including carbendazim, copper oxychloride, copper oxychloride+zineb, mancozeb, zineb were evaluated against the disease for foliar spray but the effect was insignificant (NRIP 1977, Thapa

1978). However, benomyl, PCNB, ethylmercuric chloride (Ceresan) and zineb @0.3% were reported to be effective for the control of seedborne infection (Manandhar 1987). Ceresan was banned many years ago because of its mercurial content. Lamsal et al (2010) found ediphenphos and mancozeb+carbendazim (eg Saaf) most effective to control the disease under field conditions. Seed treatment with Saaf or similar formulation and also in severe cases in the field, foliar spray with the fungicide is suggested.

Other measures

Balanced fertilization to soil is recommended. Foliar spray with 2% urea is recommended under field conditions. Lamsal et al (2010) found Nico-neem (a neem oil-based product) and 10% extract of simali plant (*Vitex negundo*) effective under field conditions.

Sheath Blight

Sheath blight, caused by *Rhizoctonia solani* Kühn, teleomorph *Thanatephorus cucumeris* (A.B. Frank) Donk, was reported in 1968 in Nepal (Manandhar 1987). The disease was reported to be associated with aggregate sheath spot caused by *R. oryzae-sativae* (Sawada) Mordue (PPD 2005). However, no further studies have been done.

Occurrence and economic importance

The disease is becoming a potential threat to rice cultivation. According to Shah (1975) the intensity of the disease increased primarily with the introduction of dwarf varieties. Later, it became prominent in the Tarai and inner Tarai regions where high yielding varieties with heavy nitrogenous fertilizer are grown (Shah 1985).Yield reductions up to 26% with sheath blight severity of 67% at Naldung in the mid hills (Shrestha et al 1998) and as high as 50% at Tarai (Chaudhary 2015) were reported.

Host resistance

International Rice Sheath Blight Nursery was started in 1975 with artificial inoculation to screen rice varieties/genotypes and identify resistant sources to the disease (Adhikari and Sah 1976). Later, it was discontinued and now national sheath blight nursery is being conducted. No desirable level of resistance was obtained in the genotypes tested (NRRP 1997). A local variety 'Andi' from Kaski was found moderately resistant to the disease (Manandhar 1987). However, no commercial varieties are resistant. In Japan, two Nepalese rice accessions (Nepal 8 and Nepal 555) had shown resistance to sheath blight (Taguchi-Shiobara et al 2013). Recently, Chaudhary (2015) found Tetep and IR-26 moderately resistant to the disease.

Chemical and other control

Foliar applications at tillering and at booting stage with validamycin (Validacin) or tolclofos-methyl (Rhizolex) @2.0 ml/litre water minimize the disease (Parajuli 1997 and Shrestha et al 1998). Use of neem-based products also reduces the disease (Chaudhary 2015). Balanced use of fertilizers, (not only nitrogen) and avoidance of dense planting is recommended.

Foot rot/Bakanae

Foot rot/bakanae, caused by *Gibberella fujikuroi* species complex (earlier known by *F. moniliforme* J. Sheld.), is a major disease of rice. The disease was considered as of minor importance till 1980s (Shah 1985). It occurs in all rice growing areas. In fact, the disease became prominent with the release of Khumal-4 variety in 1987. Since then the disease has been a problem in Khumal-4 and Pokhreli Masino, grown in different areas with grain yield losses up to 40% (Manandhar et al 1992). Khumal-4 is the cross between Pokhreli Masino and IR-28.

The disease is primarily seed-borne. A detailed systematic study on 48 seed samples of rice from Nepal showed that 70% samples yielded species of *G. fujikuroi* complex (Desjardins et al 2000). They include three mating populations (MP) such as *G. fujikuroi* MP-A [anamorph, *Fusarium verticillioides* (syn.

F. moniliforme)], *G. fujikuroi* MP-C (*F. fujijkuroi*), and *G. fujikuroi* MP-D (*F. proliferatum*) and some nonfertile *G. fujikuroi*. The gibberellins-producing species *G. fujikuroi* MP-C was commonly associated with foot rot/bakanae disease of rice and was present in seeds of Khumal-4. These days *F. proliferatum* is considered as the causal fungus of foot rot/bakanae but still one or more species could be involved.

Seed infection up to 83% was recorded in a sample of Khumal-4. Seed treatment with Bavistin @2-3 g/kg seed is recommended (Manandhar et al 1992). As the demand of Khumal-4 seed is high seed treatment with carbendazim was made mandatory at the National Seed Company and the source seed producing research stations before sales/distribution of the seeds.

False smut

False smut, caused by *Ustilaginoidea virens* (Cooke) Takah, has become a major disease now. Earlier, farmers considered its occurrence as an indication of good harvest. The disease was first recorded in 1964 (Khadka and Shah 1967). According to Shah (1975), the disease was introduced with Taiwanese varieties and spread to other varieties. The disease occurs in all rice growing areas. During 1980s the disease was more prevalent in the western Tarai (Bhairahawa area). Isolated epidemics of the disease have been reported from time to time. During mid 1980s, the disease occurred heavily in Kanchan variety in Bhaktapur (Manandhar 1987).

These days the incidence and severity of the disease has increased with the cultivation of hybrid rice (eg DY-69). Despite its increasing threat no attempts have been made on varietal resistance. Foliar sprays with mancozeb or carbendazim before and after heading is suggested.

Sheath rot

Sheath rot, caused by *Sarocladium oryzae* (Sawada) W. Gams and D. Hawksw. (syn. *Acrocylindrium oryzae* Sawada), is becoming a major problem. Until mid 1980s, it was considered of minor importance. Earlier the disease was reported from all rice growing areas, now it is considered to be mainly prevalent in the Tarai, inner Tarai and warmer areas, and more severe under upland conditions. Similar sheath rot symptoms found in the high hills have been identified as a bacterial disease.

In 1986, most of the test varieties in upland trials at Parawanipur were heavily infected by the disease (Manandhar 1987). The disease, in general, reduces grain yield by 10-30% in the mid hills and 5-25% in the Tarai (NRRP 1997). No varieties are known to be resistant to the disease. Foliar spray with carbendazim at heading stage is suggested.

Narrow brown leaf spot

Narrow brown leaf spot, caused by *Cercospora oryzae* Miyake [syn. *Cercospora janceana* (Racib.) O. Const.], teleomorph *Sphaerulina oryzina* K. Hara, is a commonly occurring disease in all rice growing areas. The disease was first recorded in 1973 from the Tarai region. However, Manandhar (1977) reported the pathogen from the sample collected at Parawanipur in 1955. The disease is common in the cooler parts of the hilly region and under dry conditions in the Tarai (Manandhar 1987).

Though the disease is considered of minor importance, some isolated epidemics of the disease have been reported. In 1984 in Makawanpur, a large rice plot was heavily infected showing complex syndrome and the presence of this disease was dominant (Manandhar 1987). In 1986, the disease occurred heavily in upland trials at Parawanipur (Bara). The disease incidence was quite high on released and pre-released varieties, including Masuli, IR-56, IET-7251 and NR-10067. No further works have been done so far.

Stem rot

Stem rot, caused by *Sclerotium oryzae* Cattaneo (sclerotial state), teleomorph *Magnaporthe salvinii* (Cattaneo) R. Krause and R.K. Webster (syn. *Leptosphaeria salvinii* Cattaneo), conidial state *Nakataea sigmoidea* (Cavara) K. Hara (syn. *Vakrabeeja sigmoidea* (Cavara) Subramanian, occurs commonly in the rice growing areas, but mostly prevalent in the inner Tarai and Tarai regions (Manandhar 1987). The disease was recorded in 1966 (Khadka et al 1968).

Though Shah (1985) listed stem rot as an economically important disease it has not been reported causing yield losses so far. No further works have been done.

Seedling blight

Seedling blight is caused by a number of seedborne and soilborne pathogens. In Nepal, it has been commonly found under dry seedbed conditions. The most commonly associated pathogen, besides *Bipolaris oryzae* is *Sclerotium rolfsii* Sacc. In 1985, the disease was severe in most of the dry seedbeds of various trials at Khumaltar (Lalitpur).

Grain discoloration

Grain discoloration, caused by various pathogens, is a commonly occurring disease. Most of the seed borne pathogens are associated with this disease. The disease is favoured by rainfall and high humidity during grain formation stage of the crop. No studies have been made to manage the disease. However, foliar sprays of fungicides like mancozeb or the mancozeb+carbendazim (eg Saaf) at the heading stage can reduce the disease.

Glume blight

Glume blight is caused by *Phoma sorghina* (Sacc.) Boerema, Dorenbosch and Van Kesteren [syns. *Phoma glumarum* Ellis and Tracy, *P. insidiosa* Tassi, *Phyllosticta glumarum* (Ellis and Tracy) Miyake, *P. glumicola* (Speg.) Hara, *P. miurai* Miyake, *P. oryzina* Padwick, and *P. sorghina* Sacc.]. The disease is greatly favored by windy and rainy weather during the heading stage. Large plots of rice with severe glume blight were observed in parts of the lower belts of Nuwakot in 1990s when high speed winds occurred at the time of heading. The disease appears as reddish brown blotches on the glumes, that causes empty or partially-filled grains.

Udbatta

Udbatta, caused by *Ephelis oryzae* Syd., teleomorph *Balansia oryzae-sativae* Hashioka, is a relatively new disease for Nepal. The disease is also known by incense rod (in Nepali *Sinke dhup rog*) or false ergot. There was no report of the disease till early 2000s. The disease was first reported from Udayapur district and now often found in several other districts, including Kathmandu valley (Manandhar et al 2016). The disease has been found even in Khumal-4 and Taichung-176 with increased incidence (PPD 2012-2015). As the pathogen is both seed and soil borne it must have been introduced from neighboring countries and got established. Despite the increasing occurrence of the disease no studies have been made so far. Seed treatment with carboxin, oxycarboxin or carbendazim is suggested.

Some minor fungal diseases

Leaf smut, caused by *Entyloma oryzae* Syd. and P. Syd. [syns. *E. lineatum* (Cooke) J.J. Davis, and *E. dactylidis* (Pass.) Cif.], was first reported by Shah (1985). Since then the disease has been seen sporadically in some isolated plots from time to time. In 2015, the disease was found in Pokhara area. No further studies have been made so far.

Stackburn caused by *Alternaria padwickii* Ganguly Ellis (syn. *Trichoconis padwickii* Ganguly) is a minor disease in the field, but the pathogen is highly associated with seeds. Of 467 seed samples, 80% were infected by this pathogen (Mathur and Manandhar 2003). Seed infection may result in seedling blight but not encountered as a major problem.

Minute leaf and grain spots caused by *Nigrospora oryzae* (Berk. Broome) Petch, teleomorph *Khuskia oryzae* H.J. Hudson is also seen in the field but does not have significant effect on the crop. The pathogen is commonly associated with seeds.

Minute leaf spots and black kernels, caused by *Curvularia* spp., including *Curvularia oryzae* Bugnicourt, are generally seen but do not seem to affect the crop significantly. The pathogen is commonly associated with seeds.

Red blotch of grains, caused by *Epicoccum purpurascens* Ehrenb. (syns. *E. oryzae* Ito and Iwad., *E. neglectum* Desmaz.), is also reported and can be seen in the field but without any significant effect. The pathogen is commonly associated with seeds.

Kernel smut, caused by *Neovossia horrida* (Takah.) Padwick and A. Khan (syn. *Tilletia barclayana* (Bref.) Sacc. and Syd. in Sacc., though is an economically important disease in other countries, including India the disease is not seen in Nepal as a problem. No further studies have been done in Nepal so far.

Scab, caused by *Fusarium graminearum* Schwabe (teleomorph *Gibberella zeae* (Schwein.) Petch, is a commonly reported disease, but has not been detected in the field. The pathogen is occasionally isolated from seeds.

Bacterial diseases

Bacterial blight

Bacterial blight (BB), caused by *Xanthomonas oryzae* pv. *oryzae* (ex Ishiyama) Swings et al (syn. *X. campestris* pv. *oryzae*), is a major disease. The disease was first found in Balaju in Kathmandu in 1965 (Khadka et al 1968) and kresek (systemic infection of seedlings 2-3 weeks after transplanting) in 1975 (Adhikari and Shrestha 1975).

Occurrence and economic importance

The disease occurs in both the hills (Manandhar et al 1987a) and Tarai where high yielding rice varieties are grown under high input conditions. However, the disease is more severe in the Tarai (>50%) than in the hills (<10%) (Adhikari and Shrestha 1989); and it is more severe in the eastern and central Tarai than in the western Tarai (Manandhar 1987). Cultivation of susceptible cultivars Sona Masuli and Ranjeet, has aggravated the disease intensity, inoculum build up and its effect on yield due to its faster spread.

Grain yield losses of 13-32% were reported on susceptible cultivar Taichung Native-1 and the yield loss was as high as 60% (Thapa 1981). Adhikari and Mew (1991) estimated average grain yield loss up to 26%. In Bara district, 90% of the plants were found infected with kresek phase at seedling stage 2-3 weeks after transplanting (IRRI 1979). Manandhar (1987) and Adhikari et al (1996) made a review on the disease and its control in Nepal.

Pathogenic variability

Virulence of BB pathogen varied from location to location with more virulent pathotypes in the east Tarai than in the west Tarai (Sharma and Singh 1979), and also the changes in pathotypes from year to year (Adhikari et al 1976). Upadhyay et al (1985) identified six different pathotypes using differential rice varieties. Karki et al (1988) found all IRRI and Japanese differentials except DV85 susceptible to BB isolates at Kankai (east Tarai).

Bacterial blight pathogen is the most and well studied among the plant pathogens occurring in Nepal. The pathogen populations were analyzed using several phenotypic and molecular markers. Nine pathogenic races were identified based on differential interactions on eight rice cultivars (Adhikari et al 1994). The races were virulent to many important resistance genes and the genetic diversity was high (0.98) in the collection from Nepal (Adhikari et al 1995). Later, genotypic and more pathotypic diversities in the pathogen were made (Adhikari et al 1999).

Host resistance

Host resistance has been a major emphasis since the research on BB began in the country after the establishment of National Rice Improvement Programme (now National Rice Research Programme under NARC) in 1972. Since then national and international BB nurseries have been conducted at different testing sites. The First National Bacterial Blight Nursery was conducted in 1975. A number of local cultivars, improved varieties and breeding lines have been evaluated for their resistance to the disease (Manandhar 1987, Karki 1991). At present, Sabitri, Barkhe-2, Khajura-2, Radha-4, Radha-7, Radha-12, Hardinath-1, Chaite-2 and Chaite-4 are resistant to the disease.

In the past and even now evaluation of genotypes for resistance are based on natural infections. Also, resistance has failed to control the disease effectively due to the presence of highly virulent strains and prolonged period of rainy weather that provide excellent conditions for disease development (Adhikari et al 1996). Over 1000 local and exotic rice germplasm lines were evaluated by inoculation with the pathogen and only a few rice cultivars and near-isogenic lines were found resistant (Adhikari 1993, Adhikari and Mew 1994). Adhikari et al (1996) suggested that many genes identified at IRRI have a limited application for use in Nepalese rice ecosystems. However, the resistance gene *Xa-21* provided resistance to several Nepalese strains of the pathogen suggesting that gene deployment is feasible in Nepal.

Amgai et al (2015) screened 96 Nepalese rice accessions using eight simple sequence repeats (SSR) markers and one sequence tagged sites (STS) marker for presence or absence of BB resistance genes. They found *Xa-3, Xa-4, Xa-5, Xa-7, Xa-8, Xa-10* and *Xa-13* on several rice accessions, but not *Xa-21*. Seventeen rice accessions had three and more resistance genes. Presence of *xa-13* on CNTRL-85033 (susceptible) confirmed that this resistance gene is not working in Nepalese rice field.

Chemical control

During 1972-74, Agrimycin-100 (streptomycin sulphate + terramycin), Neosankel and Neosankel + Uspulum were evaluated and found significant effects on both the disease reduction and yield increase (Thapa 1975). Based on availability foliar spray of Agrimycin-100 or streptocycline is recommended but seldom used for controlling the disease.

Cultural control

Dry seedbed instead of wet seedbed is recommended. Use of submerged seedlings had a significant influence on BB severity ie the disease was reduced in plants transplanted with submerged seedlings, with greater reduction in Sub1 genotypes (Chaudhary et al 2015b). Balanced use of nitrogenous fertilizer along with potash reduced the disease.

Bacterial leaf streak

Bacterial leaf streak, caused by *Xanthomonas oryzae* pv. *oryzicola* (*Fang et al*) Swings et al (syn. *X. campestris* pv. *oryzicola* (Fang et al) Dye), was first reported in around 1970 in Nepal. Its occurrence is confined to the Tarai and inner Tarai. There are reports of isolated epidemics of the disease but not encountered as destructive as bacterial blight since yield reduction due to the disease is relatively low. In 1986, the disease was found severe in seed multiplication of var. Durga at Parawanipur and the grain yield reduction was significant (Manandhar 1987). No works on varietal resistance and management practices have been carried out in Nepal so far.

Sheath brown rot

Sheath brown rot caused by *Pseudomonas fuscovaginae* Tanii, Miyajima and Akita [formerly described as *P. marginalis* (*P. fluorescens* biovar II)] is induced by chilling temperatures. The disease is seed borne and was first reported from seeds in early 1990s (Mortensen et al 1992, Shakya and Manandhar 1992). The disease symptoms are similar with the fungal sheath rot caused by *Sarocladium oryzae*, which is prevalent in warmer areas.

The inheritance of field resistance has been studied and selection in presence of the disease for taller plants and better panicle exsertion resulted in greater chilling tolerance and higher sheath brown rot field resistance (Sthapit et al 1995). According to Sharma et al (1997), sheath brown rot is not a serious problem in widely adapted local landraces (*Chhomrong, Takmare, Kalopatle, Sinjali, Seto Bhakunde, Darmali* etc) while it could be a major problem in introduced varieties. An improved variety Macchapuchhre-3, a progeny of Chhomrong, is resistant to the disease. No chemicals and other control measures have been tested against the disease.

Other bacterial diseases

Bacterial stripe caused by *Acidovorax avenae* subsp. *avenae* (earlier *Pseudomonas avenae* Manns) (Shakya et al 1995) and grain rot and seedling rot caused by *Burkholderia glumae* (Kurita and Tabei 1967) Urakami et al 1994 (earlier *Pseudomonas glumae* Kurita and Tabei) (Shakya 1989) were reported from rice seeds. The identification of these bacterial pathogens was made by pathogenicity, biochemical and serological tests. So far the diseases have not been observed as major problems. In a testing of 554 seed samples from different parts of Nepal 457 were found infected with *A. avenae* sub sp. *avenae*, the infection ranges from 1 to 89% (DD Shakya, unpublished results). Bacterial foot rot caused by *Erwinia* sp. was found in the field (Manandhar 1987) and detected in rice seed (Mortensen et al 1992). Another bacterium detected in rice seed was *Pseudomonas marginalis* (Mortensen et al 1992).

Nematode Diseases

White tip

White tip, caused by *Aphelenchoides besseyi* Christie by Allen, is a commonly occurring nematode disease. The nematode was first reported by Bhatta in 1967 from soils of the Kathmandu valley, later confirmed by Amatya and Shrestha (1969). According to Shah (1975), the nematode was introduced and confined to the localized areas of valleys and mid hills where Taiwanese rice varieties belonging to Chainung group were grown. Also, isolated epidemics, especially in Kathmandu valley were reported. In routine seed testing 11 rice varieties were found infected and of them Chainung-242, Taichung-176 and Chainan-2 were heavily infected (Manandhar 1987). Since 1980s the disease has not been encountered as a serious problem though white tip symptoms could be seen in rice fields. This author often found high number of *A. besseyi* from the seed of rice var. Khumal-4 (unpublished results). Seed treatment with benomyl is suggested.

Rice root nematodes

The rice root nematode *Hirschmanniella* was first reported by Amatya and Shrestha (1969). *H. oryzae* (van Breda de Haan) Luc and Goodey occurs throughout the rice growing areas (Manandhar and Amatya 1992). Later, *H. mucronata* (Das) Luc and Goodey was also found in lowland rice ecosystems from the Tarai (Pokharel 1993). Soil solarization during May significantly reduced the nematode population than solarization during November (Pokharel 1993). Slightly higher populations of *Hirschmanniella* spp. was found in the minimal tillage than in the conventional tillage fields (Sharma et al 2002a).

Pokharel et al (2004) reported from the field assays in long-term fertilizer experiments that significantly higher numbers of *Hirschmanniella* spp. were observed in the plots receiving N and P fertilizers as compared to those receiving N alone. Potassium fertilizer, up to 50 kg/ha, had no effect on rice root nematode populations, but significantly less nematode populations were observed in plots fertilized with 100 kg/ha potassium. Also, significantly less nematode populations and higher rice yields were observed in fields where farmyard manure was applied annually for 16-17 years. Incorporation of rice stubble and Dhaincha had no effect on nematodes.

Rice root-knot

Rice root-knot, caused by *Meloidogyne graminicola* Golden et Birchfield, is relatively a new disease of rice in Nepal. The nematode, first reported by Pokharel in 1993, is identified largely based on hook-like galls produced on rice roots. The nematode and its effects were reported in rice-based cropping systems (Pokharel 2001, Sharma et al 2001 and Sharma-Poudyal 2002b). Field surveys revealed that the nematode was more prevalent in dry bed conditions than wet bed (Dangal 2009). The nematode has also been found in Kathmandu valley infecting Khumal-4 and Taichung-176 with increased incidence (PPD 2012-2014, Manandhar et al 2016).

A detailed study, including morphometric measurements, perineal pattern, host range, variability in aggressiveness, and gene sequencing and phylogenetic analyses of the nematode were made and significant variation in aggressiveness was found (Pokharel et al 2007). Nematode-induced rice yield reduction was low when plots were supplied with nitrogen and phosphorus as compared to control plots (no fertilizer or compost) (Pokharel 2009). Sharma-Poudyal (2005) found grain yield reduction up to 97% in rice variety Masuli at highest initial population density (10 juvenile stage-2/g soil). Most of the commercial rice cultivars are susceptible to this nematode (Sharma-Poudyal et al 2004). Yield reduction up to 40% in farmers' fields was reported (Sharma-Poudyal et al 2002).

Several organic amendments in soils were tried and Persian lilac leaf treatment was found to reduce root-knot index (Sharma-Poudyal et al 2002a). Dangal et al (2008) found incorporation of chicken manure (2-3 t/ha) to improve rice seedling health in *M. graminicola*-infested soil. Also, growing seedling in nematode-free and wet seedbed minimizes the infestation of the nematode in field (Dangal et al 2010).

Other nematodes

Other nematodes reported with rice are *Xiphinema index* Thorne and Allen and *Longidorus elongatus* (de Man) Thorne and Swanger (Bhatta 1967), *Criconemoides, Helicotylenchus, Radopholus* (Amatya and Shrestha 1969) and *Tylenchorhychus* spp. (Pokharel 1993).

Virus diseases

Rice dwarf disease

Rice dwarf virus (RDV) was first reported by John et al (1978) as the presence of dwarf-like symptoms in rice fields in different parts of Nepal transplanted with the seedlings raised at Khumaltar. Later the disease was confirmed on rice cultivars KT32-2 and Taichung-176 grown in Kathmandu valley as transmitted by green leaf hopper, *Nephotettix nigropictus* (John et al 1979a), and by electron microscopy and serology (Omura et al 1982). The size and structure of the virus particles (polyhedral, ca. 70 nm diameter) were similar to those found in Japan.

The disease is seen sporadically in Kathmandu valley, but not affecting the crop significantly. Some insect transmission studies and screening of rice cultivars and lines were made (Upadhyay and Lapis 1982, Upadhyay et al 1982, Amatya and Manandhar 1987). In a survey Dahal et al (1993) detected RDV on Taichung-176 in Lalitpur with the incidence of 5 to 60%.

Rice tungro disease

Rice tungro was first listed in the fourth Annual Report of the Department of Agricultural Education and Research (DAER 1966). Later, the disease was reported from Parawanipur (central Tarai) as transmitted by green leaf hopper, *Nephotettix virescens* (John et al 1979b). In 1980, a disease with typical tungro symptoms appeared in Hardinath (eastern Tarai) and confirmed the rice tungro virus complex, polyhedral particles of about 30 nm in diameter (rice tungro spherical virus, RTSV) and bacilliform particles of about 30-35 nm in diameter and 100-300 nm long (rice tungro bacilliform virus, RTBV) by electron microscopy (Omura et al 1981).

The disease is seen sporadically in central Tarai, but not affecting the crop significantly. However, in a survey Dahal et al (1993) detected both RTBV and RTSV by both serology, and RTBV also by PCR. In cross hybridization studies, the RTBV-DNA from Nepal isolate was found closer to the Indian isolates than the Philippine isolates. They had detected the disease on rice cultivars Sabitri, Masuli and Makawanpur-1, with the disease incidence ranged from 10% on Sabitri to 80% on Makawanpur-1.

Other virus or virus-like diseases

Orange leaf was listed in the fourth Annual Report of the Department of Agricultural Education and Research (DAER 1969), but there are no further reports with confirmatory evidences. A number of virus-like diseases are seen in the rice fields. Since 2012 a collaborative project on IPM between NARC and Asian Food and Agriculture

Cooperation Initiative (AFACI), a number of rice samples with virus-like symptoms were sent to National Institute of Agricultural Sciences, South Korea for identification and none of them was diagnosed as virus disease.

Abiotic Diseases

Khaira

Khaira is a physiological disease caused by zinc deficiency. The disease occurs in the rice growing areas where imbalanced use of chemical fertilizer (using only nitrogenous fertilizer) is practiced and in low land area where drainage is a problem. During mid 1970s the disease was reported in almost all Tarai region from east (Morang to Jhapa) to mid west (Rupandehi), in valleys (Kaski and Chitwan) and even mid hills like Syangja (Shah 1985, Thapa 1976). Shahi (1975) reported the loss of 75% seedlings at Tarahara Agriculture Station and only 25% seedlings could be saved by spraying zinc. These days the problem has spread to other areas and many hilly districts, eg Nuwakot and Dhading.

Varietal response to zinc is significant (Manandhar 1987). However, varietal screening work has not been carried out so far. Application of zinc sulphate in soil @20-25 kg/ha is recommended. Also, 10 g zinc sulphate per sq. m. seedbed is suggested to avoid early suffering. If the disease occurs in the field, 2 to 3 spraying (at 10 days interval) with the mixture of 5 kg zinc sulphate and 2.5 kg of slaked lime in 1000 litre of water per ha is recommended.

Tip burn/Spikelet sterility

Tip burn due to cold injury is often seen in hill rice, especially under high hill conditions. Cold sensitive late maturing varieties may often result in spikelet sterility due to low temperature at heading and early maturity stage.

Increasing genetic diversity within a crop stand is one of the approaches to disease management. Such practice is common in our Nepalese agriculture, especially in the hills. This author had observed mix cultivation of at least three different local rice cultivars eg *Manamuri, Biram Phoole* and *Kode Gudura* in various districts of western hills (Parbat, Baglung and Myagdi). According to the farmers, the reason for such practice was to manage the pests and environmental stress (Manandhar 1987).

Acknowledgements

The author pays tributes to late Mr Bed Bahadur Khadka, the first Chief Plant Pathologist of Nepal, for his leading role in rice disease investigation and the plant diseases in large. The author would like to express sincere gratitude to his ex-boss Mr Purushottam Amatya and ex-supervisor Mr Birendra Jung Thapa, a senior colleague late Mr Hari Bahadur KC, colleague Mr Gopal Prasad Parajuli; and teachers Dr Suresh Behari Mathur and Prof. Viggo Smedegaard both from Denmark, for their inspiration and support during the work and studies on rice diseases. The author acknowledges Mr Bharat Upadhyay who guided him first time in identification of rice diseases in the field and conducting rice blast nursery; and all those whose contributions can be seen in the references listed below. Sincere thanks are due to Dr Bedanand Chaudhary, Ms Shrinkhala Manandhar and Dr Shisir Manandhar for going through the manuscript and providing suggestions.

Last but not least, I would like to take this opportunity to acknowledge Mr. Dila Ram Bhandari, who is the mastermind of and has orchestrated this whole volume of publication. In real words, this publication is a brain child of Mr. Bhandari. He and his team, especially at the Crop Development Directorate and Department of Agriculture, deserve high appreciation for hard work and tireless efforts they have put on it.

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Traditional Plant Protection Practices of Rice Production in Nepal

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सारांश

परापूर्वकालदेखि नै किसानहरूले खेतबारी र भण्डारणमा लाग्ने शत्रुजीवहरूको परम्परागत तथा स्थानीय तरिकाद्वारा व्यवस्थापनको उपायहरू अवलम्बन गरिरहेका छन् । किसानहरूले प्रकृति र उपलब्ध प्राकृतिक स्रोतहरूसँग जुध्दै जाँदा वातावरण मैत्री तथा आर्थिक दृष्टिकोणले दिगो अभ्यास तथा प्रविधिहरू विकास गरेका छन् । नेपालको भौगोलिक विविधता र स्थापित जातीय समुदायहरूको बनोटको कारण केही प्रकारको सीप/ज्ञान विकास भएको पाइन्छ । तथापि यसरी विकास गरिएका सीप/ज्ञानहरू साधारणतया प्रकाशित/अभिलेखीकरण भई औपचारिक शिक्षामा समावेश गरिएको छैन । यी सीप/ज्ञानहरू एक पुस्ताबाट अर्को पुस्तामा पुस्तान्तरण भएको भने पाइन्छ । खेतीबारीमा कृषि रसायन (विषादी) र शत्रुजीव व्यवस्थापनमा आधुनिक प्रविधि प्रयोग गर्ने युगको सुरुवाती सँगै बिरुवा संरक्षणको परम्परागत तथा स्थानीय तौर तरिकाबाट व्यवस्थापन गर्ने विधिमा वास्ता नगरिइएको वा विर्सिएको (भूल भैरहेको) देखिन्छ । हालको अध्ययन/समीक्षाबाट नेपालमा धानको शत्रुजीव व्यवस्थापनका उपायहरूको थोरै मात्र अभिलेख/दस्तावेज राखिएको स्पष्ट देखिन्छ । तथापि, हामीसँग प्रकोपित किरा, रोग, झारपात तथा चराहरूको अतिक्रमण विरुद्ध प्रशस्त परम्परागत विधिहरू प्रयोग भइआएको पाइन्छ । किरा तथा रोगहरू वानस्पातिक वस्तु तथा रसादिको प्रयोग गरेर, भौतिक तथा खेतीबारीको तौर तरिकामा परिवर्तन गरेर ज्यादातर रूपमा व्यवस्थापन गरिएका छन् । त्यस्तै गरी परम्परागत झारपात व्यवस्थापन भौतिक र खेतीबालीको तौर तरिकामा परिवर्तन गरेर गरिएको पाइन्छ भने चराहरूको व्यवस्थापन मुख्य तया भौतिक तरिकामै आधारित छ । हामीले परम्परागत तथा स्थानीय ज्ञान, सीप तथा विधिहरूको अभिलेखिकरण र वैज्ञानिक पुष्ट्याइँको लागि व्यापक प्रयासको आवश्यकता देखिएको छ । ती ज्ञान, सीप तथा विधिहरूको वैज्ञानिक पुष्ट्याइँ पछि आधुनिक बाली संरक्षणमा प्रयोग गर्दा बाली संरक्षणको क्षेत्रमा नतिजामुखी परिणाम/परिवर्तन आउने कुरा अपेक्षा गर्न सकिन्छ ।

Summary

Farmers have been combating the nuisance of several pests since ancient time through traditional practices of protection measures both in pre and post-harvest. Farmers interact with nature and available natural resources subsequently to develop ecologically sound and economically sustainable practices. Nepal's ethnic communities diverse as its geographical diversities had generated indigenous practices in rice farming. However, these practices in general were not documented and included in the formal education system but handed down from one generation to the next. After the commencement of agro-chemicals and modern techniques of pest management, these traditional systems of plant protection were neglected or forgotten. It is evident from the review that there is very little documentation on traditional plant protection practices of rice in Nepal. However, we still have many practices adopted by the farmers to tackle invading insects, pests, diseases, weeds, birds, etc. Insects-pests and diseases are being managed mostly by using botanicals, physical methods and cultural practices. Likewise, traditional weed management is a physical and cultural control method whereas bird control is mainly based on physical measures. There is need of comprehensive effort for documentation and scientific validation of traditional plant protection practices. Their integration with modern plant protection measures after fine-tuning is expected to bring meaningful change in plant protection paradigm.

Keywords: Botanicals, Indigenous practices, Physical and cultural practices, Plant protection, Rice

Introduction

Traditional farming system is an ecologically based, long established age-old farming system developed by ancient farmers through generations by interacting with nature and its components (Chhetry and Belbahri 2008). Farmers' unique practices, based on local knowledge gained through close interaction with natural and physical environments and cultural adaptation, are now recognized as eco-friendly and sustainable. Hence, those farmers once thought laggards are now considered innovators (Singh 2007). Even for the effective introduction of new technology on food production and storage, understanding of traditional plant protection practices in physical, socio-economic and spiritual context is a pre-requisite (Gurung 2002).

Nepal has one of the richest geographical diversities and many ethnic communities having rich traditional knowledge. However, in the modern days of technological advancement, this knowledge is often forgotten or neglected. Negligible efforts have been undertaken in a systematic way to understand the scientific basis of this knowledge (Sharma et al 2009). Moreover, use of agro-chemicals is now expanding all over the world including Nepal. Of the total pesticide consumption, about 40-50% is used in rice indiscriminately which results in several problems such as development of pesticide resistance pests, pest's resurgence, environmental pollution, health hazards and ultimate economic losses mainly in small holders (Pokhrel and Panta 2009). This situation has risen mainly due to elimination of natural enemies.

Many times, the farmers reject technologies deliberately produced by the current advances of science. Technologies promoted by state agricultural extension service largely failed in local conditions (Gurung 2002). Farmers, in many cases, are being neglected to be considered as true innovators. However, their long held practices generate economic and ecologically sound technologies. In this regards, documentation and scientific validation of farmers' traditional knowledge on plant protection should be prioritized.

Traditional system of insect-pest management

There are many factors leading to lower rice yield. However, infestations of insect-pests are responsible for 25-30% loss in rice yield in Nepal (Regmi 2004). Farmers rely on pesticides or chemicals to combat most of these pest problems. The traditional measures of plant protection are still in practice when and where chemical pesticides are in short supply. Richness in flora shows great scope for the development and use of botanical pesticides in Nepal (Palikhe 2002). Dangol (2008) reported that farmers use the leaves of some plants such as *Eupatorium odoratum*, *Lantana camara* and seeds of *Melia azedarach* as botanical insecticides to protect the crops. In addition, some important traditional plant protection measures are well documented and depicted in **Table 1**.

Table 1. Farmers' knowledge and practices on insect pest management in different location of Nepal

SN	Plant protection measures	Target insect pest	References
1	Combed out the cluster of rice leaves using branches of *Aiselu* or *ber (Zizyphus zizyphus)* and Bamboo (*Bambusa indica*) or locally available sticks	Rice leaf roller/rice moth	Pathak 2005, Sharma et al 2009
2	Removal of grasses around the bund of paddy field	Rice leaf folder	Sharma et al 2009
3	Application of grounded pulp of the *Khirro* (*Sapium insigne*) leaf into the paddy field through the irrigation channel or at water logged rice field	Rice leaf folder Stem borer (*Chilozonellis)*	Pathak 2005, Sharma et al 2009
4	Incorporating tobacco leaves in the puddle field	Stem borers	Thapa 2002
5	Growing rice variety Masuli which is less susceptible to stem borers	Stem borers	Thapa 2002
6	Clipping seedling tips to remove borer egg masses	Stem borers	Thapa 2002
7	Planting early in June to escape peak pest population	Stem borers	Thapa 2002
8	Hanging dead body of animals near the field	All insect pests of rice	Pathak 2005
9	Burning lamp in the field	Bugs and hoppers	Pathak 2005
10	Summer ploughing and preparation of new bunds to hold water	Many insect pest of rice	Thapa 2002

SN	Plant protection measures	Target insect pest	References
11	Trapping adult insects by using light traps, and favored naturally occurring biological agents (predators, parasitoids, pathogens) to suppress the population of rice stem borers in the field	Stem borers	Thapa 2002
12	Grain storage with ash or Neem	Storage pest	Sharma et al 2009
13	Mixing ash with cereals before packing; Putting Neem leaf put in different layers during storage; and mixing mustard oil cake with seed before packing	Storage pest	Giri 2004
14	Three to four times sun drying before packing; Bags of cereals kept in rice and wheat husk	Storage pest	Giri 2004
15	Using big mud bin (*Dehari*) for grain storage	Storage pest	Giri 2004

A comprehensive research by Giri (2004) on indigenous knowledge of Tharus in Surkhet district reported that they have been using wide range of plant species against insect-pests and diseases, which is summarized in **Table 2**.

Table 2. Plant species used to manage insect pest by *Tharus* of Surkhet

English/Scientific name	Nepali/Local name	Family	Methods
Malabur nut *(Justicia adhatoda* L.)	*Asuro* (N) *Roos* (T)	Acantheceae	Leaf extract as insecticide Mixed in soil for manure and soil insect control
Century plant (*Agave cantula* Roxb.)	*Ketuke* (N) *Kathya* (T)	Agavaceae	Mixed with soil to control soil insect
Mug wort (*Artemisia vulgaris)*	*Titepati* (N) *Titepati* (T)	Asteraceae	Leaf extract as insecticide Mixed with soil to control soil insect
Bahunia (*Bauhinia vahlii)*	*Bhorla, Malu* (N) *Mahurain* (T)	Leguminosae	Leaves are used for making *Poka** to store seeds
Pride of India *(Cassia fistula* L.*)*	*Raj brikshya* (N) *Ahiroga* (T)	Leguminosae	Used as poison for insects
Tobacco (*Nicotiana tabacum* L.)	*Surti* (N) *Surti* (T)	Solanaceae	Used to kill insect of vegetable and potato
Angle trumpet (*Datura metal)*	*Dhatura* (N) *Dhatur* (T)	Solanaceae	Fruit and parts of plant used to kill insect
Sweet flag (*Acorus calamus* L.)	*Bhojo* (N) *Boj* (T)	Araceae	Used in store
Ipomea carnea Jacq.	*Ajhambari* (N) *Dhoti* (T)	Convolvulaceae	Poisonous for many insects
Tori (*Brassica compestris* L.)	*Tori (N)* *Lahi (T)*	Cruciferae	Cake with oil used for controlling stored insects
Margosa (*Azadirachta indica* A. juss)	*Neem (N)* *Neem (T)*	Meliaceae	Repels insect Leaves used in storage
China berry (*Melia azedarach* L.)	*Bakaino* (N) *Boken* (T)	Meliaceae	Leaves used for controlling insects
Marsh pepper *(Polygonum hydopiper*)	*Pirrejhar* (N) *Biryajhar* (T)	Polygonaceae	Used as insect poison
Murraya koenigii L.	*Ban bakaino, Ashare* (N) *Bin binjhyarya, Bin binbhariya* (T)	Rutaceae	Used to control fleas Repellent for other insects It kills mite

English/Scientific name	Nepali/Local name	Family	Methods
Indian privet (*Vitex nugundo* L.)	*Simali* (N) *Sewanl* (T)	Verbenaceae	Used to control insect in vegetable
Smilax perfoliata	*Karot* (T)	Smilaceae	Leaf extract used for killing insect
Mivelliaextensa	*Gonjo* (T)	Leguminosae	Root powder kill insect Repel insect
Blumea lacera	*Kukur* (N)	Compositae	Leaf juice used to kill insect
Imperata cylindrica	*Siru* (N) *Siru* (T)	Graminae	Root extract used to kill insect (maggot)
Phoenix humilis	*Thakal* (N) *Khajuri, Khapat* (T)	Palmae	Root extract used to kill lice and other insects

*Note: N = Nepali name; T = Tharuname * A storage structure made up of Bauhinia leaves*

Source: Giri 2004.

On different field visits carried out by scientists of NARC, extension worker of Department of Agriculture, and other academicians, it has been observed that various traditional pest management measures are being adopted by the rice farmers throughout the country. However, most of them are not well documented (which is documented here in **Table 3**). Many of these traditional plant protection measures have been neglected after introduction and wider application of agrochemicals.

Table 3. Farmers' knowledge and practices on rice insect pest management in different location, Nepal

SN	Traditional knowledge/practice	Scientific reason(s)	Target/affected pests	Remarks/References
1	Clipping off the tip of rice seedlings before transplanting	This practice aids to remove egg masses of insects	Yellow rice borer	Adopted by most Tharu communities of Tarai
2	Mixing Kerosene (1 liter) with rice husk (5 kg) and applying on field		Rice Stem borer	Laxmi Bhadri, Illam 2069, personal communication
3	Broadcasting milling by-product – mustard cake in the field	Mustard cake improves the soil fertility, thereby increasing vigor of the plant.	Borer complex	Adopted by farmers of Tarai region including Chitwan
4	Collecting and burying infested or damaged parts of the plants during weeding	This practice kills the pest	Borer complex	Location: All rice growing areas
5	Drying rice field for one week		BPH	Hemmaya Chaudhary, Kanchanpur 2070, personal communication
6	Use of SimaliJhar, flood irrigation and building trench in rice field	Water or plant treated with toxins disrupts the lifecycle of armyworm	Armyworm	Tej Bahadur Basnet, Caritas Nepal 2070, personal communication
7	Spraying mixture of Ginderi juice and sour curd in field		Rice Hispa	Hem Maya Bhandari, Kaski, personal communication
8	Use mixture of dried and grounded maize with salt	Dried grounded maize attracts GH and salt destroys digestive system of GH	Grasshopper	Dhan Bahadur Rana, DADO, Kaski 2069, personal communication
9	Using wood ash as manure in the nursery bed and rice field	Ash provides potash and it strengthens the stem wall of plant	Pest of general importance	Location: Almost all rice growing areas

SN	Traditional knowledge/practice	Scientific reason(s)	Target/affected pests	Remarks/References
10	Growing legumes such as soybeans, black gram, pigeon pea on bunds of paddy field	Either acts as trap crop or checks the movement of pests. The fallen leaves serve as good source of nutrient for plants. Besides, it suppresses the weed, which may act as alternate or collateral host for pest.	Pest of general importance	Location: most rice growing areas of Tarai and mid hills
11	Mixing non-edible parts of jackfruit (*Artocarpus heterophyllas*) into irrigation channel or field	Plant grows vigorously as jackfruit improves soil fertility. Plants are resistant to pest damage.		Location: Tarai including Chitwan
12	Using thorny plants such as Baer to drag the rice in leaf folder and gall midge infested field	Thorny plants damage the home of leaf folder and gall midge so it is exposed to the predators or killed by environmental factors	Leaf folder and gall midge	Location: Tarai
13	Keeping dirty trap (jute soaked with animal urine and dung) in rice field at plant height. Killing of attracted bugs in early hour of the morning	Bugs are attracted on dirty trap and they can be killed manually	Gundhi bugs	Location: Tarai
14	Attracting bug by hanging poultry intestine in field and then killing		Gundhi Bug	Chandra Prabha Dahal, Morang 2070, personal communication
15	Spraying mixture of garlic (60 g), chilly (60 g) and water (1 ltr) for one week in milking stage of rice		Gundhi bug	Chandra Prabha Dahal, Morang 2070, personal communication
16	Using early season varieties	Host escape	Gundhi bug	Location: Tarai and mid hills
17	Maintaining standing water where termite problems was common	Standing water distracts termites' life cycle	Termites	Location: Eastern Tarai
18	Raising of wet nursery bed instead of dry	Anaerobic condition created which is not suitable for soil borne insect pest	Soil dwelling insect pest	
19	Burning of plant debris, paddy straw, dried weeds etc in the nursery plot before ploughing.	This practice aids in soil sterilization and kills soil dwelling/borne pests. The ash acts as potash source.	Soil dwelling pests	Location: Tarai including eastern part of Chitwan
20	Preparing botanicals by grinding of overnight soaked tobacco leaves	Tobacco contains Nicotine Sulphate, which kills the pest	Insect of general importance	
21	Preparing bunds before growing new crops especially in *Kharif*	This practice destructs the hibernating site of insect as well as holes of rodents	Insect pest, rodents, weeds	
22	Cutting of bund grass frequently	Reduce hiding place for insect and inoculating place for pathogens	Insect of general importance	
23	Planting of the Tulsi, Marigold in the border of the rice field	These plants repel the pest from the field (repellent)	Insect pest of general importance	

SN	Traditional knowledge/practice	Scientific reason(s)	Target/affected pests	Remarks/References
24	Spraying cow urine and water	It aids nutrition to the plant, thereby plants grow vigorously. Vigorous plant is less countered by pests.	Insect pest of general importance	
25	Using urine fermented botanical spray (UFBEs)	It acts as repellents	Insect pest of general importance	Location: Many rice growing areas mainly mid hills
26	Allowing ducks to rice fields	Ducks feeds on many insects of rice field	Insect pest of general importance	

Traditional system of disease management

Rice diseases result in yield reductions of 10-15% in tropical Asia (Savary 2000). People have tried to prevent or cure plant diseases by using different means and methods for a long time (Shrestha et al 2014). Very few traditional techniques on disease management are in practice. Some practices are depicted in **Table 4**.

Table 4. Farmers' knowledge and practices on disease management in different location, Nepal.

SN	Indigenous practices	Target disease	References
1	Fresh cow dung application during day time (2-3 times)	Blight	Tanka Kattel, Jhapa, personal communication
2	Wood ash solution	Blight	Pathak 2005
3	Drying rice field	Foot rot	Dhan Bahadur Rana, DADO, Kaski 2013, personal communication
4	Plant extract (*Neem, Titepati, Timur*)	Blast	Pathak 2005
5	Khirro (*Sapium insigne*) plant at water logged rice field	Blast	Pathak 2005

Traditional system of weed management

Weed in rice is believed to be one of the major factors limiting the productivity of rice in Nepal and its surrounding areas. Weed menace is a major problem in both the upland and lowland rice ecologies. Ranjit (2007) observed that weeds caused yield loss of 14-93% in direct seeded rice whereas in transplanted rice it was 17- 47%. The exact date for initiation of cognizant weed management practices in rice crops, and perhaps other crops is not well documented. However, farmers have been consistently involved in control of major weeds in rice fields with indigenous knowledge accumulated throughout farming history. From the very beginning of rice cultivation in Nepal, farmers got involved in weed control aiming for good harvest from their rice fields. Specially, weed management practices in rice are followed strictly, compared to other cereal crops owing to the importance of rice grains in Nepalese society as a major staple crop.

Traditional practices of weed management

Manual hand weeding is a common practice all over the country for all kind of weeds in rice fields. Farmers of Chitwan and Nawalparasi practice weeding once or twice during crop growing periods (Thapa 2002). Sherpa (2005) reported some of the traditional knowledge on weed management practices adopted by the farmers of Nepal. Farmers plough their fields approximately fifteen days before planting to kill the seeds of the weeds. During dry season, burning of the weeds in the bunds and terraces is also prevalent.

Puddling operation is common which effectively incorporates the weed seed and weed biomass in the reduced zone, and is regarded as the complementary method of weed management in rice. The precise leveling of land by using bullock-driven wooden plank lessens the chances of weed infestation due to better water stagnation in the field. Even if seedling is established, weed growth will be minimum. Transplanting practice, itself, selectively creates favorable situation to rice seedlings to grow faster without interference of weeds during early phase of rice seedlings establishment. Moreover, farmers remove weeds during uprooting of rice seedlings on the nursery bed. During transplanting preparations, bunds are also repaired and maintained in such a way that they do not contain any weeds.

Stagnant water after transplanting suppresses the weeds, requiring more aerobic situation for germination and growth. It is apparent that most farmers in Nepal maintain standing water in their fields for weed management. Major problematic perennial weed like *Cynodon dactylon* and other major grass weeds are drastically reduced by the flooding operation. Sowing soybean, pigeon pea or black gram on bunds could have positive impact in managing problematic weeds, including perennial ones.

Stale seedbed preparation before establishing dry nursery bed is a common practice in some rice growing areas of eastern Nepal. In addition, some farmers prepare dry nursery inside the standing crop just before the rice season, mainly in the maize field. The weeds in maize fields are already controlled by manual weeding and further tillage in the field for nursery preparation lessen weed infestation in nursery. This practice also provides the basis for early transplanting of rice seedlings which ultimately gets competitive advantage over weeds. Rice seedlings once established, dominates over lately emerged weeds in rice crops.

Practice of green-manuring may have smothering effect on weeds and incorporation of green manure crops into the soil reduces weed infestation to a large extent in subsequent rice crop. Farmers plough the field deeply in summer months (April, May or June) well before the onset of monsoon to expose lands to sun, which controls soil borne pests, including weeds. Land is left in a cloddy situation without watering it. Major propagating materials such as roots, rhizomes and tubers of shallow rooted perennial weeds like *Cynodon* and *Cyperus* are dried up by the scorching sunlight.

Farmers are using crop rotation as a tool for getting diversified agro-products. Baral (2012) reported that growing crops like wheat, maize and soybean in rotation with rice decrease weed seed bank and abundance of broadleaf weeds. In rice-fish integrated system, use of fresh water carp fish consumes aquatic weeds, thus reducing weed infestation. Weeds do not need to be removed often because fish consumes some weeds (Gurung and Wagle 2005). Farmers often do sickling or mowing of weeds emerged in bunds for fodder purpose, particularly before flowering period, which reduces the chances of propagation of weeds.

Traditional system of bird management

Birds like sparrow, dove, pigeon, etc cause problem to farmers during nursery and maturity period of rice. Losses by the birds, however, were not recorded by authority or research stations but it is obvious that the nuisance is prevalent throughout the country. Farmers mostly adopt knowledge or practice they have gained through generations (**Table 5**). Physical and mechanical methods are employed by the farmers to make the birds fly away.

Table 5. Farmers' knowledge and practices on bird management in different location, Nepal

SN	Traditional knowledge	Scientific reason/s	Remarks
1	Practicing throwing stone inside polythene towards birds flight	This practice scare the birds, so they flew away from such sites	Location: Tarai and mid hills; children and woman do such practice
2	Beating of steel plate or drum	Sound repellent	Location: Many locations of rice cultivation
3	Using unreeled VCR reel in field	Reflected light and scattering noise (due to wind) scare the birds	Location: Tarai and Kathmandu valley

SN	Traditional knowledge	Scientific reason/s	Remarks
4	Erecting branches of stick with plastic or polythene at the top at maturity period of the crop	The struck of polythene with wind produces sound	Location: many areas of Kathmandu valley
5	Using scarecrow (man like structure made of rice straw wearing human dress) at the paddy field mainly during grain filling stage	Birds perceived a scarecrow as real man and birds flew away	Location: Many rice growing areas of country

Conclusion

Traditional farmers through long experiences derive indigenous pest management strategies during their interactions with nature. For generations, farmers have been cultivating rice as a major staple food crop in Nepal. Consequently, they have accumulated ample of indigenous knowledge to confront the challenges during the crop season, as well as during storage of rice. Most of the traditional practices are scientifically proven and others have some logical ground. Without doubt, insect-pests, diseases, weeds and birds are the biotic factors that often tend to reduce crop yields depending upon severity of infestation. Farmers' traditional practices are, no matter, well fitted in the age-old farming system. However, this is not sufficient for the present and future agriculture. On the other hand, exclusive use of chemicals in agriculture is considered unsustainable. Conclusively, an integration of the indigenous knowledge and formal pest management knowledge paves the way for sustainable agriculture that can feed both the present and future generations.

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Integrated Pest Management and its Contribution in Rice Production of Nepal

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सारांश

धान बालीमा खैरो फडके किराको महामारी नियन्त्रण गर्न तत् अवस्थामा उपलब्ध रासायनिक विषादीहरू अप्रभावी भएपछि "एकिकृत शत्रुजीव व्यवस्थापन" विधिलाई व्यापकरूपमा कार्यान्वयनमा ल्याउन आइपिएमका सिद्धान्त, उद्देश्य, मूल्यमान्यता र पालना गर्नु पर्ने विधि बारे दक्ष आइपिएम सहजकर्ता तयार गर्न धान बालीमा पहिलो आइपिएम कृषक पाठशाला संचालन गरी क्रमशः देशका विभिन्न स्थानहरूमा यो कार्यक्रम संचालन गरिएको हो । आइपिएम कृषक पाठशाला संचालनबाट विषादीको जथाभाबी प्रयोग हुनमा कमी गर्ने र सुरक्षित एवम् स्वस्थ कृषि उपजको उत्पादन वृद्धि गर्ने उद्धेश्य राखी दशौं योजना अवधिबाटै आइपिएम कार्यक्रमलाई बाली संरक्षण रणनीतिको मुख्य अंगको रूपमा लिइएको थियो । त्यसपछिका दीर्घकालीन कृषि योजना र कृषि रणनीतिमा पनि यसलाई प्राथमिकता दिइएको छ । बहुसंख्यक नेपाली कृषकको लागि आइपिएम नौलो विषय नभएतापनि कृषि व्यवसायिकरण गर्ने क्रममा रासायनिक विषादीको प्रयोग बढेकै छ । तर राष्ट्रिय स्तरमा खास विषादी प्रति हेक्टरको प्रयोग ०.३९६ के.जि. मात्र भए पनि विषादीको जथाभाबी एवम् अविवेकी प्रयोग कम गरी सुरक्षित वातावरण र स्वस्थ कृषि उपज उत्पादन गर्न आइपिएम कृषक पाठशालाको महत्वपूर्ण योगदान रहेको देखिन्छ । हालसम्म मुख्य खाद्यान्न बालीमा २१५६ वटा कृषक पाठशाला संचालन भएका छन् र कूल विभिन्न बालीमा ३६८२ वटा पाठशाला संचालन भई करिब १ लाख कृषक लाभान्वित भएका छन् । हालसम्म भएका विभिन्न अध्ययनबाट आइपिएम कृषक पाठशालाले मुख्य खाद्यान्न बालीमा उत्पादन वृद्धिमा योगदान पुऱ्याउनुका साथै कृषकको ज्ञान/सीप र निर्णय गर्न सक्ने क्षमता वृद्धि गराई कृषक सशक्तिकरणमा महत्वपूर्ण योगदान पुऱ्याएको छ । हाल यस प्रविधिको अनुसरण पश्चा् बहुसंख्यक कृषकले लगाएको बालीमा हुने रोगकिराको नोक्सानबाट बचाउन क्षणिक उपायको प्रयोग भन्दा दिगोरूपमा वातावरण र मानव स्वास्थ्य मैत्रीबाली संरक्षण उपाय अवलम्बन गर्नु पर्ने आवश्यकतामा दृढ देखिन्छन् र हालैका दिनहरूमा विषादीको विवेकपूर्ण एवम् सन्तुलित प्रयोग गर्ने परिपाटीको समेत विकास भैरहेको छ ।

Summary

Brown plant hopper (BPH) epidemics in Chitwan valley in early rice was the activator for integrated pest management program in Nepal. First Farmers Field School (FFS) to prepare Integrated Pest Management (IPM) facilitators was organized using rice crop to impart the concept, knowledge and practice of IPM. Since the tenth five year plan period, IPM approach has been the national strategy for plant protection. Though the national average use of active substances of pesticide applied per hectare is 0.396 kg. Misuse and overuse of pesticides has triggered the need of IPM approach for plant protection and national IPM project was initiated and till 2015, more than 3682 FFS have been conducted, out of which about 2156 FFS were implemented in cereal crop only and altogether around 100 thousand farmers are exposed to IPM-FFS. The impact of IPM-FFS, though actual production gain was small, it's contribution was significant on awareness on its importance for reducing the use of hazardous chemical pesticide and ecological philosophies, farmer's empowerment, knowledge and skills and change in farmers' attitude in farming practices. Farmers now talk about long-term prevention of pests or their damage by managing the ecosystem rather than simply eliminating the pests giving due attention to environmental factors that affect the pests damage.

Keywords: Farmers empowerment, Farmers field school, Integrated pest management

Background

Integrated Pest management (IPM) is not completely a new phenomenon in Nepalese farming system. In early days, the use of hazardous chemicals in agro-ecosystem was minimal as the natural enemies of the pests by default were appropriately balancing the pest population below economic injury level. After 70's era with the introduction of high yielding varieties together with higher dosage of chemical fertilizer and pesticide gradually lead to its overuse and misuse in agriculture. Especially to minimize the crop yield loss due to insect and disease pests which is in the range of 25-35%, (PPD 2013) the use of chemical pesticide increased. Study done about a decade back shows that pesticides used in rice was 40–50% of the total pesticide consumed in the country, followed by grain legumes with 14–20%, fiber crops with around 13–15%, and vegetables and fruits with 10–20% (Manandhar and Palikhe 1999), but the trend has been changed. The national average use of active substances of pesticide per hectare is 0.396 kga.i. which is higher than the corresponding old value 142 g reported in 1995 but is lower than world average 0.500 kg ai/ha (KC and Palikhe 2014). Though it is less than the use in Pakistan, Bangladesh, and India but in general it has alerted many consumers. The epidemic of brown plant hopper in Chitwan area in early rice (inner Tarai) in 90's necessitated the development of IPM-FFS program in Nepal.

Since the tenth five year plan period IPM approach has been the national strategy for plant protection. Agriculture Perspective Plan, all periodic plans and recent Agriculture Development Strategy 2013 have also duly prioritized IPM approach for pest control.

IPM in rice farming

Rice is a major cereal crop of Nepal both in terms of production and area (5.05 million metric tonnes from 1.49 million ha) and about 77% of the total rice production takes place in eastern, central and western region (MoAD 2014). The share of eastern region is about 28%.The first IPM-FFS program was started from eastern region and rice was chosen as the model crop for imparting the concept and principle of IPM.

In the early days of IPM initiation, Nepalese farmers had older concepts of IPM that was based on intensive scouting and economic thresholds (Morse and Buhler 1997) concept was also in practice but in limited scale. But after 2000'era, it was based more on integration of management practices that went beyond scouting and economic threshold levels for decision- making (Kenmore et al 1984). After the Indonesian success in BPH management, IPM approach and the process have moved to many rice growing countries and Nepal is one to follow it, with objectives to grow healthy crops and empowerment of the farmers. In addition, it also supported to expand the Farmer Field School (FFS) to educate farmers for a market-oriented economy including farmers to farmer extension services, partnership and collaborative relationship among all the extension service providers (CBOs/NGOs/Private Sectors) and research agencies. The system has gained popularity in many districts among the farmers as it addresses the needs of the farmers of all categories in the rural areas.

Through FFS, farmers learn the field environmental condition and the farmers get exposed to variety of field problems in their community including technical, political and markets. Farmers also got chance to select technology that directly benefits them in view of their socio economic condition and their livelihood. Further, it has been noticed that FFS graduate farmers are more capable of making decisions over their farming practices and issues related to their livelihood. They can make better decision when they understand the problem themselves through their own involvement. FFS provides farmers to become expert in their field, master the ecological principles needed to manage their crop in the field organizing FFS based on plant growth (**Figure 1**). It has also supported to reorient use and application of, inputs and overall vision of extension service towards empowering the farmers. IPM field schools do not focus on insects alone, they provide farmers an opportunity to learn and achieve greater control over the conditions that they face every day in their fields.

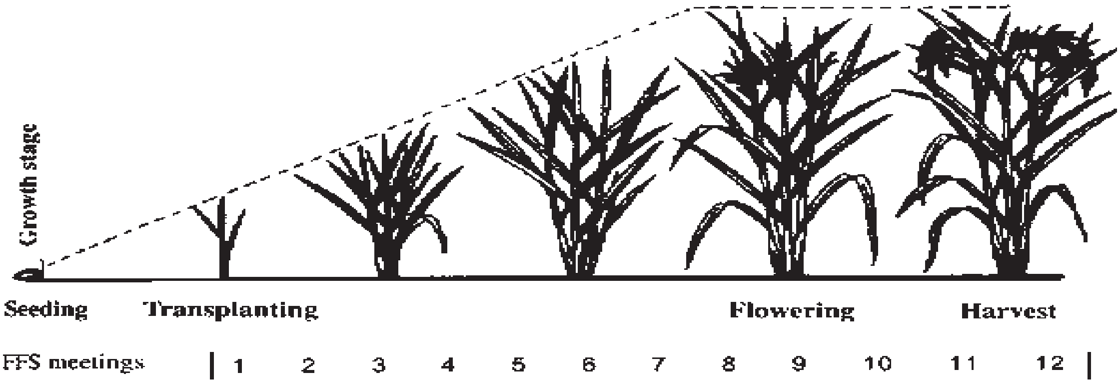

Figure 10. Plant growth and FFS meetings (number of meeting varies as per location/variety available resources etc)

Understanding the IPM

Till date, many technicians and scientists talk about IPM but don't fully understand its inner meaning. Generally, IPM has been understood by many as an alternative to chemical pesticide and talk only about pest control but in real sense it is not true. IPM does not talk only about pests and pest control tactic rather it emphasizes more on management of the whole production system. The heart of the IPM is Agro-Ecosystem Analysis (AESA) which addresses: land, labor, water, air, and temperature, and social aspect; empirical based information about plant, fertilizer and farmers. Based on system based analysis on these parameters farmers themselves decide what improvement it requires further for safe and healthy rice production. IPM as a matter of fact, is a cultivation practice for growing healthy crops, making farmers a technician and transforming technicians into farmers. Farmers Field School (FFS) has been the flag of present day IPM. A FFS is a school without any walls and a participatory approach, building sustainable capacity for food production systems that motivates the farmers to adopt IPM. A FFS graduate farmer is able to select technologies and understand: the rights of farmers, access to land and water, profitable cropping patterns, and price supports. IPM originally was understood as Integrated Control Tactics ie combination of chemical and biological control methods (Michelbacher and Bacon 1952).The concept of pest management was coined by Geier and Clark (1961), and convergence of the concepts of integrated control and pest management, into integrated pest management, opened a new era in the protection of agricultural crops (Kogan 1998).

Major components common in Nepal IPM programs

- Pest identification,
- Monitoring and assessing pest numbers and damage,
- Guidelines on when management action is needed,
- Preventing pest problems and
- Using a combination of biological, cultural, physical/mechanical and chemical management tools

IPM-FFS Status in Nepal

After the outbreak of BPH in early rice in Chitwan district in 1996, a pilot program on IPM was initiated based on season long Farmer Field School (FFS) approach in May 1997 through Technical Cooperation Programme (TCP) of Food and Agriculture Organization (FAO) of the United Nations under "Implementation of Integrated Pest Management in Rice" project (TCP/NEP/6712). This was followed by Nepal's participation in the FAO Regional Programme on Community IPM in Asia between 1998 and 2002 funded by the Government of Norway.

During the period, Nepal succeeded in training 104 officer level trainers for IPM in different crops, of which 70 were in rice, and 34 in vegetables. Similarly, 35 Junior Technicians (JT) and Junior Technical Assistants

(JTAs) were trained as trainers. At the farmers' level, 301 farmers in 42 districts were trained as trainers. Among them, 56 were women trainers. Altogether, from the FAO/Norwegian Government supported project alone, about 633 different Farmer Field Schools (FFS) were conducted. Since 1998 the total number of FFS implemented in cereals crop is around 2156 and altogether in different crop, the number exceeds 3682 (PPD 2013 and D Tiwari 2015, personal communication).

The total number of farmers exposed to FFS were 100,000 during 1998-2015 period in one or other form. Though actual production gain is very small but awareness on its importance for reducing the use of hazardous chemical pesticide has been succeeded. After their involvement with FFS, farmers understand the difference between good and bad insects. Farmers know how to grow a healthy crop by adopting handsome cropping practices including the best use of local resources.

Steps followed in FFS in Nepalese context

Site Selection

The site is identified through review of district profile; annual implementation program of user's community, and all available sources.

Preparatory meeting

After site selection a 3 days meetings are conducted before conducting FFS. The objective of the meetings are

- to inform the program to farmers, local leaders and other concerned stakeholders,
- to collect socio-economic data are collected by applying serve of the tools of PRA (cropping calendar, gender role analysis matrix),
- to select the farmers,
- to identify the production constraints and local problems faced by farmers in the community and
- to design field trials to overcome local problems and improving tentative curriculum.

Agro-ecosystem analysis stages

This is both the heart and brain of FFS as the farmer conduct season long field trials to study different component of integrated pest management practices (IPMP). Farmers study the IPM practices and farmers' practices to compare the difference and learn the difference while making observation and analyze the crop growth, yield and other relevant parameters that help them to make right decision. With the crop growth, every week farmers carry out agro-ecosystem analysis in the trial plots. Agro ecosystem analysis help farmers to understand about component of ecosystem and its interaction. It helps them to design management strategies on the basis of all the components of ecosystem such as climate, weather, soil, environment, crop weeds, pest and natural enemies.

Special topics session

In every school day/session, group conducts a participatory discussion to understand the special issue(s) come across during the FFS season. This session provides comprehensive knowledge of the issue and its possible way out. The facilitator initiates special topic or topic on demand of farmers after analyzing crop ecosystem together that is relevant to the crop growth stage. Some special topic in other areas such as group mobilizes leadership; gender, communication skill, etc are also included in the special topics.

Group dynamics

Team building and group dynamics activity is an important feature of the IPM training process in the FFS. Group dynamics encourage interactions, helps developing leadership, decision making skill and value reorientation to the participants.

Evaluation

The participants are tested and evaluated their level of knowledge before and after learning in FFS. This helps to measure the knowledge changes from the education programme. Interview, questionnaire, ballot box, spotting are the methods taken to test, however ballot box test is found effective if there are illiterate farmers.

Field day

At the end part of FFS, a field day is organized. The purpose of field day is to demonstrate the result of different trials and studies, disseminate the IPM practices comparing the local practices. The field basically organizes to motivate the non-participants farmers, local leaders and community based organizations for getting their co-operation and commitment in favor of IPM in future. Generally, at the same time graduation ceremony is organized and certificates awarded to the participants.

IPM-FFS contribution in rice cultivation including farmers' view

IPM contribution in Nepalese rice is that it has empowered rice farmers to produce safe and healthy crop by long-term prevention of pests or their damage by managing the ecosystem rather than simply eliminating the pests giving due attention to environmental factors that affect the pest and its ability to thrive. Followings are the feedbacks from farmers.

Before IPM-FFS, we planted more than 5 seedlings per hill thinking more numbers we plant more yield we will get. Now we know that we can transplant 1-2 seedlings per hill and it gives many tillers and better yield.

There has been reduction in the use of pesticide and improved the use of other inputs judiciously. Rice farmers used to spray insecticides based on their perception of potential damage and losses caused by pest species. Farmers generally over estimate the seriousness of the rice leaf eater from visible damage and apply insecticides early, but after FFS participation their perceptions have been changed and now they do not spray unless the damages level goes beyond 25%. At the same time, the use of botanical pesticides (Jholmal) has been popularized among the farmers. Use of sweet flag, neem, prickly ash, rape seed, clipping of seedlings tips, maintenance of water level, cleaning of bonds and terrace walls, use of indigenous variety that is less susceptible, weeding, summer ploughing, use of tobacco leaf, juice, early planting, use of light traps (like kerosene lamps or fire burn in the night time) are gaining popularity among the farmers.

IPM-FFS has been a good module for training farmers to make them expert rice technicians. With the practices of use of healthy seed and appropriate varieties, strong seedling management, proper soil preparation, correct time of planting has helped to achieve the goals of FFS ie farmers' empowerment. FFS graduate farmers have increased collective bargaining power for lobbying and advocating their common interests as FFS makes farmers expert in their own farm because of regular and close observation of their crop field. Their tendency of 'talking to the plant' has led to farmer's innovations in farming system.

Issues as experienced by the farmers in rice FFS

Most farmers are used to short duration classroom based training and season long training by itself was some what unusual to them and regularity in participation in FFS was difficult for the whole season. FFS for preparing trainers was costly. There is lack of research on ecological principles to suit the yearlong FFS. Special commercial production zones have low confidence in natural,/biological or cultural control method. Farming has to deal with living and nonliving and also with socio political and economic issues and IPM-FFS need to understand the network of the system. No standard technical norm in existence for IPM-FFS have been formulated. The existing norms are basically financial but with no crop specific technical norms. It is most often said that IPM-FFS is donor dependent. Weak self-scaling-up of IPM-FFS approach has also appeared as major issue in IPM-FFS approach in Nepal.

Suggestions

The IPM-FFS approach adoption coverage need to be increased undertaking a large-scale IPM programme with large number of farmer's groups across the country. It is desired to set specific targets making changes in training program and, educational institutions curriculum and policies to enhance local production of nontoxic plant protection products eg natural enemies and semio-chemicals is desired. FFS study done in rice shows up to 40% reduction in chemical pesticide use and there has been 15-25% yield increase in yield (GC et al 2009).

Conclusion

Rice was domesticated perhaps more than 6000 years ago and since then pests and their natural enemies have existed together and coevolved for thousands of generations. Rice ecosystems typically include both a terrestrial and an aquatic environment which have been able to harbor the populations of both beneficial and harmful insects. Rice plants have ability to compensate for damage. Rice plant rapidly develops new leaves and tillers early in the season, replacing damaged leaves quickly so the farmers knowing this fact need not to apply any pesticide even if some leaf eaters damage up to 25%. It has been also observed that early spraying of insecticides during the first 40 days of the crop increases the risk of higher pest populations later in the crop season. IPM aim is primarily for long-term prevention of pest's damage managing the ecosystem to keep pests from becoming a problem either by growing a variety that withstand pest attacks or make farmers capable to create conditions that are unfavorable for the pest. Thus in IPM, monitoring and correct pest identification plays important role while taking control related decisions. However, effectiveness of rice pest management approach need to have full understanding of the crop physiology, morphology and interaction with soil nutrient along with the common pest control tactics (biological control, cultural controls, mechanical and physical controls and chemical control).

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Status of Pesticides and their Uses in Rice Production of Nepal

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सारांश

विवेकपूर्ण र सन्तुलित विषादीको प्रयोगसँग धानको उत्पादनको सकारात्मक सम्बन्ध रहेको हुन्छ । तर कृषिको व्यवसायिकरणको नाममा हालैका वर्षहरूमा धानमा विषादीको प्रयोग बढ्दै गइरहेको पाइएको छ जसले गर्दा मानव स्वास्थ्य र वातावरणमा समेत प्रतिकूल असर पार्न सक्ने तर्फ गहिरो चासो पनि कायम रहेको छ । खाद्यान्न बालीहरूमध्ये सबैभन्दा बढी विषादीको प्रयोग धान बालीमा गरिएको पाइएको छ । खाद्यान्न बालीमा प्रयोग हुने ७.५% कूल विषादीको अंश मध्ये धान बालीमा मात्र उक्त परिमाणको ७५% प्रयोग भएको पाइएको छ । औषतमा धान बालीमा प्रति हेक्टर ३८० ए.आई. प्रति हेक्टर विषादी प्रयोग हुने गर्दछ । सामान्यतया रोग किराको प्रकोप देखिसकेपछि मात्र विषादीको प्रयोग गर्ने प्रचलन रहिआएको छ । धान बालीमा रोग किरा र झार व्यवस्थापनको लागि सम्पर्क, आन्तरिक र दैहिक प्रकारको किटनासक विषादी प्रयोग गरिदै आइएको छ । ढुसीनासक र झार नासक विषादीको हकमा भने सम्पर्क र दैहिक प्रकारका विषादीको प्रयोग गरिने गरिएको छ । विषादीको उचित प्रयोग र व्यवस्थापनका लागि कृषकलाई तालिम तथा जैविक विषादी प्रयोगमा सचेतना अभिवृद्धि तथा आइ.पि.एम. प्रविधिको प्रवर्द्धन गर्नुपर्ने आवश्यकता रहेको छ ।

Summary

Rice yield is generally positively associated with judicious and rationale use of fungicides, herbicides and insecticides. The trend of pesticide use in Nepal is gradually increasing each year resulting serious concern on harmful effect of pesticides in human health and environment. Pesticides use in rice is more than any cereals crops. Out of 7.5% of total pesticides used in cereals, 75% of pesticides are used in rice. The average use of pesticide in rice is found to be 380 ai/ha. The use of pesticides is generally after the outbreak of pest in the field. Contact and systemic fungicides and herbicides, and contact, systemic and stomach insecticides are used as a chemical treatment for insect pests and diseases. The urgent need is felt to train farmers about monitoring the farm regularly and take necessary action accordingly; create awareness regarding use of bio-pesticides and promote IPM technology for crop management.

Keywords: Fungicides, Herbicides, Insecticides, IPM technology, Monitoring, Rice, Yield

Introduction

Experiments with the intensive use of pesticides have determined that the yield potential of rice varieties in Asia is about 10 t/ha (Peng et al 2000). One recent Study estimated that between 120 and 200 million tonnes of grain are lost yearly due to insects, diseases, and weeds in rice fields in tropical Asia (Willocquet et al 2004). The mean region-wide rice yield loss due to pests was estimated 37%, where in Nepal it is estimated 20-25%. There is huge scope for significant increases in rice productivity in Asia through adoption of Good Agricultural Practices particularly with the judicious use of pesticides. A study of yield-limiting factors in tropical Asian rice fields determined that fungicide, insecticide and herbicide use were all positively associated with higher yields.

Collectively, rice diseases result in yield reductions of 10-15% in tropical Asia. Brown leaf spot, sheath blight and blast are present wherever rice is grown. These three diseases are responsible for losses of 10% or more each whereas rice insect result in yield reduction of more than 15% in Nepal. Stem borer and gundi bugs are the main insects. On an average, Nepalese rice farmers apply insecticides 2-4 times per season. Introduction of new selective insecticides non-toxic to natural enemies has improved the management of rice insect pests due to the intervention of IPM program in the country.

History of pesticide use in Nepal

Introduction of chemical pesticides in Nepal was recorded at the early sixties, when Paris green, gamaxone, and nicotine sulphates were imported from USA (United States of America) for malaria control. DDT (Dichloro diphenyl trichloro ethane) made its first impact in 1956. This was in continuous use by a variety of other organochlorines (1950s), organophosphates (1960s), carbamates (1970s), and synthetic pyrethroids (1980s) (Neupane 1995). Until 1950s, Nepalese were unaware of modern chemical pesticides and were dependent upon traditional organic techniques for managing disease and pests. Nepal Malaria Eradication Program (NMEP) in the 1950s was the first major channel to utilize pesticides. The chemical pesticides, provided through the grant assistance by USAID (United Nations Association for International Development), were initially in limited quantity, especially for the control of vector-borne diseases, like malaria. As a result of this program, there was ninety nine percent reductions of malaria cases by the time the program was concluded in early seventies.

Since after the introduction of pesticides in Nepal, its use has been increasing rapidly for the purpose of improving crop yields, controlling and eradicating vector borne disease, pests, disease control in agriculture and forest crops. The numbers of farmers using pesticides have been increasing over the year. Unfortunately throughout the world, overuse and misuse of chemical pesticides in agriculture cause environmental and health damage and Nepal is no exception (Sharma et al 2014).

Most pesticides used in Nepal are imported from India, some from China and other countries on the basis of a registration. Average pesticides use in Nepal is 396 g/ha (Sharma 2015), which is very low as compared to other Asian counties. Pesticide use, however, is much more intensive in areas that have greater access to markets.

The use is higher in areas with intensive commercial farming of vegetables, fruits, tea, cotton and rice. Under the present scenario, as reported by many, judicious and prudent use of pesticide by the Nepalese farmers is largely disregarded. All types of pesticides are not only repeatedly but also carelessly used. The information on status and consumption of pesticides on crops is scattered in various documents and is not readily available. Although in recent years the use of toxic chemicals for health purposes has reduced drastically, on the other hand it is continuously increasing in the field of agriculture. With the introduction of high-yielding varieties and cultivation of other commercial crops as vegetables, tea, cotton, etc the consumption of pesticides is increasing. Nepal has initiated to manage the rice pests by applying IPM principle, resulted in the use of pesticides in rice only after outbreak of pests (Sharma 2015).

Studies conducted in the past show that the chemical pesticides are intensively being used in agricultural production in Nepal. Pesticide consumption has changed significantly during past one decade. The largest quantity of pesticides was used in rice (40–50%) in 1980 followed by grain legumes (14–20%), fiber crops (13–15%), and vegetables and fruits (10–20%). Based on the amount used, pesticides has been found in the following order: insecticides, fungicides, herbicides, rodenticides, others. Pesticide use pattern on crops is as follows: use after pest outbreak (59%) followed by preventive control (39%) and post-harvest control (2%) (Manandhar and Palikhe 1999). Now pattern of use of pesticides are drastically changed and farmers are applying high amount of pesticides in vegetable crops. Nowadays use of herbicides is increasing due to unavailable of labor for weed roughing specially in rice and wheat crops.

Pesticide types and its import

The annual imports of pesticides in Nepal is 454 tonnes (ai) in terms of actual ingredients consisting of 35.70% insecticides, 42.28% fungicides, 19.82% herbicides, 2.16% rodenticides, 0.015% bio-pesticides and 0.0068% others, respectively and valued at NRs 551.99 million per annum (PRMS 2016). In total 117 different pesticides (by common name) have been registered under different trade names (**Table 1**).

Table 1. List of registered pesticides in Nepal

SN	Pesticide	Trade name	Common name
1	Insecticide	1178	47
2	Fungicide	661	34
3	Herbicide	243	20
4	Bio pesticide	43	6
5	Rodenticide	27	2
6	Acaricide	20	6
7	Bactericide	12	1
8	Molluscicide	2	1
	Total	2186	117

Source: PRMS 2016.

Trend of pesticide use

PPD (2011) reported that majority of farmers were unfamiliar to names of banned pesticides in Nepal. Farmers even did not care about waiting period for harvest after application of chemical pesticides. The use of pesticides by crops growers in the 1980's was practically unknown where the highest percentage was reported among wheat grower with only one percent applied pesticides in their farming operation. Less than one percent accounted among rice, maize, potato and sugarcane growers during the same period (CBS 2006). The numbers of farmers using pesticides have been increasing over years. The proportion of vegetable growers using pesticides increased from 7.1% in 1991/92 to 16.1% in 2001/02 (CBS 2006). The percentage of pesticides user among the maize growers has been the lowest in the country. In the last 3 censuses of 1981/82, 1991/92 and 2001/02, the percent of pesticides users among maize grower were just 0.9, 2.8 and 4.2%, respectively (CBS 2006). A study in Nepal showed that the average pesticide dose application/ha on paddy, tomato and potato in Kavrepalanchok and Bhaktapur district varied from 228 to 8845 g ai/ha (KC 2009). In the commercialized vegetable production areas, such as Paanchkhal (Kavrepalanchok), 100% of the farming households used one or other kinds of pesticides (Atreya 2007).

PPD (2015) reported that among the development regions, the use of chemical pesticide was higher (45.48%) in central development region and the lowest (5.43%) in the Far western Region where as farmers in Tarai region are using high amount of pesticides rather than hilly and high hill regions.

Farmer's perception on pesticide use

Sharma (2015) reported that farmers in many places applied pesticides in a routine manner, without considering the waiting period, residue on the treated stuff, human health and environment as a whole. All most all (95.33%) vegetable growing farmers used chemical pesticides on their crops.

Figure 1. Farmer preparing for spraying chemical pesticide

The volume and types of pesticides use declines from Tarai to mountain sharply (Thapa 1995). Though commercial farmers used pesticides in ample quantity in vegetable crops but they possessed least understanding of safe handling of pesticides and environment pollution due to these stuffs. Amount of pesticides use in some of the commodities, such as cotton and commercial vegetables is found to be much more than other crops and study of use of amount of pesticides in different crops are given in **Table 2**.

Table 2. Pesticide consumption status on different crops in Nepal

Crop/Commodity	Amount used	Area	References
Commercial vegetable	1.45 ai kg/ha		Sharma 1994
National average	142 g/ha		Dahal 1995
Cotton	2.56 ai kg/ha		Thapa 1997
Tea	2.1 ai kg/ha		Thapa 1997
Cauliflower	4.9 ai kg/ha	Bhaktapur, Kavre, Sindhupalchowk, Dhaing, Sarlahi	BPRC 2005
Tomato	4.5 ai kg/ha	Bhaktapur, Kavre, Sindhupalchowk, Dhading, Sarlahi	BPRC 2005
Paddy	0.380 ai kg/ha	Jumla, Banke, Morang, Kailali, Syangja, Dhanusa	BPRC 2005
National average	396 g ai/ha		Sharma 2015

Share of pesticide use on rice crop

More than 85% of pesticides are used only in vegetable crops in Nepal (Sharma 2014). Among the cereals, the most pesticide use crop is rice followed by maize. The study also showed that among the 7.5% of pesticide used in cereal crops (**Table 3**), about 75% pesticides are in rice. The trends of pesticide use in rice farming showed that the most farmers are only applying after the outbreak of pests. Different types of pesticides are used by farmers in rice in Nepal (**Table 4**).

Figure 2. Display pesticide in the Agro-vet.

Table 3. Share of the pesticide use by crop

Crop group	Share of pesticide (%)	Remarks
Cereals	7.5	5.625% use in rice
Vegetables	89	All types of vegetable including potatoes

Crop group	Share of pesticide (%)	Remarks
Cash Crops	2.5	Tea, cotton and sugarcane
Pulses	0.5	
Fruits	0.5	
Total	100	

Table 4. List of different pesticides used in rice

Insecticides	Fungicides	Herbicides
Acetamiprid	Carbendazim	Butachlor
Aluminium Phosphide	Carbendazim 12% + Mancozeb 63%	2,4-D
Malathion	Iprobenfos	Pendimethalin
Carbofuran	Copper oxychloride	Pretilachlor
Cartap Hydrochloride	Mancozeb	
Chlorpyrifos	Metalaxyl 8% +Mancozeb 64%	
Chlorpyriphos 50% + Cypermethrin 5%	Cymoxanil 8% +Mancozeb 64%	
Deltamethrin	Thiram	
Dichlorovos	Hexaconazole	
Dimethoate		
Phorate		
Triazophos		
Emamectin benzoate		
Rodenticide		

Conclusion

Most of the pesticides are applied in the vegetable crops due to commercialization and cash crop. Among the cereals, farmers mostly apply pesticides in rice. Some study showed that 380 g ai/ha is applied in rice which is similar to national average. Farmers have no or very few practices to use of bio-pesticides in rice crops. Farmers apply pesticides mostly after outbreak of the pests in rice.

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Climate Change, Environment and Gender Issues

(जलवायु परिवर्तन, वातावरण तथा लैंगिक सवाल)

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Monsoonal Rainfall and its Impact on Rice Production in Nepal

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सारांश

सन् १९७१ देखि २०१५ सम्मको अवधिमा धानको उत्पादनमा वर्षाको सम्बन्धको बारेमा यस अध्ययनले प्रष्ट्याउन प्रयास गरेको छ । यस अवधिका १५ वर्षहरूमा भएको धानको उत्पादनमा भएको गिरावटसँगै वर्षा र धान उत्पादनको अत्यन्तै नजिकको सम्बन्ध रहेको पाइएको छ । धानको उत्पादनमा सबैभन्दा कम गिरावट ५०,००० मे.ट. ले १९८४ मा र सबैभन्दा बढी ७००००० मे.ट. ले सन् १९८२ मा भएको पाइएको छ, जुन रकममा रूपान्तरण गर्दा क्रमशः १३ मिलियन र १२३ मिलियन अमेरिकी डलर बराबर हुन जान्छ । राष्ट्रिय अर्थतन्त्रमा महत्वपूर्ण भूमिका रहेको धानको उत्पादन र वर्षाको सम्बन्ध पहिचान तथा धान उत्पादनमा हुने गिरावटलाई कम गर्ने उपायहरूको खोजिका लागि सुदृढ अनुगमन र मूल्यांकन सहितको अध्ययन हुनु आवश्यक रहेको छ । कूल खेती गरिएको जमिनको एक तिहाई भूभागमा सिँचाइ सुविधा उपलब्ध भएको भन्ने सरकारी दावी भएता पनि अधिकाम्स क्षेत्रमा धान खेती आकाशे पानीको भरमा गरिएको अवस्था रहेको छ । वर्षात्को समयमा भरिने खोलाको पानीको भरमा धान खेती गरिने हुनाले वर्षात् कम हुँदा सुख्खापनको समस्या देखिने गरेको छ । तसर्थ, यसबाट वर्षाले धान उत्पादनमा असर गरेको हुन्छ भन्ने तथ्य प्रमाणित हुन्छ । नेपालको बढ्दो जनसंख्यालाई धान्ने गरी धानको उत्पादन बढाउनका लागि कृषि विकास मन्त्रालय, जल तथा मौसम विज्ञान विभाग, सिँचाइ विभाग र अन्य सार्वजनिक तथा निजी क्षेत्रहरू बीच कार्यरत समन्वय हुनु जरुरी छ । यस अध्ययनले १९७१ देखि २०१५ सम्मको अवधिमा धान उत्पादन र वर्षाबीच उच्च सम्बन्ध रहेको देखाएको छ ।

Summary

This study attempts to show the relationship between production of rice and monsoonal rainfall in Nepal during the period 1971 to 2015. In this period of 45 years there was a shortfall in rice production in almost 15 years showing the crucial relationship between monsoonal rainfall and production of rice. The minimum deficit year accounts for 50,000 metric tonnes in 1984 and maximum deficit accounts for more than 700,000 metric tonnes in 1982 during the study period. In terms of monetary value, the deficit comes to US$ 13 million and US$ 123 million, respectively during the minimum and maximum deficit years. Since rice occupies an important role in the national economy, a detailed study of rainfall and rice production should be carried out with strong monitoring and evaluation. Meanwhile, the measures to be adopted should be discussed and considered to minimize the future loss of rice yield and production in Nepal. Despite the claim of the Government of Nepal that one third of the cultivated land have been brought under irrigation, rice cultivation in Nepal is still very much dependent on the rainfall. Had it been so, the rice production in the country should not have fluctuated with the rainfall as the study has shown. Irrigation in Nepal is mostly from the rain fed rivers, which tend to dry up in case of low rainfall creating problem in irrigating the rice field. Therefore, the impact of rainfall on rice yield and production is quite evident. As such, it is a burning issue in the present scenario. To address enhanced rice production in Nepal there is a need of functional collaboration of Department of Hydrology and Meteorology with the Ministry of Agricultural Development Development, Department of Irrigation and concerned public and private institutions so that seasonal monsoon could be harnessed and managed for increased rice production to feed the burgeoning population of Nepal. This paper presents the relationship between the monsoon rainfall and the yield of rice for the period of 1971 to 2015 which is found to be highly correlated.

Keywords: Irrigation, Monsoonal rainfall, Yield, Rice

Introduction

In Nepal, 80% of annual precipitation is between June and September under the influence of summer monsoon. The monsoon rainfall is very important from agricultural point of view. Thus the intensity of the summer monsoon rains and the date of the onset of the monsoon are both important factors for the country's economy, because it is the main season for planting rice. The rice is still the most popular cereal grain being cultivated by more than three-fourths of the total holdings. Rice is grown in low land Tarai plains, hills and a few selected areas of mountains, such as Jumla up to 2300-3050m (Paudel 2011). Rice can be grown in Tarai plains, two to three crops in a year, wherever irrigation facilities are available. During the last decade in 2000/2001 to 2009/2010, the cultivated area of paddy was 1.529831 million hectares. At the same period, the average production was 41.99608 million tonnes. The yield for that period was 2643 kg/ha.

Methodology of the study

Data

The data for the study period was considered from 1971 to 2015 for both the rice and rainfall. The data for the rice was collected from the various publications of the Department of Food and Agriculture Marketing Services (DFAMS 1977, 1983 and 1990), Central Bureau of Statistics (CBS 1994, 1995 and 2006) and Ministry of Agricultural Development (MoAD 2011, 2013, 2014 and 2015). The rainfall data were extracted from 11^{th} different publications from Department of Hydrology and Meteorology (1971-2010). The unpublished rainfall data from 2011-2015 have also been used.

Analysis of the monsoonal data

Most of the rainfall is caused by monsoon and therefore the monsoon and their causes are also briefly described. "Monsoon is traditionally defined as a seasonally reversing wind system accompanied by seasonal changes in atmospheric circulation and precipitation. A semi-annual reversal in the wind direction, a typical characteristic of monsoon, is caused due to differential heating of continents and oceans and the Coriolis force. The term was first used in English in the then British India and neighboring countries, to refer to the large-scale seasonal winds blowing from the Bay of Bengal and Arabian Sea from south-westerly direction bringing heavy rainfall to the area." (IMD 2012) Once wind reaches the Bay of Bengal and slowly the wind is deflected and when it reaches Nepal on its south-east, we called south-east monsoon (Nayava 1974a). "The unique physiographic features of south Asia, with the vast Asian continent spread over equatorial to polar latitudes in the Northern Hemisphere contrasted by the extensive water surface of the Indian Ocean, spread over the equatorial to Antarctic latitudes in the Southern Hemisphere, primarily supports the development of intense thermal centers of action due to differential heating of land and oceans. The resultant pressure patterns and the meridional circulations in summer and winter are further accentuated by the presence of high mountain massifs (Himalayan and Tibetan Plateau) of south Asia, leading to the establishment of the South-West (SW) and the North-East (NE) monsoon, respectively" (IMD 2012).

Recently, many studies have been done on inter-annual variability and it has been identified that El Nino-Southern Oscillation (ENSO) has been recognized as an important atmospheric feature of the global climate system. ENSO is a naturally occurring phenomenon that involves fluctuating ocean temperature in the equatorial pacific. (Shakya et al 2012). Now, this summer monsoon phenomenon is connected with El Nino and La Nina events. El Nino, which is a warm coastal current that flows along the pacific coast of South America. Baidya (2015) presented the all Nepal monsoon rainfall anomaly as shown in **Figure 1**, which has supported previous statement. Shrestha (2000) showed that monsoon rainfall has a large inter-annual variation and there is a tele-connection between Nepal monsoon and warm and cold phases of ENSO. It is very interesting to note that the association between weak rainfall in Nepal and ENSO index are also found. The variation of ENSO and rice production in Nepal over the period 1960-1997 has also been shown by (Gill et al 1998).

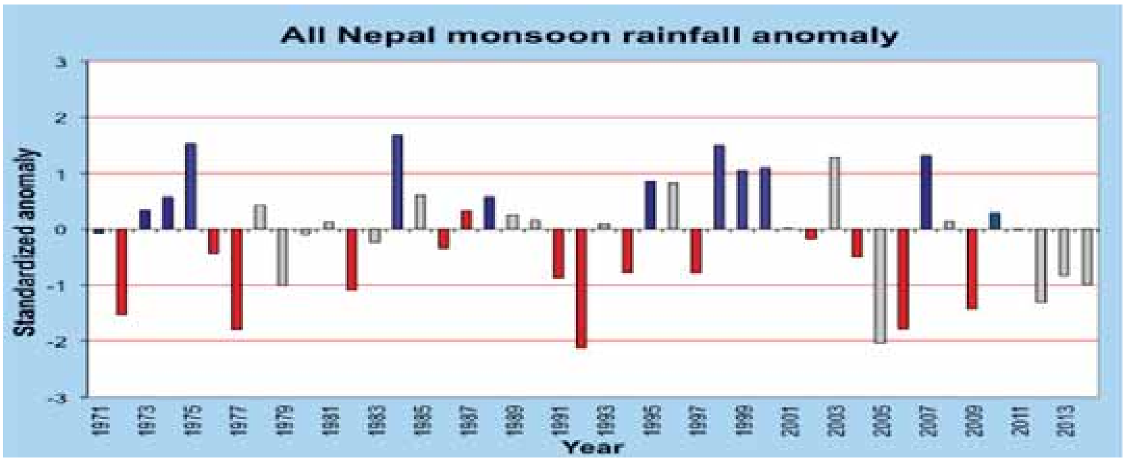

Figure 1. Standardized all Nepal monsoon rainfall anomalies (red bars are El Nino years; blue bars are La Nina years and light blue bars are neutral)

Source: Baidya 2015, Department of Hydrology and Meteorology 2015.

The normal date of onset of summer monsoon falls in Nepal in the12th of June and retreats in the 21st of September. Normally the summer monsoon enters from east of Nepal and enter Kathmandu within two days and eventually covers whole of Nepal within a week. The dates of the onset and retreat of summer monsoon in Kathmandu are shown (**Figure 2**). The date of onset of monsoon and its activities are both important phenomenon. Generally, farmers prepare seedling about a month ahead of rice transplantation. If the monsoon is delayed, seedling will be taller and show a brownish color which will negatively affect the yield and production of rice.

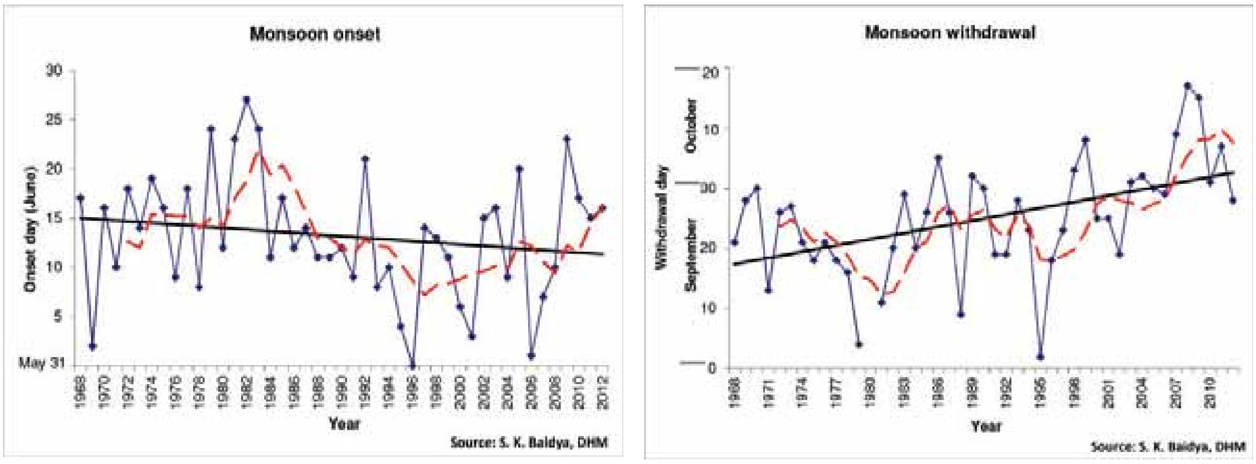

Figure 2. Onset and recession of summer monsoon in Kathmandu (After 2012, Department of Hydrology and Meteorology)

Main rice cultivation season

The main rice cultivation season of Nepal falls during June to October, which also coincides with the summer monsoon. Around 70 to 90% of annual rainfall occurs during the monsoon season of June to September. The summer monsoon starts from the eastern region of Nepal, which is close to the Bay of Bengal. The moisture laden monsoon air from the Bay of Bengal enters in the eastern region of Nepal and after two to three days it reaches Kathmandu Valley (around 12 June) which lies in the central region. Then onwards, and after a week or so, it covers whole of Nepal. The timely onset of monsoon is very important as the transplanting of rice seedling depends upon the arrival of monsoon rain. It is not only the onset of monsoon, the rainfall characteristics such as depth, frequency, intensity and distribution in time and space are all the important factors for the positive impact on growth of paddy and for that matter entire agriculture (Nayava 1974b).

Growth indices scenarios and rice production

The simplified mathematical model as growth indices developed by Fitzpatrick and Nix (1970) was calibrated in the Nepalese environment by Nayava (1981) and had presented an example with Rice Research Program, Parwanipur in central Nepal (**Figure 3a** and **Figure 3b**). Due to the prevailing climates, the country can have two to three crops in a year in lower altitude. The main rice crop is cultivated in summer monsoon during July to October; after rice the second crop as wheat is in November to March and the third crop is in from March to June which is generally early rice (*chaite dhan*) under irrigated condition. The second and third crop mainly depend upon an irrigation application, other-wise only one crop can be cultivated in rain-fed condition in optimum expected yield.

The growth Indices (G.I.) considers light, thermal and moisture regimes into a linear function with a scale ranging from zero to unity. In this analysis, growth indices (G.I.) has been defined as the most favorable G.I. (higher than 0.8), fairly favorable G.I. (0.4 to 0.8) and least favorable G.I. (less than 0.4) are defined. The most favorable is the optimum climatic potential for cultivation where all environmental indices such as light, thermal and moisture have almost non-limiting condition for growth, say as growth index is higher than 0.8. However, the moisture index greater than 0.9 is considered most favorable for rice cultivation. Therefore, the presentation, (**Figure 3a** and **Figure 3b**) show that the three crops (two tropical species as rice and one warm temperate species as wheat) can be easily managed if irrigation facilities could be extended.

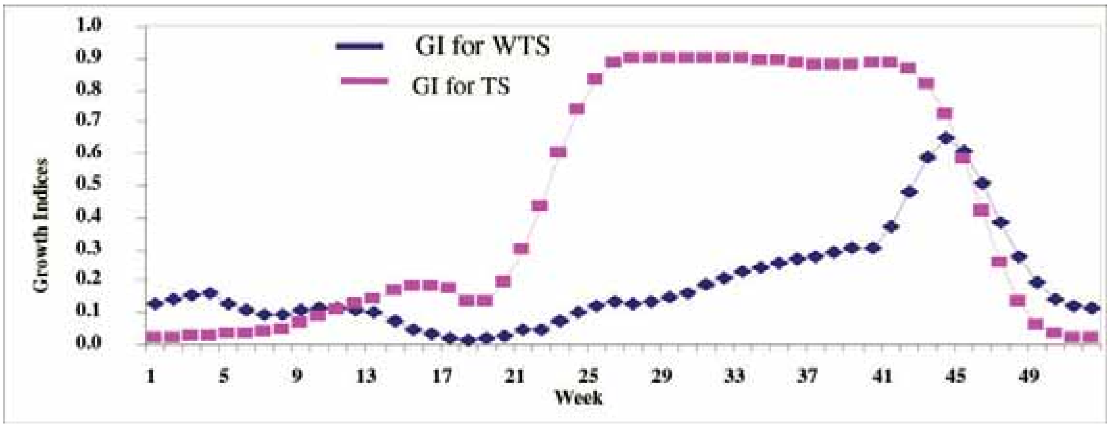

Figure 3a. Growth indices in Parwanipur at rain-fed conditions

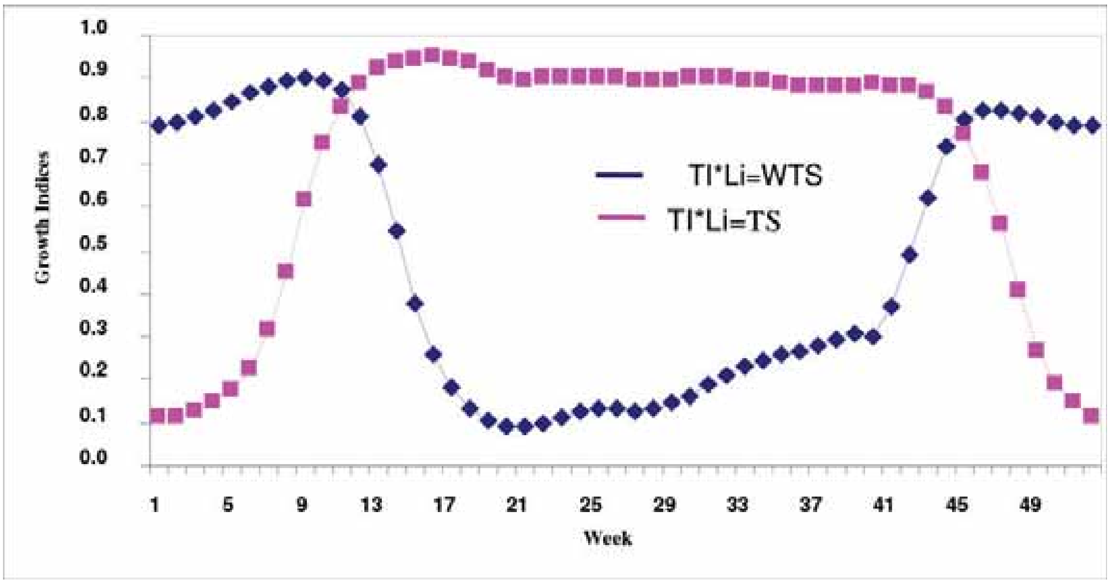

Figure 3b. Growth Indices in Parwanipur at irrigated conditions

Source: Nayava 2008.

Rice production scenario in Nepal from 1971-2015

Taking into consideration the importance of monsoon rain, this study attempts to cover whole of Nepal during the period 1971-2015. Similarly, the regional, ecological and national basis with respect to variations of rice yield with rainfall during the period 1971- 2000 is also described (Nayava 2008). The summer monsoon rainfall data for the period 1971 to 2014 were prepared and the rainfall data for 70 rainfall stations were selected, which generally represented the whole of Nepal. The data are simply analyzed to see the variations of monsoon rainfall in each year. The deficit of monsoon rainfall from the normal rainfall (1450 mm) was clearly shown in 1972, 1977, 1979, 1982, 1986, 1990, 1991, 1992, 1994, 1997, 2002, 2004, 2005, 2006, 2009, 2012 and 2014. At the same time the rice yield data for the same period were also analyzed and those two data sets were shown (**Figures 4** and **5**).

While observing the rice yield in Nepal during 1971 to 2015, there is a clear indication of sharp reduction of the rice yield during 1972, 1977, 1979, 1982, 1986, 1992, 1994, 2002 2004, 2005, 2006 2009, 2012, 2014 and 2015 as shown (**Figure 5**). This shows that there is a positive correlation between rainfall and rice yield. Whenever the rainfall is below normal, there is deficit of the rice yield in Nepal. This phenomenon was throughout the study period except for 1990, and 1997, where the rice yield was increased despite monsoon rainfall below the normal rainfall.

It is interesting to note that rainfall pattern and yield are very close to each other from the early 1970's to 1986 as shown (**Figure 5**). After 1986, the gap between rainfall and yield is far more than earlier period. This shows that the improvement of technology of producing a better yield has been noticed. Looking at the trend of rice yield during 1971 to 2000, the yield seemed to be almost similar (say as less than 2000 kg/ha) from 1971 to 1986 except an abrupt decrease of yield when rainfall was below normal in some years. From 1987 to 2000, the rice yield increased from 2000 to 2400 kg/ha. The causes of recent increment of yield is attributed to mainly uses of high yielding varieties, which has been confirmed by personal discussion with the concerned authorities as has been mentioned elsewhere earlier (Nayava 2008).

During the deficit years during the period 1971 to 2000, the production shortfall of rice varies from 50,000 metric tonnes to more than seven million metric tonnes. At the extreme lowest production year during 1982 in Nepal, the rice yield was also lowest ie lower than 500 kg/hectare compared to previous year as shown (**Figure 5**). In terms of monetary valuation, it varies from more than US$ 13 million (NRs 837.5 million) to US$ 123 million (NRs 8028.5 million) per year depending upon the severity of deficit of rainfall compared to the normal rainfall. At present Nepal produced rice worth of more than US$ 789 million (NRs 50511.4 million). **Figure 5** shows that the lowest monsoon rainfall was recorded in 1992 and the same year the cultivated land for rice was reduced to 1.49970 million ha compared to previous year 1991. Therefore, the impact of rainfall on rice yield and production is very important subject in the present scenario. Nayava (2004) studied the temporal variation of rainfall in Nepal since 1971-2000. He showed that the during the monsoon months, the rainy day seemed to be decreasing and the intensity of rainfall appeared to be increasing. There seemed to be no fixed trend of monsoon rainfall in Nepal. Due to the recent global warming, the researchers have been predicting that the summer monsoon rain will increase than earlier, but this has not been shown and rather rainfall seems decreasing.

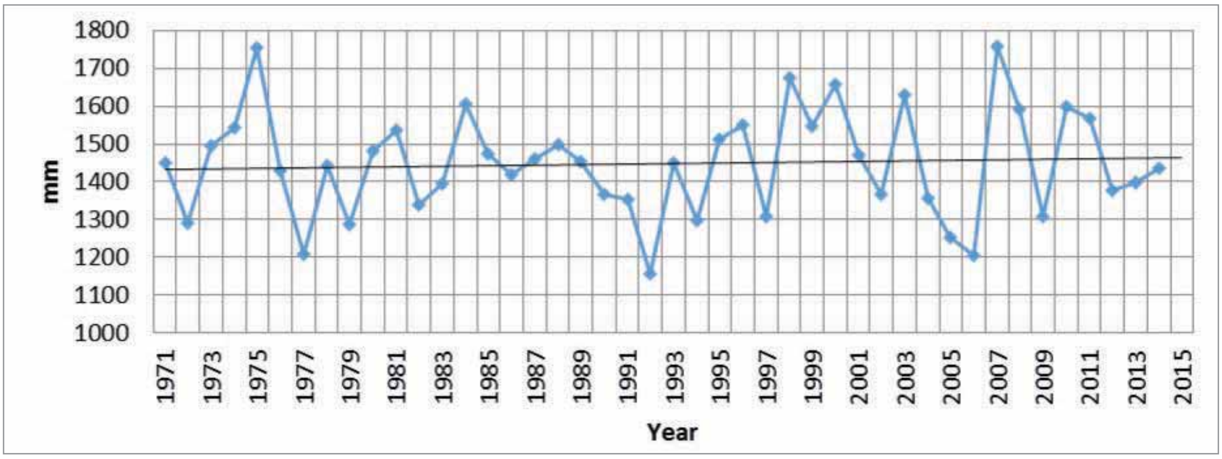

Figure 4. Summer monsoon rainfall in Nepal (1971-2014)

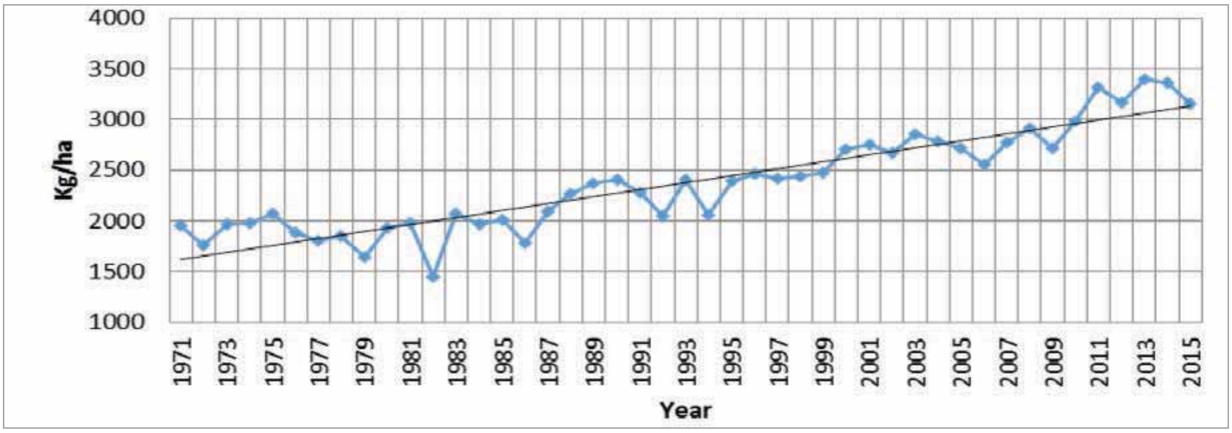

Figure 5. Rice yield (kg/ha) in Nepal (1971- 2015)

It is also interesting to observe not only the figure of yield, but the area and production as well for the same years presented (**Figures 6** and **7**). This shows that there is reduction of cultivated area due to late onset of rainfall as well as weak distribution of rainfall. Finally the sharp reduction of production occurred (**Figure 7**).

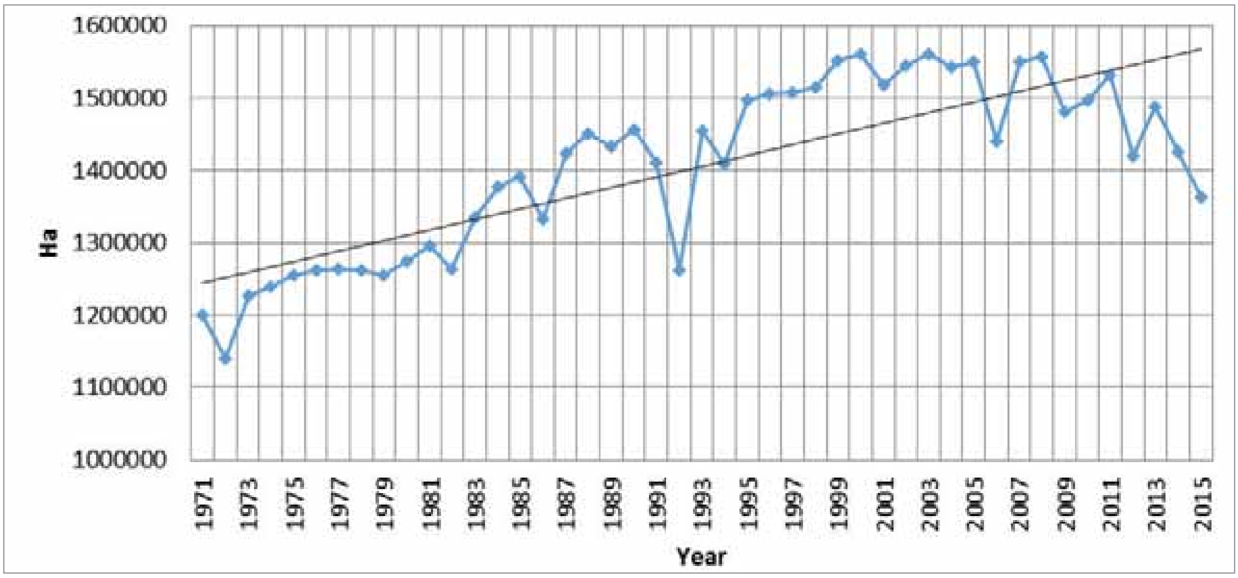

Figure 6. Cultivated area (ha) of rice in Nepal

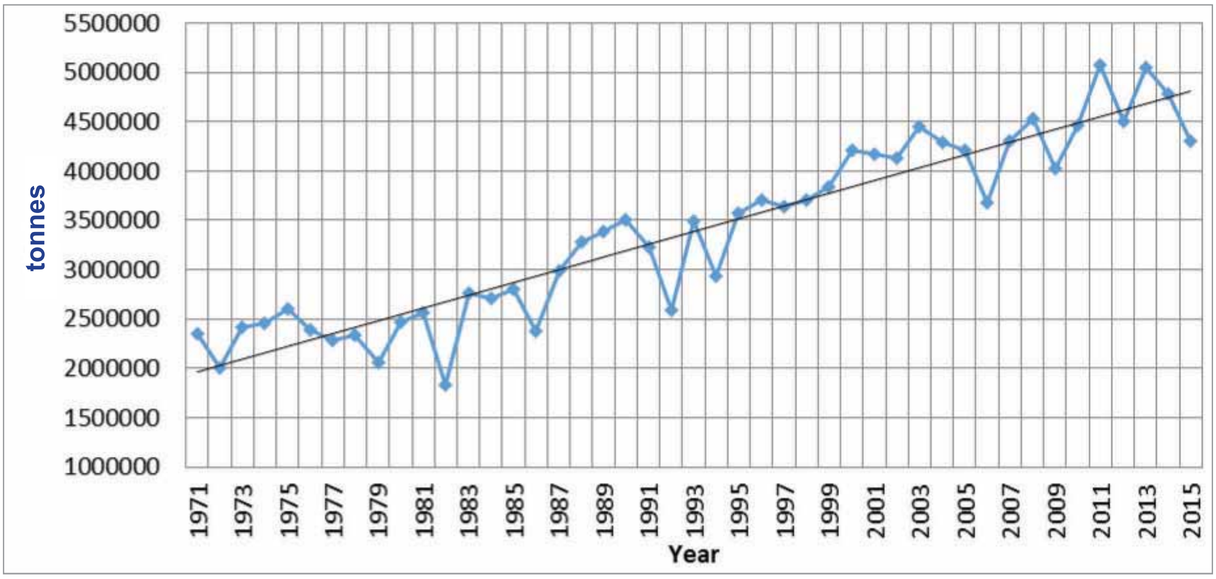

Figure 7. Production (tonnes) of rice in Nepal

The general observations of the rainfall and rice area planted and rice production in Nepal during badly affected years are given (**Table 1**). The table below depicts the badly affected year of rice production showing relationship of weather and its consequences on total production scenario of rice in Nepal. Thus, the study of rainfall, rice yield and production should be internalized in detail to see when, how and where the rice yield and production had been affected and what measures can be adopted to minimize the future loss of rice yield in Nepal. The study confirms that there is definitely a low rainfall cycle in every ten years and mostly effected in the eastern region during the years: 1962, 1972, 1982, 1992, 2002 and 2012. During those years the late onset of rainfall had occurred and the planted area of rice especially in the eastern Tarai was reduced. Therefore, the future study should not only be confined to rainfall but should also consider the detailed relationship between climatic parameters and rice yield at the district level considering all the relevant information from crop growth cycle. Under these conditions, the effect of climate change on agriculture will also be better understood and can be better planned for better management of agriculture system in future (Nayava 2008). To develop these systems, the collaborative ventures of the Ministry of Agricultural Development and the Department of Irrigation, Department of Hydrology and Meteorology and concerned authorities should come closer to monitor and evaluate the development process of rice yield and production as well as other crop yield in Nepal (Nayava 1999).

Table 1. Status of badly affected year of monsoonal rain with respect to rice production in Nepal

Year	General remarks of monsoon related to rice production in Nepal
1972	Late onset and very weak rainfall during onset/reduced area of rice in the eastern and central regions, finally lower production of rice.
1976	Poor distribution of rainfall during September, especially western regions/production of rice noted lower in western regions.
1977	Late onset and poor distribution of rainfall in September/rice production affected generally in the eastern and central regions.
1979	Late onset, early withdrawal and poor distribution of rainfall in the western regions/very badly gone down the rice production in the western regions.
1982	Late onset and poor distribution of rainfall during August in the eastern region/reduced area of rice planted and lower production of rice.
1986	Poor distribution of rainfall during August and September in the western regions/badly affected rice production in western regions.

Year	General remarks of monsoon related to rice production in Nepal
1992	Late onset and weak rainfall during August and September in the eastern region/reduced area of rice and lower production.
1994	Overall, very poor monsoon rainfall in Nepal/reduced rice production.
1997	1997 Weak rainfall distribution in August in the eastern region/affected rice product.
1999	Poor distribution of rainfall in Sep1972. Late onset and very weak rainfall during onset/reduced area of rice in the eastern and central regions, finally lower production of rice.
2002	A few days delayed of the onset of monsoon and withdrawal of monsoon was one week ahead. Overall the monsoon rainfall was below normal and therefore production of rice was a little lower than the previous year
2004	Initially the monsoon rain in that year was very poor in most parts of the country. Due to this poor rainfall, production of rice was reported to be adversely affected in the different parts of the country.
2006	Onset of monsoon over Nepal was noted on 1st of June. 10 days earlier than its normal time. The overall condition of monsoon was weak. Almost entire country experienced severe dry condition in August. Production of rice was 8% lower than the previous year.
2009	Onset of monsoon was noted on 23rd June and that was delayed by 13 days and a large part of the country received poor rainfall and production of rice was 8% lower than the previous year
2012	A week delayed of onset of monsoon and affected planting of rice in the eastern region and production of rice was 7% lower compared to the previous year.
2014	10 days delayed of onset of monsoon and poor distribution of rainfall in the month of July and August and affected rice production

Suggestions and way forward

Despite the claim of the Government of Nepal that one third of the cultivated land have been brought under irrigation, rice cultivation in Nepal is still very much dependent on the rainfall. Had it been so, the rice production in the country should not have fluctuated with the rainfall as the study has shown. Irrigation in Nepal is mostly from the rain fed rivers, which tend to dry up in case of low rainfall creating problem in irrigating the rice field. Therefore, the impact of rainfall on rice yield and production is quite evident. As such, it is a burning issue in the present scenario.

Recently in 2016 the El Nino events are predicted a few months ahead by the World Meteorological Organization. It effects need to be studied by the Department of Hydrology and Meteorology and give their views to the Ministry of Agricultural Development for their necessary action. To address enhanced rice production in Nepal there is a need of functional collaboration among Department of Hydrology and Meteorology with the Ministry of Agricultural Development Development Department of Irrigation and concerned public and private institutions so that seasonal monsoon could be harnessed and managed for increased rice production to feed the burgeoning population of Nepal.

Acknowledgements

The author wishes to dedicate this article to Professor Henry Nix for his valuable guidance to do the climatological models and crop weather modeling during my research period in the late 1970's in the Australian National University, Canberra. The author wishes to thank Department of Hydrology and Meteorology for allowing me to use their unpublished rainfall data from 2011 to 2015. The author also wishes to dedicate this paper to those scientists who had contributed the agricultural development in Nepal. Finally the author wishes to thank Mr. Rabi Singh, former Deputy Director General, Department of Statistics for reviewing my paper.

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Rice Production and Rice Growing Environments

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सारांश

धान उत्पादन पर्यावरणको सर्वमान्य वर्गीकरण गर्नु एक जटिल र अप्ठ्यारो कार्य हो । धान उत्पादन हुने मुलुकहरूमा विद्यमान रहेको पानीको अवस्था, कृषि पर्यावरण र जलवायु, विविध बाली प्रणाली तथा जग्गाको अवस्था आदि कारणबाट धान उत्पादन पर्यावरणको वर्गीकरणमा जटिलता आएको हो । कार्य जटिलता र अप्ठ्यारा बीच पनि जर्मप्लाज्मको साटासाट, स्थान विशेषको लागि जातीय तथा उत्पादन प्रविधिहरूको अनुसन्धान र विकास कार्यलाई सरल वैज्ञानिक बनाउन धान उत्पादन पर्यावरणको वर्गीकरण गर्न आवश्यक छ । यस लेखमा प्रथमतः विश्वको कुन-कुन देशमा धान उत्पादन गरिन्छ र ती देशहरूको पर्यावरण कस्तो छ भन्ने पक्षको विश्लेषण गरिएको छ । यस पश्चात् विभिन्न धान वैज्ञानिकहरूले विकास गरेको विश्व धान पर्यावरणको वर्गीकरणलाई आधार मानेर लेखकले नेपालमा विद्यमान धान पर्यावरणलाई वर्गीकरण गरेको छ । यसरी गरिएको कूल ९ (नौ) प्रकारका पर्यावरण वर्गीकरणका विषयमा थप अनुसन्धानको गर्नुपर्ने आवश्यकता महसुस गरिएको छ ।

Summary

Defining precise rice production environments is a complex and difficult task. These perplexities arise from several factors such as: land's hydro-morphological characters, agro-ecology and climatic conditions, prevailing cropping systems and land topography etc under which rice is produced globally and locally. However, classification of rice growing environments is important for germplasm exchange and development of environmental specific rice varieties and agronomic practices. This article reviews global rice production situation to figure out prevailing environments in the world where rice is being produced in a large scale. This is followed by assessment of Mega Rice Environments (MREs) in the world. Based on this analysis, author proposes a total of nine Rice Production Environments (RPEs) for Nepal- six under irrigated and three under rain-fed conditions. Scientific field research on this area is recommended.

Keywords: Factors, Growing environment, Production, Research, Rice

Introduction

Rice is one of the most important staple foods for more than 3.5 billion people in the world (CGIAR 2016). Seventeen countries in Asia and the Pacific, nine countries in North and South America and eight countries in Africa mostly depend on rice for staple food (ibid). Rice provides 20% of the world's dietary energy supply, while wheat and maize supply 19 and 5% respectively (Alexandrator and Jelle 2012). From this perspective, rice is the most important strategic crop for food and nutrition security globally.

Two species of rice- *Oryza sativa* (Asian rice) and *Oryza glaberrima* (African rice) are known for their commercial value. However, *Oryza glaberrima* is cultivated in very limited areas of South Africa. *Oryza sativa,* the most important commercial species of rice is differentiated into three sub species- *indica, japonica* and *javanica* based on their commercial production zones. The sub-species- *indica* refers to the tropical and sub-tropical varieties grown throughout South and South-East Asia and Southern China. The variety japonica is grown in temperate areas of Japan, China, Nepal and Korea, while javanica varieties are grown in Indonesia.

It is reported that rice was introduced in Nepal (and in India and Southeast Asia) from mainland China during the late 3rd millennium BC (www.ricepedia.org). However, commercial rice production is believed to have started some five hundred years ago in Nepal (Mallick 1981). Although Nepal contributes very little to global rice production and trade, rice plays a significant role in the national economy. Rice dominates the country's crop sector as it covers over 42.5% of the total area under food grains and shares 51.6% in total food grain production (MOAD 2013). As the most important staple food for Nepalese people, rice supplies about 40% of the food calorie intake and contributes nearly 20% to the agricultural gross domestic product (AGDP) and almost 7% to GDP (CDD 2015).

Global rice production and rice mega environments (RMEs)

Asian countries dominate global rice production (**Table 1**). According to USDA, Economic Research Service (2016), China tops the list of top 10 rice producing nations with a production of 145.5 million tonnes and productivity of 4.79 t/ha. The production record puts India in the second position as the country produces 103.5 million tonnes with the productivity of 2.40 t/ha. Indonesia, Bangladesh and Vietnam have found their place among the top five rice producing countries. The list, which is dominated by Asian countries, puts Brazil in the 9th position which produces 8.0 million tonnes and Japan in the 10th position with 7.9 million tonnes rice production. According to USDA projection global rice area, yield and production will increase by 3.8, 7.2 and 11.3 respectively by 2025/26 (base year 2015/16). The highest rice yield in the world during 2015/16 was achieved by Japan (4.91 t/ha) followed by China (4.79 t/ha).

Table 1. Top ten rice producing countries in the world (2015/16)

SN	Countries	Area, million ha	Yield, t/ha	Production, million tonnes
1	China	30.4	4.79	145.5
2	India	43.2	2.40	103.5
3	Indonesia	12.2	2.99	36.3
4	Bangladesh	12.0	2.88	34.6
5	Vietnam	7.7	3.68	28.2
6	Thailand	9.7	1.70	16.4
7	Myanmar	6.8	1.79	12.2
8	Philippines	4.5	2.56	11.5
9	Brazil	2.3	3.48	8.0
10	Japan	1.6	4.91	7.9
	World	**159.2**	**3.0**	

According to FAO (2015), demand for rice is expected to continue to increase in coming years, at least up until 2035. The world's demand for milled rice can be expected to rise to 496 million tonnes in 2020, from 439 million tonnes in 2010. By the year 2035, this requirement will likely further rise up to an estimated 555 million tonnes. According to this report, rice consumption will continue to rise especially between African and low earning Asian countries (Afghanistan, North Korea, Nepal and Vietnam). However, per capita rice consumption has started to decline in the middle and high-income Asian countries like Japan, Taiwan and the Republic of Korea as with growing prosperity. In these countries, consumers substitute rice with high-cost quality food containing more protein and vitamins such as: processed rice, vegetables, bread, fish and meat (Alias et al 2005). In sub-Saharan Africa, rice is considered the fastest-growing staple food with annual per capita consumption nearly doubling after the 1970s. In the Caribbean and Latin America, rice consumption was increased by about 40% in the last twenty years. Other regions showing a significant increase in rice consumption are: the Middle East, the United States and members of the European Union (ibid).

Information from the rice producing and consuming nations confirms that rice is cultivated across various environments ranging from tropical, semi-tropical, and warm temperate and under different water regimes and topographic conditions. Until 1980s, there was a huge confusion and uncertainty in portraying precise terminologies to describe various rice environments (Swaminathan 1984). Classification was important especially for international and national rice breeding programs for identifying, exchanging and developing rice varieties in a scientific and strategic way. Based on this need, IRRI International Rice Research Conference held in 1982 decided to establish a widely representative International Committee to develop classification system for rice growing environments at global level (Swaminathan 1984).

The committee divided rice environments into five major categories in 1984 and each category was divided into distinct subcategories (**Table 2**). Factors such as water regime (deficit, excess, or optimum), drainage (poor or good), temperature (optimum or low), soils (normal or problem), and topography (flat or undulating) were considered for naming the global rice production environments.

Table 2. Rice production environments in the world (Khush 1984)

Main Categories	Sub-categories
Irrigated	Irrigated with favorable temperature Irrigated, low-temperature, tropical zone Irrigated, low-temperature, temperate zone
Rainfed Lowland	Rainfed shallow, favorable Rainfed shallow, drought-prone Rainfed shallow, drought-and submergence-prone Rainfed shallow, submergence-prone Rainfed medium deep, waterlogged
Deep water	Deep water Very deep water
Upland	Favorable upland with long growing season (LF) Favorable upland with short growing season (SF) Unfavorable upland with long growing season (LU) Unfavorable upland with short growing season (SU)
Tidal wetlands	Tidal wetlands with perennially fresh water Tidal wetlands with seasonally or perennially saline water 'Tidal wetlands with acid sulfate soils 'Tidal wetlands with peat soils

As cited in Fischer et al (2014) recent classification by Dawe et al (2010) somehow departs from the former classification by Khush (1984). According to this, global rice production environments are classified into seven categories (four irrigated, two rainfed and one for deepwater rice). The feature of this classification is the integration of overall cropping systems with other criteria (**Table 3**).

Table 3. Rice mega-environments (RMEs), relative areas and major producing regions

RMEs	Description		Major regions	% area (160 million ha)- average of 2008-10
	Hydro-morphology	Climate		
1	Irrigated	Warm to hot-tropics (rice all seasons) and subtropics (double crop summer rice)	Indonesia, Sri Lanka, Vietnam, the Philippines, south-eastern India, southern China, Bangladesh	25
2	Irrigated	Warm-tropics (higher altitudes) and subtropics (sole rice after winter crop)	South Asia hills, Indo-Gangetic Plain, central China	16
3	Irrigated	Temperate (summer rice after winter fallow, warm and humid)	Japan, Korean peninsula, north-eastern China, southern Brazil, southern USA	15
4	Irrigated	Temperate (summer rice after winter fallow, hot and dry)	Egypt, Iran, Italy, Spain, California (USA), Peru, south-eastern Australia	1

RMEs	Description		Major regions	% area (160 million ha)- average of 2008-10
	Hydro-morphology	Climate		
5	Rainfed lowland	Tropics	Cambodia, North-East Thailand, eastern India, Indonesia, Myanmar, Nigeria	31
6	Rainfed upland	Tropics	South Asia, South-East Asia, Brazilian Cerrado, western Africa	9
7	Deep water	Tropics	River deltas of South Asia and South-East Asia, Mali	3

Percentage of world area; percentages apply to global rice area around 2008–10 (160 million ha).

Source: Fischer 2014 based on Khush 1984, World Rice Statistics (IRRI 2012), with adjustments within irrigated rice from Dawe et al 2010 and RME4 was estimated by the author.

Rice Production environments in Nepal

In Nepal, rice is grown in three agro-ecological regions (Tarai and inner Tarai- 67 to 900 masl; mid hills- 1000 to 1500 masl; and high hills- 1500 to 3050 masl) under two water regimes (Irrigated, Un-irrigated) and in two topographic conditions (lowland and upland). In general, Tarai represents tropical climate whereas mid hills and high hills correspond to sub-tropical and warm temperate climates, respectively. These variations have made classification of rice growing environments in Nepal a complex task. By combining these factors and considering the Global Mega Rice Environments (MREs) criteria, **Table 4** summarizes major rice growing environments in Nepal. It can be noted that water regimes, agro-ecological types and topography are the major factors explaining the variability among rice production domains in the country.

Table 4. Major Rice Production Environments (RPEs) in Nepal

RPEs	Agro-ecology (Climate)	Hydro-morphology	Topography	Cropping system
Irrigated	Tarai and inner Tarai Tropical	Irrigated	Lowland	Single crop
	Tarai and inner Tarai Tropical	Irrigated	Lowland	Double crop
	Tarai and inner Tarai Tropical	Irrigated	Lowland	Triple crop
	Mid hill sub-tropical	Irrigated	Terraces *Khet*	Double crop
	Mid hill sub-tropical	Irrigated	Terraces *Khet*	Single crop
	High hill warm temperate	Irrigated	Terraces *Khet*	Single crop
Rainfed	Tarai and inner Tarai Tropical	Rainfed	Lowland	Single crop
	Tarai and inner Tarai Tropical	Rainfed	Upland *Pakho*	Single crop
	Mid hill sub-tropical	Rainfed	Upland *Pakho*	Single crop

The Tarai region, which is considered the granary of the country, accounts for about 70% of the country's rice output; the hills produce 27%, and the mountain produces about 3%. Available data shows that only about 7% of the rice areas have assured irrigation during summer, winter and spring seasons allowing farmers to produce double rice crop in a year. Although in very limited areas, farmers in the eastern Tarai produce three rice crops in a year. In the mid hills and valleys (warm sub-tropical climate) with year round assured irrigation facilities rice farmers grow spring rice in addition to main season rice. However, majority of the rice in the mid hills is produced as a single crop in the pond terraces. In the high hills up to 3,000 m irrigated rice is grown only once in a year due to longer growing period.

In rain-fed areas (in all three ecologies) rice is transplanted with the onset of the monsoon rain between June and August and harvested from September to November. The monsoon rain first arrives in the eastern part of the country and gradually advances to the west. Majority of the rice areas in the Tarai and inner Tarai are rain-fed. In the upland areas of the Tarai and the hills, upland rice varieties (*Ghaiya*) are grown. Due to extreme lower yield of local *Ghaiya* varieties, farmers are gradually replacing *Ghaiya* rice with maize. In recent years, with the scientific innovations, farmers in the Tarai upland environment are producing hybrid rice (eg US 312) as intercrop with maize. This kind of cropping system is traditional for far west region where farmers mix Ghaiya with maize. However, farmers in the central Tarai are gradually being attracted to hybrid rice and maize intercropping due to higher yield and return.

Rice based cropping systems in Nepal under various RPEs

Several crop combinations in rice based areas are in practice. These areas are determined by agro-ecology and climate, hydro-morphology, topography, market and domestic needs. Some of the popular rice based cropping systems are summarized below.

Rice-maize mixed cropping

System of mixing direct seeds upland rice with maize under rain-fed condition is a tradition practice in the far western Tarai and river basin areas. According to farmers, the mixing practice ensures higher income, maintains better soil quality and reduces risks. In general, rice and maize seeds are mixed in the ratio of 5 to 10:1 depending on farmers' interest and needs.

Rice-legumes intercropping systems

Farmers in Nepal grow rice intercropped with soybean (*Glycine max* L.), black gram (*Phaseolousmungo* L.), green gram (*P. radialus* L.), pigeon pea (*Cajanuscajan* L.) utilizing the bunds in the rice terraces. This practice is common in both the irrigated and rain-fed systems.

No till relay cropping system

The seed of succeeding winter crops like lentil, gram, pea, lathyrus is broadcasted in muddy or marshy conditions of maturing rainy season rice fields during the month of November. The rice crop is harvested within a few days, leaving the seeds to germinate and grow utilizing the residual soil moisture.

Sequential cropping

Several rice based sequential cropping systems prevail in Nepal depending upon the agro-climatic, hydro-morphic and topographic conditions (**Table 5**). Major sequential cropping systems in the rice growing areas include Rice-wheat-fallow (Irrigated); Rice-wheat-rice (Irrigated); Rice-maize-rice or fallow (irrigated); Rice-wheat-maize (Irrigated); Rice-fallow-fallow (rainfed); Rice-barley or wheat (irrigated).

Table 5. Major sequential cropping system in Nepal

i. Tarai (<1000 masl)

Irrigated area	Rainfed area
Rice-wheat-rice	Rice-fallow-fallow
Rice-wheat-fallow	Rice-wheat-fallow
Rice-wheat-Dhaicha	Rice-lentil-fallow
Rice-wheat-mung	Rice-rapeseed –fallow
Rice-maize-rice	Rice- fallow-tobacco
Rice/lentil-rice	Jute-rapeseed-fallow
Rice-chickpea, linseed	Jute-wheat-fallow
Rice-wheat-maize	Maize-chickpea, lentil

Irrigated area	Rainfed area
Rice-potato-Dhaicha	Rice/lentil
Rice-pigeon pea (in bund)- wheat	Maize-chickpea+rapeseed
Rice-potato-maize	

ii. Mid-hill (1000-2000 masl)

Irrigated area	Rainfed area
Rice-wheat-fallow	Maize/millet-wheat
Rice-wheat-rice	Maize/millet-fallow
Rice-wheat-maize	Maize + soybean-rapeseed-fallow
Rice-black gram (in bund)-wheat	Maize-wheat
Rice-barley	Maize-oat
Rice-maize	Maize + upland rice
Rice-rapeseed-maize	Maize + upland rice- wheat
Rice-rapeseed-rice	
Rice-potato-maize	

iii. High hill (> 2000 masl)

Irrigated area	Rainfed area
Rice-barley	Maize –fallow
Rice- necked barley (uwa)	Maize –wheat
Rice-wheat	Wheat- finger millet (2 years cropping pattern)
Buckwheat- necked barley (uwa)	Maize- naked barley (uwa)-finger millet (2 years cropping pattern)
Potato + necked barley (uwa) – fallow (2 years cropping pattern)	Maize-wheat-finger millet (2 years cropping pattern)
Rice-fallow-finger millet-barley-wheat (2 years cropping pattern)	Potato-fallow, potato-buckwheat, maize-rapeseed, uwa-fallow, maize-buckwheat

Source: CDD 2015.

Integrated rice farming

Rice-fish-poultry and rice-fish-duck are also practiced in the Tarai regions of Nepal. This system ensures better yield for rice and poultry/duck. Birds and fish add manures to the soil and eat insect pests and help to circulate oxygen in the rice field. Fish grown in the paddy fields, is an ideal use of land and easy source of cheap animal protein. Thus, fish culture can contribute to the socio-economic and nutrition welfare of rural population.

Conclusion

Rice is the most widely consumed staple food for a large part of the world's human population. Rice is normally grown as an annual plant, and is grown well in hot and moist climate. Although in tropical areas it can survive as a perennial crop and can produce a ratoon yield too. So defining precise rice production environments is a complex and difficult task. However, classification of rice growing environments is important for germplasm exchange and development of environmental specific rice varieties and agronomic practices. In this context the article reviews rice production and rice growing environments in the Nepal with reference to cropping system, rice production environments and in world with reference to rice mega environments.

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Climate Change Effect on Growth Stages of Rice

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सारांश

मौसम परिवर्तनले धान बालीको विभिन्न अवस्थामा पार्ने असरबारे सन् २०१६ मा एक अध्ययन गरियो । नेपालले कृषि र गैह्र कृषि क्षेत्रबाट हरित गृह ग्यास उत्सर्जन गरी मौसम परिवर्तन भएको कुरामा कुनै ठूलो भूमिका रहेको छैन । तर पनि नेपालमा समग्र धान खेती र धानको विभिन्न वृद्धि अवस्थामा यसको प्रभाव केही पहाडी र उच्च पहाडी क्षेत्र बाहेक नकारात्मक देखिन्छ । कार्वनडाईअक्साईड उत्सर्जन वृद्धि भैरहँदा प्रकाश संश्लेषण र पोषणमा वृद्धि भै धानको विकास र वृद्धिमा सकारात्मक प्रभाव पर्ने हुन्छ । तथापि, हरित गृह ग्यासका कारण सृजित अजैविक (बढी वा कम तापक्रम वा वर्षा) र जैविक (रोग, किरा, झारपात) कारणका उच्च प्रभावबाट धानको बाली अवधि, जातीय वितरण, समग्र बोटको वृद्धि र बाली उत्पादनमा तीव्र असर पुगेको छ । समयमा पानी नपर्नाको कारण ब्याड राख्न र रोपाइँ गर्न ढिलो हुने गरेको, ब्याडमा बीउको उमार कम हुने, कम गाँज हाल्ने, पोटाउँदा होचो हुने साथै बाला निस्कदा, परागशेचन हुँदा, बाली पाक्ने विषयमा असामान्य देखिने र बाली अवधि छोटो हुने गरेको छ । फूल लाग्ने, परागशेचन हुने र पोटाउने अवस्था खडेरी र डुवान दुवैको लागि ज्यादै सम्वेदनशील अवस्था हुन् । धान पाक्ने समयमा पर्ने असिना र वर्षाको बाढीले गर्ने खेती कटान पनि उत्तिकै सम्वेदनशील देखिन्छ । ब्याड राख्न, रोपाई गर्न, बोटको वृद्धि, बाली प्रजनन र बाली पाक्ने अवस्था सबैमा पानी र तापक्रमको महत्व र प्रभाव पनि त्यत्तिकै महत्वपूर्ण छ । यी सबै चिजले बाली अवधि, बाली उत्पादन र बालीको गुणस्तरमा प्रभाव पार्दछन् । जैविक नकारात्मक प्रभावले भने बीउ उम्रने बेलादेखि बाली भण्डारण समयसम्म सक्रिय रहन्छन तर गजाउनु पूर्व अवस्थामा सक्रिय किराहरू र झारपात तथा गजाउने र बाला लाग्ने बेला रोगहरूको प्रभाव उच्च रहन्छ । मौसम परिवर्तनको जोखिम र नकारात्मक प्रभाव घटाउन धान खेतीमा अनुकूलन कार्यक्रमहरू अवलम्बन गर्नु पर्दछ । यसको लागि तथ्यहरू संकलन गर्ने, जोखिम आँकलन गर्ने, अनुकूलनका उपायहरूको अभिलेखिकरण गर्ने, जानकारी मूलक कार्यक्रमहरू संचालन गर्ने, नीतिगत लविङ पृष्ठपोषण गर्ने र सिधै स्थानीय रूपमा धान बालीमा अनुकूलन कार्यक्रमहरू कार्यान्वयन गर्न जरूरी छ ।

Summary

Nepal's contribution (both agriculture and non-agriculture) to greenhouse gases emission and global warming is negligible but the overall impacts on rice growth stages are negative except some positive impact in hills and mountains. Increased CO_2 is expected to have positive physiological effects by increasing the rate of photosynthesis and carbon dioxide fertilization. However, higher intensity of abiotic (heat and water) stresses and biotic (diseases, insect pests and weed) epidemics because of global warming have impacted on rice growing period, overall plant growth and reproduction. Delayed on seeding and transplanting, low germination and emergence, low tillering, slow inter node elongation, abnormalities on panicle initiation, booting, heading, anthesis and ripening, with shorter crop duration are some negative impacts of climate changes. The extreme and dangerous vulnerable stages for abiotic stress are the anthesis followed by booting. It is because of rainwater (flood and drought) and heat stresses. Other climate induced disaster eg hail stone, river cutting of rice field etc are also important factors. Availability of irrigation water is inter-related factor for rice seeding, transplanting, growth, reproduction and harvesting. The biotic stresses prevail throughout the growing period however, pre-tillering stage for weeds and tillering and heading stages for diseases and insect pests are more vulnerable. Climate change adaptation can reduce the vulnerabilities and negative effects.

Keywords: Climate change, Green house gases, Global warming, Rice, Vulnerabilities

Background

Climate change is a natural phenomenon related to changes in the concentration of the greenhouse gases (water vapor, CO_2, CH_4, N_2O, SO_2, CFCs, PFCs, HFCs, SF_6, etc) in the atmosphere of the earth's surface, which trap infrared radiation and thus cause the greenhouse effect resulting changes in: the air temperature, precipitation patterns, sea-level rise, and melting of glaciers. Human activities, such as fossil fuel combustion, deforestation, and some industrial processes have led to an increase in greenhouse gases concentration (CEU 1999). There are some physical indicators for climatic changes. They are changes in bio-geography (vegetation, insects and animals), glacial geology and ice core, dendrology (tree ring analysis), hydrology, maliso-palynology (pollen analysis), biology (crop, animal, and pest) and ecology/ecosystem (food chain, natural control, decomposition of organic matter and pollination).

Among the greenhouse gasses the trend of methane emission from paddy field (Gg/year) in Nepal is increasing year after year. Nepal's contribution on N_2O emission is not significant. Nepal's contribution on CO_2 emission is only 9,747 Gg/yr (UNSD 2008; NNC 2004). Nepal's average temperature rise is 0.06°C/year. However, the rate is higher in mountain (0.08°C/year) followed by hills and the Tarai (0.04°C/year). The days and nights are becoming warmer and Nepal faced twelve warmest years since 1987 to 2005(Shrestha et al 2000).The rainfall pattern is also changing in season, duration, intensity and amount. Pre-monsoon rain, delay monsoon, unusual precipitation, decreased rainy days and increased intense rainfall events are the common features of rain fall with climate change. The number of annual rainy days have decreased, dry days have increased, evapo-transpiration has increased (mainly in mid-western Tarai, Mustang, Ramechhap) and there are increased number of rainy days with >100 mm rain. The frequency of flash flood is increasing at present. The biggest flash flood recorded in 1996 was reoccurred after 17 years in July 1983 then after 10 years in August 1993 and August 2003. This kind of flash flood is returning in every 3 years eg in August 2006. The linear line of all Nepal's monsoon rainfall during the year 1971-2005 is in increasing trend. Three years 1975, 1984 and 1998 were the years with peak total rain fall in Nepal (Baidya and Karmacharya 2007). All these affected hydrology and available water for rice production.

Changing glacial ecology is one of the evidences of climate change in Nepal. Himalayas are sensitive to temperature rise. Snows of Himalayas is expected to be disappeared by 2035 (ICIS 2005). What will happens to rice cultivation if the Himalayas and the Himalayan River dry in Nepal? Melting of the Himalayan snow is responsible for increasing the water level in several glacier lakes in Nepal Himalayas. Some of them has been outburst in the past resulting increase in debris flow, increased the discharge of snow fed rivers in the downstream causing flooding in Tarai and affecting rice crop. Change in crop biology and bio geography is another evidence of climate change in Nepal (Paudeletal 2013). Rice cultivation has shifted to 2400 masl from 1800 masl at Murza VDC of Myagdi. Another physical evidence of climate change in Nepal is damage of agricultural lands and irrigation structures from the inundation of the flood. In mid-western region heavy rain created flooding and destroyed crop land in 2007. Irrigation systems were damaged in Sarlahi and Rautahat in 1993. The per annum loss of paddy land is about 100 ha (115 ha in 2001, 116 ha in 2003, 120 ha in 2005). The hydrology and soil water availability has been changed in different ecological zone. Change in water table in Tarai (increase/decrease) has created irrigation and drainage problems.

Increased evapo-transpiration created drought and peak runoff accelerated nutrient loss from the top soil. Higher soil temperature was responsible for faster decomposition of the organic matter (OM) and decreased the availability of soil nutrients for a longer period, and affected soil microbial activities and finally on growth and development of rice plant in different stages. The pattern, type and frequency of pests outbreak have been changed. Some of the new weed species have invaded agro-ecosystem. Some other have shifted their distribution range up to higher elevation. Biotypes of some insect pest and pathogens have been changed. Also the population and types of natural enemies have increased enabling for the natural control of the pest in non-disturb agro-ecosystem with ecological balance. There are some critical examples of pest outbreak and natural control in Nepal. Rice BPH/WBPH was outbreak in 1996 in Chitwan and its natural control was found effective with Mirid bug (Pokhrel et al 998/1999). Rice white fly (*Alleurocybotus occiduus* Maria) has been reported as a rice pest in 2003 in Nepal which is the first time in world history. Predator (*Encarsia* sp.) was closely associated for its natural control (Pokhrel and Thapa 2008). All these factors affected rice growth, reproduction and yield.

Climate changes on rice growth and production

The overall impact of climate change on rice growth and production in fact can be negative in Tarai and foot hills and positive in mountains. The increased concentration of Green Home Grasses (GHGs) is responsible to temperature rise and alteration of rice yield. Increased evapo-transpiration and temporal variation on rainfall causes drought and the increased rainfall causes flashflood and flooding in river basin and Tarai, affecting rice crops in different stages and ultimately reducing rice production. Erosion with 15% increased runoff also reduces crop productivity. Landslides in hills may increase in debris flow in downstream with flash floods in Tarai effecting rice growth and reproduction. Disease and pest epidemics related to climate change also hamper rice growth and reproduction. Thus, the climate effect on overall yield gains of rice in Nepal was negative for the period, 1980-2008 (Meehl et al 2007).

Effect on seed germination

Rice seed germination occurs when the seed coat has imbibed adequate water to become soft and elastic. Under dry-seeded or aerobic conditions the radicle emerges before the coleoptile. Under water-seeded or reduced oxygen (anaerobic) conditions the coleoptile may emerge before the root (radicle or coleorhiza). This typically occurs within two days when temperature is between 18° to 40°C. Below or above this temperature, germination requires more time. Germination fails below16°C and above 45°C (Karen et al 2016). Thus, global warming influences rice seed germination. On the other hand, scarcity of water hinders wet bed seed sowing and lack of rain for dry bed delayed seedling rising in Nepal. Excess soil moisture with dry bed some time helps for *Fusarium* wilts and some other fungal diseases. Ones the seeding becomes week or shortage, it hampers rice yield.

Seedling emergence

Emergence occurs when the first internode, called the mesocotyl, has elongated and pushed the tip of the rice coleoptile (epiblast) through the soil surface. The prophyll (first sheathing leaf) emerges through the coleoptile (Karen et al 2016). This process can also be affected from soil moisture. Climate change effect has increased both the moisture stresses (high or low) together with heat stresses. The optimum temperature for seedling emergence is 25-30°C. Below 12°C and above 35°C seeding emergence stops. With the seedling emergence, rooting started. The optimum temperature for rooting is 25-28°C. Below 16°C and above 35°C rooting stop (Yoshida 1978). Leaf elongation starts in seeding emergence stage that needs optimal temperature of 31°C with lower limit of 7-12°C and maximum of 45°C. Without rooting and leaf elongation the rice seeding may not enter into pre-tillering phase. All these phenomena are related with soil moisture, irrigation and climate change vulnerabilities. Submergence in this stage can cause seed death and drought can be fatal.

Pre-tillering

The period from the development of the first to fourth-leaf stage requires 15 to 25 days. During this period the seminal root further develops, the secondary or lateral roots develop and the first 4 leaves appear (Karen et al 2016). Pre-tillering delayed with moisture stresses and especially from drought. Heat stresses also affect pre-tillering. Optimum moisture and temperature needed on this stage to have excesstillering. Heat stresses in this stage can cause white leaf tip. Drought may cause seedling death and weed infestation (**Figure 1**). Submergence may cause seedling death. All these events are inter related to global warming and climate change.

Figure 1. Rice plant severely affected in pre-tillering stage from drought in Rautahat, Nepal, 2007

Tillering

Tillering usually begins at the fifth-leaf stage (Karen *et al* 2016). Symptoms of heat stress in rice tillering stage is white leaf tip, chlorotic bands and blotches, white bands and specks that reducestillering andplant height (Yoshida 1981). It is the most vulnerable growth stage of rice that results to successful reproductive phase leading to good yield. Tillering stage is comparatively tolerant to flood and drought than reproductive phase, depending up on the tolerance of the rice varieties (**Figure 2**) maximum tillering is expected with sufficient irrigation, use of manure and fertilizer with 25-31^{o}C atmospheric temperature. Tillering stops beyond 33^{o}C and below 9-16^{o}C (Yoshida 1978). The tillering in tropics was mostly affected from heat stress and in sub-tropical region by cold stress. Severe drought during the vegetative stage can reduce the rice yield by 21% and submergence can reduce the yield by 26-49% (**Table 1**) (Zainoladedin et al 2008).

Table 1. Grain yield loss of paddy crop due to abiotic stresses

SN	Stress	Growth stage	Loss (%)
1	Drought	Vegetative	21
		Flowering	50-60
		Grain filling	21
2	Submergence	Vegetative	26-49
		Grain filling	20
3	Combination of high temp (42-46%) + low (60%) and high humidity (85%)	Grain yield reduction	30

Source: Zainoladedin et al 2008.

Unavailability of sufficient irrigation, followed by elongation of cloudy weather reduces photosynthesis and number of tillers. Vulnerability of insects, diseases and weeds in this stage is most critical for overall plant growth development and rice yield as well.

Figure 2. Rice plant under submergence in Sarlahi, Nepal in tillering stage 1993

Reproductive phase

The reproductive phase is characterized by booting, emergence of the flag leaf, heading and flowering. This phase usually lasts approximately 30 days in most cultivars. The beginning of this phase is sometimes referred to as the internode elongation or jointing stage that varies slightly by cultivar and weather conditions (Karen et al 2016). Heat stress during reproductive phase hampers anthesis, reduce spikelet number and increase sterility. It also reduces grain-filling (Yoshida 1981). Panicle initiation and booting stages during microsporogenesis and anthesis are the stages that are most sensitive to lower temperature. High temperature also causes increased sterility during flowering. Combination of high temp (42-46%) + low (60%) and high humidity (85%) during different growth stage can reduce the rice yield by 30% (**Table 1**) (Zainoladedin et al 2008). Thus, flooding and drought in reproductive stage is very dangerous.

Flooding at flowering stage returns in each 5-10 years in Nepal and is highly dangerous. Flooding is reoccurring at the interval of 2-5 years and is dangerous in this stage. Drought during flowering is also extremely dangerous and is reoccurring in the gap of every 6 years in Nepal. Drought during booting stage is reoccurring in each alternate year and is severe for rice yield (**Table 2**).

Table 2. Return period of floods and droughts on paddy crop in central Tarai

Hazard	Period	Severity	Return period (years of incident)
Flood	Flowering	Highly dangerous	5-10 years (1989, 1996, 2002, 2009)
	Booting	Slightly–moderately dangerous	2-5 years (1987, 1989, 2007, 2009)
Drought	Flowering	Extreme	About 6 years (1995, 2002)
	Booting	Severe	About 2 years (2004, 2006, 2010)

Source: Nepal National Communication Report 2004.

Panicle initiation

This is the time when the panicle primordia initiate for the production of a panicle in the uppermost node of the culm (Karen et al 2016). Sufficient irrigation in this stage with optimum air temperature is needed. The air temperature below 12^{o}C is dangerous on this stage. Panicle differentiation begins from this stage which needs air temperature of 20-30^{o}C. Below 15^{o}C this process also stops and rice fails to produce the ears. Soil moisture during this period is also equally important. Air temperature and soil moisture both are the factors affected from climate change.

Internode elongation

Internode elongation begins about the time of panicle initiation and will be continue until full plant height is reached (Karen et al 2016). Excessive photosynthesis is needed during this period. Soil fertility level together with full sun shine, heavy irrigation and optimum temperature are the important factors for the maximum growth and internode elongation together with lignin formation to give the strength against lodging. Plant height is directly related with internode elongation. Drought hampers directly on internode elongation. Most disease and insectpest population increases in this stage and their epidemics occurs in many times related to climate events.

Booting

This stage is loosely defined as that period characterized by a swelling of the flag leaf sheath which is caused by an increase in the size of the panicle as it grows up the leaf sheath. Full or late boot occurs when the flag leaf has completely extended (https://www.uaex.edu/publications/pdf/mp192/chapter-2.pdf, 2016). Normal irrigation is needed in this stage. Flooding is moderately dangerous and drought is severely dangerous in this stage (**Table 1**).

Heading

Heading starts when the panicle begins to exert from the boot. Heading over an individual field may take over 10 to 14 days due to variations within tillers on the same plant and between plants in the field. Agronomicallyheading date or 50% heading is defined as the time when 505 of the panicles have at least partially exerted (https://www.uaex. edu/publications/pdf/mp192/chapter-2.pdf 2016). Heading time may be shortened with increased temperature. Excess humidity during heading may be favorable for rice blast. Most of the insect pestseg rice borer, BPH, gundy bugs and several other diseases may outbreak in this stage, that favor by the climate change. Irrigation is most needed in this stage. However, alternate irrigation and drying may maintain sufficient soil moisture. Drought is dangerous in this stage too.

Anthesis

Anthesis or flowering refers to the events between the opening and closing of the spikelet (floret) and acts for 1 to 2½ hours during which pollination occurs. Flowering generally begins upon panicle exertion or on the following day and is consequently considered synonymous with heading. Anthesis generally occurs in late morning to afternoon but is related to the intensity of light. Anthesis generally needs warm temperature (30-33^{o}C). Extremes in temperatures, such as 22°C or less, for two consecutive nights, 2 weeks prior to and/or at flowering can cause excessive sterility or blanks. Also, strong winds, rain showers, fertilizer or pesticide applications while blooming during anthesis can increase sterility. During flowering, air temperatures >35°C may increase blanking (Yoshida 1978). The most damaging effect is on grain sterility; just 1 or 2 hours of high temperature at anthesis (about 9 days before heading and at heading) result in a large percentage of grain sterility (Yoshida 1981). Flooding is highly dangerous and drought is extremely dangerous in this stage. Present climate change has increases these short of vulnerabilities during anthesis. Zainoladedin et al (2008) reported that drought during flowering can reduce the yield by 50-60% and during grain filling additional 20% (**Table 1**).

Ripening phase

The grain filling and ripening or maturation phase follows ovary fertilization and is characterized by grain growth. During this period, the grain increases in size and weight as the starch and sugars are trans-located from the culms and leaf sheaths where they have accumulated, the grain changes color from green to gold or straw color at maturity and the leaves of the rice plant begin to senesce. Light intensity is very important during this interval since 60% or more of the carbohydrates used in grain filling are photosynthesized during this time interval. This period is also affected by temperature. High nighttime temperature during grain filling result in increased respiration which causes the plant to consume more carbohydrates. This reduces the efficiency of photosynthesis during the day, resulting in less filled spikelets. This leads to reduced grain yields. It also results in increased chalky kernels, a thicker bran and aleurone layer, which result in reduced head rice yield (Karen et al 2016). The warm temperature between 20-29°C is optimum in this stage. Higher temperature beyond 30°C is not good and the temperature below 12-18°C may cause cold injury during ripening phase.

Milk stage

At this stage, the developing starch grains in the kernel are soft and the interior of the kernel is filled with white liquid resembling milk. The interval for development from growth stages is about 90 DD 50 units and 3 to 6 days (Karen et al 2016). Proper irrigation in this stage is needed. Insufficient growth and development of rice plant until this time may reduce the efficiency on this stage. Drought or heat stress in this stage reduces milking process.

Dough stage

The starch in the grain is beginning to become firm but is still soft and thus is called soft dough stage. Hardening of the starch includes the end of grain filling which is called hard dough stage. Here, the grain-drying stage begins and the grain is firm during this stage and almost ready for harvest. The moisture content for the entire grain will be 22%. Irrigation can be stopped during the end of hard dough stage. Fair sunshine is needed with no rain and clouds. The growth stages: heading milking dough are very susceptible to high nighttime air temperatures. Unusual climate condition can adversely affect this process to.

Maturity

In this stage, the whole grain become hard (20% moisture) and ready for harvest. Maturity may take 27 days from the day of dough stage. Normally rice is harvested after maturity while developing grains continue to dry as the later grains are still filling. Consequently, waiting until the last grains fill is impractical and results, normally, in reduced milling quality (Karen et al 2016). The optimum temperate of 20-29°C is fair in this stage. Temperature below 12°C and above 30°C is not good for grain maturity. Excess moisture and rainfall may reduce the grain quality, sometime those may cause seed germination on ear and reduce the seed quality. This problem is severe during the summer/spring rice. Extreme climate hazards ie rainfall, hailstone, snow fall etc are dangerous to this stage. These calamities are increasing in present days due to climate changes.

Crop period

Duration of crop growth cycles are related to temperature. An increase in temperature will speed up development. In the case of an annual crop, the duration between sowing and harvesting will shorten. For example, the duration in order to harvest could shorten between one and four weeks. The shortening of such a cycle could have an adverse effect on productivity because senescence would occur sooner (Karen et al 2016). Thus, global warming is shortening the rice crop period.

Potential effects of climate change on pests, diseases and weeds

A very important point to consider is that weeds would undergo the same acceleration of cycle as cultivated crops, and would also benefit from carbonaceous fertilization. Since most weeds are C_3 plants, they are likely to compete rice plants. However, some results make it possible to think that weed killers could gain in effectiveness with the temperature increase. It may also cause an increase on the emission of GHGS. Global warming would cause an increase in rainfall in some areas, which would lead to an increase of atmospheric humidity and the duration of the wet seasons. Combined with higher temperatures, these could favor the development of fungal diseases. Similarly, because of higher temperatures and humidity, there could be an increased pressure from insects and disease vectors (Karen et al 2016). There was rice BPH/WBPH outbreak in 1996 in Chitwan and its natural control was found effective with Mirid bug (Pokhrel et al 1998/1999). Rice white fly (Alleurocybotus occiduus) Maria reported as a rice pest in 2003 in Nepal which is the first time in world history (**Figure 3**). Predator (Encarsia sp.) was closely associated for its natural control (Pokhrel and Thapa 2008).

Figure 3. Rice hispa *Dicladispa armigera* (Olivier) after submergence and rice whitefly *Aleurocybotus occiduus* Maria under warm humid condition in Chitwan Nepal 2003

Increased CO_2 concentration increases the C: N ratios in plant tissue resulting slow insect pest development and increase the length of life stages vulnerable to attack by parasitoids (Coviella and Trumble 1999). However, overall climate change effect is somewhat favorable to natural enemies (NEs). It has been estimated that with a 2^{o}C temperature increase NEs might experience 1-5 additional life cycles per season (Yamamura and Kiritani 1998). Increased temperature could increase pest populations which provide a field for NEs propagation (Coviella and Trumble 1999). Each year NEs population is increasing by 10% given other factors constant. Moreover, the insect parasitic nematodes are susceptible to extreme temperature (www.ext.colostate.edu/pubs/insect/05573.html). The mycophagus fungi like *Metarhizium* and *Beuveria*are also susceptible to extreme temperature and becomes non-functional beyond 30^{o}C. These vulnerabilities have been created from the present climate changes.

Rice yield

Studies on rice productivity under global warming also suggest that the productivity of rice will decrease as global temperature increases. Mohandrass et al (1995) using the Hadley-coupled model, predicted a yield decrease of 14.5% for summer rice crops across nine experiment stations in India in 2005. Peng et al (2004) reported that the yield of dry-season rice crops in the Philippines decreased by as much as 15% for each 1°C increase in the growing season mean temperature. Zainoladedin et al (2008) reported that the combination of high temp (42-46%) + low (60%) and high humidity (85%) can reduce grain yield by 30% (**Table 1**). Lobell et al (2011) also reported that the 47 ppm increase in CO_2 over the time period may increase 3% global rice yield with present temperature trend impact of +0.1% with precipitation impact of -0.1% (**Table 3**).

Table 3. Global impacts of temperature and precipitation trends, 1980-2008, on average rice yield. Estimates of the 47 ppm increase in CO2 over the time period

Crop	Global production (1998-2002 average, millionmetric tonnes)	Global yield impact of temperature trend (%)	Global yield impact of precipitation trend (%)	Subtotal	Global yield impact of CO2 trends (%)	Total
Rice	591	0.1	–0.2	–0.1	3.0	2.9
		(–0.9, 1.2)	(–1.0, 0.5)	(–1.6, 1.4)		

Note: Values in parentheses show 5th-95th percentile confidence interval estimated by bootstrap resampling over all samples.

Source: Lobell et al 2011.

In Nepal, rice yield increases under elevated CO_2 (3.4% in Tarai, 17.9% in hills and 36.1% in mountains) without change in temperature and irrigation (Malla 2008). Beyond 4°C, yield decline in Tarai by -3.4% (-0.8%/1°C) but increases in hills (+17.9%) and mountain (+36.1%) (Sherchandet al 2007). Precipitation has negative effect in summer (−1% per 100 mm) but has positive effect in spring in Tarai (1% per 100 mm) on the mean rice yield and vice versa in hills. Poudel and Kotani (2012) forecasted up to 3.9% decrease in rice yield with 20% increase on seasonal climate variables in different altitude in Nepal (**Table 4**).

Table 4. Forecasted % change in rice yields when seasonal climate variables increase by 20% relative to the sample means

Rice	Spring temp	Summer temp	Both spring summer temp	Spring rain	Summer rain	Both spring and summer rain	Both temp and rain
Low altitude	−0.547	−3.157	−3.705	0.165	−0.384	−0.219	−3.924
Mid altitude	0.396	0.453	0.849	−0.17	0.381	0.211	1.061
High altitude	0.802	0.588	1.39	0.117	−0.272	−0.155	1.235

Source: Poudel and Kotani 2012.

There are some evidences of reduced crop yield in Nepal in the past. Rice yield was reduced by 12.5% in 2006 and productivity reduced to 2.71 t/ha in 2008 from 2.91 of 2009 due to drought. In eastern Tarai rice production was reduced by 30% and 9.6% because of failure on transplanting and reduced productivity in 2006. 50% rice area failed rice transplanting in 2012 in Dhanusha, Sirha and Saptari, losing about 58% yield (MoAD 2014).

Effect on quality

According to the IPCC's TAR, the amylose content of the rice grain, a major determinant of cooking quality is increased under elevated CO_2 (Conroy et al 1994). Cooked rice grain from plants grown in high-CO_2 environments would be firmer than that from today's plants. However, concentrations of iron and zinc, which are important for human nutrition, would be lower (Seneweera and Conroy 1997). The protein content of the grain decreases under combined increases of temperature and CO_2 (Ziska et al 1997). It also reduces the quality of straw and other byproducts.

Conclusion

Different growth and reproduction stages of rice are vulnerable in different degree with abiotic and biotic stresses. Frequency of these stresses has been increased at present time because of global warming. The effect by increased CO_2 concentration is positive however the increased temperature, with uneven rainfall pattern, with changing hydrology, ecology, biology and geography is affecting rice growth and reproduction. Climate change adaptation can reduce these vulnerabilities and negative effects.

Acknowledgements

Author would like to appriciate the iniation of Mr. Dila Ram Bhandari, Director General of Department of Agriculture and his team for bringing out historical document on rice. Thanks also goes to those who have directly or indirectly supported by providing necessary information during preparation of this manuscript.

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Greenhouse Gas Emission from Rice Fields and its Impact on Environment

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सारांश

यो लेखले साधारण रूपमा हरित ग्यास उत्सर्जन सम्बन्धमा केही विषयगत कुराहरू तथा नेपालमा धानखेतीबाट उत्सर्जन हुने मिथेन ग्यासबारे चर्चा गरेको छ । साथै, हरित ग्यास उत्सर्जन सम्बन्धमा मिथानोजिनेसिस, नाइट्रीफिकेसन, डिनाइट्रीफिकेसन र गुम्सिएको अवस्थामा गोबर व्यवस्थापनबारे पनि प्रकाश पार्ने प्रयास गरेको छ । नेपालको धानखेतबाट उत्सर्जन हुने मिथेन ग्यासबारे परिमाणित समीक्षा गरिएको छ । यो सन् २००० देखि २०१० सम्ममा १११.५ गिगाग्राम देखि १३३.०७ गिगाग्राम प्रतिवर्ष भएको पाईएको छ । उक्त अवधिमा पशु पालन तथा धानखेती दुवैबाट उत्सर्जन हुने कूल मिथेन ग्यासको तुलनामा धानखेतीबाट मात्र हुने उत्सर्जन १७.४८ प्रतिशत देखि २०.४८ प्रतिशतको दायरामा रहेको पाइयो । वायुमण्डलमा हरित ग्यासको घनत्व बढेको प्रभावले संसारभरी तापक्रम बढ्ने गरेको छ । नेपालबाट हरित ग्यास नगण्य रूपमा उत्सर्जन भएपनि नेपालले जलवायु परिवर्तनको असर र प्रभावहरू अनुभव गरिरहेको छ ।

Summary

This paper briefly throws some highlight on greenhouse gases (GHG) emissions in general and methane gas emission from rice fields in Nepal in particular. Besides, the process of methanogenesis, nitrification and denitrification and anaerobic condition of manure management aspects in the context of greenhouse gas emission are briefly given. Quantified methane gas emission from rice fields in Nepal has been reviewed. It falls in the range of 111.5 Gg (Giga gram) to 133.07 Gg per year from 2000 to 2010. During the same periods, methane emission from rice in Nepal is in the range of 17.48% to 20.61% of the total methane emission both from rice and livestock sector in Nepal. Global warming is the impact of GHG concentration in the atmosphere. Despite negligible contribution global GHG emission, Nepal has been experiencing adverse impact of climate change. Some relevant climate change resilient rice cultivation measures are suggested.

Keywords: Climate change, Climate resilient, Global warming, Green house gases, Methanogenesis, Rice

Introduction

There are both natural and human sources of methane emissions. The main natural sources include wetlands, termites and the oceans. Natural sources create 36% of methane emissions. Important human sources come from landfills and waste, biomass burning, livestock farming, rice cultivation, as well as the production, transportation and use of fossil fuels. Human-related sources create the majority of methane emissions, accounting for 64% of the total. Due to the swamp-like environment of rice fields, this crop is responsible for 9% of human methane emissions. Rice agriculture creates 31 million tonnes of methane annually (Bousquet et al 2006).

Rice is an important emitter of methane (CH_4) which is one of the major greenhouse gases (GHG). In wetland soils some anaerobic microbial processes include denitrification, sulphate reduction and methanogenesis and are responsible for release of nitrogen (N_2), hydrogen sulphide (H_2S) and methane (CH_4). Most CH_4 produced in paddy fields is emitted via rice plant and not across the water-air interface (Huang 1991, Siserone and Shelter 1981). After submergence, paddy soils undergo sequential reduction processes and in the final step methane (CH_4) and hydrogen (H_2) are formed (Ponnamperuma 1972). Methane production by methanogenesis is a microbial processes strictly limited to anaerobic condition in rice plant (Ma et al 2010). Rice straw or biomass burning also causes a substantial amount of methane emissions.

According to Gatherone-Hardy (2013) on-farm greenhouse gases emissions for rice production fall into four main categories: 1. Methane emissions, 2. Nitrous oxide emissions (from microbial action in soils) 3. Carbon storage in the soil - soil organic carbon (SOC), 4. Direct and indirect CO_2 emissions associated with on and off-farm energy production and use. Understanding how these emissions arise, and potential mitigating steps, are important not only for environmental scientists, but also for social and political scientists who wish to understand the interactions between the social and environmental aspects of agriculture.

Nepal has been experiencing adverse impact of climate change despite negligible contribution to global greenhouse gas emission. Climate change is a natural process but recent trends related to climate change are alarming mainly due to anthropogenic reasons. Climate change has already affected people, their livelihoods and ecosystems, and presents a great development challenge for the global community in general and for the poor people in developing countries in particular. In Nepal, increased awareness towards improved management practices of rice cultivation that minimizes the production of GHG are suggested for the farmers.

Understanding GHG emission

Main GHGs are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The magnitudes of GHG emissions are influenced by soil properties and crop production as well as associated management practices. Understanding the factors that control greenhouse gas emissions and developing appropriate strategies to mitigate greenhouse gas emissions from agricultural sources are important tasks faced by today's agriculture. In the context of GHG emission, some important microbial processes in the soils are as follows:

Methanogenesis

It is a microbial process of production of methane (CH_4) in rice fields which is strictly limited to anaerobic conditions. It produces CO_2 and CH_4 in equal quantities, but from the climate perspective it is the quantity of CH_4 that reaches the atmosphere that matters and this is often substantially less than that originally produced. Significant quantities of methane are oxidized before release (Huang 1991, Gathorne-Hardy 2013).

Methane is a colorless and odorless gas. There is biofuel (Gobar gas) and the main part of natural gas is also methane. There is 2 ppm CH_4 and 0.5 ppm N_2O at atmosphere. Global warming potential of methane and nitrous oxide is 21 and 310 times in comparison to that of CO_2 and their increase rate in atmosphere is 3% and 0.3% per year respectively. Rice fields have been cited as major generators of methane and nitrous oxide. Out of total emission (from mines of coal, petroleum and gases, swampy land, urban waste dumping sites, inundated rice fields, digestive system of ruminants and termites) 12% of methane is produced from rice fields.

Rice crop emits methane, a potent global warming gas, because of the decomposition of organic matter in submerged paddy fields. There is mostly an anaerobic environment in the water logged rice field. If organic matter is also preset in the water logged soil, methanogenic bacteria decompose the organic matter and more of methane is produced. Methane can escape from the rice paddy soil in three ways: via aerenchyma in the plant (90%), via ebullition or bubbling (9%) and via diffusion through the soil and water layer (1%). There are aerenchyma tissues in the leaves stem and roots of rice plants. Aerenchyma is a spongy tissue that forms spaces or air channels in the roots, stems and leaves, which allows exchange of gases between the root system and atmosphere to the roots where it may be released into the rhizosphere. At the same time methane, carbon dioxide, ethylene and other gases produced in the inoxic root zone are transported through aerenchyma (of stem and leaves) and emitted into the atmosphere.

To reduce the methane production: drain the flooded rice fields frequently, prefer to the urea instead of ammonium sulphate and use neem coated or sulfur coated urea and adopt dry cultivation (*Ghaiya* farming) or SRI of rice.

Anaerobic decomposition of organic material in flooded rice fields produces methane (CH_4), which escapes to the atmosphere primarily by diffusive transport through the rice plants during the growing season. Figure

1 illustrates this process of such anaerobic decomposition. There are three processes of CH_4 release into the atmosphere from rice fields. Diffusion loss of CH_4 across the water surface is the least important process. Methane loss as bubbles (ebullition) from paddy soils is a common and significant mechanism, especially if the soil texture is not clayey. During land preparation and initial growth of rice, ebullition is the major release mechanism. The third process is CH_4 transport through rice plants, which has been reported as the most important phenomenon. The period between flooding of the soil and the onset of methanogenesis can apparently be different for the various soil types. Extrapolation of emission rates to a global scale is very difficult, because the effects of variations in agricultural practices, number of crops per year, soil types and many other factors are uncertain. However, countrywide emission rate of methane have been reported by many countries.

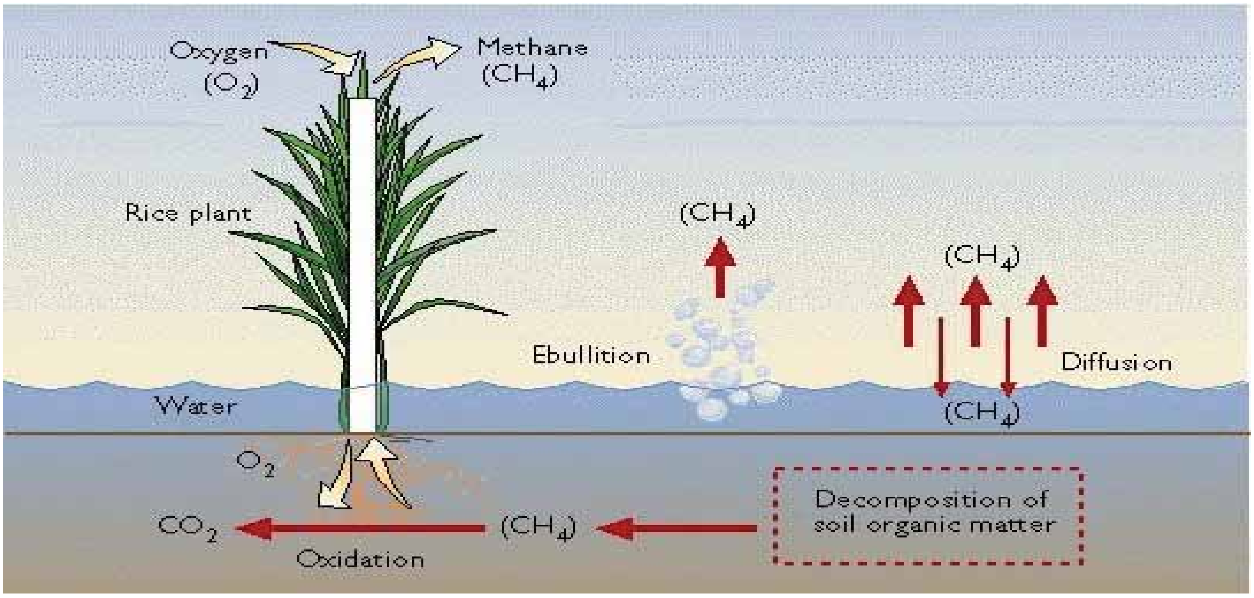

Figure 1. The process of methanogenesis in flooded rice fields

Source: Towprayoon 2004.

Carbon-dioxide (CO_2) emission

Carbon dioxide has been the largest emission because of the combustion of fossil fuel. The release of carbon dioxide during the process of respiration from rice crop is not significant as compared to its emission through methanogenesis process from rice field in the process. Emission of carbon dioxide from rice is very also high if urea fertilizer is applied in wetland rice fields as a top dress. Besides leaching losses, some of the nitrogen loss happens through volatilization to the atmosphere. Therefore, ammonium sulfate and diammonium phosphate (DAP) are better option to apply in rice fields.

Nitrification and denitrification processes

Biological conversion of ammonia or ammonium to nitrite followed by oxidation of nitrite to nitrate is called nitrification. Nitrogen oxide is produced from the combustion of fuels and organic matter, decomposition of organic material and use of nitrogenous fertilizers in rice fields. In inundated and fertilized with N fertilizers rice paddy fields, nitrate and nitrite (NO_3 and NO_2) are converted into gaseous nitrogen (N_2O, N_2) by denitrifying bacteria. To reduce de-nitrification –instead of NO_3-N fertilizers (CAN, ammonium sulphate nitrate NPK complex) use urea (is converted into ammonium later) and $NH4^+$ -based fertilizers (ammonium sulphate, ammonium chloride) inside the soil or in the form of pellets in split doses; replace top dressing with foliar spray of N; apply urea in the form of super granules or neem coated or sulfur coated granule; apply SSP and well decomposed manure; incorporate urea in soil, do not apply on soil surface. Intermittent irrigation increase N_2O emission and reduces CH_4 emission, but the overall effect of frequent drainage is positive.

In rice soils, various biochemical processes can occur regarding N cycling, including nitrification, denitrification, and nitrogen fixation. It may cause N loss from rice soils, while it can also reduce environmental pollutions such as nitrate leaching and emission of nitrous oxide (N_2O). Intermittent drainage reduces methane emissions whereas, drainage increase N_2O emissions. Nitrous oxide is produced naturally in soils through the microbial processes of nitrification and de-nitrification. During nitrification, ammonium (NH_4) produces nitrates (NO_3). During de-nitrification, nitrates (NO_3,) are reduced to nitrogen gas (N_2). An intermediate step in both of these processes is the creation of nitrous oxide (N_20) which is one of the GHG emissions.

Manure management

Methane is produced by the anaerobic (without oxygen) decomposition of manure. When manure is handled as a solid or deposited naturally on grassland, it decomposes aerobically (with oxygen) and creates little methane emissions. However, manure stored as a liquid or slurry in lagoons, ponds, tanks or pits, decomposes anaerobically and creates methane emissions. Dairy cattle and swine produce about 85% of the methane emissions. Methane emissions will increase as the number of large scale livestock confinement systems increases.

Methane emissions can be reduced through the application of technologies designed to capture the methane and use it as an energy source. In addition to reducing methane emissions, methane capture by biogas plants improve the profitability of the livestock operation by offsetting the need for fossil fuel energy from outside sources.

Methane emission from rice fields in Nepal

Recently, methane emission from rice fields and from livestock management sector of Nepal were estimated following IPCC Guidelines, 2006 by RIMC and SIDeF 2013. Joshi (2016) has reported the status of methane gas emission from paddy fields in Nepal. Rice cultivations are mainly done under flooded condition. Anaerobic decomposition of organic materials take place in flooded rice field because the flooding limits the oxygen supply to the deeper layers producing methane. Soil type, temperature, and rice cultivar also affect CH_4 emission rate. CH_4 emission from paddy cultivation is estimated at 131.75 Gg in 2000 and 127.13Gg in 2010 (**Table 1**).

Table 1. Annual CH_4 emission from Agriculture sector in Nepal, 2000-2010

Year	CH_4 emissions (Gg)					% of total methane emission from rice field
	Livestock sectors			Rice fields	Total CH_4 emission from livestock sector and rice fields	
	CH_4 from EF	CH_4 from MMS	Total CH_4 from livestock	CH_4 from rice		
2000	470.69	41.22	511.91	131.75	643.66	20.47
2001	456.58	40.07	496.64	128.92	625.56	20.61
2002	464.97	40.11	505.08	111.57	616.65	18.09
2003	472.98	41.90	514.88	133.07	647.95	20.54
2004	482.10	42.64	524.74	132.29	657.03	20.13
2005	490.48	43.35	533.83	132.82	656.48	20.23
2006	502.84	43.67	546.51	122.64	669.15	18.33
2007	512.88	45.40	558.27	132.46	690.73	19.18
2008	535.55	46.64	582.19	132.21	714.39	18.51
2009	539.30	47.92	587.22	126.22	713.44	17.69
2010	551.02	49.26	600.28	127.13	727.41	17.48

Note: EF=Enteric Fermentation, MMS=Manure management system, Gg = gigagram

Source: RIMC and SIDeF 2013.

Annual variation of CH_4 emissions from paddy cultivation in Nepal is found to be only 17.48% of the grand total of 727.41 Gg of cumulative CH_4 emission both from rice cultivation and livestock sector (agriculture sector as a whole) during 2010 (**Table 1**). However, minimizing total methane emission both from rice cultivation and livestock sector management is of great significance and the practice of climate change resilient measures are reduced tillage in the crops as far as feasible and by capturing methane emissions from anaerobic manure through mass campaign to establish biogas plants, emphasizing short duration rice varieties, need based application of nitrogenous fertilizer by using leaf color chart (LCC), alternate drying and wetting of the rice fields instead of continuous flooding, etc.

Impacts on environment

The increased level of GHGs has created a greenhouse effect which subsequently altered precipitation patterns and global temperature around the world. Although methane is a rare gas in the atmosphere, its existence and increased concentration in recent years has proven to have a close relation with the problems of greenhouse effect that will lead to the rising of temperature on the global surface. "Destruction of ozone layer" and rising of ultraviolet rays in the atmosphere are menacing the life on earth. Flooded rice is considered to be one of the major biogenic methane sources (Huang 1991, Towprayoon 2013). Generally, methane in the paddy soil is directly released to the atmosphere through rice plants.

Nitrous oxide is produced naturally in soils through the microbial processes of nitrification and de-nitrification. During nitrification, ammonium (NH_4) produces nitrates (NO_3). During de-nitrification, nitrates (NO_3,) are reduced to nitrogen gas (N_2). An intermediate step in both of these processes is the creation of nitrous oxide (N_20).

Global warming is the impact of greenhouse gas concentration in the atmosphere. Greenhouses gases evolved in the atmosphere are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases. The gases spread around the planet earth in the atmosphere like a blanket capturing the solar heat that would otherwise be radiated out into space. GHG like CO_2 and CH_4 trap heat in the atmosphere.

The increasing concentrations of greenhouse gases in the atmosphere have been projected to cause an average global temperature rise of 3.6-10.8 degrees Fahrenheit by the end of 21stcentury. To combat this trend, efforts have been made to reduce the amount of greenhouse gas emissions from all contributing sectors. Agricultural activities account for about 14% of overall greenhouse gas emissions globally.

The large increase in the use of nitrogen fertilizer for the production of high nitrogen consuming crops like corn has increased the emissions of nitrous oxide. Although nitrogen fertilizer is essential for profitable crop production, the development of practices for more efficiently using nitrogen fertilizer has the potential to significantly reduce nitrous oxide emissions while also reducing production costs and mitigating the nitrogen contamination of surface and ground waters.

Nepal has been experiencing adverse impact of climate change despite negligible contribution to global greenhouse gas emission.

Suggestions towards minimizing methane emission

- To reduce carbon dioxide, agriculturists should be encouraged to discard organic waste instead of burning, decrease plowing and provide mostly carbon dioxide in the carbon cycle in an organic form to slow organic decomposition and increase photosynthesis.
- For methane reduction, agriculturists should avoid adding large amounts of organic fertilizer, improve soil quality by increasing aeration and drain water from the paddies prior to the panicle-formation stage.
- Promotion of alternate drying and wetting of rice fields to mitigate CH_4 emission and increase water use efficiency.

- For nitrous oxide reduction, farmers can add organic fertilizer instead of chemical fertilizer; however, organic fertilizer must also contain a low quantity of nitrate.
- Application of organic fertilizer in agriculture, especially paddy field farming, would protect and conserve the environment through pollution prevention.
- Governments of Nepal must create incentives for lowering greenhouse gas emissions and expanding sinks to take advantage of these by sequestering carbon in agricultural soils by reducing tillage and by capturing methane emissions from anaerobic manure handling facilities through mass campaign to establish biogas plants.

Acknowledgements

The author express sincere thanks to Mr. Dila Ram Bhandari and Mr. Prakash Acharya of Department of Agriculture for his continuous suggestions and feedback during preparation of this article. Author would also like to thank Mr. Nar Bahadur Saund, for providing valuable information for this article.

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Climate Change, Disaster and their effects on Rice Farming in Nepal

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सारांश

अल्पविकसित कृषि प्रधान मुलुक नेपाल विभिन्न विपदहरूबाट निरन्तर प्रभावित हुने गरेको छ । पछिल्लो एक अध्ययन अनुसार विश्वव्यापी तापमान वृद्धि एवम् वातावरण परिवर्तनले गर्दा हिमालय पर्वत श्रृंखलामा रहेको कृषिक्षेत्र बढी प्रभावित हुँदै आएको छ । यसले गर्दा खाद्य सुरक्षाको सवाल संवेदनशील बनेको छ । विभिन्न प्राकृतिक विपद्हरू मध्ये सुख्खा खडेरीले कृषिक्षेत्रलाई धेरै असर पुर्‍याएको छ । नेपालीहरूको प्रमुख खाद्यान्न बाली धानलाई सुख्खा खडेरी, असिना, एवम् हावाहुरीले प्रतिकूल प्रभाव पारिरहेको छ । सुख्खा खडेरीको कारणबाट धान बालीमा वर्षेनी कम्तिमा ५० हजार मे. टन देखि बढीमा ९ लाख मे.ट. सम्म नोक्सान हुने गरेको छ । धान बालीको सफल खेतीको लागि वर्षा, तापक्रम एवम् आद्रता जस्ता वातावरणीय तत्वले महत्वपूर्ण भूमिका खेल्दछन् । नेपालमा औसत वर्षाको स्थिति असार महिनामा उच्चत्तम हुने र औषत उच्च तापक्रम जेष्ठ महिनामा एवम् औसत न्यूनतम तापक्रम भाद्र आश्विन महिनामा हुने भएकोले कृषक समुदायले सोही अनुसार आफ्नो धानखेतीको कार्यतालिका बनाई खेती गरेमा उच्चत्तम फाइदा लिन सक्नेछन् ।

Summary

Various types of disasters have badly been affecting agriculture sector of Nepal. Recent studies have shown that there is increasing frequency and intensity of climate related disasters with the result of global warming and climate change. Among the natural calamities: floods, landslides, epidemics are more frequent in agri-sector, and drought has been the most catastrophic among them. The droughts are specifically due to intra-seasonal monsoon variation like late onset, long dry spells, intensive rainfall spells after long dry spells. Rice is the most important staple food crop which is associated with the phenomena of temperature and rainfall during the period of its vegetative growth. A simulated study showed that the minimum of 50 thousand to more than 9 lakh tonnes of rice crop was lost by the drought alone in given year in the last 50 years. The rainfall and temperature data of last 12 years showed that the largest average quantity of rainfall occurred during the month of July and that the maximum average temperature occurred during the month of June and the lowest average temperature occurred during the month of August and September. Thus, farmers if manage their rice farming schedule accordingly, can reduce the crop loss.

Keywords: Climate change, Calamities, Drought, Earthquake, Rice production

Background

Nepalese agriculture sector has been very much vulnerable due to climate related events. Recent studies have shown that there is increasing frequency and intensity of climate related disasters with the result of global warming and climate change. Researches have made some future scenario projection of climate change and potential increment or worsening of climatic condition more specifically in the Himalayan region like Nepal. Those situations will force agricultural sector badly with leading to food insecurity and affecting most the poor and marginalized people.

The agricultural production and productivity has been constrained by altered frequency, timing and magnitude of climatic variables like precipitation and temperature. Regarding the disaster management practices adopted by the Ministry of Agricultural Development, very little curative part has been addressed in regular annual programs but in Livestock Sector, "Caracas Management and Action Plan for Risk Management" has been prepared by the Ministry of Agricultural Development (MoAD) as per the directives of National Disaster Response Framework (NDRF), and Natural Calamity Relief Act, 1982.

Among the crops grown in Nepal, the rice is the master crop as the first staple food crop which is grown almost across the country that is contributing 20% of AGDP (7.5% GDP). In spite of the lower level of its productivity (3.36 t/ha) compared to other SAARC countries, the crop solely occupies 50% of cultivated area with supplying 58% of total food grain production (Bhandari 2016). This highly important food crop has been badly affected by various natural calamities. Of them, drought is the major one. From the drought alone, the annual loss is USD 75 million compared to the annual loss of USD 4 million from other hazards during the period of 2001-2010 (UNDP 2013).

Figure 1. Drought in rice field

Natural calamities and agricultural sector

Common natural calamities

Since Nepal is highly prone to various types of disaster, thus both the preparedness and relief and recovery from those disasters is quite important job. The **Figure 1** shows that the fire is the most frequent with largest occurrence, but among others: drought, flood and landslides are in the second top range that are devastating to agricultural sector.

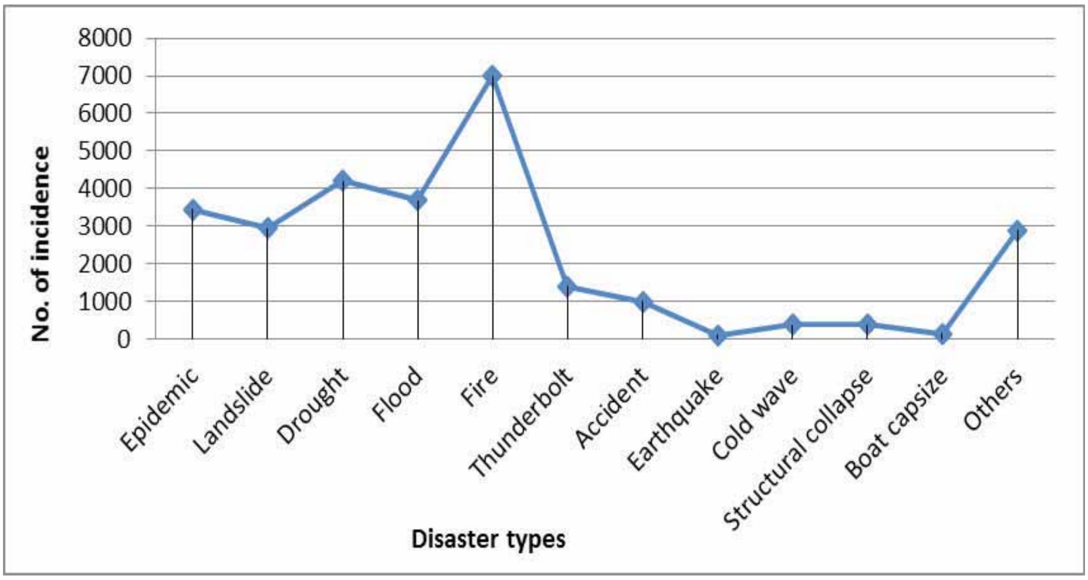

Figure 2. Major disaster types and their occurrences in Nepal over 42 years (1971-2012)

Source: MoHA/DPNet 2013.

Disasters highly affecting agriculture

Though National Disaster Response Framework (NDRF) for Nepal is already prepared for the effective coordination and implementation of disaster preparedness and response activities, it is mainly concerned on general damages and losses but not focused to agriculture. Country has been facing huge losses from frequently occurring flood and droughts in agri-sector. The flood is making damages mainly in Tarai and landslides in hills. Among the natural calamities: floods, landslides, epidemics are frequent in agri-sector, and drought has been the most catastrophic among them.

A study conducted by the UNDP to assess the agriculture vulnerability to climate hazards in Nepal showed that droughts in country are specifically due to intra-seasonal monsoon variation like late onset, long dry spells; intensive rainfall spells after long dry spells that led to crop losses. The crop losses categorically includes or leads to drying of rice seedbeds, delay of seeding, compulsion of using old seedlings, delay planting, flooding of seedbed and transplanted rice, farmers not being able for reseeding and re-transplanting due to lack of seed, incidence of disease, insect pest outbreak, and even inundation of paddy field.

The study covering 2000 to 2009 fiscal years, revealed that an average of 70,000 ha of rice crop was affected by droughts annually, but more wide spread droughts occur once every 5 to 7 years (MoAD 2015). **Figure 2** shows the minimum of 50 thousand to more than 9 lakh metric ton of rice crop was lost during those droughts period.

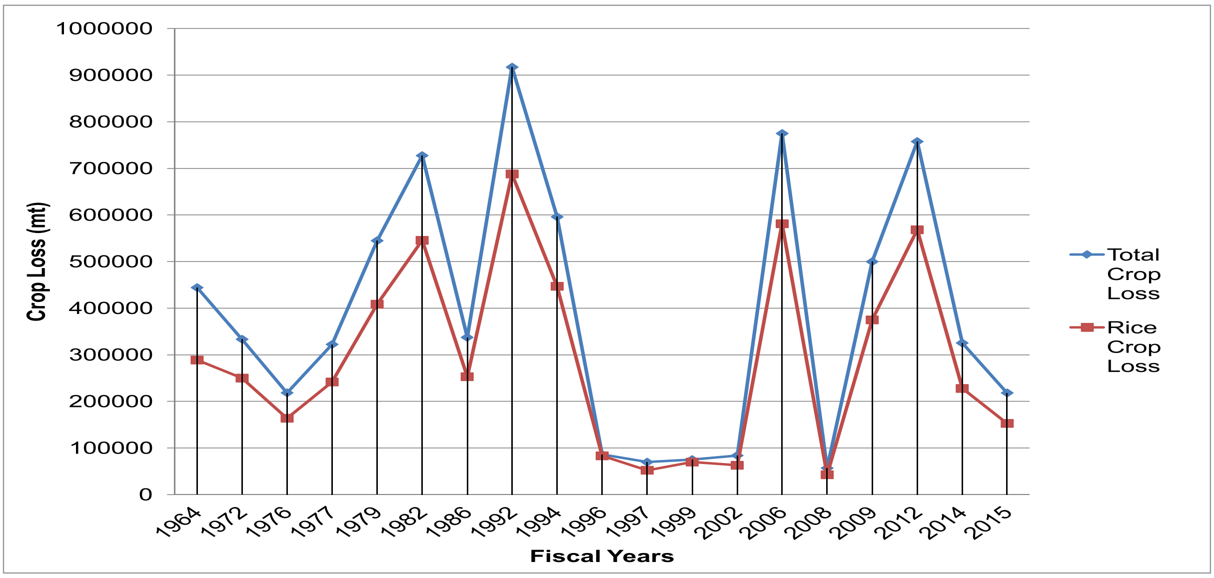

Figure 3. Scenario of total crop loss and rice crop loss in Nepal by the drought alone in the given period of time

Source: UNDP, MoAD 2003-2014.

Rice crop as the most important staple food crop of Nepalese people has been constrained by the frequent drought which is quite associated with the phenomena of temperature and rainfall during the period of its vegetative growth. The scenario of average temperature and average precipitation during the four month period of rice crop growth and development for last 12 years has been shown graphically in **Figure 3**.

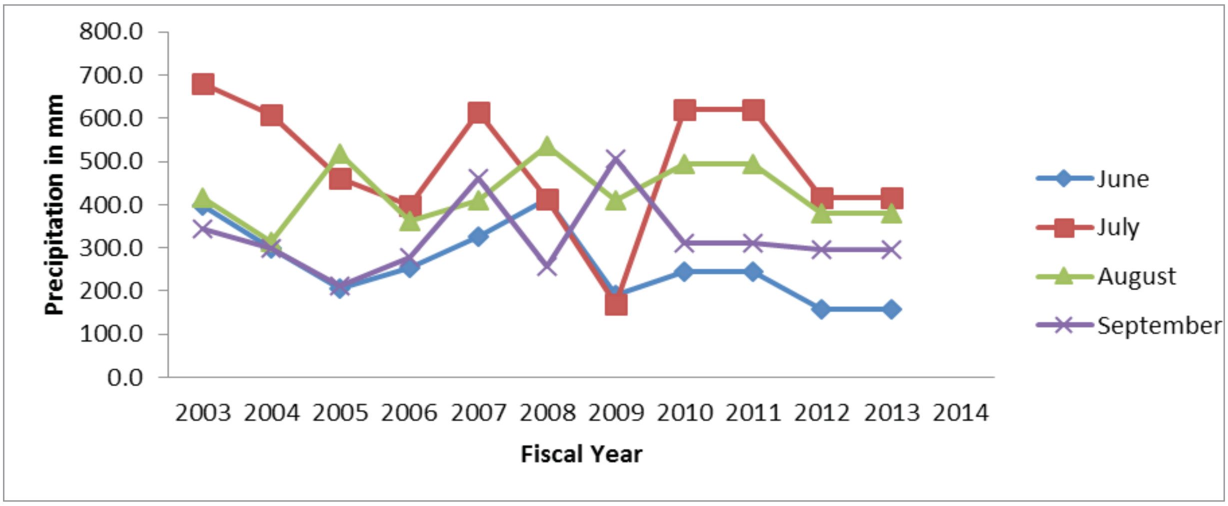

Figure 4. Average precipitation in rice growing season of four months (over 12 years)

Source: MoAD 2003-2014, FAO/UNDP 2013.

Figure 3 indicates that the largest average quantity of rainfall occurred during the month of July, but somewhat equal average quantity of rainfall occurred during the month of August and the lowest average quantity of rainfall occurred during the month of June and September. The rainfall figure tells the general lesson that, farmers, if manage their paddy seeding and transplanting during the month of July, will have less stress on paddy cultivation.

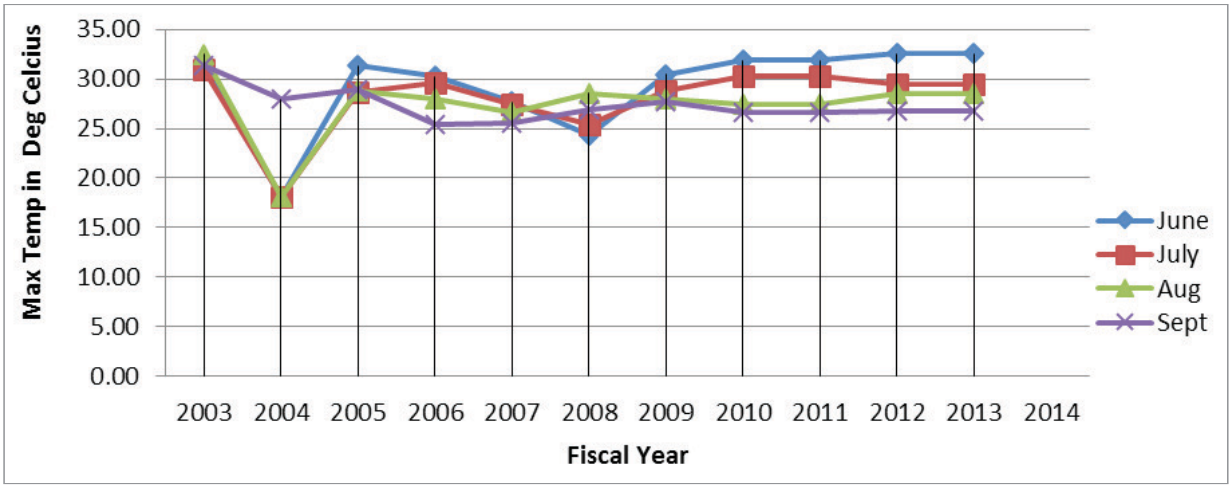

Figure 5. Average maximum temperature during the rice growing season of four months (12 years)

Source: MoAD 2003-2014, FAO/UNDP 2013.

Figure 4 indicates that the maximum average temperature occurred during the month of June, but somewhat equal average temperature occurred during the month of July and lowest average temperature occurred during the month of August and September. **Figure 5** indicates that the minimum average temperature for all four months remained almost in the same line though it seems slightly higher in July and slightly lower in September.

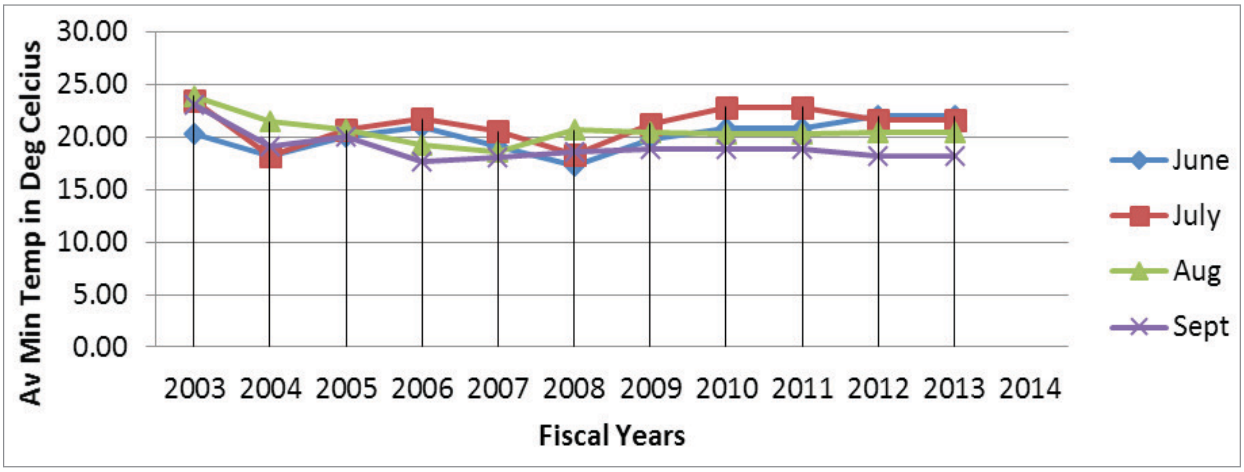

Figure 6. Average minimum temperature during the rice growing season of four months (12 years)

Source: MoAD 2003-2014, CDD 2015 and MoAD 2015.

Losses of food grain due to the Gorkha Earthquake (25th April 2015) and recovery needs

The two devastating earthquakes (the Gorkha Earthquake and its major aftershock) that struck Nepal on 25 April and 12 May 2015, rendered a colossal loss to the agricultural sector. The damages and losses in agriculture sector were prominent affecting around one million already poor small farming households in 31 districts. The major loss was in 24 districts that were badly affected. These are: Gorkha, Dhading, Rasuwa, Nuwakot, Sindhupalchowk, Dolakha, Ramechhap, Makwanpur, Kavrepalanchowk, Lalitpur, Kathmandu, Bhaktapur, Sindhuli, Okhaldhunga, Solukhumbu, Khotang, Chitwan, Lamjung, Tanahun, Kaski, Syanja, Palpa, Gulmi and Bhojpur. Other seven districts viz: Baglung, Parbat, Dhankuta, Sankhuwasabha, Nawalparasi, Arghakhanchi and Myagdi were declared later as moderately affected by the disaster. The aggregate estimate of damages and loss and its recovery needs are given in the **Table 1**.

Table 1. Losses of food grain due to the earthquake and recovery needs

SN	Losses types	Quantity (tonnes)	Loss in value (,000 NRs)	Remarks
1	Food and grains	135187	8111191	Cumulative for 31 districts
2	Aggregate loss	As per PDNA- 24 districts	28366000	Includes buildings damages
3	Recovery needs	As per PDNA- 24 districts	15560000	For three years
4	Recovery and reconstruction needs	As per PDRF- 31 districts	26894000	For five years

Source: PDNA 2015 and PDRF 2016.

The total quantity of food grain loss and its monetary value was 1.35 lakh tonnes and NRs 8.11 billion respectively (**Table 1**) but the total aggregate loss including loss and damages of: office buildings, irrigation canals, storage houses, etc equivalent about NRs 28.36 billion as per the data obtained in Post Disaster Need Assessment (PDNA). Recovery and Reconstruction needs are estimated at NRs 15.56 billion and NRs 26.89 billion as per PDNA and Post Disaster Recovery Framework (PDRF) report of agri-sector respectively.

Due to the damage of storage cereal seeds at farmers' home, Government, NGO/INGO, NSCL, donors have supplied immediately 423 tonnes of rice seed for the compensation of seed to the affected area, and 18394 tonnes of food materials was distributed in those highly affected areas.

Disaster related legal provisions in agri-sector, Nepal

There are already numerous legal regimes related to agricultural development and post disasters activities, but most of them either are cross cutting or overlapping and very conventional. They are not duly implemented in order to fulfill the spirit of the laws. Some of the legal regimes related to agricultural sector are broadly categorized as below.

- Domestic Laws – more than 2 dozen,
- International Contracts and Agreements including Hyugo Framework for Action and
- Government's directives and circular with new Institutional Arrangements.

Conclusion

Nepalese agricultural sector has been badly affected by adverse climatic conditions and recurrence of various natural hazards. There may be different levels of impacts of those disasters in agricultural sector depending upon the nature of farming, geographical situations, level of modern technology and precautionary measures adopted during the farming courses. Nepal, one of the landlocked developing countries (LLDCs), having difficult terrain geography needs to pay special attention towards timely and adopt due precautionary measures against disaster. Disaster management in Nepalese Agricultural sector has been in low priority in previous period, but it has been felt that creating and adopting climatic resilient technology and farming protecting measures is urgent need. Necessary legal regimes and policies related to agricultural development also needs to be effectively implemented. Rice crop as the most important staple food crop of Nepalese people, has been constrained by the frequent drought which is quite associated with the phenomena of temperature and rainfall during the period of its vegetative growth. The roles and responsibilities of Government and Non-Government agencies, development partners, CBOs, local bodies and other stakeholders who are directly involved in disaster risk management in agri-sector of Nepal should clearly be delineated for active participation and lively coordination for creating climatic resilient farming community for sustainable agricultural development.

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Drought and Submergence Tolerance Rice Variety for the Rain-fed Lowland Ecosystem of Nepal

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सारांश

सुख्खा र बाढीका कारण वर्षाको भरमा गरिने धान खेती अत्यन्तै जोखिमपूर्ण रहेको छ । साथै नियमित तथा एकनासको वर्षा नहुनु र समय-समयमा हुने भारी वर्षाका कारण हालैका वर्षहरूमा धानको उत्पादन र उत्पादकत्व अपेक्षाकृत रूपमा बढ्न सकिरहको छैन । परिवर्तित जलवायुको यस परिवेशमा राष्ट्रिय धान बाली अनुसन्धान कार्यक्रम हर्दिनाथले सुख्खा सहन सक्ने हर्दिनाथ-२, तरहरा-१ र सुख्खाधान-१, २, ३, ४, ५ जातहरूको विकास गरी राष्ट्रिय बीउ बिजन समितिबाट तराईदेखि मध्यपहाडको बेसी क्षेत्रमा समुद्र सतहबाट ७०० मिटरसम्म खेती गर्न सकिने गरी सिफारिस गरेको छ भने स्वर्णसब-१ र सम्भा मसूली सब-१ जातहरू बढी पानी सहने जातहरूको रूपमा तराईदेखि मध्य पहाडी बेसी क्षेत्रलाई समुद्र सतह भन्दा ७०० मिटरसम्म खेती गर्न सकिने गरी सिफारिस गरेको छ । साथै बढी पानी र सुख्खा दुवै सहन सक्ने सुख्खाधान–६ लाई समुद्र सतहबाट ७०० मिटरसम्म खेती गर्नको लागि सिफारिस गरेको छ । तसर्थ, परिवर्तित मौसममा समेत राम्रो उत्पादन दिने जलवायु अनुकूलित उल्लेखित धानका जातहरूको खेती गरी खाद्य सुरक्षालाई टेवा पुर्‍याउन सकिने सम्भावना रहेको छ ।

Summary

Rice area under rain-fed is always in risk due to drought and submergence. As a result, production and productivity under rain-fed low land has not increased in recent year due to erratic and early termination of rainfall. National Rice Research Program has therefore, developed and released rice varieties: Hardinath-2, Tarahara-1, Sukkhadhan-1, Sukkhadhan-2, Sukkhadhan-3, Sukkhadhan-4, Sukkhadhan-5 for drought tolerant and Swarna Sub-1 and Samba Masuli Sub-1 for flash flood tolerant in the country. Sukkhadhan-6 is tolerant to drought and submergence conditions. The country can reduce import and ensure food security by increasing yield and intensifying production through these climate resilient rice varieties adapted to rain-fed stress-prone conditions.

Keywords: Climate resilient, Drought, Food security, Productivity, Rice, Submergence

Introduction

The low production of rice is a major problem particularly where farmers grow rice without irrigation, which is referred to “rain-fed ecosystems.” Drought and submergence are now becoming problems to millions of rain-fed rice farmers due to climate change. Climate change scenarios suggest a likely increase in the frequency and severity of drought, floods and heat. Improving irrigation system is generally not a viable option for extenuating drought problems in rain-fed rice-growing systems. However, flash flood is still a problem to the farmers of low land areas where seedlings of rice suffer from rotting because of water remains long duration in the rain-fed low land.

In Nepal, irrigated rice accounts for 56% of the total rice area. However only 28% of total irrigated rice areas have year the round irrigation. Large rice production still occurs under rain-fed condition. Out of the 44% of rain-fed rice areas, 39.4% and 4.6% areas are rain-fed lowland and upland respectively in the country.

Among the rain-fed rice areas, 30% and 15% areas are often prone to drought and flash flood respectively (Gumma et al 2011). Farmers in these areas rely predominantly on rain water for field operations and are highly affected due to uneven rainfall. Even in the years of normal rainfall, the crop can be affected by drought stress of varying severities during the growing season. The largest drought affected areas of Asia are India and its adjoining areas of Nepal, with more than 17 million hectare of rain-fed rice areas (Huke and Huke 1997). Nepal has diverse ecological zones but Tarai and inner Tarai are referred as the "granary" of Nepal, which consists of flat and fertile alluvial land that extends from the Indo-Gangetic plains at the altitude of 60 to 800 meter of Mahabharat foot-hills. Therefore, National Rice Research Program has initiated varietal development works on drought and submergence tolerant rice for rain-fed lowland areas in collaboration with International Rice Research Institute (IRRI) through Stress Tolerant Rice for Africa and South Asia (STRASA) project since 2009. Although rice varieties were derived from crosses of drought and submergence tolerant landraces, popular high-yielding varieties have proven beneficial for both high yield potential and drought submergence tolerance (Kumar et al 2009, Venuprasad et al 2007, Venu Prasad et al 2008). Thus, developing drought and submergence tolerant rice varieties are the most promising approach to tackle the submergence and drought stresses in the changing context of climate.

Rain-fed ecosystems

Rain-fed lowlands are known as typically level to slightly sloping field with non-continuous flooding of varying depth and magnitude. The rice rain-fed areas are mainly found in tropical climate areas: in river deltas, flood plain and inland swamps. The basic feature of rain-fed lowlands is built bunds and dikes around the field to capture the rainwater for rice farming. Rice farming under rain-fed is solely depended on rainfall but in some cases, water may supply from canal, tube well and swollen of river. Variability and intensity of rainfall usually cause either drought or flood stresses. Rain-fed has basically divided into five environments based on the water regimes: shallow favorable; shallow drought prone; shallow drought and submergence prone, shallow and submergence-prone; and medium-deep waterlogged conditions. Rice is grown in diverse ecosystems which have been classified on the basis of water regime into irrigated, rain-fed lowland and upland. The rice areas are 56%, 39.4% and 4.6% of irrigated, rain-fed lowland, and upland respectively in the country (Yadaw et al 2007).

Drought and flash flood areas in Nepal

The larger rice area reduction was mainly in rain-fed districts of the eastern, central and mid-western regions due to severe drought incidence, particularly in 2006-2009 (Gumma et al 2011). The map (Figure 1) shows that major drought is in Tarai region where rice is mainly grown. A total of 30% rain-fed rice area is prone to drought. Whereas, 15% of total rain-fed rice area is prone to flash flood in the country.

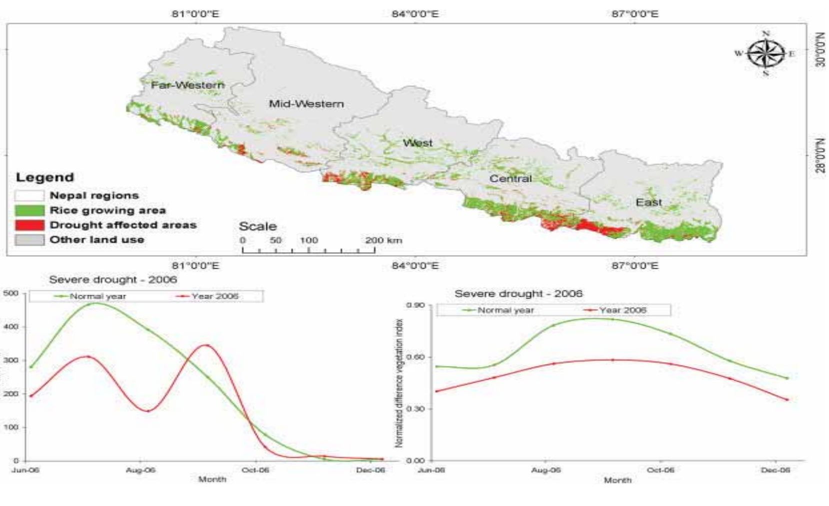

Figure 1. Rice growing areas along with drought affected areas in Nepal

Source: Gumma et al 2011.

Types of drought stresses

Water stress adversely affects yield potential, timing and duration of phonological process in rice (Jongdee et al 2002). There are three basic drought patterns affecting rice production namely early season drought, intermittent drought and late drought (Fukai and Cooper 1995). Early drought often results in delayed sowing or transplanting and also reduces tiller number at vegetative stage after crop establishment, which ultimately results reduction of grain yield (Boonjung et al 1996, Jongdee et al 2002). Intermittent or continuous drought (occurring between the tillering and flowering stages) may greatly reduce yields despite no apparent drought symptoms (eg leaf rolling), mainly as a result of reduced leaf expansion and photosynthesis (Fukai and Cooper 1995). When drought occurs during later growing stages (following panicle initiation and especially during flowering), spikelet fertility is reduced and this becomes the main factor contributing to yield loss (Liu et al 2006). Since the diverse drought patterns have different impacts on the crop, it is, therefore, important to consider which type of drought stress is targeted in a breeding program (Fukai and Cooper 1995). Stresses are further classified into severe, moderate and mild stress based on the percentage yield reduction in comparison to their non-stress counterpart. Under lowland condition, the rice yield reduction of 30% or less, 31%-65%, and >65% are termed as low land mild stress (LMiS), low land moderate stress (LMS), and low land severe stress (LSS), respectively. However, under upland condition, the stress showing a yield reduction of 40% or less, 41%-75%, and 7% or higher are referred to as upland mild stress (UMiS), upland moderate stress (UMS) and upland severe stress (USS), respectively.

Types of submergence stresses

Rice is the only crop plant adapted to aquatic environments because of its well-developed parenchyma tissues that facilitate oxygen diffusion through continuous air spaces from shoot to root and avoid anoxia development in roots. However, complete submergence due to frequent flooding can adversely affect plant growth and yield. Two types of flooding cause damages to rice. The first one, flash flooding, results in rapid ascending of water levels with submergence for 1-2 weeks. This type of flooding could also occur after sowing in areas, where direct seeding is practiced and could result in substantial reduction in stand establishment. The flash flood areas is around 12% of the total rice cultivated rice areas in Nepal. The second type is deep water and floating rice, where water depth exceeds 100 cm and remains at these depths for several months. Plants may become completely submerged for short periods if flooding is severe. Elongation ability of leaves and internodes are essential to keep pace with increasing water levels and escape complete submergence. The deep water area is 3% of the total rice areas in Nepal. Under flash flooding, few features are playing a key role in submergence tolerance in rice, the most critical are: maintenance of high carbohydrate concentration, optimum rates of alcoholic fermentation and energy conservation by maintaining low elongation growth rates during submergence. Protective mechanisms as the up-regulation of antioxidant system and low synthesis or sensitivity to ethylene during submergence were also found to be useful.

Varietal improvement on drought and submergence rice

Both conventional and Marker Assisted Selection (MAS) approaches have been used in breeding programs for drought and submergence tolerance. The empirical breeding approach is based on selection for yield and its components in a given a biotic stress environment. It is now well accepted that the complexity of the drought and submergence can only be tackled with a holistic approach that integrates physiological dissection of crop, a biotic avoidance and tolerance traits using molecular genetic tools such as MAS. The systematic study was initiated at IRRI to identify major QTLs for grain yield under drought which has resulted into identification of some major QTLs. It was reported that several QTLs:$qDTY_{2.1}$$qDTY_{2.2}$, $qDTY_{3.2}$, $qDTY_{4.1}$, $qDTY_{9.1}$, and $qDTY_{12.1}$ were identified at IRRI and introgressed into high yielding rice varieties for drought tolerant (Bernier et al 2007, Venuprasad et al 2009). The genotype IR-87707-446-B-B-B (IR64) was developed by transferring two drought tolerant QTLs ie$qDTY_{2.2}$and $qDTY_{4.1}$ and released with name of the Sukkhdhan-4 in Nepal. The other drought rice varieties namely; Sukkhadhan-1, Sukkhadhan-2,Sukkhadhan-3, Sukkhadhan-4, Sukkhadhan-5, Sukkhadhan-6 and Tarhara-1 were developed and released for drought tolerant at reproductive stage stress in

Nepal (**Table 1**). Similarly, flash flood also affects grain yield of rice in rain-fed areas. Farmers also frequently re-transplant rice after flash flood in their fields. The SUB-1 gene was identified to tolerant with the major determinant of submergence (Xu et al 2006, Septiningsih et al 2008, Bailey-Serres et al 2010). Swarna Sub-1 and Sambamasuli SUB-1 were developed by transferring Sub-1 gene (Collard et al 2013).

Table 1. Salient features of drought and submergence stresses tolerant rice varieties released in Nepal

SN	Variety name	Salient features	Suitable domains
1	Hardinath-2	High yield, short duration, resistant to blast, BLB, sheath blight, BPH and stem borer, drought tolerant, and good for aerobic rice, coarse grain, good for *chiura* and puffed rice	Rain-fed shallow wet land and rain-fed lowland conditions for *Bhadaiya* and normal season up to 700 m altitude
2	Tarahara-1	High yield, short duration, resistant to blast, BLB, sheath blight, BPH and stem borer, drought tolerant, good eating quality and good for aerobic rice, good for *chiura* and puffed rice	Rain-fed shallow wet land and rain-fed lowland conditions for *Bhadaiya* and normal season up to 700 m altitude
3	Sukkhadhan-1	High yield, short duration, resistant to blast, BLB,sheath blight, BPH and stem borer, drought tolerant even at reproductive stage, good eating quality, good for *chiura* and puffed rice	Rain-fed shallow wet land and rain-fed lowland conditions for *Bhadaiya* and normal season up to 700 m altitude
4	Sukkhadhan-2	High yield, short duration, resistant to blast, BLB, sheath blight, BPH and stem borer, drought tolerant even at reproductive stage, good eating quality, good for *chiura* and puffed rice	Rainfed Shallow wet land and rainfed lowland conditions for *Bhadaiya* and normal season up to 700 m altitude
5	Sukkhadhan-3	High yield, short duration, resistant to blast, BLB, sheath blight, BPH and stem borer, drought tolerant even at reproductive stage, good eating quality, medium fine grain, good for *chiura* and puffed rice	Rain-fed Shallow wet land and rain-fed lowland conditions for *Bhadaiya* and normal season up to 700 m altitude
6	Sukkhadhan-4	High yield, short duration, resistant to blast, BLB,sheath blight, BPH and stem borer, good eating quality, fine grain,good for *chiura* and puffed rice	Rain-fed Shallow wet land and rain-fed lowland conditions for *Bhadaiya* and normal season up to 700 m altitude
7	Sukkhadhan-5	High yield, short duration, resistant to blast, BLB, sheath blight, BPH and stem borer, drought tolerant even at reproductive stage, good eating quality, plant type is same as Sona Masuli, fine grain, good for *chiura* and puffed rice	Rain-fed Shallow wet land and rain-fed lowland conditions for *Bhadaiya* and normal season up to 700 m altitude
8	Sukhhadhan-6	High yield, short duration, resistant to blast, BLB, sheath blight, BPH and stem borer, drought and submergence tolerant, good eating quality, fine grain, good for *chiura* and puffed rice	Rain-fed Shallow wet land and rain-fed lowland conditions for Bhadaiya and normal season up to 700 m altitude
9	Swarna Sub-1	High yield, long duration, resistant to blast, BLB, BPH and stem borer and moderately resistant to sheath blight, submergence tolerant, good eating quality, medium fine grain, good for *chiura* and puffed rice	Rain-fed lowland and flash flood conditions for main season up to 700 m altitude
10	Samba Masuli Sub-1	High yield, long duration, resistant to blast, BLB, sheath blight, BPH and stem borer, submergence tolerant, best eating quality and fine grain	Rain-fed lowland and flash flood conditions for main season up to 700 m altitude

Conclusion

Drought and submergence tolerance are important factors affecting grain yield in context of climate change. There is a dire need of high yielding with drought and submergence tolerant rice varieties to farmers under rain-fed lowland conditions. Drought tolerant rice varieties: Sukkhadhan-1, Sukkhadhan-2, Sukkhadhan-3, Sukkhadhan-4, Sukkhadhan-5 and Sukkhadhan-6 have been released to be cultivated in drought prone areas in the country. The submergence tolerant rice varieties: Swarna Sub-1 and Samba Masuli Sub-1 are options for farmers to cultivate in flash flood conditions. Farmers if cannot transplant rice in the field on time due to delay of rain, Hardinath-2 and Tarahara-1 are suitable and therefore released for dry direct seeded rice (aerobic rice cultivation). These genotypes are good to be grown in drought and submergence prone areas for increasing yield and ensuring food security in the country.

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Assessing Growth and Productivity of Rice through Crop Simulation Model: Research Achievements in Nepal

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सारांश

संसार भर नै अन्न बाली, दलहन र तेलहन बालीको उत्पादकत्व बढाउन बिरूवाको आन्तरिक वृद्धि चक्रसँगै बाली सिमुलेशन मोडेलको प्रयोग गरी उत्पादन दक्षता बढाइएको पाइन्छ । त्यस्तै गरी सन् २००८–०९ देखि रामपुर चितवनको आवोहवामा सिएसएम- सेरेस- धान मोडेलको प्रयोग गर्दा उत्पादनका कारक तत्वहरू जस्तैः मलजल प्रयोग, दक्षतामा वृद्धि हुनुको साथै बाली विज्ञानका प्रविधिहरू जस्तैः छर्ने समय तथा रोप्ने दुरी लगायत जातीय व्यवस्थापनमा प्रत्यक्ष लाभ भएको पाइयो । हावापानी परिवर्तनको परिवेशमा पनि बाली मोडेलले राम्रो नतिजा प्रदर्शन गरेको प्रमाणीकरण रेकर्ड पाईयो । सन् २०२० पछिका दिनहरूमा हावापानी परिवर्तनको असरले हाल प्रचलनमा रहेका धानका जातहरूको उत्पादकत्व घट्ने तथा हाइब्रिड जातका धानलाई स्थानीय र उन्नत जातका धानभन्दा बढी नकारात्मक प्रभाव पार्न सक्ने सिमुलेशन नतिजा पाईयो । बाली मोडेललाई थप प्रभावकारी बनाउन भौगोलिक सूचना प्रणाली, रिमोट सेन्सिङ तथा अन्य डाटा रेकर्डिङ सिस्टमलाई व्यवस्थापन गरी अधिकत्म र गुणस्तरीय डाटा रेकर्ड राख्न सक्दा नेपालमा पनि धान खेतीको हालको उत्पादकत्व भन्दा धेरै गुणा बढी उत्पादकत्व लिन र उत्पादन दक्षता वृद्धिमा बाली सिमुलेशन मोडेलको व्यापक प्रयोग गर्न सकिने उपयोगिता भेटिएको छ ।

Summary

Prediction of potential yield using crop simulation model is common for cereals, legumes and other agronomic crops in the world and its application started in Nepal since 2008-09. Crop simulation models could be effective tools in achieving real-time agronomic options including water and nutrient management and for interpreting experimental results and extrapolating to the new environmental and management conditions. Crop modeling studies on rice at Rampur, Chitwan highlighted that CSM-CERES-Rice is beneficial in extrapolating the agronomic and climate change simulation results to the real field condition. Empirical investigation of several agro-climatic indices such as growing degree days (GDD) and its derivatives may also make straight regression model and can predict the growth and phenology of rice. However, simulation models have some limitations such as: lack of data on spatial and temporal variability, poor quality of data sets, incomplete simulation models and inaccessibility and poor system of disseminating the information. Together with systems-approach tools such as: expert systems, decision support systems, databases, geographic information systems (GIS), and remote sensing, crop models constitute a valuable tool that facilitates integration of knowledge and its use by a variety of users. Like developed countries, the productivity and profitability in rice cultivation could be augmented through the proper and scientific use of crops models in Nepal.

Keywords: Growth and productivity, Research achievements, Rice, Simulation model

Simulation models and decision support systems

Crop simulation models are required to help consultants, researchers and other farm advisors to determine the pattern of field management that optimizes production or profit. However, the effective use of these tools require their evaluation in fields to be optimized, their integration with other information tools such as GIS, geo-statistics, remote sensing, and optimization analysis. Crop simulation models like CERES (maize, wheat, rice, sorghum, barley, and millet) CROPGRO (soybean, peanut, dry bean and tomato), SUBSTOR (potato), CROPSIM (cassava), and CANEGRO (Sugarcane) embedded in Decision Support System of Agro-technology Transfer (DSSAT) ver. 4.5 models have been developed for 28 crops by researchers from several countries. Crop growth simulation models provide a means to quantify the effects of climate, soil and management factors on crop growth and bio-geo-chemical processes in soil. Recently, the Denitrification and Decomposition (DNDC) model was evaluated for its ability to simulate nitrogen dynamics and balance in the rice-wheat cropping systems in the Indo-Gangetic Plains with various N and water management practices (Pathak et al 2006 and Aggarwal et al 2006). Another model, Nutrient Expert-Rice can estimate the yield gaps between potential, experimental and actual yields of rice through Nutrient Expert recommendation, government recommendation and farmer's fertilizer management practices, in general. It also calculates the economic benefits (Satyanarayan et al 2012).

Soil-crop simulation models or combined crop-climate system models are also used in combination with field information and actual weather data to make water and nutrient prescriptions at the beginning of the growing season as well as in real time N management during crop growth phases. The site-specific yield potentials can be estimated determining spatial pattern crop and land information and using it in above simulation models.

Levels of crop production and yield gaps

For understanding the complex production systems, de Wit proposed four levels of crop production in order of descending productivity (Penning de Vries et al 1989). The understanding of production level (**Figure 1**) may clarify the production constraints in the crop field and helps to manage the production resources.

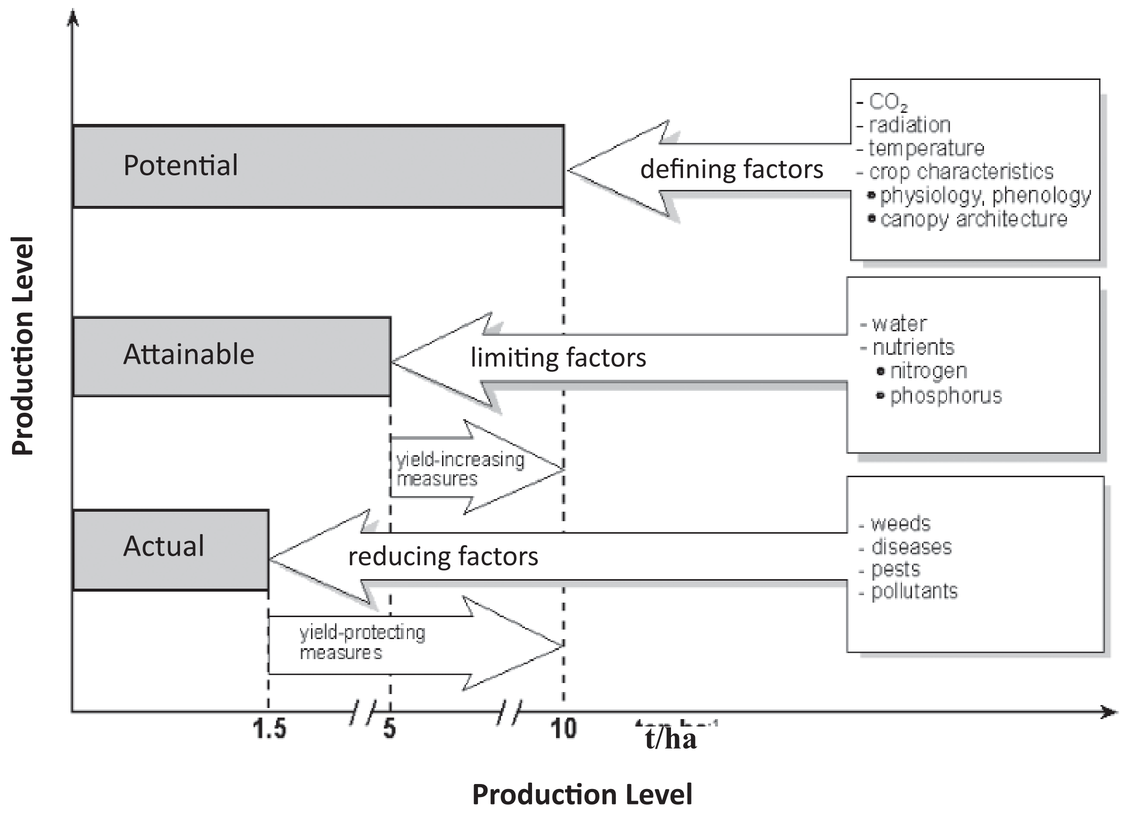

Figure 1. Relationship among potential, attainable and actual yields

Major glimpses of Nepalese rice research through crop model

Yield gap analysis of rice

The potential yields of major crops grown in Chitwan valley, Nepal are quite low (**Table 1**). The common rice cultivar Masuli grown in Chitwan has the yield potential of 5.5 t/ha (MoAC 2009). The gaps between the potential and farmers' field yields (yield gap 3) of rice is 2.76 t/ha. For rice, the yield gap between potential and research station yields (yield gap 1) is larger suggesting that improved agronomical research on rice varieties and crop and soil management would be required to reduce this gap. Since the potential yield is governed by both biotic and abiotic factors, it is often difficult to harvest the same yield either in farmers' field or in an experimental research station.

Table 1. Yields and yield gaps (t/ha) of major crops in Chitwan

Crops	Potential yield (A)	IAAS station yield (B)	Farmers' yield (C)	Yield gap 1 (A-B)	Yield gap 2 (B-C)	Yield gap 3 (A-C)
Rice	5.50	3.40	2.74	2.1	0.66	2.76
Maize	4.40	3.30	1.82	1.1	1.48	2.58
Wheat	5.00	3.50	1.88	1.5	1.62	3.12
Finger millet	3.30	2.20	1.09	1.1	1.11	2.21
Mustard	1.10	1.00	0.71	0.1	0.29	0.39
Soybean	2.00	1.50	0.85	0.5	0.65	1.15
Lentil	2.50	1.75	0.82	0.75	0.93	1.68
Potato	20.0	16.5	10.90	3.5	5.6	9.1

Source: Ministry of Agriculture and Co-operatives 2008/09, Adapted and modified from Amgain and Timsina 2005

Climate change and crop modeling research in Nepal

Global air temperature in South Asia including Nepal is increasing with an average rate of 0.6°C per decade between 1977 and 2000 and it is estimated to be increased more in the future. This is affecting the whole crop production throughout the country.

Simulation of weather effects on rice

CERES-Rice was run for the standard treatment using 4 years of weather data (2005-2009) from NMRP Rampur (**Table 2**). The simulated yields were sensitive to various weather years.

Table 2. Sensitivity of simulated yield and phenology of rice cultivars to weather years

Rice cultivar	Weather year	Simulated yield (kg/ha)	Percent yield	Anthesis (days)	Physiological maturity (days)
Hybrid (Prithivi)	2008[a]	5754	100	74	104
	2007	4759	83	75	105
	2006	5679	98	75	104
	2005	4629	80	75	103
Improved (Masuli)	2008[a]	3892	100	103	134
	2007	3420	88	102	132
	2006	3530	91	99	128
	2005	3640	94	101	133
Basmati (Sunaulo Sugandha)	2008[a]	4468	100	112	145
	2007	3939	88	111	142
	2006	4098	92	108	137
	2005	4208	94	110	143

[a] *Standard years*

Source: Lamsal and Amgain 2010.

It was revealed that there was 17% yield declined in Prithivi in the year of 2007, whereas for high yielding varieties (HYV) Masuli and Sunaulo Sugandha, yield declined was about 12% for each one. This decline in the yield was due to the lower solar radiation and high rainfall in the year 2007 as compared to the other years. Result depicted that daily average temperature was quite high and low rainfall over rice growing season in 2005 resulting in the decline of yield of Prithivi, Masuli and Sunaulo Sugandha by 20, 6 and 6%, respectively. Amien et al (1999) reported that decrease in rainfall in conjunction with increase in temperature results declined in the yield of rice. It was revealed that average temperature was higher in 2006, which shortened maturity days of Masuli and Sunaulo Sugandha and yield declined by 9 and 8%, respectively. Singh and Ritchi (1993) reported that increased temperature reduces yield significantly.

Transplanting date simulation in rice

Either advancing or delaying by 10 days on transplanting dates from July 11 in rice, the yield variation was small. Simulated yield increment of 5 and 16% with longer crop duration resulted under delayed transplanting of hybrid variety, Prithivi under July 21 and July 31, respectively, but 13% yield was reduced with early transplanting. Increase in the yield was due to longer grain filling period (72 days) and higher leaf area index (3.67 and 3.77) than from July 11 (**Table 3**). However, after July 21, reduction in the grain yield was measurable for HYVs. In case of Masuli and Sunaulo Sugandha, reduction in yield was 13 and 19%, respectively and hence late transplanting should be avoided. In longer duration varieties the lower average temperature during the reproductive stage and lower solar radiation during grain filling stage forced to declining yield under late transplanting. Also with delaying transplanting date, there was reduction of the grain filling period, which might be responsible for decrease in yield. Timsina et al (1995) also reported that simulated rice yields were the lowest for 13 July to 27 August in Pantanagar having more or less similar environment as in Rampur condition.

Table 3. Sensitivity of simulated yield and phenology of rice cultivars to date of transplanting

Rice cultivars	Planting date	Simulated yield (kg/ha)	Percent yield	Anthesis (days)	Physiological maturity (days)
Hybrid (Prithivi)	July 11[a]	5754	100	74	104
	July 21	6014	105	75	107
	July 31	6308	116	75	107
	July 01	4732	87	75	104
Improved (Masuli)	July 11[a]	3892	100	103	134
	July 21	3918	100	102	138
	July 31	3387	87	102	142
	July 01	4135	106	103	136
Basmati (Sunaulo Sugandha)	July 11[a]	4468	100	112	145
	July 21	4328	97	111	148
	July 31	3603	81	113	149
	July 01	4505	101	112	140

[a] *Standard dates*

Source: Lamsal and Amgain 2010.

Climate change simulation using CSM-CERES-Rice

The simulation studies for the rice in the sub-tropical environment by the use of DSSAT crop model indicated that though the hybrids are high yielders found to be more sensitive to various scenarios of climate change (**Table 4**). The effect of global climate change is also seen in Nepal and the study being done on this line clearly indicated that the increased temperature and concentration of CO_2 gas would be most harmful to the rice by reducing the yield because of shortening crop duration and other effects on the formation of net assimilates. Hence, the adoptive measures like changes in crop varieties, transplanting date, crop geometry, etc are suggested to minimize this yield gap in field crops.

Table 4. Simulation of rice yield with changing climatic scenarios at IAAS, Chitwan, Nepal

Scenarios				Crop yield and biology			
Min T (ºC)	Max T (ºC)	CO_2 conc. (ppm)	Solar radiation (MJ/m²/day)	Crop varieties	Growth duration (days)	Simulated yield (kg/ha)	% yield change
Standard model parameters				Prithvi	104	5754	-
				Masuli	134	3892	-
				S Sugandha	145	4468	-
+4	+4	0	0	Prithvi	96	2310	-77
				Masuli	111	2310	-41
				S Sugandha	117	2928	-44
+4	+4	+20	-1	Prithvi	86	1548	-73
				Masuli	111	2104	-46
				S Sugandha	117	2686	-40
-4	-4	+20	+1	Prithvi	139	9342	+62
				Masuli	212	5486	+41
				S Sugandha	226	6385	+42

Note: The observed phenology (anthesis and physiological maturity days) and yields (kg/ha) were 74, 101 and 5754 for Prithvi; 103,134 and 3852 for Masuli and 112,145 and 4468 for Sunaulo Sugandha respectively.

Source: Lamsal et al 2013.

Simulation on crop geometry

CERES rice was run for 3 different crop geometries in 2008 at Rampur. In the standard treatment, plant was transplanted with geometry of 25 cm × 25 cm, where sensitivity was analyzed with geometry of 20 × 20 and 30 × 30 cm² (**Table 5**). It was raveled that with narrower spacing, yield increased by 3% in Masuli and higher tillers resulted in higher plant population. Jayawardena and Abeysekera (2002) reported that 20 × 20 cm² is the optimum geometry for the HYVs. Prithivi yields 5% less at closer geometry that might be due to the higher sterility percentage of the hybrid rice at closer geometry. Verma et al (2000) reported that hybrid rice planted at closer geometry (20 × 10 cm²) results significantly higher sterility percentage than wider geometry.

Table 5. Sensitivity of simulated yield and phenology of rice cultivar to crop geometry

Variety	Planting geometry	Simulated yield (kg/ha)	Percent yield	Anthesis (days)	Physiological maturity (days)
Hybrid (Prithivi)	25×25 [a]	5754	100	74	104
	20×20	5459	95	74	104
	30×30	6035	105	74	104
Improved (Masuli)	25×25 [a]	3892	100	103	134
	20×20	4017	103	103	134
	30×30	3856	100	103	134
Basmati (Sunaulo Sugandha)	25×25 [a]	4468	100	112	145
	20×20	4497	100	112	145
	30×30	4421	98	112	145

[a] *Standard crop geometry*

Source: Lamsal and Amgain 2010

At wider geometry of 30 × 30 cm, Prithivi yields 5% more than standard. In general it can be concluded that hybrid rice responded better in wider geometry and HYVs in closer geometry.

Simulation on nitrogen management

Sensitivity of grain yield and different nitrogen levels was investigated (**Table 6**). At all the levels of nitrogen, application was splitted thrice, half at basal and remaining one fourth at 30 DAT and 60 DAT. N-stress in hybrid (Prithivi), Masuli and Sunaulo Sugandha resulted in yield reduction by 34, 34 and 38% (**Table 6**). Amgain and Timsina (2007) reported that simulated yield was reduced by 58% by reducing N level from 120 to 0 kg/ha at Punjab. Nitrogen stress limits cell division, chloroplast development, enzymes activity and reduced dry matter yields (Gardner et al 1985). High N of 200 kg/ha didn't show any increase in the yield and that might be due to high leaching loss. However, in case of Masuli application of 200 kg N/ha reduced the yield by 83%. Nitrogen application greatly affected the above ground dry matter production and the amount partitioned to the grain, but for Prithivi and Sunaulo Sugandha, there was mostly no additional benefit in the application of N above 160 kg/ha on grain yield. Masuli declined in yield by 17% with increase in level of nitrogen from 120 to 200 kg N/ha. It might be due to lodging effect of Masuli, because of high vegetative growth at higher N application.

Grain yield increased significantly with nitrogen application and was found up to 160 kg N/ha. This might be attributed to the significant effect of nitrogen on chlorophyll formation, photosynthesis and assimilated production that resulted in optimum production of yield components which had direct bearing on the final grain yield. Reddy (2005) reported that leaf expansion depends upon N supply, whereas high nitrogen application leads to development of larger leaves. Leaves are the primary organs for solar radiation interception and photosynthesis. As the leaf area index increases, light interception results in higher dry matter production and grain yield.

Table 6. Sensitivity of simulated yield of rice to applied nitrogen to rice varieties

Levels of nitrogen (kg N/ha)	Variety	Simulated yield (kg/ha)	Percent change	Volatilization loss (kg/ha)
160 [a]	Hybrid	5754	100	38.9
	Sunaulo Sugandha	4468	100	55.6
0	Hybrid	2566	44	0
	Sunaulo Sugandha	2700	62	0
200	Hybrid	5755	100	48.7
	Sunaulo Sugandha	4452	99	83
120 [b]	Masuli	3892	100	38.3
0	Masuli	2566	66	0
200	Masuli	3246	83	51.1

[a] *Standard levels of nitrogen, ½ nitrogen at basal and ¼ was splited in to 30 and 60 DAT*

[b] *Standard levels of nitrogen, ½ nitrogen at basal and ¼ was splited in to 30 and 60 DAT*

Source: Lamsal and Amgain 2010.

Heat and radiation use efficiencies and grain yields of rice using agro-climatic indices

HYVs of rice were more efficient in depicting more heat and radiation use efficiencies at normal growing condition than the late growing conditions (**Table 7**).

Table 7. Radiation, dry matter, heat and radiation use efficiency of rice cultivars in Chitwan

Treatment	Radiation MJ/m²/day	Dry matter kg/ha	HUE kg/⁰C day	HTUE kg ⁰C hour	RUE kg/MJ
Ram Dhan					
June 1	1878	9348	4.12	0.76	4.98
June 20	1897	8847	4.03	0.81	4.66
July 5	2036	8125	3.85	0.82	3.99
Prithvi					
June 1	1648	13292	5.36	1.33	8.06
June 20	1658	11383	5.62	1.17	6.86
July 5	1774	9161	4.81	0.97	5.16
Masuli					
June 1	2433	11948	4.46	0.57	4.91
June 20	2538	10041	3.90	0.60	3.96
July 5	2663	9481	3.52	0.52	3.56
S. Sugandha					
June 1	2727	12526	4.40	0.61	4.59
June 20	2786	12208	4.53	0.66	4.38
July 5	2849	9861	3.81	0.49	3.46

Note: S. Sugandha = Sunaulo Sugandha

Source: Amgain 2011a.

Hybrid Prithvi showed higher HUE (5.62 kg/⁰C day) under 20 June sowing. However, the radiation and helio-thermal use efficiencies too are also higher with earlier sowing. The late sowing reduced the duration of vegetative phase and resulted in the decreased AGDD and HTU, which correspondingly decreased the values of HTTU and RUE. The results are in accordance to Amgain (2011b) in winter maize, as evidence with Paul and Sarker (2000) in wheat. The date of planting is major governing factors in crop production and it is considered to be low-cost high monetary returned technology under best management conditions. Rice varieties planted on 5 June has been producing higher yield than their subsequent late plantings almost for all rice cultivars (**Table 8**). The percentage reduction in yield was more for 5 June vs 20 June planting than the June 20 vs 5 July planting for early varieties Ram Dhan and Hybrid Prithvi and the lowest for longer duration varieties Masuli and Sunaulo Sugandha, suggesting that early planting is must for long duration varieties. This might be due to the late planting of rice resulted less dry matter and metabolized less photosynthates as a result of less growing degree days and helio-thermal units. The reduction in yield was more for 5 June vs 5 July planted rice varieties. Rao and Singh (2007) have also found the lesser yield of pearl millet when planted delay in Rajsthan, India.

Table 8. Grain yield (kg/ha) and yield reduction (%) due to delayed planting in different rice cultivars

Rice cultivars	Grain yield (kg/ha)			Yield reduction (%) due to late sowing		
	5 June	20 June	5 July	5 June vs 20 June	20 June vs 5 July	5 June vs 5 July
Ram Dhan	3885	3415	3125	12.10	8.49	19.56
Prithvi	5754	4732	4164	17.76	12.0	27.63
Masuli	4435	3892	3214	12.24	17.42	27.53
Sunaulo Sugandha	4468	4108	3547	8.06	13.66	20.61

Source: Amgain 2011a.

Correlation and regression model

Correlation between the calendar days and AGDD and HTU indicated that significant relationship between calendar days and AGDD and HTU were obtained during emergence to panicle initiation stage for all promising rice cultivars, while calendar days and HTU during PI to flowering was found to be non-significant (-0.891) for Ram Dhan and on Prithvi (-0.271) during flowering to physiological maturity stages, respectively. The correlation was found variable and inconsistent on Sunaulo Sugandha especially during panicle initiation to flowering and especially at the later stages (**Table 9**). This might be due to the several ups and downs in temperature and sunshine hours during the longer vegetative phase of long duration rice cultivars.

Further regression equations were developed to predict the phenology of rice using AGDD and HTU in all rice cultivars and reported as under:

Ram Dhan:	Y= 71.23 + 0.1650 AGDD - 0.0070 HTU	R^2= 0.964
Prithvi:	Y= 12.71 + 0.0385 AGDD + 0.0015 HTU	R^2= 0.999
Masuli:	Y= 47.72 + 0.0371 AGDD - 0.0001 HTU	R^2= 0.984
Sunaulo Sugandha:	Y = 49.21 + 0.0444 AGDD - 0.0014 HTU	R^2= 0.926

Physiological maturity can be predicted using AGDD and HTU which accounted for 96, 99, 98 and 92%, respectively for Ram Dhan, Prithvi, Masuli and Sunaulo Sugandha (**Table 9**).

Table 9. Correlation coefficients between calendar days and AGDD and HTU during different phenol-phases of rice under different planting dates

Pheno-phases	Ram Dhan		Prithvi		Masuli		Sunaulo Sugandha	
	AGDD	HTU	AGDD	HTU	AGDD	HTU	AGDD	HTU
E- PI	0.999	0.966	0.998	0.964	0.999	0.999	0.997	0.982
PI- F	0.999	-0.891	0.980	0.690	0.999	0.858	-0.969	-0.973
F- PM	0.776	0.999	0.989	-0.271	0.996	0.996	0.998	-0.739
E- PM	0.982	0.953	0.999	0.973	0.992	0.851	0.962	-0.123

Note: E- Emergence, PI- Panicle initiation, F- Flowering, PM- Physiological maturity

Source: Amgain 2011.

Limitations of the simulation model

The simulation models are based on a quantitative understanding of underlying processes, and integrate effects of soil, weather, crop, pests, and management factors on growth and yield. Once integration and validation have been judged successful, the models can help in analysing the effect of various biotic and abiotic factors on crop growth, yield, losses of N and N-use efficiencies. Such analyses are normally not possible with conventional experimental methods. Together with systems-approach tools such as expert systems, decision-support systems, databases, geographical information system (GIS), and remote sensing, crop models constitute a valuable tool that facilitates integration of knowledge and its use by a variety of users.

Conclusion

Crop models are supplementary to the field research but not complimentary. The garbage input results garbage output and hence makes the crop model failure. Due care from the beginning of the experimentation on data observation and acquisition is considered the vital elements for the successful implementation of the results in any crop models. In Nepal the science of crop modelling is at budding stage and a multi-disciplinary research team could be formed to build, evaluate and apply different models to extrapolate the agronomic and climate change scenarios. Rice being the major crop, its sustained yield and higher profitability would be gained with the rigorous use of crop modelling as a precision agriculture tools. The historical yield records of various crops from the multi-location trails and the daily weather data of all meteorological stations are tested through crop model, and we can forecast the yield in large area and predict the other production constraints easily.

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Use of ORYZA-3 Simulation Model for Rice Productivity Assessment in Tarai Districts of Nepal

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सारांश

धान नेपालको प्रमुख खाद्यान्न बाली हो । नेपालमा धानको उत्पादन र उत्पादकत्व छिमेकी मुलुकहरूको तुलनामा निकै कम रहेको छ । हालैका वर्षहरूमा करिब २५२ मिलियन अमेरिकी डलरभन्दा बढी विदेशी मुद्रा धान/चामल आयातका लागि विदेशिएको अवस्था छ । त्यसैले नेपालमा खाद्य सुरक्षा सुनिश्चिता गर्न धान खेती प्रविधि अनुसरणमा आमूल परिवर्तन नै आवश्यक रहेको महसुस गर्न थालिएको छ । प्रस्तुत लेखमा धानमा कम्प्युटर अनुकरण मोडलको प्रयोगबाट नेपालको तराई क्षेत्रमा वर्षे र चैते धानको सम्भाव्य उत्पादकत्व र हालको उत्पादकत्वबारे चर्चा गर्दै यी दुई उत्पादकत्वबीचको दुरीलाई कम गर्न ध्यान पुऱ्याउनु पर्ने प्राविधिक पक्षहरू जस्तै उपयुक्त जातको छनौट, सिँचाई, मलखादको प्रयोग, बीउ रोप्ने, रोपाई गर्ने समय तथा झारपात व्यवस्थापन, जलवायु परिवर्तन अनुकूलन हुने गरी धान खेती प्रणालीबारे अध्ययनबाट प्राप्त विश्लेषणहरू प्रस्तुत गरिएको छ । यस लेखमा सुनसरी, धनुषा, बारा, चितवन, नवलपरासी, दाङ, बाँके र कञ्चनपुर गरी तराईका ८ जिल्लाको आँकडा प्रयोग गरी कम्प्युटर अनुकरण मोडेल प्रयोग गरिएको चैते र वर्षे धान बाली सम्बन्धी उत्पादकत्व वृद्धि सम्बन्धी नतिजा उल्लेख गरिएको छ ।

Summary

Rice is the principal staple food crop in Nepal; however, its production and productivity is far below the neighboring countries. In the recent years, Nepal is importing rice worth of around 250 million US dollar per year. There is a need for the paradigm shift in rice cultivation to sustain the food security of the country. By making use of rice simulation model ORYZA3, an attempt is made to understand the potential and attainable yield gap of rice and explore the various agronomic options for sustainably narrowing down yield gap for early and main season in Tarai region of Nepal where there is potentiality of double cropping of rice provided there is irrigation for early rice cultivation. The study revealed that rice yield is greatly affected by adoption of improved varieties, irrigation, date of sowing, application of fertilizers, and weed management. The study also showed climate change as one of the important factors to affect yield of rice in Tarai region. There is a scope of narrowing down the yield gap of spring/early and monsoon/main season rice by adoption of best management practices and appropriate measures to respond to the climate change effects.

Keywords: Climate change, Food security, Management, Rice, Simulation model

Introduction

Rice (*Oryza sativa* L.) is the principal staple food crop of Nepal. It is grown under diverse environmental conditions ranging from sub-tropical plains of Tarai to foot hills and terraces of hills and the mountain at elevation up to 3050 m. In 2013 it is grown in 1.42 million hectares area and produced 4.78 million tonnes. Of this area 68% is in Tarai, 28% is in hill, and 4% is in mountain region and about 70% of the total rice production comes from Tarai region (CBS 2013). Compared to other countries, like India (3.7 t/ha), Bangladesh (4.4 t/ha), China (6.7 t/ha), and Pakistan (3.5 t/ha), productivity of rice in Nepal is the lowest (3.17 t/ha) (FAOSTAT 2015). In Nepal, rice alone contributes nearly 20% to agricultural gross domestic product and supplies more than 50% of the total calories requirement. Up to 1980s Nepal was a rice exporter country but thereafter it has become a net importer of rice. In 2014 and 2013 it imported rice worth of US$ 252 million and US $159 million, respectively (CBS 2014). All these figures indicate an urgent need for considerable demand-led incentives for enhancing the current domestic production and productivity of rice in Nepal to sustain food and nutritional security as well.

In Nepal, more than 65% of rice is produced under rainfed lowland system. It is grown during two seasons, i.e. monsoon season (*Barkhe Dhan*, June-November) and spring/early season (*Judi or Chaite Dhan*; March-June). The major reasons for the low yield of rice in Nepal are the lack of site specific proper cultivation packages, rainfed production system, use of low yielding crop varieties, low or no fertilizer application, untimely planting of old aged seedlings, and poor weed and other crop management practices subjected to the high temperature and rainfall variability, and drought conditions. The recommended fertilizer rate for irrigated rice is 6 t/ha organic fertilizer plus 100:30:30 kg $N:P_2O_5:K_2O$ per hectare for irrigated and 6 t/ha organic fertilizer plus 100:30:30 kg $N:P_2O_5:K_2O$ per hectare for rainfed condition (GoN 2015). However, only a few number of farmers apply organic manure in rice (Takeshima et al 2016) and the amount of inorganic fertilizer application is also far below the recommended rate either due to unavailable or unaffordable chemical fertilizers. In Nepal, the fertilizer use has grown steadily in the past two decades. However, the overall intensity of chemical fertilizer use lags behind many Asian countries (Takeshima et al 2016) and the scope for the sustainable intensification of both spring and monsoon season rice production in Tarai region of Nepal has not been well understood yet.

In the recent years, the conventional puddled transplanted rice (PTR) production system is facing problems of acute labor shortage due to laborers shifting from agriculture to industry, public works, and most importantly the overseas employment (Devkota et al 2013, Ladha et al 2009), and high cost of cultivation (Jat et al 2009), and low water and nutrient productivity (Humphreys et al 2010, Sudhir-Yadav et al 2011). This has demanded a need for the paradigm shift in rice cultivation to sustain the food security situation of the country and under such condition direct seeded rice (DSR) has been recognized as an alternative rice establishment method. Further, IPCC (2007) has projected that a global temperatures could raise by 1.4 to 5.8°C in 2100. Under such climate change conditions, rice production in Tarai region of Nepal could further be affected even with the doubling of the CO_2 emission. In Nepal, where agriculture is the main source of income for the majority of people and is highly dependent on climatic factors; and adaptive capacity is low, proper understanding of the impact of climate change in rice production could be important for the timely implementation of the adaptation and mitigation strategies. A long-term simulation study in eight Tarai districts under 20 different soil profiles was conducted in 2016 using rice simulation model ORYZA3 to understand the potential and attainable yield gap of rice and explore the various agronomic options for sustainably closing this yield gap. Most of the important findings from this study have been presented in the following section.

Rice yield gap in Nepal

In Nepal, the national average yield of rice is 3.2 t/ha and the average yield of rice in Tarai region is 3.49 t/ha (CBS 2013). While the long term simulation study showed the attainable yield of rice under irrigated condition with 150 kg N is 8 t/ha and the climatic potential yield is 10 t/ha (Devkota et al 2017 forthcoming). Farmers in Tarai region are getting only the 44% of the attainable yield of rice and were even lower for the farmers of other regions of the country (**Figure 1**).

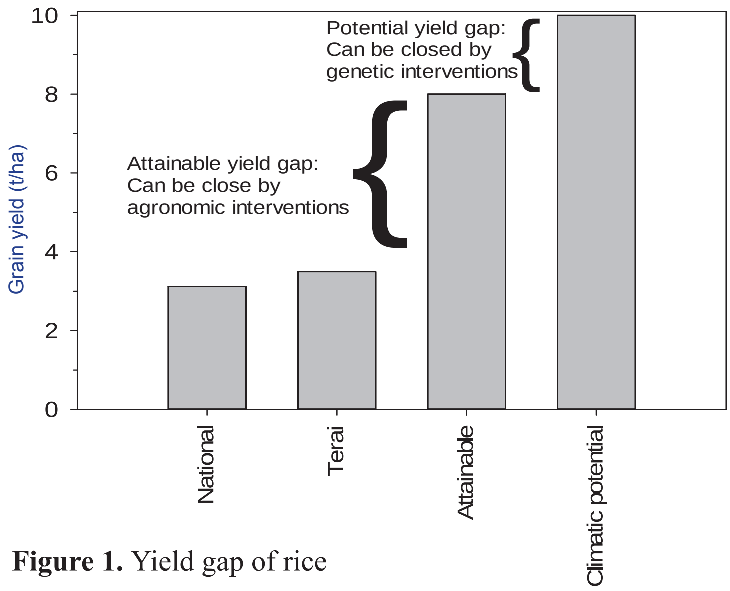

Figure 1. Yield gap of rice

The data for grain yield of rice was taken from the CBS (2013) and the attainable and potential yield were taken from the long-term simulation results of Radha-4, Sabitri and Swarna varieties using ORYZA3 in 8 Tarai districts (Sunsari, Dhanusha, Bara, Chitwan, Nawalparasi, Dang, Banke, and Kanchanpur) under 20 different soil profiles (Devkota et al 2017 forthcoming).

This yield gap is very similar in both spring and monsoon season rice. The attainable yield of rice in experimental station is lower (~6 t/ha) than described above (Amgain and Timsina 2004). However, even with this yield gap, there is a huge scope to double rice production in the region. The higher solar radiation (16 $MJ/m^2/d$) and optimum average temperature ($20^{°C}$) during 15 January to 30 April in Tarai districts shows a huge scope of increasing early rice production in Tarai region of Nepal by the cultivation of spring season (March-June) rice. However, under rainfed condition, cultivation of spring/early rice is not possible as during March-May the total rainfall in the Tarai region is <200 mm while the potential evaporation (315 to 477 mm), transpiration (265 to 337 mm) (Data not shown) and the several other uses and losses of water in rice cultivation (eg puddling, seepage, percolation, runoff accounts at least almost the same amount as of the potential evaporation and transpiration) greatly exceeds the availability of production factors. The spring rice cultivation during this time desperately needs the assured supply of irrigation water. But in the areas where assured irrigation is existed or possible, scaling out of spring rice cultivation could be the one of the major interventions of the government to boost the food security situation in Nepal.

The attainable yield gap of around 4.5 t/ha during monsoon season could be narrowed down mostly by the use of improved varieties, improvement in agronomic practices, and better adaptation strategies and there is a plenty of scopes to decrease potential and attainable rice yield gap in Tarai through the selection of district specific variety, improvement in agronomic practices such as timely sowing, adoption of better crop establishment method, assured irrigation, and optimization of nitrogen (N) fertilizer rates, and adaptation of climate change adaptation strategies.

Improved varieties

Rice varieties which are recommended for the PTR are suitable for DSR. Recently there have been introduction of many improved and hybrid varieties of rice in bordering India and China in Nepal. Among the popularly grown improved and hybrid varieties in Tarai districts of Nepal are Gorakhnath, Bioseed-786, Loknath, Aries-6444, DY-69, and Radha-4. Even under farmer's management conditions, these varieties can produce 25% higher yield than the varieties that farmers are currently using (Devkota et al 2017b). The long-term simulation result of Devkota et al (2017) showed that long duration varieties followed by medium- and short- duration varieties could produce high yield and can bring down yield gap by 15% through the use of better varieties. However, short duration varieties has the longest planting window and can provide 20 days more compared to medium duration varieties 35 days more compared to long duration varieties for the cultivation of vegetable or other crops after rice utilizing the residual soil moisture. Also, short duration varieties could be the better choice for spring season as the harvesting and drying process of medium and long duration varieties could severely be affected due to the onset of the monsoon rainfall. Thus, based on the location and farmers plan for the next season, preferred rice varieties should be chosen.

Alternative rice establishment methods

In Nepal, due to the increasing labor migration to other countries for better jobs, and the higher costs of production for PTR; cost-, labor-, and energy- efficient crop establishment methods is demanding in rice cultivation. The long-term simulation study across the Tarai districts by Devkota et al (2017) showed, under conditions of all production factors are none-limiting DSR could produce 10% higher grain yield than PTR in Tarai region of Nepal, however, under rainfed condition (water limited condition), PTR could be the better choice than DSR. The DSR technology turned-out to be district climate specific and the performance of DSR is mostly governed by the climatic factors and soil conditions. Compared to PTR, the performance of DSR, is variable and it is even more variable under rainfed condition. It is variable across the years and correlated (DSR under rainfed condition) with the rainfall and the radiation of a location.

Further, heavy soil texture and high soil organic carbon content are vital for the better performance of the DSR. Thus, before expanding DSR technology, proper characterization of climate and soil conditions are inevitable. Also, DSR needs more attention as it is the new and recent introduction, it is more knowledge and tool driven, and farmers are still not perfect to implement the DSR packages. After considering these points, except in a few Tarai districts, where rainfall pattern is scanty and the total rainfall during the rice growing period (May-November) is less (<1300 mm), in all other Tarai districts where rainfall during the rice growing period is >1300 mm, even under rainfed condition and without irrigation, DSR is better crop establishment technique as it yields at par or higher than PTR.

Appropriate sowing dates

The simulation study of Devkota et al (2017) shows compared to the base year 1982-1991 to 2004-2013, the optimum sowing window of rice has been shifted earlier by 10 days and rainfall has been decreased by 6 mm per year and irrigation requirement has been increased (**Figure 2**). Selection of a variety and the sowing date for a particular location is mostly governed by the temperature, solar radiation and the duration and intensity of rainfall during the rice growing period. In sowing after August 1, spikelet sterility due to cold, which decreases grain yield, varies from 4-24% across the districts, and the highest decrease due to cold injured spikelet sterility could be 23% in long duration followed by 8% in medium duration and 7% in short-duration varieties. Similarly, in sowing before 15 May, 1-16% of the spikelet could get sterile due to hot in across the districts.

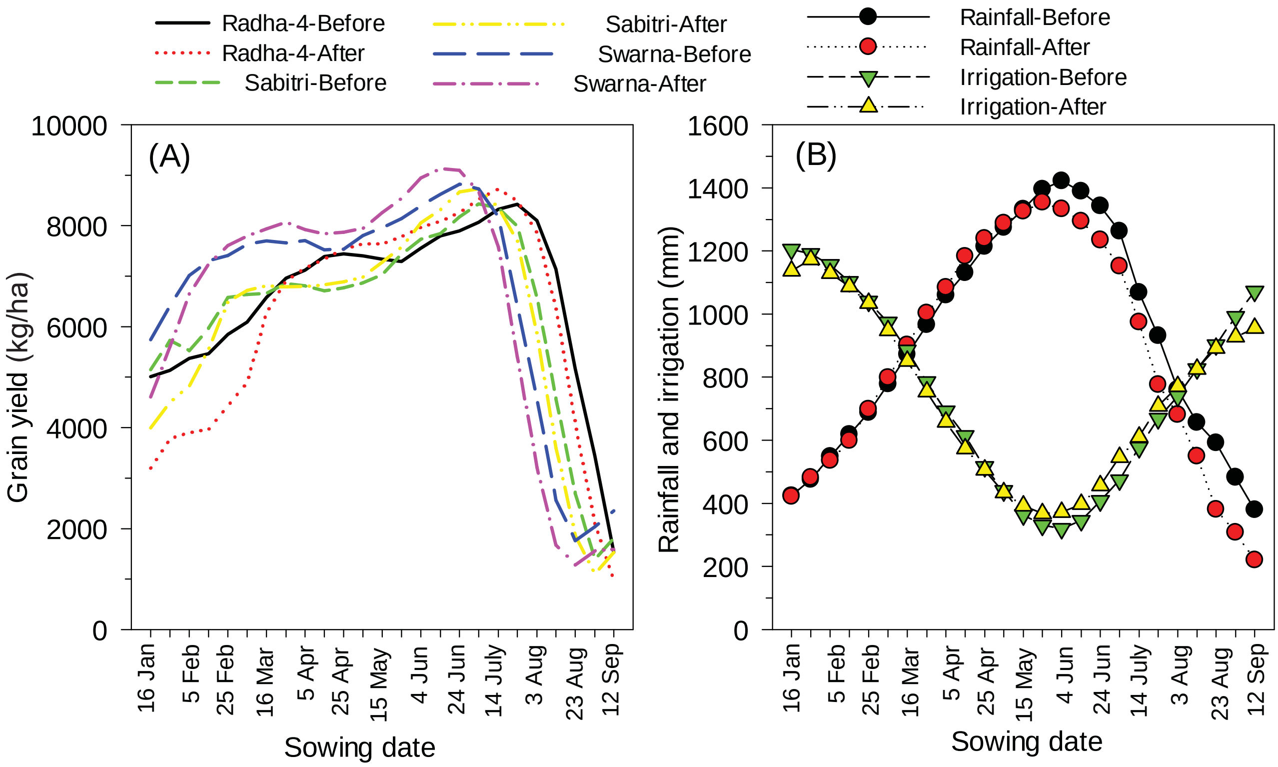

Figure 2. Optimum sowing time for 3 maturity duration rice varieties at different sowing dates (A) and cumulative rainfall and the irrigation requirement (mm) for rice at different sowing dates (B) on 1982-1991 (Before) and 2004-2013 (After) under irrigated condition in Rupandehi, Banke and Kanchanpur districts.

Under irrigated condition, DSR can be sown from the beginning of February to the mid- July, indicating a huge scope of double rice cultivation (spring and rainy season), which could significantly contribute to sustain the food security situation of Nepal . But there is the significant trade-off with the amount of irrigation and the sowing time. For the highest yield with lowest amount of irrigation, the sowing time for monsoon season rice could be between 1 June to 15 July (**Figure 2**). The sowing date for short duration variety could range from 4 July to 24 July, medium duration variety could range from 24 June to 14 July, and the long duration variety could range from 4 June to 24 June. Sharp yield decline starts for short duration variety after 1st August, medium duration variety after 20 July and after 1 July for long duration variety.

Appropriate amount of nitrogen fertilizer application

The long-term multiple soil profile simulation study shows the indigenous N supply can produce around 3.5 t/ha grain yield of rice. Under both establishment methods of DSR and TPR, rice responded to N rate up to 200 kg per hectare, where the simulated averaged grain yield increased by 39, 28, 18 and 10% from 0 to 50, 50 to 100, 100 to 150 and 150 to 200 kg N per hectare, respectively. However, N response under rainfed and irrigated systems were different and under both establishment methods. Almost linear increase in grain yield up to 200 kg N per hectare was observed in the simulation and also up to 180 kg N per hectare in experimental results (Devkota et al 2017). Even under these soil profiles strongly indicate that rice yield in Tarai district of Nepal is mostly limited by the soil fertility and especially the N content in the soil. The national average fertilizer recommendation for rice is 100:30:30 kg $N:P_2O_5:K_2O$ per hectare (GoN 2015). Framers in Bara and Rupandehi apply higher N (up to 70-100 kg N per hectare) while in other districts, its application is far below age old blanket recommendation rate. In Tarai region of Nepal, fertilizer use has increased over the past two decades, but the overall intensity of chemical fertilizer use in rice in Tarai lags behind many Asian countries (Takeshima et al 2016). Thus, a huge scope exists for the intensification of rice through increasing fertilizer rate in both establishment methods. This study shows that the prime time to revise the national blanked fertilizer recommendation rate and also demands district and domain specific N fertilizer recommendations considering climate (district), indigenous nutrient supply, establishment method, irrigation availability, soil type, organic carbon content of the soil, rice variety used, and also the sowing time. Current national recommendation method which considers only the irrigation availability is quite insufficient and inefficient method of fertilizer recommendation.

Integrated weed management

This simulation model does not account for the yield reduction in rice due to weed, disease and insects. Compared to weed, disease and insects are less problematic in rice in Tarai. Weed control is an enduring challenge to the broader acceptance of especially the DSR among farmers (Awan et al 2015, Chauhan et al 2015, Matloob et al 2015).

Supplementary irrigation

Two supplementary irrigations (one at panicle initiation and one at flowering, if no rainfall during these growth stages) increased grain yield of rice by more than 10%. This simulation study found a significant benefit of irrigation and supplementary irrigation could impart a significant contribution to sustain the rice production sustainably in Tarai and especially under climate change scenarios. Gradual increase in irrigated areas and expansion of micro-irrigation, shallow tube-well, deep tube-well and mega irrigation schemes especially in western Tarai (Dang and Bardiya) are encouraging farmers producing yield increment of rice. Further, in the recent days, the area under the release of drought tolerant varieties (Sukha series 1 to 6 released by IRRI and NRRP) are increasing rapidly, which is shifting the varieties towards high yielding, stress tolerant, and water and nutrient responsiveness.

Climate change and rice in Nepal

Rice production has been challenged by the climate change in Tarai districts of Nepal. Over the last 30 years, during the initial 5 years vs. final 5 years comparison, the measured daily average temperature in 8 Tarai districts increased by 0.80°C (ranging from 0.8 to 7.66%), the total annual rainfall decreased by 119 mm (4.8%), and the average daily solar radiation decreased by (0.3 MJ $/m^2$/year) during the rice growing period (1 May to 15 December) in the Tarai region of Nepal. During this period, the long-term multi-location simulated grain yield of rice showed a declining trend over years, where, under farmers practice of PTR, compared to the initial 5 years in each district rice yield declined by 0.4 t/ha (5%).

With increased temperature and decreased solar radiation and rainfall, compared to the base year, the decrease in simulated yield of all 3 rice varieties (Radha-4, Sabitri and Swarna) over different sowing dates under farmers' practice of PTR-rainfed condition, and shifting of rice sowing period earlier by 10 days (**Figure 2**) confirms that so called climate change has really already been happened and has already affected rice production in Nepal. Based on the spatial variation of climatic parameters, the intensity of the effect of climate change in districts where the daily average temperature during rice growing period is already >26 ˚C, grain yield of rice is declining, indicating this is the threshold temperature for the current popular varieties and management conditions in Tarai. Rice yield could decrease by 2-6% per centigrade with an average mean daily temperature of 26 °C (Baker and Allen 1993, Matthews et al 1995, Sheehy et al 2006). Carbon dioxide (CO_2) enrichment is likely to increase the photosynthetic rate and hence biomass production, which in turn may positively affect assimilate allocation to reproductive organs (Wassmann et al 2009). However, the yield decline under increased temperature conditions is the result of spikelet sterility due to the negative effect on pollination processes (Krishnan et al 2011). The most important factor to sustain the food security by mitigating the effect of climate change is through increasing the rice area under irrigation and a significant government and non-government initiatives for increasing the irrigation supply and increasing the on-farm water use efficiency has urgently been needed. For this, the most effective and immediate action could be the rehabilitation of the old irrigation schemes for example the ground water supply of Bhairahawa of Rupandehi district.

Conclusion

A huge scope exists for the sustainable intensification of rice production in Tarai region of Nepal especially through the area expansion in spring rice (provided the assured irrigation and optimum N rates) and through the adoption of domain specific agronomic packages in both early/spring and main season/monsoonal rice. Significant scope exists to bring down yield gap of rice through optimization in sowing date, varieties, irrigation, N rate and better domain/district specific recommendation of N fertilizers, and revision of old blanked fertilizer recommendations. Sufficient scope exists for closing rice yield gap, by promoting at scale the best management practices with irrigation for conventional PTR. Through the proper weed control, the attainable yield gap in rice should be narrowed. Rice in the Tarai region has already been experienced the impact of climate change and under this condition, assured irrigation with PTR establishment method could be the more reliable. It is already the prime time to implement the strategies, policies, investments, research, and infrastructures (especially for irrigation) to negate the impact of climate change in rice production in the region. This will help sustain food and nutritional security of Nepal by enhancing rice production in areas where there is production potentiality of double rice cropping.

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Women in Rice Farming System in Nepal

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सारांश

महिला र धानबीच सांस्कृतिक, सामाजिक तथा आर्थिक सम्बन्ध रहेको छ । अन्य एशियाली मुलुकमा जस्तै नेपालमा धानको उत्पादनमा आवश्यक श्रमको ५० प्रतिशतभन्दा बढी योगदान महिला कृषकको रहेको छ भने धानको उत्पादन प्रणालीमा बीउ छनौटदेखि रोपाई, गोडाई तथा उत्पादनोपरान्तका कार्यहरूमा उनीहरूको संलग्नता रहेको पाइन्छ । तथापि क्षेत्रगत रूपमा तराई, पहाड तथा हिमालमा र विभिन्न समुदायका महिलाहरूमा धान उत्पादन प्रणालीका कार्यहरूमा संलग्नता एकै किसिमको भने पाइदैन । विगत केही वर्षहरूमा बढ्दो क्रममा रहेको घरका पुरूष सदस्यहरूको आप्रवासनका कारणले समग्र कृषि क्षेत्रका साथै धान खेतीमा महिला संलग्नता बढ्दै गइरहेको देखिन्छ । यसले गर्दा परम्परागत रूपमा पुरूष कृषकहरूले गर्दै आएका कार्यहरूमा समेत महिला कृषकहरूको भूमिका बढ्न थालेको छ । खासगरी उन्नत जातको प्रयोग, यान्त्रिकीकरण लगायत उन्नत प्रविधिको अवलम्बन तथा अनुसरण गर्न एवम् सोसँग सम्बन्धित निर्णयहरूमा समेत महिलाहरूको भूमिका बढेको देखिन्छ । धानको उत्पादन पश्चात् त्यसको प्रशोधन गर्ने, परिकारहरू तयार गर्ने एवम् त्यसको उपयोग गर्ने कार्यमा समेत महिला संलग्न हुने हुँदा परिवारको पोषण सुरक्षाको सुनिश्चितता गर्न सहयोग गर्ने भएकोले उनीहरूको भूमिका अझ महत्वपूर्ण हुन जान्छ । विभिन्न चाडबाडमा चामलसँग सम्बन्धित संस्कृतिहरूलाई निरन्तरता दिने कार्यमा समेत महिलाको भूमिका अहम रहँदै आएको छ । राष्ट्रिय अर्थतन्त्रमा महत्वपूर्ण योगदान भएको कारणले प्रविधिको विकास एवम् अवलम्बन गरिंदा महिला कृषकको आवश्यकता, चाहना तथा समस्याहरूलाई समेत सम्बोधन हुने गरी गर्नु पर्दछ भने यस्ता प्रविधि, बजार आदिमा समेत उनीहरूको पहुँच बढाई महिला कृषकहरूको भूमिकाको पहिचान, उनीहरूको क्षमतामा अभिवृद्धि तथा सम्मान गर्न आवश्यक देखिन्छ ।

Summary

There is cultural, social and economic relationship between women and rice. As with most Asian countries, women in Nepal contribute more than 50% of labor in rice farming and are engaged in various activities of rice production system, right from seed selection to transplanting, weeding and postharvest activities. However their degree of involvement in these activities varies in different agro-ecological region and among various communities. The recent trend of migration of male members of household is resulting increased feminization of rice farming, in particular, and therefore, women are even undertaking the roles previously considered domain of men; including decision making on adoption of improved varieties and mechanization. They are also equally engaged in food processing, food preparation and utilization, further emphasizing their role in post-harvest loss management and ensuring nutrition of the household members. They carry forward various rituals and cultures associated with rice and rice products. Due to their significant contribution to the economy, their need, preferences and constraints need to be accounted during technology development and adoption. Their access to assets and new technologies and market need to be ensured so that women farmers, who are contributing to rice economy, are duly recognized, capacitated and rewarded.

Keywords: Development, Economy, Women, Rice, Role

Introduction

Several studies on the roles and responsibilities of men and women across the globe show that women contribute significantly more than men to rice-based agriculture. These roles are often conditioned by several socioeconomic (class, ethnicity, religion etc), political and environmental factors, including agro-ecological zones; they are dynamic and can change over time (GRISP 2013). These roles may differ in different production systems, among castes and ethnic communities and type of household (nuclear or extended) and also between social and economic status. The availability of male family members in the household is also found to influence the roles of women, the later being prominent with the increased migration of male members and feminization of the agriculture.

With the changing socio-economic context, the traditional role of women in rice farming is rapidly changing. Their role is shifting from traditional farm laborers to more of farm managers and owners as a result of male outmigration to urban areas and abroad in search of better economic opportunities. This is reflected in the rise of women farm landholders across Asia, with striking increases in Thailand and even Nepal in the past two decades (Mohanty and Bhandari 2014). In case of Nepal, the share of agricultural holdings by women made an 11-point jump from 8 to 19% while the women headed household also increased by 11 point from 14.87 to 25.73% between the period of 2001 and 2011(CBS 2014). On the contrary, due to out migration of rural women and mechanization of rice farming, many of the Southeast Asian countries such as Thailand, Vietnam, and the Philippines have witnessed declining labor input of women into rice farming, with their share decreased by at least 10% points in the last two decades suggesting that this trend might be evident in South Asia as well (Mohanty and Bhandari 2014).

As in most Asian Countries, both men and women farmers are engaged in the rice production system, their role often defined and mostly similar in production system of different countries, although variation among different, agro-ecological region, ethnic communities and socioeconomic groups exist. Unlike other subsector, there have been limited studies to understand the regional and ethnic diversities among women, particularly in rice production system in Nepal. This paper aims at drawing upon from the studies and documentation, in understanding the overall role of women in rice production system including their role in changing context, different practices among different communities in different agro-ecological condition, constraints they are facing and the way forward to increase their productivity.

Women and rice farming

There is a close tie between women and rice from cultural, social and economic perspective. Culturally, Hindu Goddess Laxmi, also known as, *Annapurna*, is considered, provider of the bounty of rice. She is also considered as the Goddess of Prosperity (Mohanty 2011). Various mythological stories are associated with her, wherein, when not duly respected, she is believed to bring drought and famine. Various countries in South Asia and some parts of Southeast Asia are found to associate their goddess with rice and therefore hold special ceremonies to worship her. Also, it is the women, who mostly uphold the cultural practices and since rice is the staple food in these regions, many cultural practices associated with rice is thus sustained by women.

It is not just the culture but economies of rice also revolves around women. Rice is the predominant crop in most of these countries and women are engaged in various activities along the rice value chain, right from seed selection to postharvest activities. Studies on the gender division of labor in rice production reveals that women in Southeast Asia contribute 25–60% of the required labor. In South Asia it is as high as 60–80% while in Africa, 80% of Africa's food is grown by Africa's 100 million rural women (GRISP 2013).

In general, women are involved in establishing the crop, harvesting, and post harvesting activities while men are found to take the lead in preparing the land, managing the crop, operating farm machines, and marketing (**Table 1**).

Table 1. Percentage share of male and female labor inputs by rice production activities in selected Asian Countries (2008-2010)

Country	Gender	Land preparation	Crop establishment	Crop care management	Harvesting and threshing	Postharvest activities
Bangladesh	M	98	89	77	95	49
	F	2	11	23	5	51

Country	Gender	Land preparation	Crop establishment	Crop care management	Harvesting and threshing	Postharvest activities
India (Assam)	M	100	0	100	40	10
	F	0	100	0	60	90
Nepal	M	80	26	43	48	57
	F	20	74	57	52	43
Srilanka	M	92	86	92	61	67
	F	8	14	8	39	33
Cambodia	M	86	39	76	47	60
	F	14	61	24	53	40
Laos	M	62	45	58	53	33
	F	38	55	42	47	67
Average	M	82	45	65	55	43
	F	18	55	35	45	57

Source: IRRI farm household survey data Base in Mohanty and Bhandari 2014.

In early ninety's, women's participation in rice cultivation was about 54% for Nepal, 19% for Philippines, 48% and 55% in Andhra Pradesh and Tamil Nadu State of India, whereas women in Bangladesh were found involved only in seed selection (Pradhan, 1983). But the current statistics shows that on average, Asian women contribute nearly half of the total labor input into rice production ranging from 17% in the Philippines (decreased from the past) to 74% in the Indian state of Uttar Pradesh while women in Bangladesh do not participate in field work but do almost all of the post harvest processing mainly because of their religious and cultural practices (Mohanty and Bhandari 2014).

Women activities in rice value chain in Nepal

Women play a major role in rice production system including cultivation, post-harvest processing and marketing. In a study conducted in selected districts of Nepal, 74% of crop establishment, 57% of crop care and management, 52% of harvesting and threshing and 43% of postharvest activities were found to be done by women farmers.

They are usually the seed savers/keepers in the household. Since they have long been involved in rice farming, they are the repositories of indigenous knowledge of crop and natural resource management, particularly on traditional rice varieties, its traits and management aspects, among others. However, as women have less access to land and other productive assets and services, the decision on technology adoption including varietal selection, use of machineries for various operations and marketing of the produce are mostly commanded by men.

While men are mostly responsible for seedbed and land preparation; terrace and bund repair and maintenance (in hills and mountain), irrigation management while uprooting of seedlings for transplantation, transplanting and weeding are predominantly done by women.

Women are culturally prohibited to plough the land, with the belief that, if they plough the land, there will only be the production of husk. However, in some parts of the country, due to males' migration, women are even undertaking the land preparation (ploughing), previously considered as the sole domain of men.

Box 1.
Religiously, women often are barred to plough the fields with the superstitious belief that it would bring bad luck and may cause famine and drought. However, with changing socioeconomic context, and due to out-migration of the male members, women are found breaking the age old belief. Sushma, a young girl from Bajura District, Far western development region "Breaking the Tradition".

Figure 1. Women ploughing field in Bajura

They often work in their fields as family labor and also contribute as "exchange labor". During exchange labor, often two women are substituted for one man, suggesting that they are paid less than men for the same work, undervaluing women's contribution.

Figure 2. Manual weedingFigure

Figure 3. Women as exchange labor during transplanting

Although transplanting and weeding are mostly manually done, but currently there has been an increasing trend of use of rice transplanter and weeders, especially in Tarai. These are found to reduce the time and drudgery for women. Harvesting are manually done, mostly by women whereas threshing either manually, using bullock or by machines are done, mostly by men. Combined harvester, thresher etc are available to do these works while women are heavily engaged in post-harvest processing (drying, milling) and seed storage. Increasing access of women to these technology and services need to be ensured for their wider adoption. However, it should also be taken into consideration that those machineries may replace their labor, affecting their income, which needs to be supplemented by other income generating activities during their saved time.

Diversity among women in rice production system in Nepal

To understand the diversity among rice farming women in Nepal, it is easier to relate it with the agriculture production system of the country as a whole. Nepal's agriculture can be broadly categorized into three distinct physiographic regions: Tarai, Hill and Mountains across different administrative divisions. While rice is the predominant crop in Tarai, maize dominates in hills, and millet and potato in mountain. Most of the irrigated land falls in flat land of Tarai and therefore can have either two crops of rice (summer and spring) or any other crops, including high value cash crops. When multiple crops are grown, it often adds drudgery to women farmers.

In all the regions, women have similar role in rice production system. Although major activities conducted by women in these regions and caste are similar, certain degree of variation are observed. As each region is dominated by specific caste (**Table 2**), their role would be explained across this variation.

Table 2. Predominant caste of Nepal 2011

Development region	Tarai	Hill	Mountain
Eastern	Brahmin Hill	Rai	Limbu
Central	Yadav	Tamang	Tamang
Western	Brahmin Hill	Brahmin Hill	Gurung
Mid-Western	Tharu	Chettri	Chettri
Far-Western	Tharu	Chettri	Chettri

Source: Population Atlas of Nepal. CBS 2014.

Usually, the participation of women in crop and natural resource management is found to increase with poverty and environmental stresses (drought, submergence and problems soils). For example, in the upland, in "boro" rice farming, the role of women in mountain is found also in the land preparation (www.resourcenepal.com).

The transplanting is mostly done by women across different regions and castes. However in central Tarai, where the predominant castes are *Yadav*, traditionally women of their household do not work in the field. They rather mobilize the hired labor for transplanting and harvesting or male members do such activities. Women in these regions are involved in other post harvest operations inside the household periphery.

Figure 4. Winnowing rice by women

Figure 5. Manual harvesting with sickle in Tarai

Tharu women, who are predominant caste in mid and far western Tarai, on the other hand, are however, engaged in the field as well post harvest activities. *Hill Brahmin* and *Chettri* women, predominant in Eastern and Western Tarai and Western Hill, however are involved on farm as well as post harvest operations.

Figure 6. *Tharu* women planting paddy

Figure 7. Rice pounding in Gumgadhi

Mountain regions are dominated by ethnic groups such as: *Limbu, Gurung, Tamang* and also *Chettri*. The upland rice farming in mountain is highly labor intensive and challenging, especially for women since the women in the regions have to do most of the farm work such as taking care of animals, weeding, drying, and milling. The lack of new modern varieties, quality seeds, and better crop management technologies, and limited access to public services, are some of the many concerns of upland women farmers (www.resourcenepal.com).

In most cases, the participation of women in farm activities are often guided by socioeconomic status as well. Better off women farmers do not work in the field but hire the waged labor, or otherwise, they are involved in both cultivation and post harvest practices.

Women and rice technology[1]

Adoption of improved varieties

Regarding the innovation and technology, it cannot be denied that women have rich knowledge on the traditional varieties, its traits and its selection and storage. Hence, their knowledge has been valued by the agencies and institutes involved in in-situ conservation and community seed banks.

Government of Nepal has been promoting various improved rice varieties to suit different agro-ecological and stress conditions. During development and recommendation of rice varieties, the gender preference are often ignored, resulting in the low adoption of certain varieties for its particular traits. For example, it is reported that local women farmers preferred to grow lower iron white-grained rice varieties than red varieties with higher iron content, as white rice is considered socially more prestigious (cultural norms) and also it requires less labor to remove red bran with a rice pounder (www.irrinews.org). A study on Farmers' choice of the modern rice varieties in rain fed ecosystem of Nepal and showed that out of five variables (of four varieties) taken for the assessment; it is not only the yield that matters but also the threshability and other products from rice (suitability for preparing *murahi* and *beaten rice)*. Though gender perspective is missing in the study, the traits preferred indicates that their perceptions of the labor requirement for threshing and preparation of the special products, which are closely associated with women's roles (Joshi and Bauer 2006).

A similar study conducted by IRRI also indicated that men preferred high and stable grain yield and tolerant of stress, whereas women looked for other traits, such as: quality of rice straw for animal fodder, eating and cooking quality traits for rice as food and as special food products, post harvest quality and duration so that they can grow other crops after rice (IRRI**,**2015). Women who tend the livestock, they have valuable knowledge to inform choices on grain quality and feed quality of the straw. Similarly, in choosing rice varieties while men were concerned more about increasing yield and production, women were found to consider taste, smell and ease of threshing and cooking. They also expressed a preference for fine grain rice varieties for home consumption and coarse grain varieties for selling in the market (CSISA 2015).

These studies suggest that when technology is promoted, it is equally important to consider women's voice and to tailor the technology for female farmers as well. Acknowledging the needs of women farmer can have higher rate of uptake of a technology, and more benefit from the technology for the family (CSISA 2015).

Women in rice farming mechanization

Many of the activities in rice production system are still being conducted manually and using traditional labor. Women manually spray fertilizers, use sickles to harvest, use traditional method for winnowing, pounding, drying and storing among others. The traditional wooden tools and implements have continued to remain in use in the hills and mountains. There has been some improvement in their design and performance capabilities over time.

With the migration of male members in the household, women have additional burden in rice farming and for this reason, and also with the introduction of new machineries for various farm activities, women are slowly adopting new technologies. Tractors and pump sets represent the two most dominant forms of

1 Refers to new varieties and mechanization

mechanization in Nepal. There has been increasing trend of mechanization (particularly four wheel tractors), in Tarai in the last three decades (Takeshima et al 2016). But in hills and mountain, the trend has been not been very encouraging. The mechanization for transplanting, weeding, threshing etc are also equally common in rice in Tarai and many women friendly tools are also designed so that even women headed households can use those machines. However, due to the lack of physical facilities (viz. road networks and electricity) and narrow terrace cultivation in hilly areas, hill agriculture still largely depended upon human and animal power. To the consequence women in this region suffers even more.

Figure 8. Using mechanical transplanter by woman, Morang District

Figure 9. a-Woman carrying plow for land preparation, Rolpa **b-**Woman using earthway spreader in Bardia

One of the drudgeries of rice farming is manual weeding. Mechanical weeder, especially in row planting is found women friendly and reduce the drudgery of women.

The paddy sheller and polisher and mechanical grinding mills are found to be adopted in majority of villages of Tarai and hills. In the mountains, still the milling is found to be performed in local devices such as mortar & pestle, quern and water mills (www.un-csam.org). Mechanization not only reduces drudgery of women but also increases the efficiency of farming. Hence, Government of Nepal has laid emphasis on promotion of mechanization by approving Mechanization Promotion Policy and subsequent activities to encourage the awareness and adoption of the technology.

Women and postharvest operation in Nepal

Postharvest and food processing activities are predominantly done by women in Nepal. Because of their role, they can be instrumental in minimizing the postharvest losses and ensuring proper utilization of the nutrients through increased quality of rice.

Figure 10. Paddy sorting/winnowing

Figure 11. Paddy winnowing

For the postharvest processing, women farmers are still using various local tools and techniques for the milling and pounding of rice using arm power (*Okhal, Jato*) and foot power (*Dhiki*). Use of water mills and currently solar mills, which processes the grains in shorter time can thus avail women some free time.

The role of women in marketing of the product is minimal. However, many women farmers, involved in seed production and marketing through farmers' groups, cooperatives and community seed production have better access to market. Their role has been very pronounced in community seed banks.

It is not only the production and processing, but women add value to rice by preparing them into finished products for home consumption or for sale. *Murahi, Beaten Rice, Latte* etc are some of the processed rice based foods. Women from different ethnic groups make various rice based delicacies such as: *Yomari, Sel, Kheer, Anarsha, Jhilinge* etc. Since they are responsible in consumption and utilization of rice and rice products at home, their role is extended in ensuring nutrition security of the family members as well.

Figure 12. Making "*sel*", a traditional food made from rice flour

Figure 13. Yomari making

Women are also found utilizing the byproduct (straw) for weaving mats (*gundri, chatai, sukul, mandro, chakati*), mostly for household purpose. But there is growing demand for such traditional mats as well, specially, in ethnic restaurants and for home decor as well.

Women, in many parts of Tarai, are also involved in decorating their mud house walls and make beautiful designs on the floors with the rice flour mixed with water called "*pithar*" to make "*aripana/alpana"*, make "rangoli", the colorful pattern in the floor (using pithar with colours) to celebrate "*sankrati*" and other festivals and also to mark puberty of girl child, wedding etc. Often known as *Mithila* arts, women in Mithila region of Nepal and large part of India including Bengal are found to be involved in this art, which is gradually becoming commercial as well.

Figure 14. Weaving *gundri* with paddy straw

Figure 15. *Aripan/Alpana*, an art, made with rice flour

As there is still predominance of traditional methods of post harvest operations, such as: manual threshing, winnowing, milling and storage, there is significant losses of rice grain. Use of mechanical thresher can save their time and also minimizes losses. Similarly, use of proper storage such as combination of metallic bins together with hermetic bags, can significantly reduce the losses, both in terms of quantity and quality. Increasing knowledge and awareness among women and accessing to these technologies is very important. In addition, promotion of value adding technologies and improving the access to market can help women to get increased income.

Women farmers and agricultural policies

Ministry of Agricultural Development (MoAD), through its establishment of Women Farmers' Development Division (WFDD), is one of the first Ministries within the Government of Nepal to dedicate a separate division to address the concerns of women farmers. Many gender related studies were done and collection of sex disaggregated data was initiated during that time. Policy thrust targeting women farmers were advocated by this division, which can be seen reflected in many subsequent policies, programs and projects. Later, this division was integrated with Environment Division as Gender Equity and Environment Division (GEED) and recently, limited to a section within a division.

Despite the effort for gender mainstreaming, the technology generation, development and dissemination, considering women farmers in particular is still inadequate and additional efforts are needed to understand their roles and preferences to enhance their technical knowledge and capacities and increase their access to agricultural assets and technologies and benefits. Since there is greater contribution of women farmers in rice economy, understanding these dynamics in rice production system is crucial to increase overall productivity of the rice and to increase their share in benefit from rice value chain.

Conclusion

Like in most of the Asian Countries, the role of women in rice production system in Nepal is very crucial since rice alone contributes almost 20% of AGDP and more than 50% of labor force for the same comes from women. This underscores women's role in AGDP and overall economy of the country. Although, most of the activities along the production system are similar for the women in rice, the degree of involvement, their preferences over the technology may vary in different agro-ecological region and across different communities. The development of new technologies and its adoption therefore requires addressing the need and priorities, preferences and acceptability of women farmers across all the sectors.

Increasing the productivity of rice requires not only promoting innovative technologies but also enhancing the capacity and productivity of women rice farmers by increasing their access to extension services, developing suitable technologies (including farm machineries and varieties considering preferred traits) by acknowledging the diversity; access to new technologies and credit among others. The research institute in Nepal, responsible for developing and testing new varieties, has given importance to this dynamics through Participatory Varietal Selection including both men and women farmers. For these reasons, gender perspective needs to be considered while developing technologies and their adoption.

In addition, out migration of male members of household is in rising trend in Nepal, like in other parts of Asia. It requires appropriate policies and programs to address the concern associated with feminization of agriculture, including women's access to resources, technology and services.. Since women are involved in value addition and income generation through postharvest activities, their knowledge and skill in this sector and linkage of their produce with market is also equally important. Agricultural policies, programs and projects in general and rice research and production in particular, need to put adequate emphasis on women farmers. For this, both agro-ecological and inter community dynamics between men and women rice farmers and among women farmers need to be understood. Ensuring women's involvement along the entire rice value chain is important such that women farmers contributing to rice economy, are duly recognized, capacitated and rewarded.

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Post-Harvest Management
(पोष्ट हार्भेष्ट व्यवस्थापन)

Post-Harvest Quality of Some Rice Varieties of Nepal

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सारांश

चामलको गुणस्तर कुटानी गुण, भौतिक गुण, पौष्टिक गुण एवम् पकाउने गुणमा निर्भर रहन्छ । चामलको दानाको आकार, तौल, नरमपना, रासायनिक संरचना, सुगन्ध आदिले समेत चामलको गुणस्तर निर्धारण गर्दछ । यी सबै गुणस्तरका सूचकहरू एक आपसमा अन्तर सम्बन्धित रहेका हुन्छन् । नेपालमा अध्ययन गरिएका धानका जातहरूमा सबैभन्दा धेरै लम्बाई चौडाई अनुपात बर्खे-१०२७, चैते-२ र घैया-१ को क्रमशः ४.३, ४.२ र ४.२ पाइयो भने सबैभन्दा कम ताइचुङ-१७६ को १.६ पाइयो । त्यस्तै सबैभन्दा धेरै १००० दानाको तौल खुमल–७ र चाइनान–२ को क्रमशः ३१.४ र ३०.१ ग्राम पाइयो भने सबैभन्दा कम रामपुर मन्सुलीको १८.१ ग्राम पाइयो । सबैभन्दा धेरै चामल पर्ने जातहरूमा क्रमशः छोम्रोङ (७७%) र माछापुच्छ्रे (७६%) देखिए भने सबैभन्दा कम चामल चाइनान-२ को जम्मा ६०% पाइयो । त्यस्तै पकाउँदा पानी सोस्ने अनुपात, भात बढ्ने अनुपात तथा एमाइलोजको मात्रा सबैभन्दा बढी चैते-२ जातमा क्रमशः ३.२, १.८ र २८.७% पाइयो ।

Summary

Milling quality, physical quality, nutritional quality and cooking quality define overall quality of rice. Quality characteristics of rice are related to the physiochemical properties, dimensions, shape and weight, pigmentation, hardness, chemical composition of the endosperm, aroma and nutritive value. All the quality parameters are interrelated to each other. Among the studied rice varieties available in Nepal, maximum L/B ratio was found in Barkhe-1027 (4.3) followed by Chaite-4 (4.2) and Ghaiya-1 (4.2) whereas the minimum was of Taichung-176 (1.6). Similarly, maximum 1000 kernel's weight was obtained in Khumal-7 (31.4g) followed by Chainan-2 (30.1g) whereas the minimum was in Rampur masuli (18.1g). Highest milling recovery of 77% and 76% were recorded in Chhomrong and Machhapuchhre-3 variety respectively, which was found lowest in Chainan-2 (60%). Regarding the cooking quality, highest water uptake ratio (3.2), kernel elongation ratio (1.8) and amylose content (28.7%) were recorded in the variety Chaite-2.

Keywords: Cooking quality, Gel consistency, Milling quality

Background

Quality characteristics of rice are related to the physiochemical properties, dimensions, shape and weight, pigmentation, hardness, other milling properties, chemical composition of the endosperm, aroma and nutritive value. Rice quality is usually evaluated according to its stability for a specific end-use product. The important quality traits of rice from the post-harvest point of view are its milling, cooking and processing characteristics. The physical, chemical and nutritive quality of rice is also important and serves as a mean of categorizing rice into different groups or grades.

Grading of rice

Grading with its standard is necessary in the marketing process because they furnish the means of describing varietal quality. It also provides a basis for merchandizing contracts, for quoting prices and incentive to farmers to produce better crops. Good milling results and their storage stability can only be obtained when the rice or grain is properly graded. FAO (1972) have recommended the standard for rice in international trade on different basis such as on the basis of L/B ratio: slender (>3), medium or bold (2-3) and round or short (<2);

on the basis of milled grain length: extra-long (>7 mm), long (6-7 mm), medium (5-6 mm) and short (<5 mm); on the basis of 1000 kernels weight: extra heavy (>25 g), heavy (20-25 g) and moderately heavy (<20 g). The bulk density, length, breadth, L/B ratio and 1000 kernel weight of some Nepalese rice varieties were in the range from 510-698 g/lit, 4.5-10.4mm, 1.5-4.0 mm, 1.6-5.0 and 16.6-31.6 g, respectively.

Table 1. Physical properties of rice varieties of Nepal

SN	Variety	Bulk density	Length, mm	Breath, mm	L/B ratio	Shape	1000 kernel wt., g	Grain type
1	Barkhe-1027	-	7.70	1.80	4.28	Slender	-	-
2	Barkhe-2014	-	7.30	2.65	2.75	Bold	-	-
3	Barkhe-3004	-	9.23	2.53	3.65	Slender	-	-
4	Chainung-242	591	7.28	3.59	2.03	Bold	28.10	Extra heavy
5	Chaite dhan- 6	565	8.19	2.40	3.41	Slender	19.60	Moderately heavy
6	Chaite dhan-4	557	9.65	2.29	4.21	Slender	22.63	Heavy
8	Chaitya dhan-2	631	7.66	2.57	2.98	Bold	22.42	Heavy
9	Chandannath-3	587	7.24	3.37	2.15	Bold	26.20	Extra heavy
10	Chhomrong	590	-	-	2.45	Bold	27.28	Extra heavy
11	Chinan-2	569	8.05	3.70	2.18	Bold	30.57	Extra heavy
12	Ghaiya-1	-	6.50	1.54	4.22	Slender	-	-
13	Hardinath -1	591	8.40	2.42	3.47	Slender	20.56	Heavy
14	Hardinath -2	-	-	-	2.50	Bold	-	-
15	Himali	607	9.61	2.74	3.51	Slender	24.48	Heavy
16	Janaki	566	9.29	2.62	3.55	Slender	29.02	Extra heavy
17	Kanchan	608	8.18	2.56	3.20	Slender	21.68	Heavy
18	Khumal-10	571	-	-	-	-	27.90	Extra heavy
19	Khumal-11	603	7.27	3.48	2.09	Bold	29.20	Extra heavy
20	Khumal-13	561	-	-	-	-	27.00	Extra heavy
21	Khumal-2	573	9.87	2.59	3.81	Slender	26.60	Extra heavy
22	Khumal-3	635	9.02	2.99	3.02	Slender	27.05	Extra heavy
23	Khumal-4	582	5.82	2.06	2.83	Bold	-	-
24	Khumal-5	617	9.27	2.99	3.10	Slender	29.07	Extra heavy
25	Khumal-6	613	9.45	2.62	3.61	Slender	25.06	Extra heavy
26	Khumal-7	625	8.76	3.40	2.58	Bold	31.44	Extra heavy
27	Khumal-8	547	6.66	2.19	3.04	Slender	23.90	Heavy
28	Khumal-9	617	9.48	2.98	3.18	Slender	29.82	Extra heavy
29	Lekali dhan-1	593	6.96	3.48	2.00	Bold	24.64	Heavy
30	Lekali dhan-3	595	6.96	3.30	2.11	Bold	25.20	Extra heavy
31	Loktantra	583	8.19	2.51	3.26	Slender	20.52	Heavy
32	Machhapuchhre-3	510	-	-	2.39	Bold	23.43	Heavy
33	Makwanpur-1	575	8.41	2.58	3.26	Slender	25.90	Extra heavy
34	Manjushree-2	584	8.98	2.66	3.38	Slender	25.40	Extra heavy
35	Mithila	586	8.43	2.44	3.45	Slender	19.00	Moderately heavy
36	Palung-2	559	9.60	2.75	3.49	Slender	25.43	Extra heavy

SN	Variety	Bulk density	Length, mm	Breath, mm	L/B ratio	Shape	1000 kernel wt., g	Grain type
37	Pokhreli Jethobudo	-	5.72	2.42	2.36	Bold	-	-
38	Radha-11	599	-	-	-	-	19.60	Moderately heavy
39	Radha-12	592	7.96	3.05	2.61	Bold	23.90	Heavy
40	Radha-4	611	8.20	2.56	3.20	Slender	23.40	Heavy
41	Rampur Masuli	605	8.34	2.20	3.79	Slender	18.10	Moderately heavy
42	Sabitri	613	8.43	2.54	3.32	Slender	21.60	Heavy
43	Samba Masuli sub-1	529	7.60	2.23	3.41	Slender	22.20	Heavy
44	Sukha dhan-1	564	8.57	2.59	3.31	Slender	23.74	Heavy
45	Sukha dhan-2	558	8.61	2.58	3.34	Slender	23.94	Heavy
46	Sukha dhan-3	551	8.86	2.41	3.68	Slender	21.70	Heavy
47	Sukha dhan-4	-	7.40	2.40	3.08	Slender	-	-
48	Sukha dhan-5	515	6.90	2.10	3.29	Slender	23.46	Heavy
49	Sukha dhan-6	541	6.50	2.30	2.83	Bold	-	-
50	Sunaulo Suganda	-	9.80	2.45	4.00	Slender	-	-
51	Super-115	-	8.70	2.20	3.95	Slender	-	-
52	Super-125	-	9.20	2.40	3.83	Slender	-	-
53	Swarna sub-1	582	7.61	2.56	2.97	Bold	18.60	Moderately heavy
54	Taichung-176	632	5.13	3.18	1.61	Short	-	-
55	Tarahara -1	589	-	-	2.51	Bold	29.10	Extra heavy
56	US-323	-	6.50	2.30	2.83	Bold	-	-
57	US-382	-	6.12	2.11	2.90	Bold	-	-
58	DRH-748	-	6.17	2.24	2.75	Bold	-	-
59	DRH-775	-	6.60	1.95	3.38	Slender	-	-
60	DY-18	-	7.08	2.88	2.46	Bold	-	-
61	DY-28	-	6.90	2.73	2.53	Bold	-	-
62	DY-69	-	6.40	3.10	2.06	Bold	-	-

Milling quality

Milling quality is directly related to milling recovery. Environmental factors such as temperature and humidity during ripening and postharvest handling are known to influence grain breakage during milling. Head rice recovery is also depends on the grain size, shape and appearance. In general, varieties and breeding lines with long or long bold grains and those having chalky grains give lower head rice yields. Varieties having medium, long, slender, translucent grains give the best head rice yield. From the study on milling quality: brown rice (%), husk (%), bran (%), milling recovery (%), head rice (%) and broken rice (%) of some Nepalese rice varieties were found in the range of 75-86%, 14-25%, 4.2-17%, 60-79%, 34-98% and 1.9-66%, respectively.

Table 2. Milling quality of some Nepalese rice varieties

SN	Variety	Brown rice (%)	Husk (%)	Bran (%)	Milling recovery	Head rice (%)	Broken (%)
1	Barkhe-1027	-	-	-	66.00	-	-
2	Chainung-242	82.10	17.90	7.80	74.30	83.59	16.41
3	Chaite dhan-6	77.90	22.10	6.12	71.78	86.03	13.97

SN	Variety	Brown rice (%)	Husk (%)	Bran (%)	Milling recovery	Head rice (%)	Broken (%)
4	Chaite dhan-4	78.45	21.55	9.31	69.14	70.92	29.08
5	Chaitya dhan-2	77.90	22.10	11.80	66.10	66.00	34.00
6	Chandannath-3	81.30	18.70	9.60	71.70	93.60	6.40
8	Chhomrong	80.47	19.53	2.95	77.52	67.93	32.07
9	Chinan-2	77.70	22.30	17.43	60.27	52.00	48.00
10	Delta Rani	-	-	6.50	69.50	-	-
11	Hardinath-1	81.00	19.00	10.55	70.45	75.90	24.10
12	Janaki	79.60	20.40	9.60	70.00	65.27	34.73
13	Khumal-10	76.70	23.30	7.60	69.10	74.04	25.96
14	Khumal-11	82.90	17.10	7.80	75.10	80.64	19.36
15	Khumal-13	81.20	18.80	7.00	74.20	91.44	8.56
16	Khumal-2	75.50	24.50	10.90	64.60	62.60	37.40
17	Khumal-3	78.90	21.10	8.80	70.10	46.17	53.83
18	Khumal-4	75.74	24.26	5.95	69.79	80.40	19.60
19	Khumal-5	77.78	22.22	9.58	68.20	77.00	23.00
20	Khumal-6	76.60	23.40	5.03	71.57	68.47	31.53
21	Khumal-7	79.90	20.10	9.08	70.82	33.61	66.39
22	Khumal-8	79.40	20.60	7.18	72.22	85.36	14.64
23	Khumal-9	76.60	23.40	10.38	66.22	71.20	28.80
24	Lekali dhan-1	83.20	16.80	10.60	72.60	85.60	14.40
25	Lekali dhan-3	83.40	16.60	9.10	74.30	93.30	6.70
26	Loktantra	78.40	21.60	7.60	70.80	71.98	28.02
27	Machhapuchhre-3	79.72	20.28	3.69	76.03	61.44	38.56
28	Makwanpur-1	79.90	20.10	9.30	70.60	60.90	39.10
29	Manjushree-2	75.80	24.20	8.10	67.70	95.80	4.20
30	Mithila	78.60	21.40	8.10	70.50	90.03	9.97
31	Pokhreli Jethobudo	80.85	19.15	7.00	73.85	-	-
32	Radha-12	80.00	20.00	80.00	-	-	-
33	Radha-11	81.20	18.80	7.60	73.60	87.80	12.20
34	Radha-4	82.60	17.40	7.80	74.80	74.30	25.70
35	Sabitri	79.30	20.70	7.40	71.90	91.90	8.10
36	Samba Masuli sub-1	74.90	25.10	8.70	66.20	83.79	16.21
37	Sugandha dhan-1	-	-	-	68.00	-	-
38	Sukha dhan-1	78.50	21.50	8.50	70.00	65.22	34.78
39	Sukha dhan-2	79.10	20.90	8.00	71.10	71.69	28.31
40	Sukha dhan-3	78.40	21.60	8.60	69.80	63.92	36.08
41	Sukha dhan-4	-	-	-	70.00	-	-
42	Sukha dhan-5	75.70	24.30	12.20	63.50	62.04	37.96

SN	Variety	Brown rice (%)	Husk (%)	Bran (%)	Milling recovery	Head rice (%)	Broken (%)
43	Sukha dhan-6	75.60	24.40	9.30	66.30	51.38	48.62
44	Swarna sub-1	80.80	19.20	8.40	72.40	83.13	16.87
45	Taichung-176	82.43	17.57	11.91	70.52		
46	Tarahara -1	80.60	19.40	8.70	71.90	77.70	22.30
47	US-323	-	-	-	70.00	-	-
48	US-382	-	-	-	71.70	-	-
49	DY-18	-	-	-	70.30	-	-
50	DY-28	-	-	-	71.20	-	-
51	DY-69	-	-	-	73.30	-	-

Chemical composition of rice

The rice grain consists of carbohydrates, nitrogenous compounds (mainly protein), lipids (fat), mineral salts and water together with small quantities of vitamins, enzymes and other substances, which are important for the human diet. Some Nepalese rice varieties had: moisture (%), crude protein (%), total ash (%), crude fat (%), crude fiber (%), carbohydrate (%), amylase (%), iron (mg/100 g), phosphorous (mg/100 g), and calcium (mg/100 g) in the range of 10.9-14.8, 5.1-12.9, 0.4-2.0, 0.6-1.9, 0.3-0.4, 74-86, 11-29, 0.5-2.5, 105-615 and 10-57, respectively.

Table 3. Chemical composition of rice available in Nepal

SN	Variety	Moisture	Crude protein	Total ash	Crude fat	Crude fiber	Carbohy-drate	Amylose	Iron	Phospho-rous	Calcium
		(%)							(mg/100g)		
1	Chainung-242	11.95	6.43	0.58	0.86	-	80.18	-	0.84	408.50	49.28
2	Chaite-2	12.60	6.80	1.33	-	-	79.27	28.7	-	-	-
3	Chandannath-1	12.43	7.44	1.76	-	-	78.37	22.9	-	-	-
4	Ghaiya-2	12.37	6.58	1.64	0.94	-	78.47	22.5	2.53	217.69	40.10
5	Hardinath-1	11.72	6.81	0.66	1.02	0.30	79.79	25.2	-	-	-
6	Janaki	12.56	8.14	0.61	0.64	-	78.05	24.4	2.17	195.86	29.95
8	Khumal-10	12.63	6.66	0.62	0.94	-	79.15	-	2.05	571.28	51.56
9	Khumal-11	11.14	6.37	0.63	1.10	-	80.76	-	0.99	579.55	51.60
10	Khumal-13	11.63	8.15	0.81	1.20	-	78.21	-	0.87	408.21	37.36
11	Khumal-4	12.81	8.04	0.74	1.13	-	77.28	-	2.02	481.58	52.07
12	Khumal-8	10.94	7.73	0.51	1.20	-	79.62	-	2.21	485.49	45.72
13	Lalka Basmati	11.57	8.24	0.80	1.19	0.36	78.20	24.0	-	-	-
14	Lekali-1	13.61	9.23	0.66	0.77	-	75.73	-	0.54	552.12	-
15	lekali-3	13.49	8.53	0.66	0.63	-	76.69	-	0.57	614.72	-
16	Loktantra	13.26	6.17	0.63	-	-	79.94	-	-	-	-
17	Makwanpur-1	12.91	7.14	0.52	0.77	-	78.66	22.8	2.36	224.10	27.08
18	Mithila	11.64	7.11	0.42	0.80	0.42	80.03	23.1	-	-	-
19	Radha -11	11.38	5.09	0.79	1.22	0.42	81.52	24.4	-	-	-
20	Radha -12	12.40	7.35	0.75	1.22	0.41	78.28	24.6	-	-	-

SN	Variety	Moisture	Crude protein	Total ash	Crude fat	Crude fiber	Carbohy-drate	Amylose	Iron	Phospho-rous	Calcium
		(%)							(mg/100g)		
21	Radha -4	11.67	7.12	0.62	1.00	0.29	79.59	24.5	-	-	-
22	Sabitri	12.50	9.80	0.58	0.90	0.29	76.22	24.3	1.24	185.28	57.15
23	Sukha dhan-1	11.93	7.12	0.67	0.87	-	79.41	21.9	0.62	203.51	33.72
24	Sukha dhan-2	11.66	8.12	0.68	0.99	-	78.55	20.3	1.18	183.50	18.93
25	Sukha dhan-3	13.00	8.16	0.62	0.76	-	77.46	21.0	2.51	201.52	26.62
26	Sukha dhan-5	11.89	7.64	0.59	1.00	-	78.88	26.6	1.60	104.89	10.13
27	Sukha dhan-6	11.75	7.92	0.51	0.96	-	78.86	23.8	1.12	132.46	13.72
28	Swarna Sub-1	12.60	7.40	0.64	1.01	0.40	78.35	24.4	1.45	278.59	15.38
29	Taichung	14.80	7.88	0.90	1.47	-	74.95	-	-	-	-
30	Chhomrong	14.47	8.28	1.39	1.71	0.94	74.15	27.5	1.16	203.28	16.17
31	Machapuchhre-3	13.70	9.56	1.36	1.63	0.95	73.75	24.6	2.47	333.26	28.77

Cooking quality of rice

Cooking quality of rice is an exclusive factor determined by subjective preference. However, stickiness or cohesiveness of the cooked grains is generally accepted as the most important characteristics determining cooking quality. Milled rice that has a high protein content or high gelatinization temperature (GT) requires more water and longer time to be cooked than rice with lower values (Juliano et al 1965). Low GT rice such as japonica varieties start to swell at a lower temperature during cooking than intermediate or high GT rice. However, these properties may affect the eating quality. Rice that has high protein or high GT tends to be undercooked when boiled at the same rice:water ratio than rice with lower values. However, the method of cooking is less important than varietal differences in determining the relative eating qualities of milled rice (Batcher et al 1956). Water absorption and volume expansion during cooking are positively correlated with amylose content. Waxy rice expands the least during cooking and its boiled grain has the heaviest bulk density. Soaked milled rice of Basmati, D-24-4 and certain Iranian varieties show extreme grain elongation during cooking. This property is not confined to long grain rice varieties. In fact, the highest elongation ratio was obtained with the medium grain, Burmese variety, D25-4 which has intermediate amylose content and low GT (IRRI 1967). A darker tan color in the raw and cooked rice of some rice varieties may be related to high protein content but varietal differences also exist. BPI-76 has a grain that is more characteristically tan colored than other varieties with the same protein level. Aromatic varieties are preferred in many countries but the preferred aroma may differ from region to region. Climatic factors have marked effect on the intensity of aroma which is volatile (IRRI 1984).

Many institutions have shown a keen interest to evaluate the cooking quality of rice such as, Central Food Technology Research Institute (CFTRI) of India and International Rice Research Institute (IRRI) of Philippines. Several physicochemical quality parameters have been used to determine the cooking quality of rice. These include water uptake ratio, alkali scores, starch iodine blue value, kernel elongation ratio, hardness etc. However, none of these parameters seem to give unfailing indication of the cooking behaviors of rice in isolation because the cooking quality of rice is a subjective criterion. The ultimate tests of cooking quality of rice appear to be the sensory evaluation (Juliano 1985). The alkali digestion values have been employed as an estimate of GT. Generally, alkali spreading and clearing values are negatively correlated with GT (Bhandari 1978). GT could be indexed by either alkali score or water uptakes ratio or soluble amylose ratio.

Table 4. Alkali spreading scale card

Scale	Spreading	Clearing
1	Kernel not affected	Kernel chalky
2	Kernel swollen	Kernel chalky, collar powdery
3	Kernel swollen; collar incomplete or narrow	Kernel chalky; collar cottony and cloudy
4	Kernel swollen; collar complete and wide	Center cottony; collar cloudy
5	Kernel split or segmented; collar complete and wide	Center cottony; collar cleared
6	Kernel dispersed; merging with collar	Center cloudy ; collar cleared
7	Kernel completely dispersed and intermingled	Center and collar cleared

Source: Bhattacharya 1971.

Cooking involves hydration and gelatinization of starch. The starch in the rice however is gelatinized by adding water and by heating. When starch is steeped in water, it slowly becomes hydrated and finally reaches equilibrium of about 30% moisture. When this starch slurry is heated, the hydration gradually increases and finally the rate of hydration rises sharply while at the same time, the starch slurry suddenly becomes viscous and also more transparent. This change is called the gelatinization of starch and corresponding temperature is GT. To gelatinize the starch, the minimum moisture content is about 25% and temperature is about 70°C. Final GT ranges from 55-79°C in rice starch and may vary by as much as 10°C within a variety. Final GT may be Low (below 70°C), Intermediate (70-74°C) and High (above 74°C). From the data available in Nepal the gel consistency (mm), kernel elongation ratio and water uptake ratio were reported in the range of 40-100, 1.3-1.8 and 1.4-4.9, respectively.

Table 5. Cooking quality of rice

SN	Variety	Spreading	Clearing	Gelatinization temperature (GT)	Gel consistency (mm)	Kernel elongation ratio	Water uptake ratio
1	Chaite-2	2	1	High	68	1.81	3.19
2	Chaite-4	2,3	1,2	High	-	-	-
3	Chaite-6	7	5,6	Low	-	-	-
4	Chandannath-1	2,3	1,2	High	100	1.71	2.9
5	Chinan-2	7	7	Low	-	-	-
6	Ghaiya-2	2,3	1,2	High	70	1.65	2.87
7	Hardinath-1	2	1	High	-	-	-
8	Khumal-11	4	2,3	Intermediate	-	1.57	2.03
9	Khumal-2	6	4,5	Intermediate	-	-	-
10	Khumal-3	4	2,3	Intermediate	-	-	-
11	Khumal-4	3,4,5	2	Intermediate	-	1.7	2.31
12	Khumal-5	7	5,6	Low	-	-	-
13	Khumal-6	7	5,6	Low	-	-	-
14	Khumal-7	4	2,3	Intermediate	-	-	-
15	Khumal-9	7	7	Low	-	-	-
16	Lalka basmati	4	2,3	Intermediate	-	-	-
17	Mithila	2	1	High	-	-	-
18	Radha-11	7	5,6	Low	-	-	-
19	Radha-12	4	2,3	Intermediate	-	-	-
20	Radha-4	2,3	1,2	High	-	-	-

SN	Variety	Spreading	Clearing	Gelatinization temperature (GT)	Gel consistency (mm)	Kernel elongation ratio	Water uptake ratio
21	Sabitri	4	2,3	Intermediate	-	-	-
22	Tainan-1	7	5,6	Low	-	-	-
23	Chhomrong	3,4,5	2	Intermediate	-	1.43	2.41
24	Machapuchhre-3	4	2,3	Intermediate	-	1.29	1.72
25	Makwanpur-1	-	-	Intermediate	-	-	-

Conclusion

Rice quality is defined by different aspects such as: milling quality, physical quality, nutritional quality and cooking quality. It can be seen that all the quality parameters are interrelated to each other. From the data available in Nepal about the quality characteristics of rice, it is found that there is variation according to varieties. Different cultures have different preferences regarding the taste, texture, color, and stickiness of the rice varieties that they consume. For example, dry flake rice is eaten in South Asia and in Middle East; moist sticky rice in Japan, Taiwan, the Republic of Korea, Egypt and Northern China; and red rice in parts of Southern India. Preference of rice is affected by locality and region. For instance, the Japanese and Korean prefer round rice, whereas Americans prefer long grain. Most people prefer white rice but Indians and Pakistanis prefer purple or blue strains. Cooking method of rice differs from place to place. In Nepal and India, rice is cooked in boiling water as *bhat* or *chawal*. However, there are other methods of cooking rice. For an example, some Nepalese people prefer *bhakka* (steam cooked rice flour), others like *roti* (pan fried rice dough), *chiura* (beaten rice), etc. Among Americans, rice is most popular in preparing canned soup; whereas in Philippines, fermented rice cake is preferred. But usually rice is consumed as a whole grain after cooking.

Importance of rice as a food crop increases along with the increase in human population. Among cereals, rice is even more nutritious than wheat. Although rice is primarily a source of carbohydrates, it also constitutes a principal source of protein to millions of Asians. The net protein utilization value for rice is 63, compared to 49 for wheat and 36 for maize. Rice is relatively non-allergenic and has an enduring palatability too. Since this paper doesn't include all the released variety, data published in this paper may not generalize the overall quality of rice.

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Rodent Management for Secure Harvest of Rice in Nepal

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सारांश

मुसाको प्रजनन तथा सन्तान उत्पादन, खेतबारी तथा भण्डारणमा तिनले गर्ने क्षती र घर तथा खेतमा तिनको रोकथाम सम्बन्धी विगतमा नेपालमा गरिएका अध्ययन अनुसन्धानबाट निस्केका नतिजा तथा प्रविधिको यहाँ सार संक्षेपमा विवरण प्रस्तुत गरिएको छ । मुसाको प्रजनन् सम्बन्धी अनुसन्धानमा घर मुसाको भाले ११ र पोथी १३ हप्ताको उमेरमा सन्तान उत्पादन गर्न परिपक्व देखिए । एक वेतमा घर मुसाले ३-१४ वटा बच्चाको जन्मदिन सक्यो । उपयुक्त अवस्थामा यसको गर्भधारणको समय २०-२१ दिनको देखियो र यसले ब्याएको २-३ दिन मै अर्को गर्भधारण गर्न सक्ने देखियो । खेत मुसामा भाले खोज्ने अर्थात कामुक हुने अवस्था ३-७ दिनको फरकमा दोहोरियो र कामुक अवस्था २४ घण्टा सम्म रह्यो । कृषकका घर तथा खेतमा मुसाको क्षतीको अध्ययनबाट मकै खेतमा मुसाले मकैको उत्पादन १.६, ३.६ र २.६ प्रतिशत नोक्सान गरेको पाइयो । धान र गहुँको प्रति हेक्टर जग्गामा गरेको अनुसन्धानमा धानको १.५ प्रतिशत र गहुँको १.२ प्रतिशत जग्गा मुसाले क्षती गरेको र ५७५ के.जी. धान र ११२२ के.जी. गहुँ नोक्सान भएको पत्ता लाग्यो । काठमाडौं उपत्यकामा कृषकका घरमा गरेको अध्ययनले १,५०,००० कृषकका घरमा ८,४३,००० मुसाले एक वर्षमा कूल ११२२ मेट्रिक टन अनाज नोक्सान गरेको अनुमान प्राप्त भयो । मुसाको रोकथामको लागि घर, खेत एवम् प्रयोगशालामा विभिन्न प्रकारका तरिकाको अनुसन्धान गरिएका थिए । घर मुसाका रोकथामको लागि घरमा खोर पासो र्‍याटस् र्‍याटस् मुसाको लागि र मुस् मस्कुलस् मुसाको लागि टाँसिने पासो राख्दा प्रभावकारी भएको पत्ता लाग्यो । धान खेतमा खेत मुसाको लागि धराप पासो प्रभावकारी भएको थियो भने गहुँ खेतमा जिंक फोस्फाइडको २ प्रतिशत चारा प्रयोग गर्दा खेतका ७० प्रतिशत खेतमा मुसा मरेको नतिजा प्राप्त भयो । प्रयोगशालामा घरमुसामा गरेको अध्ययन अनुसार १३ हप्ता उमेर पुगेका घरमुसालाई प्रति मुसा ४० ग्रामको एक खुराक मात्र निमको तेल मिश्रित दाना (८० मि.ली. तेल/के.जी. दाना), निमको बीउको धुलो मिश्रित दाना (८० मि.ली. धुलो/के.जी. दाना) र सरिफाको बीउको धुलो मिश्रित दाना (८० मि.ली. धुलो/के.जी. दाना) खुवाउँदा प्रत्येक दानाले मुसामा परीक्षण अवधीभर (मुसाको उमेर ३८ हप्तासम्म) गर्भधारण अर्थात सन्तान उत्पादन गर्न रोक्यो । यस प्राविधिलाई खेतमा अनुसन्धान गरी भविष्यमा धान-गहुँ खेती प्रणालीमा मुसा नियन्त्रण गर्न प्रयोग गर्न सकिने सम्भावना देखियो ।

Summary

Studies on reproductive biology showed that male and female of house rat (Rattus rattus) sexually matured at 11 and 13 weeks, respectively. It produced 3 to 14 offsprings per birth and its gestation period was of 20-21 days, and mating was occurred after 2 to 3 days of parturition. Estrous cycle of field rat was of 3 to 7 days and its heat period persisted for 24 hours. The yield losses of maize were 1.6, 3.6, and 2.6% in maize fields in three different sites. In a study, 1.5% area of rice field and 1.2% area of wheat field were damaged in a hectare where losses of rice and wheat in a hectare were 574 kg and 1122 kg, respectively. In Kathmandu valley, the total food grain loss in farmer's house was estimated to be 1122 tonnes in a year by 834000 rats of 150000 houses. Various control methods of rodent were tested in farmer's house, in fields and in laboratory. Wire trap was more effective to capture house rat while sticky glue trap was more effective to catch house mouse in house. Snap trap was highly effective to capture field rat in rice field. Poisonous baiting of 2% zinc phosphide was effective to kill 70% of field rats in wheat field. A single dose feeding of 40 g per rat of neem oil mixed diet (80 ml oil/kg diet), neem seed powder mixed diet (80 g powder/kg diet) and custard apple seed powder mixed diet (80 g powder/kg diet) were effective to stop pregnancy in house rat during whole testing period of 38th week-age of the rats in laboratory condition. The botanical powder or oil mixed diets can be utilized in minimizing rodent populations in rice-wheat cropping system.

Keywords: Biology, Damages, Management, Rats and mice, Reproduction, Rice production, Rodents

Introduction

Rodents cause enormous losses to both standing crops and stored produce. Cereal crops are particularly more vulnerable to rodent attack. Among the cereals, rice and wheat crops are mainly damaged more by rodents- by cutting growing plants, by extensive burrowing of crop fields and by collecting crop ears in their burrows. In storage, they consume certain amount of food grain but spoil a much larger quantity by dropping feces and urine including body hairs. The contaminated produce is unfit to human consumption. Besides the direct damage to crop produce, rodents also carry diseases which get transmitted to human and pet animals. More than 6000 species of rodents are reported in the world, among which only 600 species belonging to genus *Rattus* are called rats (Fall 1977). In Nepal, 30 different species of rodents are identified (Joshi et al 1991). Of which only five species are economically more important. They are house rat (*Rattus rattus*), house mouse (*Mus musculus*), field rats (*Bandicota bengalensis* and *Bandicota indica*) and field mouse (*Mus booduga*) (Joshi et al 1991, Paneru and Giri 2011). In Nepal, rodent pests cause agricultural losses up to 15 to 25% every year (Shrestha 2001a), whereas 25-30% post-harvest loss was reported in India. In a 100 x 100 m^2 godown, the loss due to rodents was reported to be 4200 kg (Ghosh and Durbey 2003).We reviewed the past studies on rodents in agriculture in Nepal and provided comprehensive information on its biology, damages and management methods including the general information on rodents.

General habits and biological characteristics of rodents

Several reports (Mechan 1984, Joshi et al 1991, Ghosh and Durbey 2003, Paneru and Giri 2011) have mentioned the general habits and biological characteristics of rodents. Rodents are very clever and suspicious to accept new objects for the first time. They are color blind and have poor eye sight but have strong sense of taste, smell, hearing and touch. They use their body and facial hairs to touch things. They can swim well and are not afraid of water. They can easily climb on concretes, pipes, wires and trees. They are nocturnal in habit and are usually most active through sunset to midnight and 90% of their feeding is at night. They are omnivorous and are highly adaptive to new places. They usually use the same path every time to search for food and water. Their front incisor teeth (**Figure 1C**) grow continuously at the rate of 0.4 mm per day (or 12 cm per year) throughout the life. So they gnaw the things like cloths, papers, woods, plants, trees in most of the time to restrict growth and make the teeth trimmed and sharp. They mostly prefer to eat meat, grains, eggs and potatoes. Reproduction process of rodents continues year round. One pair of rat is capable of reproducing up to 2000 rats during their life span. They come to estrous immediately after giving birth and may become pregnant within 2 days of delivering their litters. They have promiscuous mating habit. They generally live for 1 to 2 years but in optimum condition in laboratory they can live up to 3 years. Gestation period is of 21 to 30 days but in optimum condition it is of 21 days.

General behavior and identification features of agriculturally important rodents

Only five rodent species are economically important in agriculture. The general behavior and identification features of the five rodent species (Joshi et al 1991, Ghosh and Durbey 2003, Paneru and Giri 2011) have been described herein brief.

House rat (Rattus rattus Muridae, Rodensia)

It inhabits and breeds inside houses (**Figure 1A**). It cannot make burrows in hard places. It can climb on trees, walls, pillars and also can walk on pipes and electric wires. It cannot live in naked lands without trees, houses and grasses. It lives in house but goes from the house out to get water. It prefers to eat cereals, fruits, and animal feeds in storage. It damages field crops around house during harvesting. It has medium sized body (250-360 g) and body length is 35-38 cm. Its ears are large, naked and translucent; nose is pointed; tail is 20-22 cm longer than its head + body length. It has 6 pairs of mammary glands, 3 pairs in thorax and 3 pairs in abdomen.

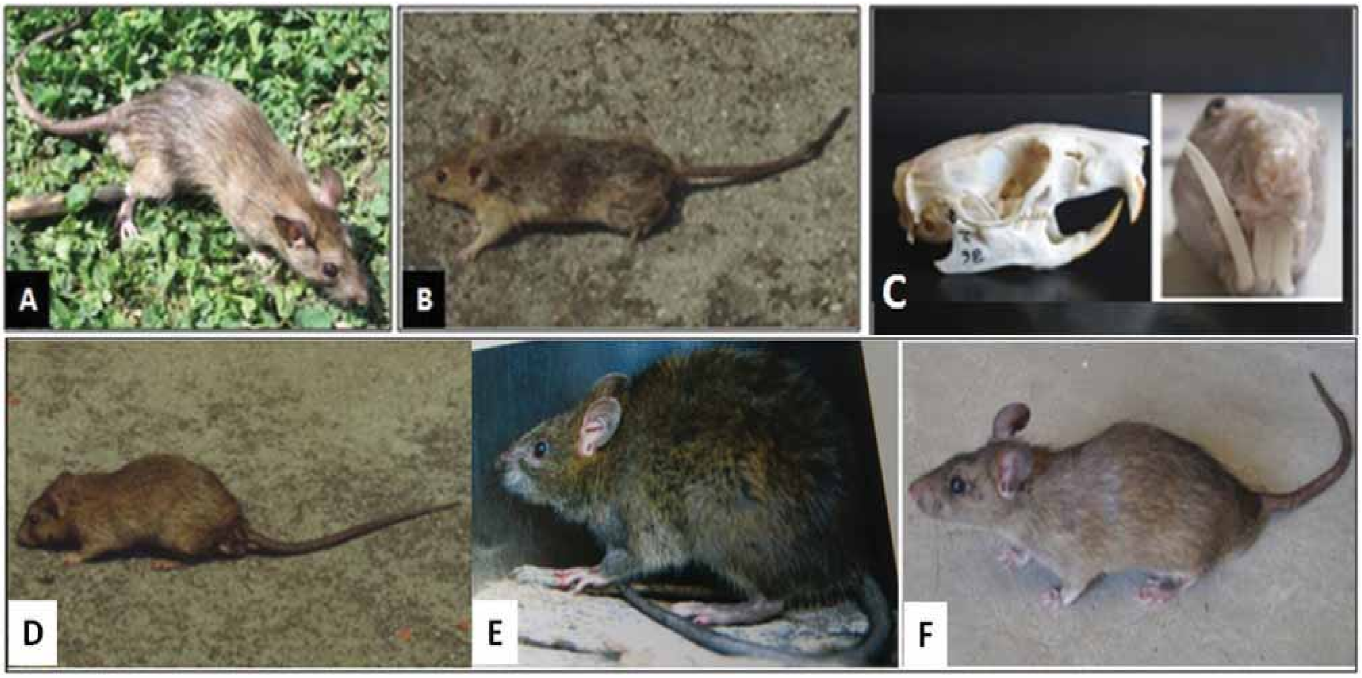

Figure 1. (A) House rat (*Rattus rattus*), (B) House mouse (*Mus musculus*), (C) Scull & Incisor teeth of rat (D) Field rat (*Bandicota bengalensis*) (E) Field rat (*Bandicota indica*) (F) Field mouse (*Mus booduga*)

Source: Entomology Division, NARC

House mouse (Mus musculus **Muridae, Rodensia)**

It inhabits and breeds in house. It is called *Duhure Musa* in Nepali (**Figure 1B**). It is very small in size (15 - 25 g) and lives in the periphery of house. Its tail is 6-7 cm longer than its body length (15-20 cm). It can live and breed in storage without water. It is because of the moisture content of dry grains in storage that it feeds, is enough to fulfill its water requirement. It does not have bait-shyness to new objects. So it can be adapted to new baits and traps easily; thus, no pre-baiting of non-poisonous bait is necessary before the poisonous baiting. It damages field crops around house during harvesting. Its ears are small, thin and translucent; and nose is pointed. Its fur color in above part is dark to light brown and below is paler light brown. Female has 5 pairs of mammary glands, 3 pairs in thorax and 2 pairs in abdomen.

Field rat (Bandicota bengalensis **Muridae, Rodensia)**

It is peri-domestic rat, mostly remains in crop fields in the periphery of house (**Figure 1D**). When the crop field is wet it shelters in dry places. It is expert burrower and makes burrows at bunds of field and has the habit of heavy collecting of crop ears in its burrows. It causes heavy damage to field crops. It needs water to drink, so it shelters surrounding the house and near the source of water where the lands are covered with grasses. It is good swimmer in water. It has vigorous and large body (370 – 550 g) and the face is pig shaped. The color of back hair is grayish brown and abdominal hair is darkish brown. Female has 6 pairs of mammary glands, 3 pairs in thorax and 3 pairs in abdomen. Ears are small, round and thick.

Field rat (Bandicota indica **Muridae, Rodensia)**

It is an expert burrower and heavy collector of crop products in its burrows (**Figure 1E**). It remains in paddy fields during the crop growing season. It makes large and complex burrows with many rooms at the bund of fields, in stream banks and even in city streets and in high ways causing serious land damage often. It is good swimmer and runs near water ways and cultivated lands for its food. It is of ferocious nature and can be recognized by its noisy growling and its threatening posture when trapped in a cage. It is omnivorous and feeds largely on cultivated products such as rice grains and sugarcane. It has vigorous and large body

(2000 – 2500 g) with the face shape similar to pig. It has dark brown back hair, dark grey ventral hair and guard hairs on the back. Ears are small, stout and thick. Female has 6 pairs of mammary glands, 3 pairs in thorax and 3 pairs in abdomen.

Field mouse (Mus booduga ***Muridae, Rodensia)***

It is small in size (10 – 20 g) and is morphologically similar to *Mus musculus*. It differs from *Mus musculus* with respect to shelter. It makes burrows in fields for shelter instead of living in house (**Figure 1F**).

Reproductive biology of rodents

The reproductive biology of house rat (*Rattus rattus*) was studied (ED, 1995-96a; ED, 1996-97; Shrestha, 2001b) at Entomology Division in Khumaltar, Lalitpur. The studies showed that male and female rats were sexually matured at 11 and 13 weeks, respectively. High rate of mating was successful during spring (90%) and autumn (90%) as compared to winter (80%) and summer (70%). A female rat could produce 4-13 offspring with male and female ratio of 1:1. Gestation period was of 20-21 days. Mating took place immediately after 2-3 days of parturition. Relation between eye lens weight and age of rat was found highly significantly correlated (r = 0.98). The weight of eye lens at 4 weeks old was 14 mg and at 58 weeks old it was 40 mg. Young rats attained fully hairy and their eyes opened after 8-12 days of birth. Growth curve was compared for rearing in single, in pair and in mass. No significant difference was observed in growth curves when rearing single, in pair and in mass. However, when a pair (male and female) was reared together male rat showed higher growth curve then the female one. One dominant rat was recognized when they were reared in mass. In the studies (ED 1998-99a, ED 2000-2001) on reproductive biology of field rat (*Badicota bengalensis*) it was found that its estrous cycle was of 3-7 days and its actual heat period was known to persist for 24 hours. Young rats were sexually matured after 3 months of birth. The average body weight of newly born young rat was 5-6 g and their body weight was attained 490 g of male and 470 g of female rat after 58 weeks old age. The male and female mouse were reproductively matured after 10 and 11 weeks, respectively. One female mouse could give birth of 2 - 10 litters with an average of 1:2 ratio of male and female. The body weight of male and female rats at 38th week old was 23 g and 20 g, respectively. Age of house mouse was directly correlated to its eye lens weight.

Damages of rodents

Studies on rodent damage

Rodent caused 1.6, 3.6 and 2.9% yield loss of maize in field of Khumaltar, Thecho and Dhapakhel, respectively (ED 1988-89). In a different study in Dhulikhel village, one hundred eighty-three rats were trapped in 6 days in wheat fields. It was estimated to cause 1.160 tonnes wheat yield loss per hectare where average yield of wheat was 3.59 t/ha (ED 1997-98). A study conducted in rice-wheat cropping field at Naldunga site showed that rodent caused 0.507, 1.09 and 1.3 tonnes yield loss per hectare in rice, wheat and finger millet, respectively (ED 1997-98).

Damage of rats in house in Kathmandu valley

The studies (ED 1998-99a) conducted in farmer's house in Kathmandu valley (Kathmandu, Lalitpur and Bhaktapur) showed that the amount of food grain loss by one rat per house per day was 21 g in winter (3 months) and 10 g in other seasons (9 months). Based on this, it is estimated that one rat can loss 1.9 kg in winter and 2.7 kg in other seasons. Thus, the total food grain loss by one rat per house per year was 4.6 kg. The numbers of rat trapped per house were 0.56, 0.9, 1.6 and 2.5 in spring, summer, autumn and winter, respectively. There were 150000 farmers' houses in Kathmandu valley excluding the houses in the city area. Based on this data, the numbers of rats in Kathmandu valley were 84000, 135000, 240000 and 375000 in spring, summer, autumn and winter, respectively. The amounts of grain losses caused by these numbers of rats were 75.6, 121.5, 216 and 708.75 tonnes in spring, summer, autumn and winter, respectively. Thus, the total food grain loss in Kathmandu valley was 1122 tonnes per year.

Damage of rats in field in Kathmandu valley

Field damage of rats was studied (ED 2051) in terms of number of damaged spots in rice and wheat fields in 151 meter periphery from the farmer's house. Maximum number of damaged spots ie 82 and 62% of total damaged spots were observed within 50 m distance from the farmer's house in rice and wheat fields, respectively. No damaged spot caused by rats was observed beyond 100 m from the house in rice field. Whereas 11.5% of total damaged spots was observed in wheat field beyond 151 m from the house. Both, house and field rats were trapped in rice and wheat fields within 50 m periphery of the house. But farther beyond the distance of 50 meters from the house, less or no house rat and some or few field rats were trapped. Losses of food grains were studied in the rice and wheat field as well. Of the total area inspected separately for rice and wheat field, 1.5% of rice field and 1.2% of wheat field was damaged by rats. When per unit damaged area of rice and wheat field was studied, it found that 57.4 g of rice and 112.7 g of wheat was damaged in per square meter area. With this ratio, 574.2 kg of rice and 1127.1 kg of wheat was damaged in one hectare. The total cultivated areas of rice and wheat in Kathmandu valley was 18550 and 16480 hectares, respectively. In which, 278.25 hectares of rice field and 197.76 hectares of wheat field was damaged by rats. In the damaged areas, about 160 tonnes of rice and 223 tonnes of wheat was lost in Kathmandu valley in this year.

Management of rodents

Studies on rodent management

It was necessary to keep attractive bait in traps for successful trapping of rats. Preference of various baits by rats was studied. The study showed that potato slice coated with Japanese sesame oil oremental cheese (made in Swiss) was the most attractive bait followed by potato alone, potato coated with animal ghee and potato coated with Chinese sesame oil (ED 1995-96b). A study was conducted for controlling rats in field by using three different methods: installation of snap trap with potato slice as bait, offering of toxic Roban (bromadiolane) cake and fumigation of rodent burrows by Celphos tablet @1 tablet per burrow. The three methods decreased rat population (taking live burrows as the rat population indicator) by 20, 40 and 50% by using Roban (bromadiolane), snap trap and Celphos (Aluminum Phosphate), respectively (ED, 1998-99b). In a study, wire trap was found more effective than the sticky glue trap and rodenticide to catch house rat; while sticky glue trap was found more effective to trap house mouse (ED 1999-2000). In a rat control campaign at Lumle VDC, various rat control methods such as wire trap, sticky glue trap ('No rat') and 2% poisonous bait of zinc phosphide were used in 40 households and in wheat fields of farmers. Each household were provided two wire traps (with potato slices as baits to place in the traps) to set in their house at evening time for five days. The trapped rats were killed and counted every day. The sticky glue traps were placed on wooden plates at various places; and observation was taken twice a day at morning and evening. A 10 g poisoned bait of 2% zinc phosphide was placed in each open burrow; and the burrows were closed with mud in wheat fields. In this study, 115 rats were caught by wire traps plus sticky glue traps in house; while 45 rats were killed by 2% zinc phosphide baits in wheat fields. It was observed that wire trap was more effective to catch house rat (*Rattus rattus*) whereas sticky trap was more effective to catch house mouse (*Mus musculus*). The poisonous bait consisting of 98 parts of normal diet and 2 parts of zinc phosphide was effective to kill 70% of field rats (*Badicota bengalensis*) in wheat fields (ED 1999-2000). In a study in rice-wheat cropping field at Naldunga site, it was observed that the consumption of Roban (Bromodiolone) in field burrows was very high (95%) as compared to Lanirat (45%) by rats (ED 1997-98). In a report, two methods – use of rat traps with bait and use of poisonous baits of zinc phosphide were recommended to kill rats (PHMD 2006-2007). Metal bin was recommended to protect grains from attacks by rats (PHLRD 1980-81, PHLRD 1995-96).

Research on traps in rodent management

Use of pesticides is more easy and effective to control rats. But it requires technical knowledge and skilled manpower to handle the pesticides. It is more time, money and labor consuming; and is very tedious work.

Chemical pesticides not only affect the domestic animals but also are detrimental to environment and risky to user's health. The minimum amount of rodenticide that is added in poison bait is effective to kill only one species of rat but which may not be equally effective to several other economically important species of rodents. So, use of traps is cheaper and less time and labor consuming as compared to pesticide use. Keeping these points in view, several studies (ED 2051) were conducted both in farmer's house and farmer's fields in Kathmandu valley by Entomology Division, Khumaltar, Lalitpur under joint efforts of Nepal Agricultural Research Council (NARC) and Japan International Cooperation Agency (JICA) which are briefly mentioned hereunder.

Management of house rat with wire trap

House rat can be trapped in house successfully. So, traps should be kept in house to control it. In a study, effectiveness of two types of trap, wire trap and locally made native trap (**Figure 2A**) was tested for their capacity to capture house rat in farmer's house. It was investigated that wire trap was highly effective than the native trap. Twenty rats were trapped by wire trap while only 6 rats were trapped by native trap. It suggested that design of trap is one of the crucial factors for successful trapping of rats. It indicated that better the design of the trap more is the capture of the rats. The wire trap was successful to reduce 85% of total grain loss in farmer's house conducted at Kakani in Nuwakot. There were 149 g and 22 g food grain losses in farmer's house before and after setting of traps, respectively. It was found that house rat lives in house in winter (Mansir, Paush, Magh/November-December, December-January, January-February). In spring, summer and autumn, they move out in crop fields in the periphery of house in search of food and water. So, winter is proper time to keep traps in house for successful control of house rat. House rat generally lives in gaps of under face of roof and in gaps in between the unmanaged matters placed here and there in the house. They move every day out and in from their nest to search for food and water. The suitable places to keep traps in house are near their resting place, near the path they use every time and near the food stores. Better preferred baits by rats are necessary to keep in traps for their successful catch. It was found that a house rat normally prefers the foods having more amount of water like: sweet potato, potato, par-boiled rice, etc. A study was conducted in field for bait attractiveness for field rat. It showed that potato and sweet potato were equally preferred than the small dried fish by field rat. The potato slice coated with Japanese sesame oil was found most attractive bait followed by potato alone (ED 1995-96b). In early studies (Sagar and Bindra1976, Spillet 1968) it was investigated in foreign countries that field a rat prefers European cheese, butter (animal ghee) and vegetable oils besides variety of food grains.

Figure 2. (A) Native trap and wire trap (B) A field rat is captured by a snap trap in a hole of rat burrowing harvested rice field in winter

Source: NARC, ED 2051.

Management of field rat with snap trap

Both, field and house rats damage field crops. Control of house rats can be successfully done in house as mentioned above. Field rat usually lives in field. So, the traps need to be kept in fields for its control. Exact identification of its nests is necessary to set the trap. Before harvesting of rice, lands are covered with grasses, shrubs and rice crops. During that time, rats are scattered in large area and it is very difficult to notice their nests. After harvesting rice, land should remain free of crops and vegetation in the winter; hence it is very easy to detect their nests in the winter. Due to the panic of natural enemies like eagle and owl, the rats strictly hide in their burrows in the winter to protect them from their enemies. A study (ED 2051) was done guessing that field rat, due to the terror situation in winter, lives in grassy and shrubby lands near the bunds of rice fields. Out of 28 spots of rat's damage in rice field, field rats were trapped only from the 3 spots. The 3 spots were located in grassy and shrubby land at the bund of rice field where the source of water was near and the place was sunny (**Figure 3A**). It suggested that, in winter, field rats live in shrubby and grassy land but not in burrows of naked field. In a study (ED 1998-99b), after harvesting of maize crop it was found that field rats were nested under the piles of maize stalks (**Figure 3B**). In a study, two different traps - wire trap and snap trap were tested to capture field rat in rice field in winter. In the study, since the size of wire trap was bigger than the hole of the rat tunnel, the wire trap was placed outside the tunnel in the rice field. The study showed that no rat was captured in the wire trap; it was due to the reason that the life activities of field rat were restricted inside the tunnel in winter. Then, a small snap trap adjustable to tunnel hole was inserted in the tunnel after making some space at the opening of the tunnel. A piece of sweet potato or potato was fixed as bait in the trap. The study showed that the snap trap was effective to capture the field rat (**Figure 2B**).

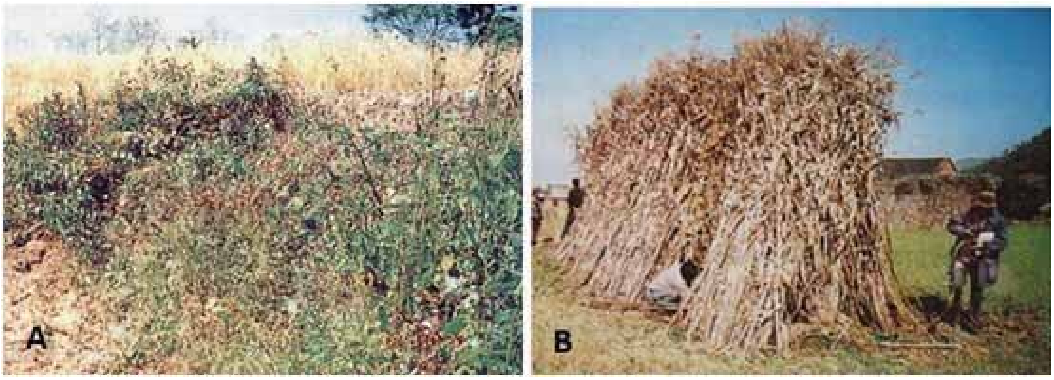

Figure 3. (A) The grassy and shrubby bund of rice field where the field rats were nested due to the reason that the rice field was naked in winter after harvesting it in autumn. (B) The heaps of maize stalks under which the field rats were found to be nested

Source: NARC, ED 2051.

Physical control of rodents

Various physical measures of rodent control mentioned in past studies (Joshi et al 1991, Ghosh and Durbey 2003, Paneru and Giri 2011) have been described below.

Cleaning and rodent proofing

(i) Rodents like to hide in grasses, trash, dirt, dust, straw, old cloth, garbage, litter, junk materials, etc around outside and or inside of house and farm buildings. So, cleaning of such items is necessary. (ii) Keep the food items in covered containers. (iii) Rats can climb on trees and get through windows and roofs in to the house or farm buildings. So, the branches of trees that are touching the windows and roofs need to be cut. (iv) Place storage bins and grain sacks at least 1 m above the grounds that the rodents cannot climb or jump on the storage bins; because rodents cannot jump more than 90 cm high. (v) Do not keep any taller things such as ladder, bicycle or equipment near the storage bins and sacks so that the rodents cannot reach the storage structures using the taller things. (vi) Use rodent proof storage bins such as metal bins so that the rodents cannot damage the metal bins. (vii) Use metal sheet at least up to 50 cm high around the base of mud, bamboo and cement storage structures so that the rodents cannot climb and gnaw the structures. The storage structures should be placed on concrete or rodent proof floor without having gaps between the base of the storage structures and the floor. (viii) The door or grain chute of storage structures should be tightly fixed so that the rodent cannot eat the grains through. (x) Cover windows and large openings of storage buildings with heavy wire netting. (xi) Cover the ends of pipes with wire net that are entering the storage building.

Use of traps

Traps are effective if they are used properly. Different types of traps can be available in markets or it can be made locally. Traps should be kept near the rodent runways, tunnels, nests and burrows. If rodent problem is in roof use the traps on shelves, beams, pipes and other high places. Never use poison bait or poison in the traps. Rats transfer dangerous diseases to man; so it is wise not to touch dead or alive rats with naked hands. Instead, a stick or hand glove should be used in removing rats from the traps. Burn or bury the dead rats. Higher degree of rat control can be achieved if high trap density is used. Some of the commonly used traps are as follows: (i) Pot trap: A petrol drum or clay pot partially filled with water is taken and over which any suitable bait such as a maize cob is hanged. When the rat jumps to get the bait it falls in water in the pot. (ii) Snap trap: It is made of wooden or metal. It consists u-shaped spring wire which is pulled back with the help of a string used as trigger. When a rat touches the trigger the u-shaped spring wire comes down forcefully over its back and the rat is killed. (iii) Wire trap: It is the cage type trap made of iron wire. Attractive bait should be kept in it. Rats are captured inside it. Farmers have to kill the rat after its capture. (v) Sticky glue trap: Sticky glue traps are available in markets for trapping rats and mice in the house.

Chemical control of rodents

Several publications (Joshi et al 1991, Paneru and Giri 2011, Ghosh and Durbey 2003) have mentioned the chemical control measures of rodents that have been described here in brief as following.

Killing of rats and mice in house by feeding the single dose of acute poison

The Zinc phosphide, Difenacom and Brodifacom can be used as the fast acting poisons to kill the rats and mice in house. These poisons can kill the rats and mice just by single dose feeding. Zinc phosphate is the most widely used acute poison. Rats and mice can be killed in house by baiting in two steps-first step is pre-baiting of on-poisonous baits and then, next step is baiting of poisonous baits. The foods used for pre-baiting (non-poisonous baits) and baiting (poisonous baits) should be the same. Zinc phosphide or any one of the acute poisons is added in pre-baiting food to prepare the poisonous baits. Cooked rice, soaked wheat or maize flour with syrup can be the attractive foods for pre-baiting and baiting (Joshi et al 1991). Or 45 parts of ground rice, 45 parts of ground wheat, 5 parts of roasted groundnut and 5 parts of mustard oil is mixed evenly to prepare the baits for pre-baiting and baiting (Paneru and Giri 2011, Sharma et al 2015). Poisonous bait is prepared by mixing 1 part of zinc phosphide and 19 parts of pre-baiting food. The amount of bait is 20 g and 10 g for pre-baiting and baiting, respectively. The places and containers used for pre-baiting and baiting should be same for every next baiting. Freshly prepared baits should be used for every next baiting. The best time for baiting is at dark when the children are already sleeping. Pre-baiting should be done first for 3 to 4 days to familiarize the rats to eat the non-poisonous baits. Then, baiting of poisonous bait is done for killing the rats by single dose feeding. The poisonous baiting should be continued for every following day until the rats are observed to consume the baits or dead rats are observed in every following day. The dead rats and mice including the remaining amount of poisonous baits should be collected every next morning before the wake up of the children. The collected dead-rats and poisonous-baits should be destroyed by burning or burying in ground.

Killing rats and mice in house by feeding the multi-dose of chronic poison

The Racumin, Warfarin and Bromodiolone (Roban) aroused as slow acting poisons for killing threats and mice in house. Rats and mice are killed only after several days feeding of the chronic poison. The chronic poisons are the anticoagulants that kill the rats and mice causing them the internal bleeding. The rats and mice do not show any bait-shyness to these poisons. So, the rats and mice eat the poisonous bait without any hesitation. In this case, no re-baiting is needed until the bait is consumed completely by rats. To prepare poisonous bait from the chronic poison, 18 parts of crushed wheat/maize/rice, 1 part of sugar or salt and 1 part of any one of the anticoagulants are mixed uniformly (Joshi et al 1991). The amount of poisonous bait for rats and mice is 300 g and 50 g, respectively. The poisonous bait must be kept in the bait station that should have an entrance and an exit hole; because the rats and mice do not like to eat in open place. The bait stations should be placed in same places and positions at the running path of the rats and mice until the killing campaign of the rat is ended. To set bait stations, for brown rats and mice it requires 15-20 m and 2 m distance between the two bait stations, respectively; whereas for black rats it needs more number of small bait containers (tins or trays) to be distributed all over the floor in about 2 m distance to each other (Joshi et al 1991). At least 7 intakes or 7 days feeding of poisonous bait is necessary by rats to cause them to die. When the rats and mice are affected by feeding the poisonous baits after 7 to 8 days, they move from the stores out to seek for fresh air and water; and they die outside the stores. The affected rats and mice are generally killed in about 10 and 20 days, respectively. The dead rats and mice including the remaining amount of poisonous baits should be collected and destroyed very carefully to avoid the contamination of the anticoagulants.

Killing rats and mice in field by feeding the acute or chronic poison

The acute and chronic poisons that are mentioned above can also be used for killing the rats and mice in field. The methods for preparing baits for acute and chronic poisons have been already mentioned above. Before application of baits in field, it is necessary to detect live and dead burrows of rats in the field. For this, all the burrows noticed in field should be closed with loose soil at previous evening. When the closed burrows are observed next day, some burrows are observed opened and some others are observed closed. The opened burrows denote the presence of rats in the burrows which are called the live or open burrows. The closed burrows indicate the absence of rats in the burrows which are called dead burrows. To kill the rats and mice with acute poison, 20 g non-poisonous bait is placed inside each live burrow as pre-baiting for 3-4 days to attract the rats and mice to eat the baits. Then, 10 g poisonous bait of acute poison is placed in each live burrow for killing the rats and mice by single feeding of the poisoned bait. To kill the rats and mice with chronic poison, required amount of chronic poison should be placed near the open burrow sat least for seven days continuously. Poisonous baits are very risky to contaminate the non-targeted animals in fields. So, the poisonous baits should be placed in borrows at previous evening; and take out the remained baits from the burrows early in the morning next day. The dead rats and mice should be collected and destroyed by burning or burying in ground.

Killing rats and mice in field by using poisonous fumigants

Aluminum phosphide (Celphos) is the most widely used poisonous fumigant to kill the rats and mice in field. Live burrows should be identified in field first following the method as mentioned above. One or two tablets of Celphos, depending on the size of the burrows, should be inserted in each live burrow, and then, the burrow should be closed with wet mud. Poisonous gas is released from celphos tablet inside the closed burrows that kills the rats and mice hidden in the burrows. The dead rats and mice should be collected and destroyed every day during the killing campaign of the rats.

Studies on effect of botanicals on sterility of house rat (*Rattus rattus*)

With the aim to minimize rodent populations in rice-wheat cropping fields, series of studies were conducted in laboratory to evaluate the effect of botanicals on sterility of house rat (*Rattus rattus*) (ED 2008, ED 2012, ED 2013 and Sharma et al 2015). Normal and botanical mixed diets were prepared to feed the experimental rats. Normal diet was prepared by mixing various ingredients at the proportion of 400 g chicken feed (no: 3), 200 g grinded wheat, 200 g grinded gram, 100 g broken pieces of groundnut, 60 g skim milk, 20 g sodium chloride and 20 ml mustard oil. To prepare botanical mixed diets, 80 g or 80 ml botanical powder or oil was mixed in 1 kg of normal diet. The botanical mixed diets (7.5% botanical powder or oil mixed diets) were fed to experimental rats just for one time @80 g per pair (40 g per rat) in a day when the rats were matured on the age of 13th week. The experimental rats were fed normal diet in other days during whole experimental period up to 38th week age of the rat. The study revealed that the neem (*Azadirachta indica*. Juss) oil mixed diet, neem seed powder mixed diet and custard apple (*Annona reticulata* L.) seed powder mixed diet were found effective to stop pregnancy and parturition in rats during whole experimental period ie up to 38th week-age of the rats; whereas the pregnancy and parturition were frequently observed in the rats that were fed only the normal diet (Sharma et al 2015). The investigation indicated that after further research in field condition, the botanical-mixed diets can be utilized in minimizing rodent populations in rice-wheat cropping system in future.

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Post-Harvest Loss of Rice by Insects Pests and Management Practices in Nepal

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सारांश

धानको संचयनमा हुने नोक्सानीमा कमी ल्याउन सके देशको खाद्य सुरक्षामा टेवा पुऱ्याउन सकिन्छ । मुख्यतः मुसा र किराहरूले गर्दा संचित धानमा नोक्सानी हुन जान्छ । आधुनिक र सुधारिएका संचयनका सामाग्रीहरूको प्रयोग, भण्डारणको सरसफाई र संचित अनाजका शत्रुजीवको व्यवस्थापन गर्न सके संचयनमा हुने नोक्सानी कम गर्न सकिन्छ । यसै सम्बन्धमा उपलब्ध सन्दर्भ सामाग्रीहरूको अध्ययन गरी यो लेख तयार गरिएको हो । नेपालमा उत्पादित करिब ७० देखि ८० प्रतिशत धान कृषक स्तरमा र २० देखि ३० प्रतिशत अन्य संचयनमा रहने गरेको छ । धानको संचयन हालसम्म पनि मूलतः परम्परागत व्यवस्थापनमा नै चलेको छ । परम्परागत भण्डारणका उपकरणहरू क्रमशः मेटल बिन र हर्मेटिक ब्यागहरूले विस्थापन गर्दै छन् । विगतमा भएका अध्ययनहरूमा संचयनका क्रममा १५ देखि २० प्रतिशतसम्म धानको नोक्सान हुने र त्यसमा करिब ८ देखि १० प्रतिशत किराहरूको कारणबाट हुने गरेको देखिएको छ । किराहरूबाट हुने नोक्सानी हालका वर्षहरूमा क्रमशः घट्दै गई हाल करिब २ देखि २.५ प्रतिशत हुने गरेको छ । संचयनमा लाग्ने किरा व्यवस्थापनका लागि विभिन्न वनस्पतिहरूको असरबारे अध्ययन भएता पनि बोझो जति प्रभावकारी अरू देखिएका छैनन् ।

Summary

Storage loss reduction of the rice grains is important aspect of the food security in the country. Rodents and insects caused the major portion of the storage grain losses. Use of improved/modern storage structures, maintaining storage hygiene, proper drying and storage pest management are the possible management options for the reduction of losses. A review of the available sources regarding the farmers' practice, research and development on this aspect was done to frame this article. In Nepal, 70-80% of the rice produced is stored in the farm level and the rest goes to central level storage system. The storage system is still mostly traditional. However, the use of metal bins and hermetic bags is increasing in the place of traditional containers. Information on overall food losses recorded in postharvest operations in the past was in the range of 15-20% and the loss due to insect in storage alone was approximately 8-10%. The loss by insects is gradually decreasing over the years and now is around 2-2.5%. Though many botanicals are in practice and tested, *bojho* (sweet flag) is proved to have effective control over storage pests of rice.

Keywords: Botanicals, Pest management, Rice grains, Rodents and insects, Storage loss

Introduction

Cereal grains constitute a major portion of the daily food requirement of the world's population. Among cereals, rice is most preferred food particularly in South Asian countries. Increasing production is one major aspect to meet the food requirement while another important aspect being post-harvest loss reduction. Both aspects should be considered equally for the food security of the country. Considerable efforts have been made to minimize post-harvest losses in the past and at present. In the context of agriculture sector facing the challenges posed by climate change, limited land and water resources, food security cannot be achieved merely through increase in agricultural productivity. Reduction in these losses would increase the amount of food available for human and animal consumption, increasing demand for bio-fuel and other industrial uses.

There are two types of storage systems in Nepal: one is farm level and other is central level storage. Almost two-third (60-70%) of the produce remains in storage at farm level (KC and Adhikari 2016) in Tarai and almost 100% in hills and mountains. The farm level storage period varies from 6 to 12 months depending upon the size of the landholdings and volume of total production of the individual farmers. About 30% of the total produced food grains enter the trade channel (off-farm/central level storage) for internal distribution to urban consumers, food deficit areas, export and retention with various marketing agents. Central level storage includes storage by institutions like Nepal Food Corporation (NFC), processing industries or local traders, and cooperatives. Cooperatives in Tarai districts act as procurement agents for NFC. They are mostly engaged in procurement and short time storage of rice (KC 1989). Similarly, private millers and traders procure from farmers and middlemen and store for short period to supply to NFC for local distribution and exports.

Of the various postharvest operations, storage has been recognized to be the activity where the loss is highest. Roughly one-third of the edible parts of food produced for human consumption, gets lost or wasted globally, which is about 1.3 billion ton per year (Gustavasson et al 2011). Food losses can be quantitative as measured by decreased weight or volume, or can be qualitative, such as reduced nutrient value and unwanted changes to taste, color, etc. The quantitative loss is caused by the reduction in weight due to spillage, pest infestation and also due to physical changes in temperature, moisture content and chemical changes (FAO 1980). Quantitative food loss leads to reduction in weight of edible grain or food available for human consumption.

This paper is basically a review of the articles and information on post-harvest loss management and storage structures of rice from different journals, proceedings, annual reports, bulletins and books published by concern institutions. Relevant technical information is also taken from different web sources. Personal information and communication is also included in the paper.

Historical perspectives of post-harvest loss management in Nepal

The institutional effort for agriculture modernization in Nepal was initiated with the establishment of Agriculture Office in 1921. At that time, the focus of agriculture development was on varietal research, agriculture education and livestock development. Gradually, different farms and offices were established for research and extension of the agricultural technologies. The Department of Agriculture was established in 1951 to look after the agricultural modernization in Nepal. The food grains losses in storage and their management issues were being recognized gradually after 1952 from Entomology Division, Department of Agriculture (KC 1988). With the increasing attention to reduce post-harvest losses in staple crops, "The Prevention of Food Losses (PFL)" program was implemented by Food and Agriculture Organization (FAO) globally in about 103 countries in 1977. The FAO in collaboration with Government of Nepal initiated PFL program in Nepal which is better known as "Rural Save Grain Program (RSGP)". With the task of reducing losses and improving grain quality in post-harvest activities, the RSGP started its work in February 1980 (APROSC 1986). The phase II of the project was started in 1984 with previous two years' positive impact during PFL Program of FAO. Several activities were conducted during this program regarding research and extension of post-harvest loss management. Among others, RSGP helped to improve the local storage structures and introduced metal bins for storage of grains in Nepal. The studies on magnitude of post-harvest losses on different commodities, the development of possible management options adoptable to farm levels and their extension to the farmers were among the major activities of post-harvest management during late 80's and early 90's. After the completion of RSVP, the Post-Harvest Loss Reduction Section was established under the Plant Protection Directorate of the Department of Agriculture in 1992 to continue the post-harvest loss management activities. This section was later upgraded to the Post-harvest Management Directorate under the Department of Agriculture in 2004. Integrated Grain Storage Farmers Field School approach was implemented for storage loss management mainly due to insects in paddy and other crops (PHMD 2004/05) which not only gave field level information to losses but also delivered integrated management practices of post-harvest losses. Entomology Division and other stations of Nepal Agricultural Research Council (NARC) and Institute of Agriculture and Animal Science (IAAS) are working mainly for the development of post-harvest loss management technologies.

Rice storage structures/systems in Nepal

About 70% of food grains produced in the Tarai and as high as 100% produced in the hills and mountains are retained at the farm level (APROSC 1986). The off-farm storage includes mainly the storage of: NFC, stockists, millers/processors and co-operatives. Storage structures used by the farmers vary depending upon the locally available construction material, quantity of production, local tradition, and economic condition of the farmers.

Traditional storage structures

Various types and sizes of rice storage structures and containers are traditionally in use depending upon the volume of the storage and locality. They are being made with different types of locally available materials and skills. In out-door storage; *bery/bhakari* (made of bamboo splits and timber), *muja-ko bhakari* (made of straw/reed), *thungki* (wooden-granary with roofing), *dhansar* (a separate house made of timber and planks for storage) are common where as in in-door storage; *chitra/choya-ko bhakari* (made of bamboo splits), *kath-ko bhakari* (made of wooden planks), *gundri-ko bhakari* (made of straw/bamboo mats), *kotho* (made of bamboo splits), *dalo*/bamboo basket (made of bamboo strippings and splits as well as reeds), *dehari* and *kothi* (mud-bins-respectively smaller and bigger in sizes), *gagro* and *ghyampo* (clay pots-respectively smaller and bigger in sizes), *dhukuti* (mansonary structure-brick wall *bhakari*) are common (KC 1989).

Figure 1. Some traditional storage structures used in storage of rice

Improvements in traditional storage structures

Commonly used traditional storage structures are not air tight, rodent proof and moisture proof. In using these structures, considerable amount of losses in storage were incurred by the farmers. Thus, attempts to make the structure insect proof, moisture proof and rodent proof, various materials were tested and studies to find out the appropriateness of the improvement in reducing the losses in local and improved storage structures. Some of these improvements are given below (KC 1989).

- Proper plastering of mud-cowdung-straw mix from both the sides - inner and outer - of structures made of bamboo splits/strippings/bamboo and straw mats/reeds and regular sanitary measures for their disinfection.
- Sandwiching polythene between two layers of mud-bins (*dehari*).
- Cement plastering on mud-bins (*dehari/kothi*) from outside.
- Bitumen painting of mud-bins from outsides
- Placement of these structures in the house on at least 30 cm raised platform and 30-40 cm away from the sides/walls of the house to allow enough ventilation and light to reduce the chances of rodent attack and increase aeration to get rid of dampness.
- Sanitary/preventive measures and maintenance of these structures by regular re-plastering and repairing/sealing the cracks and crevices as well as dusting/spraying them for the prevention of insect infestation.
- Earthen/clay pots are bitumen painted and lids are also painted and smeared/sealed with the dough of wheat and/or maize flours/cow-dung-mud mix to make it airtight and moisture proof to study the effective storage periods of grains under this condition with and without use of fumigants.
- Results obtained from the various experiments on these improvements showed reduced losses, and their management is also comparatively easier and cheaper as for example the inner plastic lining of jute bags (Malla et al 2007). Any successful and manageable improvements in Mud-bin will bring revolution change in the saving of grains in storage particularly in Tarai (KC 1989).

Modern storage structures

Metal bins and other structures were introduced as modern storage structures by RSGP. Metal bins and *pucca-kothi/dhukuti* (*bhakari* made of brick and cement mortar) and Ferro-cement bins of different capacities were proved completely effective against rodents and birds. If handled and managed properly, food grains could safely be stored against insects and molds without the use of any chemicals. Among these structures, Ferro-cement bins have not been liked by farmers because of handling problem and *pucca-kothi* is costlier (KC 1989). But, metal bins are getting popular with wider acceptance by farmers and use of metal bins have performed superior in comparison to traditional containers (GC 2006). Gunny bags are the most common now in Tarai and hills for rice storage on-farm level or in off-farm level. These are easy to handle and transport but not air tight or moisture proof. Thus, hermetic bags/super grain bags are introduced recently for rice storage and are getting popularity.

Figure 2. Modern rice storage facilities in jute bags, wooden bins and metal bins

Losses of rice in storage

Losses in the storage are mainly caused by rodents, insects and fungi. Incidence of insect attack was found to vary from locality to locality and from commodity to commodity depending upon the type of godowns, storage period, type of storage (bulk or bags) ecological conditions, type of variety and treatment type. During early fifties, the studies/works on storage were mostly in: insect biology, evaluation of different traditional storage structures and their likely improvement and control measures of the pests using chemicals and raising awareness to farmers. Gradually loss assessment in the existing storage and improved storage structures and other stages of post-harvest were done. Considering the fact that more than 70% of the production is retained on farm and this is where the larger part of losses (7-10%) occurs, the farm level storage clearly emerges as an area of priority for implementing the loss reduction activities.

Loss assessment studies were carried out in major cereals by different authors and various similar and sometimes conflicting results have been shown. The results might have differed on different localities, commodities, varieties, storage structures, study periods etc. In general, an average of 8-10% storage loss for a period of twelve months has been accepted for planning purpose (Pflser 1972). Most of the studies show the loss of 15-20% in food grains at various post harvest stages (KC 1992). Of the various stages of the postharvest chain due to poor methods in handling and unavailability of improved storage structures highest loss has been observed during storage (6-8%) in durable commodities (KC 1984).

The estimated paddy loss in Nepal was 19% of total production (FAO 1977). In a study done on paddy stored concrete bin, asbestos bin, polythene sand witched bin, and local bin, the loss (by weight) was found to be 4.4%, 9.0%, 14.9% and 19.3% respectively (Rana and KC 1977). Another study shows an average loss in paddy to be at 2.3% at 11.4-15% moisture. A follow-up study conducted in the subsequent year showed the average losses of 2.6% in paddy in the Tarai storage condition while it was 2.0% in hill storage condition system (PHMD 2000/2001). Loss assessment study conducted in paddy from harvest to storage at Lamatar, Lalitpur district showed losses of 0.4%, 0.8% and 2.4% in harvesting, threshing and drying processes, respectively; thus, constituting a total post-harvest operation loss up to 3.6%. Similarly, losses in the stored paddy grain for a period of six months was observed at 0.8%, 0.9% and 1.4% in metal bin, drum and in *Ghyampo* respectively. The loss of 1.8%, 2.2% and 2.5% was observed, in wooden *Kothi*, *Choyako Bhakari* and plastic *Bora* (bag) respectively (PHMD 2006/2007).

Rana and Pflser (1973) surveyed different local bins and storage practices in different villages of Nepal and found 15-30% loss of grains due to insect pests, rodents and birds. The total food grain loss as perceived by the farmers was 6.2%, of which the loss due to insect was 2.5% in paddy (PHMD 1984). In an FFS study, the losses by insects in metal bins, plastic bags, improved *choyako bhakari*, local *choyako bhakari*, pastic drum, painted *ghyampo* and unpainted *ghyampo* were 1.05%, 2.25%, 1.99%, 3.5%, 2.3%, 1.96% and 3.2%, respectively (PHMD 2004/05). The variation in losses was assumed to be variation in the storage structures and also the variation in moisture level of grains.

The off-farm storage includes mainly the storage of NFC, stockists, millers/processors and co-operatives. These storages are bulk/bags with high volume. The losses in off-farm storage were estimated as high as 19% of which around 5% by insects in public sector godowns (APROSC 1982). The stock taking losses of food grain in NFC storage complex in Kathmandu between the periods of 1974-1977, was 0.26% but in general the overall loss of 3-5% is reported to incur due to insect pest in raw rice (Conway, 1978). The parboiled rice stored in Butyl silo for a period of 12 months suffered a weight loss of 7%, whereas it was 20% in raw rice during a period of 18 months in NFC Godown and 7% in 9 months in hired godown (Conway 1978). The reduction of post-harvest losses at the level of stockists and private traders (2-3%) becomes more difficult because their profits are not significantly affected by wastage/losses. The cooperative societies are following traditional method of handling and storage. However, the NFC has attempted to modernize the techniques of handling and storage of food grains and seeds (KC 1989).

Biology of some important insect pests of rice storage

The major storage insects observed in local bins in paddy were rice: weevil, *Sitophilus orzae* (L), *Sitotroga cerealla* (Oliver), saw toothed grain beetle, *Oryzaephilus surinamusis*, red flour beetle, *Tribolium castaneum* (Hbst), lesser grain borer, *Rhizopertha dominica* (F), black fungus beetle, *Alphitobious sp.* (Rana and KC 1977).

Rice weevil (*Sitophilus oryzae)* is one of the major storage pests of rice. Adult and larvae both cause damage by feeding and contaminating. Environment with high temperature (>27^{0}C), high relative humidity (>70%) and high grain moisture content (>12%) is conducive for the growth and development of weevils in stored grains (Paneru and Giri 2011). In a research, *S. oryzae* preferred polished rice to unpolished rice at Rampur, Chitwan (Subedi et al 2009). However, in general unpolished rice could be more attractive to the insect pests due to its higher nutrition content.

Grain moth (*Sitotroga cerealella* Oliver) larvae cause damage by feeding on and hollowing the grains thus making quality and quantity loss. In heap of grains, the upper layer is highly affected (Paneru and Giri 2011). *Sitotroga cerealella* egg lying preference was more in improved varieties CH45, Chandini and Taichung than in local varieties Sarjung and Oshan, which possessed 3-7 times more resistibility quality than the rice grain (Thapa 1991). All types of rice grains are found to be susceptible to *S. cerealella* but long and slender grains are more susceptible than coarse grain types (Timalsena 2007).

Research recommendations for storage insect pest management in rice

Considerable amount of post harvest loss of rice is caused by the insects. Many studies have generated information on the management of these insects. Commonly used storage pest management options are: maintaining storage hygiene; maintaining grain moisture content not more than 12%, harvesting fully matured grains, using modern storage structures, using botanicals and using chemical pesticides. The selection of the management option also depends upon the volume of storage, storage containers, localities, bulk or bag handling, period and purpose of storage, type of grain, need for cash, preservation cost, transportation facilities etc. As most of the farmers have low volume storage, the management options also should be cheap, easy to handle, simple and continuous. The aim of the sanitation is to create an unfavorable environment for the growth and breeding of insects. The storage structures, drying and aeration play a very important role in on-farm storage of food grains. Efforts have been made by RSGP to develop new designs of storage structures and metal silos. The metal silos of variable capacities ranging from 100-300 kg have been well accepted by the farmers in Nepal. The IPM concept and FFS approach applied in pre-harvest was introduced in managing the rice pest in storage, and was found effective in minimizing the store grain losses (Adhikari 2003). Nepal Agricultural Research Council (NARC) has identified Angoumois grain moth and rice weevil as important pests of rice. It has prioritized the research on botanical pesticide screening, varietal screening, development of low cost storage structures, studies on natural enemies for pest management (Bista et al 2015).

Use of botanicals

Use of botanicals is very common practice of farmers for rice storage pest management. Many herbs and their products like *bojho, titepati, khirro, asuro*, oil cakes, wood ash, *bakaino,* neem were some of the examples. Farmers are using these indigenous knowledge/practices like neem powder 1.0-10 gram/kg, neem leaves 5-7 cm, *bojho* powder and wood ash 1 g/kg rice seed, 30 g *timur*/kg of grain, 10 g *titepati*/kg of grains.

Much information from smaller researches is available on use of botanicals. The effectiveness of these botanicals shows mixed results. The efficacy might be different in different temperature and moisture levels, use of containers, age of the materials use etc. On farm research conducted to see the traditional method of mixing oilcake powder of *Brassica campestris* var. toria was found to reduce the population of the rice weevil, *Sitophilus oryzae* (Björnsen Gurung 2002). Botanicals such as neem (*Azadirachta indica* A. Juss), china berry (*Melia azedarach* L.), malabar nut (*Justicia adhatoda* L.), Indian privet (*Vitex negundo* L.), and mug-wort (*Artemisia vulgaris* L) leaves powder were used against cowpea weevil (*C. chinensis*) and rice weevil (*S. oryzae*) (KC and Adhikari 2016) and it was effective to control the pests in close containers only, but in open containers such as *Dalo* and semi-open container such as gunny bag it was not found effective.

Bojho is found to be very effective against several insect pests of storage grains including Rice weevil and grain moth. In a study on storage pests of rice and wheat by using kapoor (*Cinnamomum camphora* (L.), dalchini (*Cinnamomum zeylanicum*), gumpati (*Leucas cephalotes)*, tulsi (*Ocimum sanctum* L.), neem (*A. indica*), bojho (*A. calamus*), masala (*Eucalyptus citriodora* Hook.) and Malathion 0.5%; the result showed that bojho was found most effective followed by neem and timur in order (PHMD 1997). Similarly, the average loss of paddy grain due to storage pest insects is less (0.5%) when bhojo (10g/kg) used followed by marich (1.38%), timur (1.61%) and Neem (2.28%) (PHMD 2004/05). In a study of 13 botanicals against *Sitophilus oryzae* in maize, sweet flag (bojho) stolen powder @10g/kg grain was found very effective to cause 100% mortality of weevils within 14 days of its application. It was also found effective to suppress progeny emergence in treated grains for 60 days (ED 2007). Though it was tested in maize crop, this can be taken as the reference for rice too.

Use of chemical pesticides

Use of chemical pesticides in the storage structure prior to the storage of food grains with proper sanitation and use of recommended fumigants where applicable, has been recommended for the management of storage pests (KC 1989). The use of chemical pesticides like: Celphos, Malathion, Fenitrothion and Nuvan for the control of storage pests started in late sixties (Sharma 1994) and application of Celphos and EDCT mixture were in recommendation in 80's and 90's (Neupane 1989). Application of chemical fumigants such as Aluminium phosphide in between piles of grain sacs (a) airtight room @20 tablets/30m^3 (b) under partial airtight room @40-80 tablets/30m^3. Application of fumigants into grains under airtight container @1tablet Celphos/tonne grains, and under partial air tight container @2-4 tablets/tonne grains is recommended (Paneru and Giri 2011). Surface treatment of the store room and container/sacks by 0.05% solution of malathion 50% EC is also recommended. Post Harvest Management Directorate has recommended the fumigation of store by Phosfume or Phostoxin @2-3 tablets/tonne or 2 tablets/m^3 for 72 hrs to control rice weevil and moth along with other stored grain pests. Spray of Malathion 0.5-0.7% at the store godowns or in *Bhakari* controls rice storage pests (PHMD 2014).

Limitations

There are very less researches done regarding the loss assessment in pre-harvest or in post harvest conditions. Most of the information is coming from the nonsystematic studies done by the concerned institutions. Most of them are very old. No or very less institutional recording have been done of the information generated. They are mostly scattered among the concerned people so it is difficult to access the literature for review. The methodologies adopted in the studies were either clearly mentioned and or were not consistent.

Conclusion

The agricultural research and development priority was mainly concentrated in raising production of the commodities. Despite of huge amount of losses occurring in the storage, post- harvest loss management has got little attention from the government sector in terms of investment on research and extension and also in human resource mobilization. This situation has not improved from the past to the present.

The pre-harvest factors of crop production play an important role in the occurrence and management of pests in storage, but the interrelations of cultural practices, effect of climatic factors in storage such as the temperature of the air, the relative humidity and the moisture content of the stored produce, in general are still not given due consideration by the farmers.

The extension activities of the post-harvest loss management were mainly performed by demonstrations, trainings and distribution of modern storage structures. Now, technology delivery through FFS, a long term participatory module has been in practice. Still extension activities in this aspect in District Agriculture Development Office (DADO) are very limited.

The RSGP was a pioneer program that prepared the base of post-harvest loss management in Nepal. This program conducted several studies on PHLM, worked for improvement of the storage structures, introduced new storage structures and created awareness to farmers about PHLM. No such other programs/projects have been implemented after the phase out of this program.

The later results show the extent of losses of food grains in storage is gradually in decreasing trend. It was around 15-20% in 70's which is decreased to 7-10% in 80's and 90's (1981-2003) and now around 2-2.5% (PHMD 2004-2005). This may be the results of the post harvest management programs, increased awareness of farmers, availability of the improved storage structures and stored pest management options. Still this is a quite big amount which will have significant role in food security of the country. In general, the loss in traditional structures is higher than improved structures. The small improvement in the traditional storage structures saved quite huge amount of food grains. They were made to avoid the rodent attack and insect infestation. Awareness in harvesting of matured grains, drying to reduce moisture level around 12%, storage hygiene etc also reduced the molds and insects in the storage.

The storage structures at farm level are also gradually changing because of the availability of the modern storage containers, and also the decreasing volume of storage due to fragmented land. The traditional *kotho, gudri ko bhakari, ghyampo* are now replaced by metal bins, sacks or hermetic bags. *Choyako bhakari* is still predominant in hills.

Use of botanicals to reduce the loss due to insects in the storage has been successfully practiced. It is a farmers' practice which was later modified with the scientific researches. This approach is economical, environment friendly and also easily available. However, for high volume storage like in central level storage it might not be a good option.

For high volume storage, chemicals are being used from the past till date, which is not the preferred option for food items. However, fumigants are now being more preferred than the liquids. Research on use of safe pesticides or non-chemical approach for such storage systems is insufficient. No research on biological control of storage pests or development of resistant cultivars of rice has been done so far.

The socio-economic aspects of the food grains loss in the storage has not been studied systematically. This has created the lack of information on the role of this sector on overall food security of the country and the consequences of this on the development of the country.

Acknowledgements

I would like to thank Megha Nath Timalsena, Parashuram Rawat and Ashish KC for the pictures of rice storage from different parts of the country

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Rice Production and its Impacts on Poverty, Livelihood Enhancement and Stability in Nepal

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सारांश

यस खण्डमा नेपाली जनताको जीविकोपार्जनमा धान बालीको महत्वपूर्ण भूमिका दर्शाउँदै धान उत्पादन तथा चामलको खपत, सोको गरिबी तथा द्वन्दसँगको सम्बन्ध र देशमा विद्यमान राजनीतिक अस्थिरतासँगको अन्तरसम्बन्धका बारेमा चर्चा गर्ने प्रयास गरिएको छ । उपलब्ध जानकारी अनुसार धान नेपालको सबैभन्दा महत्वपूर्ण बाली हो र यसको खेती तराई मधेशको समथर भूभागदेखि ३०५० मिटरको उचाइसम्म गरिन्छ । यसले कृषि क्षेत्रको गार्हस्थ उत्पादनको करिब २०% हिस्सा ओगटेको छ र नेपाली जनताका लागि आवश्यक क्यालोरीको करिब ४०% भन्दा बढी आपूर्ति गरी रहेको छ । सन् १९८१ सम्म धान नेपालको सबैभन्दा महत्वपूर्ण निर्यात हुने वस्तु थियो । धानको महत्व दर्शाउन सन् २००४ देखि असार १५ (२९ जुन) लाई राष्ट्रिय धान दिवसका रूपमा मनाउन थालिएको छ । सशस्त्र द्वन्दको अवधि (सन् १९९६-२००६) समग्र विकासको दृष्टिले नेपाल पछाडि परेको समय थियो । खासगरी ग्रामीण भेगका युवाहरू द्वन्द कालमा बढी प्रभावित भए तापनि धान बाली लगायत खाद्यान्न बालीको क्षेत्रफल र धानको उत्पादनमा उल्लेख्य प्रभाव परेको देखिएन । बरू सिँचाइको लागि पानीको स्रोत, कुलो, पानीको बाँडफाँड आदिमा समुदायबीच र उही समुदायमा पनि घरधुरीहरूबीच साना ठूला अनेकौं वादविवाद, झगडा तथा द्वन्द हुने गरेको पाइएको थियो । तर, त्यस्ता वादविवाद, झगडा तथा द्वन्दहरू समुदायस्तर वा स्थानीयस्तरका हुने गरेको र त्यसले देशको समग्र राजनीतिमा खासै प्रभाव पारेको देखिंदैन । त्यसैगरी, हिमाली जिल्लामा बढ्दो चामलको माग र यातायातको असुविधा अनि महँगो ढुवानी खर्चका कारण माग अनुसार चामल आपूर्ति गर्न नसक्नाले स्थानीय जनता र सरकारबीच हरेक वर्ष द्वन्दको जस्तै अवस्था सिर्जना हुने गरेको छ । तर क्षेत्रीय वा राष्ट्रिय राजनीति र राजनीतिक अस्थिरतामा ती सानातिना विवादहरूले प्रभाव पारेको देखिएन । सशस्त्र द्वन्द लगायत देशमा बेलाबखत घट्ने गरेका साना ठूला घटनाहरू, देशमा छिटोछिटो परिवर्तन भैरहने सरकार र समय समयमा हुने राजनीतिक परिवर्तनका कारणहरूमा जनताको ठूलो हिस्सा कृषिमा निर्भर रहनु तर बालीनालीको उत्पादकत्व तथा जनताको आम्दानी न्यून हुनु आदिले महत्वपूर्ण भूमिका खेलेको बुझिन्छ । तर धान उत्पादन वा चामलको खपतले मात्र राष्ट्रिय राजनीतिमा त्यति ठूलो भूमिका खेलेको पाइएन । यसबारे तथ्यपरक जानकारी पाउन थप अध्ययन अनुसन्धानको आवश्यकता देखिएको छ ।

Summary

This chapter deals with the importance of rice in the livelihoods of Nepalese people: in relation to production/consumption, poverty and conflicts; and its relation with political instability in the country. Rice is the most important crop of the country, grown widely up to an altitude of 3050 m, contributing about 20% to the GDP (through agriculture) and fulfilling more than 40% of the total calorie requirement of the population. It was the most important exportable commodity of the country until 1981. National Rice Day (on 15th Ashad/29th June) is being celebrated since 2004 to mark the importance of rice in the country. During the armed conflict period (1996-2006), the development work of the country seriously lagged behind. Poor people and the youth of rural area were most affected by the conflict but there are no evidences to show that the conflict affected area coverage, production of cereals and the rice or that the crop farming was adversely affected due to conflict. Cases of conflicts between households or communities who share common water sources or a water canal for rice cultivation have been reported. However, such conflicts were of minor importance and had no impact at the regional or national level. Similarly, high demand for rice was reported in remote mountainous districts and the shortage of rice had resulted in political turmoil and conflicts at the local/regional level, but had less impact at the national level. Occasional political turmoil including the one during conflict period and frequent changes of government and political system in the country could be due to poor or very poor crop productivity and low or very low income level of people in the country. However, no strong evidences were found regarding the rice production/consumption and political instability in the country. It is suggested to undertake some studies to explore the implications of rice production/consumption on (i) poverty, (ii) livelihoods, and (iii) political instability in the country.

Keywords: Conflict, Government, Livelihood, Poverty, Rice, Stability

Introduction

This chapter briefly describes the importance of rice in the livelihood of Nepalese people, analyses the implications of rice production on poverty and/or consumption of rice in the country and tries to explore whether there is any relation between rice production/consumption and the political instability in the country.

Rice and livelihoods of Nepalese people

Agriculture contributes to almost one third of the Gross Domestic Product (GDP) while about two third of the country's population is dependent on this sector. Contribution of this sector to GDP was 32.12% in fiscal year 2014/15 (MoF 2016). Production and productivity growth achieved in major food crops ie, rice, maize, wheat, and potato has supported Nepal's food security and livelihoods. Likewise, increase in seasonal and off-season vegetable production and productivity in the last two decades contributes largely to food and nutrition security and livelihoods of the people.

Among food crops, rice is the most valued, prestigious and most appreciated crop in Asia and in Nepal. Rice is the number one food crop in Nepal based on area coverage, total production and contribution to Agricultural GDP of the country, which is about 21% (MoF 2016). Similarly, rice fulfills about 40% of the total calorie requirement of the total population. Rice forms an integral part of life from birth till death of a person in Hindu culture and rituals. Civil servants and other employees join their family in rice transplanting occasion every year, which is considered an important celebration. Similarly, farmers who have gone to India for short or longer-term employment visit their family during rice transplanting and harvesting time and join hands with their family members. Ashad 15 (usually 29th June) is a special day to celebrate rice transplanting which has been celebrated as *National Rice Day* in Nepal since 2004.

Rice productivity decreases with the increase in altitude above 1500 masl. However, rice cultivation is found up to an altitude of 3050 m in Jumla, where the productivity is extremely low. Despite its very low productivity, farmers continue to grow rice in high mountain area due to the value given and auspicious feeling of growing rice. Therefore, rice is a very important crop in Nepal not only in terms of area coverage and total production but also because almost the whole population of Nepal prefers rice over other cereal crops and there are social values associated with consumption of rice products. All of these suggest that rice is very much rooted to the culture, livelihoods and daily life of Nepalese people.

Available information reveals that rice was the most important export commodity of the country three decades ago. Rice worth 495.4 million rupees was exported in 1975/76 and the export decreased over the years to only 11.3 million rupees in 1982/83. Export continued until 1986/87. Around 14.4 million rupees worth of rice was exported in fiscal year 1986/87. However, a total of 34,602 tonnes of rice was imported in the same fiscal year[1]. *Dhan-Chamal Niryat* Company (Rice Export Company), a semi-government institution was established in 1974 and milled rice was exported to India, Bangladesh and China through this company. This company was dissolved in 1981 mainly due to lack of rice available for export in the company. Currently, Nepal has been a net rice importing country for many years now. It is assumed that rice might have been exported informally by business houses occasionally, but record of such export is not available.

Rice production/consumption, poverty and conflicts

Though the consumption of potato, wheat and maize (produced locally) is far cheaper compared to the consumption of rice in the areas where rice cannot be produced locally, Nepalese people prefer to eat rice.

Political armed conflict period of over 10 years (1996 - 2006) was the most destructive and the largest conflict in the modern history of Nepal. Poorer districts and poorer sector of the community were

1 Information compiled from - International Rice Commission Newsletter. Web archive - Rice development programme in Nepal, TP Pokhrel, Rice Coordinator, Nepal Agricultural Research Council, Nepal

drawn earlier in the conflict and deaths were significantly higher in remote areas (Do and Lyer 2010). Districts such as: Jhapa, Morang, Sunsari, Bara, Parsa, Rautahat have large area under rice cultivation, but had less involvement/participation of local people/youths during the conflict period. Districts with very little rice production area such as Rolpa, Rukum, Jajarkot, Gorkha had higher level of youth participation in insurgency during the 10 years of conflict period. However, the case of Chitwan, Dang, Bardiya, and Kailali was different, where participation of youths in armed conflict period was higher despite larger area under rice cultivation, better food security, livelihood situation and opportunities available for youths.

Disputes and conflicts (minor to very serious) between households or between communities who share a water source or share water canal for rice cultivation are common. A number of such cases have been reported. Some of these are: Water Aid Nepal, 2012, Upreti 1999, Malla and Khadga 1997, Pradhan and Pradhan 1997, Shivakoti et al 1997, KC and Pradhan, 1997, Pradhan et al 1996, Kattel 2005. There could be much more such cases in Nepal, which might not have been reported or documented, however, all of them were of minor importance while we talk about the armed conflicts and political riots which have/had major role in the political instability in the country.

Disputes between households on the use of water for irrigation (mainly for rice cultivation) are sometimes so serious that both parties fight until death or serious injury of either one party or the other. Such cases were occasionally reported in Nepal and there are many other such cases (of less severity), which are not reported and/or documented. Water-Aid in Nepal, in partnership with the Federation of Water and Sanitation Users in Nepal (FEDWASUN), carried out a study covering 146 cases across 12 districts to analyze the water source conflict in detail. The study showed an increasing trend towards water source conflicts in recent years due to various reasons. The major cause was increasing water scarcity, although disputes were also seen in areas where there was an abundance of water (Water-Aid in Nepal 2012). It was also found that 29% of conflicts arose because empowered communities did not want to share their water sources with weaker communities. Similarly, source of conflict also included political disputes, negative use of legal frameworks and the increased influence of urban societies on rural communities (Water-Aid in Nepal 2012).

Rice and political instability in the country

Introduction of rice culture to mountain region of Nepal by development agencies/workers during the last four decades has changed the food habit of mountain people. Local people in the mountain region were used to eating of locally produced nutritious food grains such as buckwheat, finger millet, foxtail millet, proso-millet, barley, beans etc and potatoes in the past and consumption of rice as a staple crop was minimal. But food habit of mountain people changed because of flow of people from cities and lower altitude areas for various purposes such as services/administration, business and development interventions that sharply increased the demand for rice in high mountain region. There has always been a short supply of rice in the high mountain region for the last three decades or so because of increased demand and very poor or non-existence of road network causing very high transportation cost of bulky items such as rice. That has resulted in high demand and less supply of rice, which has caused disputes and conflicts number of times, particularly in district headquarters of Karnali zone, where shortages of rice is most common. There are also blames on the government and other development agencies that they pushed local people of Karnali zone into *BHATE SANSKRITI* (rice culture) and made them dependent on rice, which needs to be imported and is very expensive. So there are disputes/conflicts at various level regarding *BHATE SANSKRITI* and short supply of rice in the mountain region of the country. However, such disputes/conflicts are mostly at the local level and not strong enough to create political turmoil and instability in the government at the regional or national level.

However, wide prevalence of centralized mindset and orientation of Nepalese people and their leaders made it difficult to utilize the very high comparative advantage of other professions in these mountain regions (particularly tourism, high value medicinal and aromatic plants, fruit, vegetable seeds etc). National priorities have always subsided the regional or local priorities of these high hills and mountain regions leaving poorer sector of the country poorer and poorer, despite their huge potentiality for prosperity. This has remained a serious issue in the country, which has encouraged people to unite and fight against the centralized system and against the central government. This was one of the reasons that Nepal became a fertile ground for a 10 year long conflict. This kind of negligence and/or discrepancies could cause conflicts and political unrest at various levels in the future as well.

Big irrigation projects and facility of all the year-round irrigation in Tarai, inner-Tarai and valleys could have engaged farmers and a large number of people all the year-round production, processing, and marketing of rice and various other commodities. Their livelihoods would have improved and/or they could have achieved prosperity through agriculture production, processing and marketing locally, nationally and globally and problem of political unrest could have been reduced. Irrigation all the year-round could also have good impact on vegetation and greenery all the year round, which could also have positively impacted the mindset and orientation of people. This could promoted positive thinking and that may drive the community towards politeness and could move the country towards peace and prosperity.

Past scenario of rice being considered the most valued and prestigious crop has changed in accessible area where number of other high value crops and their appropriate varieties such as: off-season vegetables, cash crops such as cardamom, fruit crops such as mango, citrus, apple, their production technologies and market are available and peoples' awareness and level of education has increased. So, rice is no more valuable and prestigious crop in the area where high value crops have taken their place. This means that rice is being replaced by high value crops and the governments in some countries such as Vietnam had to impose rules so that farmers are compelled to grow rice and government can meet that national requirement of rice from their own production.

Similarly, the issue that the food cooperation has not performed the transportation of rice in remote and food deficit districts of Karnali, has been raised in parliament of Nepal and at the national level. Several clips of people sitting in a line in-front of offices of Nepal Food Corporation to receive rice in Karnali region have often been broadcasted in Television.

Nepal has remained politically instable for a long time and that is one of the reasons for poor economic growth and prosperity of the country. However, studies regarding the relationship between various levels and types of poverty (also due to poor yield or crop failure of rice) and conflicts and political unrest in the country are still inadequate or lacking in Nepal. Assessment of direct relationship between rice production and political instability in Nepal has still remained as difficult task. Similarly, poverty due to subsistence farming and lack of commercialization in agriculture and their impact on livelihoods has also not been studied/documented in the country. Systematic studies to explore the relationship between yields/production of major crops and their impact on livelihoods of people and violence (conflict) and political instability in the country is strongly recommended.

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Rice: Staple Food in the Global Context

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सारांश

संसारको जनसंख्याको आधा भन्दा बढी लागि धान प्रमुख खाद्यान्न हो । यसले खाद्य सुरक्षामा महत्वपूर्ण भूमिका खेल्छ । विश्वको कूल उत्पादनको ९० प्रतिशतभन्दा बढी धान एशियामा उत्पादन हुन्छ भने हाल संसारका अन्य क्षेत्रहरूमा पनि यसको क्षेत्र बढ्दै गइरहेको छ । धानको उत्पादन बढ्ने क्रममा छ । विश्वमा भारत, थाइल्याण्ड र भियतनाम प्रमुख चामल निर्यात गर्ने राष्ट्रहरू हुन् भने चीन, नाइजेरिया, इरान र युरोपेली संघ (ईयू) चामल आयात गर्ने राष्ट्रहरू हुन् । तल्लो मध्यम आय भएका देशहरूका जनताहरूको भात खाने प्रवृती र जग्गाको खण्डीकरणले गर्दा भविष्यमा चामलको माग बढ्ने देखिन्छ । तसर्थ बढ्दो जनसंख्याको खाद्य सुरक्षा सुनिश्चित गर्न र माग पूर्ती गर्न धान बालीको प्रवर्द्धनका लागि लगानीलाई प्राथमिकता दिनुपर्दछ ।

Summary

As the staple food for more than half of the world population, rice plays an important role in global food security. Although most of the rice, ie 90% of the total global production, is produced in Asia, its production is increasing in other regions around the world. Global rice production is in increasing trend mainly due to the increase in yield. India, Thailand, and Vietnam are the major rice exporters whereas China, Nigeria, Iran, and European Union (EU) nations are major importers. Total consumption of rice is expected to increase further in the future due to the increase in rice eating population, increasing urbanization and change in food habit mainly in low and lower-middle income countries. Investment in the rice sector should be a priority to ensure food security and to meet growing food demand.

Keywords: Consumption, Demand, Production, Rice

Background

Three leading cereal crops: rice, wheat and maize account for 94% of all cereal consumption in the world (Ranum et al 2014). In various regions of the world, one among these three crops are produced and consumed as main food.Among these three major crops, rice is the most important crop for people in low and lower-middle income countries (GRiSP 2013). Since a significant proportion of maize produced in the world is used for the purposes other than human consumption, rice is the main crop for human calorie intake. Rice provides around 13% of per capita protein (GRiSP 2013) requirement. Similarly, around 20% of global per capita calorie requirement is supplied byrice, whereas wheat and maize supply around 19% and 5% of the human calorie requirement (Kubo and Purevdorj 2004, Hegde and Hegde 2013).

At least 114 countries in the world cultivate rice and among them more than 50 countries produce more than 100,000 tonnes annually (Jirawut, 2012). Rice is the predominant source of energy in 17 countries of Asia and Pacific, 9 countries of North and South America and 8 countries of Africa (Hegde and Hegde 2013).

Rice in global food security

Around half of the world's population subsists wholly or partially on rice (IRRI, 2006) although 90% of the crop is grown and consumed in Asia (**Figure 1**). However, its demand and consumption is gradually increasing in Africa, Latin America and Middle East (FAOSTAT 2015, GRiSP 2013).

Worldwide, 400 million small-scale producers are involved in rice cultivation (CIRAD 2016). In Asia and sub-Saharan Africa, almost all rice is grown by small farmers. The size of their farms ranges from 0.5 to 3 ha. Rice production is growing at a faster rate in Sub Saharan Africa (SSA),

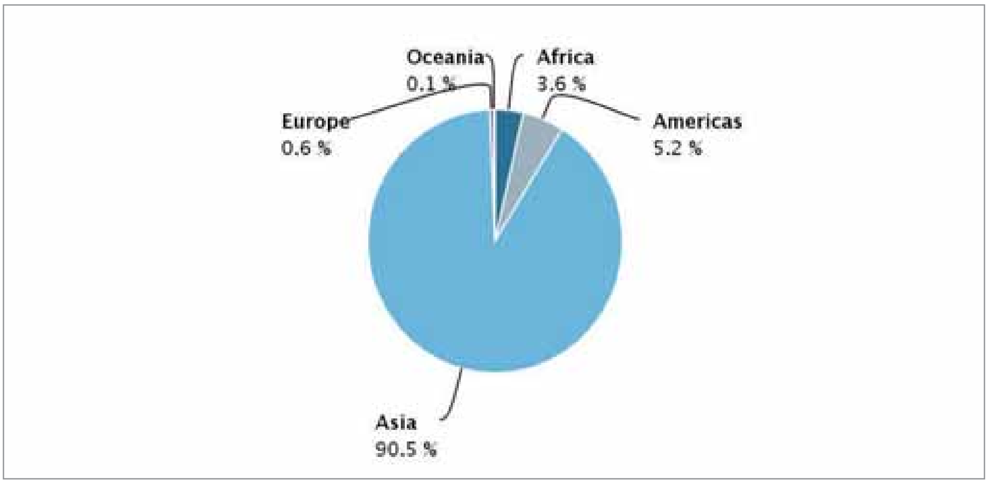

Figure 1. Share of different regions in rice production (Average of 2004 to 2014)

Source: FAOSTAT 2015.

But the consumption is growing even faster than the production.In comparison to 1970s, per capita rice consumption has nearly doubled nowin this region.

Although dominated by wheat and maize,rice is also an important source of calories in Latin America and Caribbean. Its consumption increased by about 40% during the last twenty years, primarily attributed to steadily increasing incomes and continued population growth (GRiSP 2013). The consumption of rice is also increasing rapidly in Oceania by displacing other staples. Significant increase in rice consumption can be seen in the United States of America (USA) and European Union (EU), mainly due to migration and global availability of food materials (Mohanty 2013).

There was a gradual increase in the rice area and production in the past all over the world. The total area under rice in the world reached 163,246,747 hectares and the total production reached 740,955,973 tonnes in 2014 (**Figure 2** and **3**).

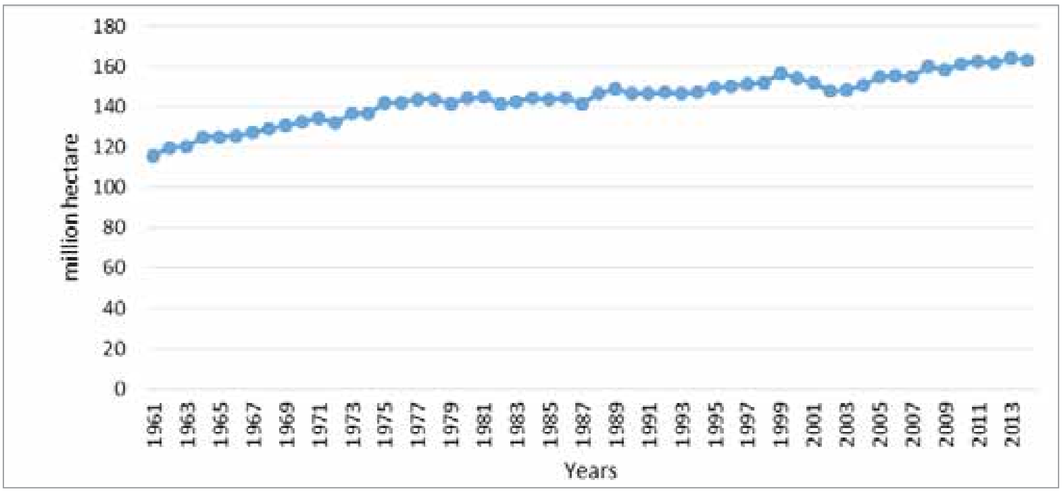

Figure 2. Trends in global rice area

Source: FAOSTAT 2015.

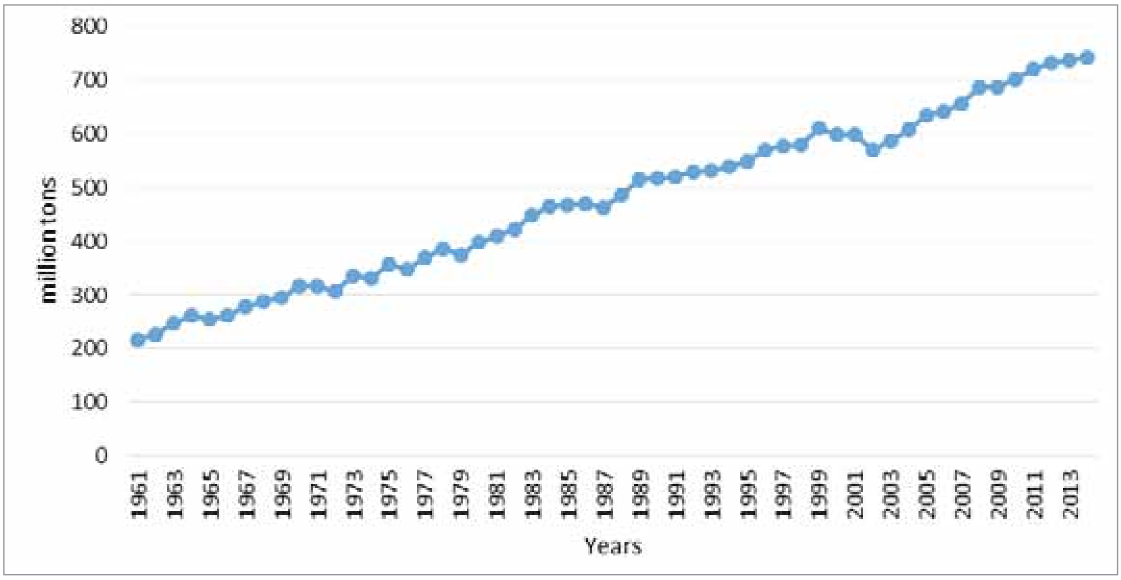

Figure 3. Trends in global rice production

Source: FAOSTAT 2015.

Global rice production increased by three times from 1960s to 2000s with the growth rate of 2.24%. However, this growth rate is slowing down in recent years. In the contrary, the world average yield of rice is gradually increasing and reached 4.53 t/ha in 2014 (**Figure 4**). In fact, the introduction of innovative technologies have direct contribution in increasing yield. Australian rice farms were most productive in 2014 with the nationwide average yield of 10.9 t/ha, followed by Egypt, Greece, USA and Uruguay (FAOSTAT 2015).

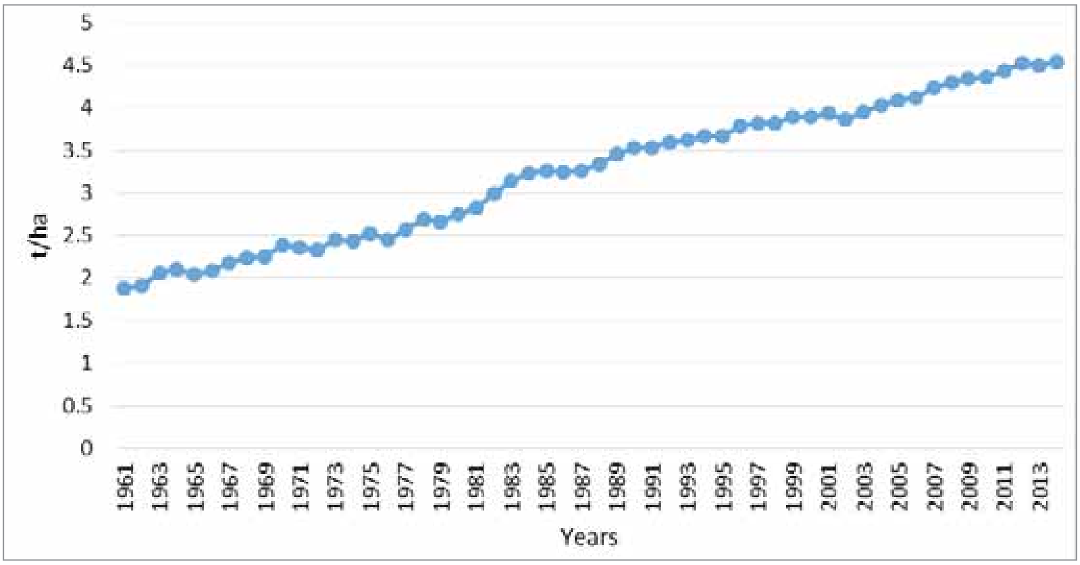

Figure 4. Trends in global rice yield

Source: FAOSTAT 2015.

China (206 million tonnes) and India (157 million tonnes) are the largest rice producers in the world (**Figure 5**). Higher production in China than in India is mainly due to higher yield. The average rice yield in China is 6.7 t/ha, whereas the average rice yield is only 3.6 t/ha in India (FAOSTAT 2015). One of the major contributing factors for higher yield in China is irrigation. Nearly all rice fields are irrigated in China, but in India only less than half of the rice growing area is irrigated. After China and India, Indonesia, Bangladesh and Vietnam are the next largest producers (**Figure 5**).

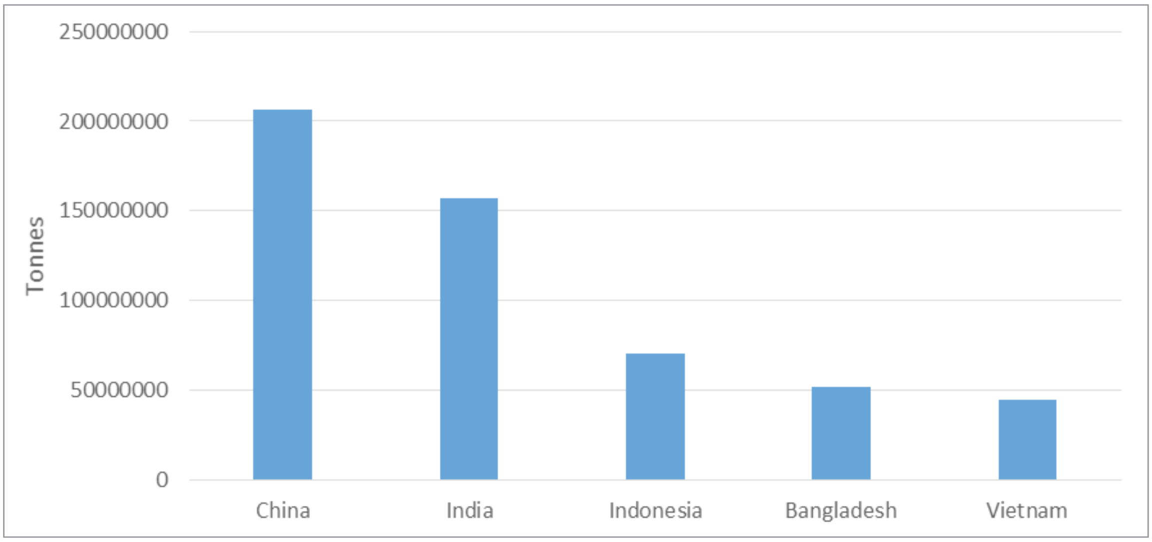

Figure 5. Top five rice producing countries in the world 2104

Source: FAOSTAT 2015.

In the case of sub-Saharan Africa, around 66% of total production is done in Western Africa and it is the main rice producing sub-region. Leading producers in Africa are: Nigeria (6.7 million tonnes), Egypt (6 million tonnes), and Madagascar (4 million tonnes) respectively (FAOSTAT 2015). In the Latin America and the Caribbean region, Brazil produces nearly half of the total rice (12 million tonnes) followed by Peru (3 million tonnes), Columbia (1.82 million tonnes) and Ecuador (1.5 million tonnes) (FAOSTAT 2015).

Being a major food crop to fight against hunger, rice consumption is growing at a faster rate than that of any other important staples. Global rice consumption is driven by population growth and economic growth. More than 3 billion Asians get 35 to 75% of calories from rice (Kush 2005). Six Asian countries namely: China, India, Indonesia, Bangladesh, Vietnam and Japan accounted for 80% in the world's production and consumption (FAOSTAT 2015). Regarding consumption, 90-181 kg per person per year is estimated to be consumed in Asia which is higher than any other region in the world. In America, per capita consumption is only 11 kg per year albeit it is increasing (Prasad et al 2015). Rice consuming population is increasing at the rate of 2% annually. Outside Asia, rice consumption continues to rise steadily, with the fastest growth in sub-Saharan Africa. The growth in rice consumption in SSA is primarily the result of preference and rising income of urban consumers. The preference will inevitably grow among rural consumers with their increasing income in future.

Total consumption of rice will grow at the rate of population growth if per capita consumption follows the trend of the past two decades. This will even exceeded if uptrend continues in the per capita consumption in top three rice consuming countries, ie China, India and Indonesia since the crop diversification in Asia is slow and not widespread (Mohanty 2013). In the contrary, if Asian countries follow rapid diversification in food production and consumption, total global consumption of rice may start declining.

Rice in international trade

Most of the rice is produced and consumed in producing countries. Therefore, small amount of production is traded internationally. However, international trade is progressing rapidly from less than 4% in the mid-1990s to almost 10% in 2015 (CIRAD 2016). Only a few exporting countries are interacting with large number of importing countries. With 83% of exports and 85% of imports, developing countries are the main players of rice international trade (Hegde and Hegde 2013).

India is the topmost rice exporter. In 2013, India exported 11,300,105 tonnes of rice followed by Thailand, Vietnam, Pakistan and USA (**Figure 6**). Global rice trade is based on non-fragrant and fragrant rice. Jasmine and basmati rice fall under fragrant category while parboiled, glutinous and other long grain rice fall under non-fragrant categories. Parboiled and other common non-fragrant rice are mainly exported to Middle Eastern and African countries by India and Thailand. Thailand is a dominant exporter of Jasmine rice. Cambodia and Vietnam are becoming competitor of Thailand in jasmine rice export. Trade of Basmati rice, which is primarily exported to Middle East countries, is dominated by India and Pakistan (Mohanty 2015).

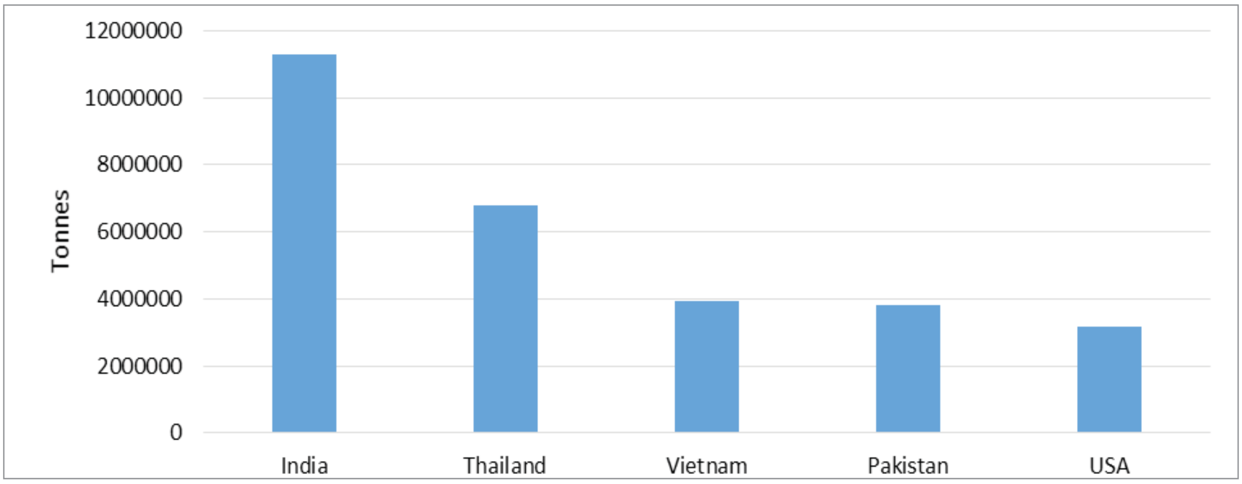

Figure 6. Top five rice exporting countries in the world 2013

Source: FAOSTAT 2015.

Topmost rice importer in the world is China, followed by Nigeria, Iran, and EU (**Figure 7**). Demand for new varieties tends to increase as the modernization and diversification of diets occur in the world's top consumers that allows other countries to play important role in global rice market. It is estimated that an additional rice supply of around 112 million tonnes will be required by the year of 2040 to meet the growing demand, especially if Sub-Saharan African countries fail to address their growing needs since most of the rice consumed in SSA is imported (Mohanty 2015).

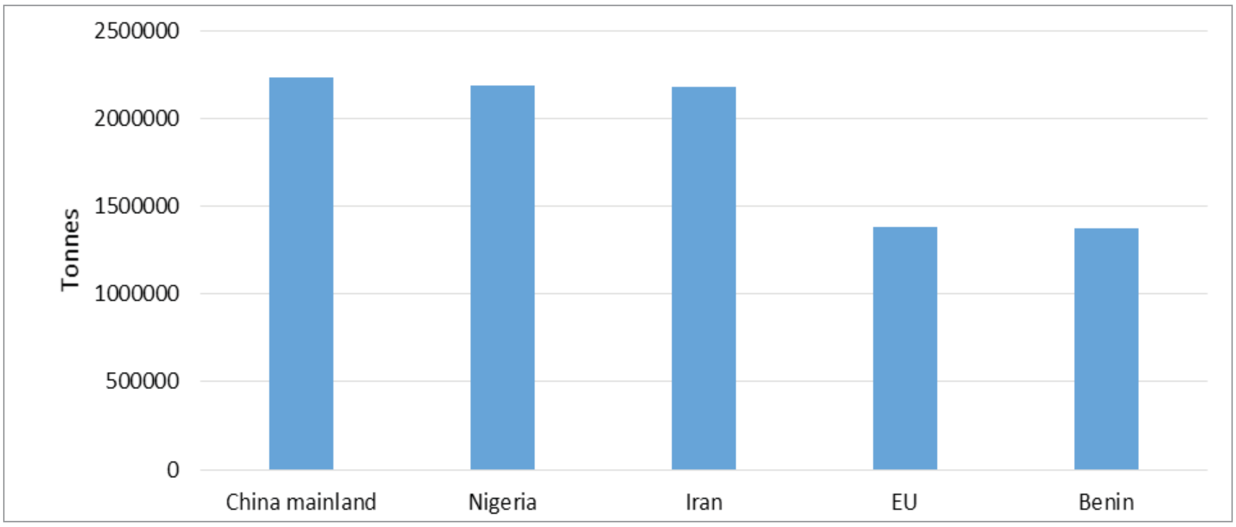

Figure 7. Top five rice importing countries in the world 2013

Source: FAOSTAT 2015.

Challenges in rice production and consumption

According to UN estimates, world population will grow to 8 billion in 2025 and most of this increase, ie, 93% will occur in developing countries. By 2025, population growth in the world's ten most populous rice-eating countries will increase the demand by 25% (Smil 2005).

Rice production as well as yield has been increasing continuously since green revolution era, but the growth rate is slowing down (GRiSP 2013). Population is growing steadily while the land and water resources are on the decline along with the climate change evidences; increasing temperature, rising sea levels, draught and changing rainfall patterns are adversely affecting rice production and productivity in different parts of the world. Sustainable increase in rice production and productivity is required to adapt to global climate change. Urbanization in developing world causes increasing rice consumption on the one hand and on the other hand rice growing fertile land around the world is decreasing. Urbanization is also responsible for the less availability of labor in developing world. Limited possibility of increasing rice area enforces production intensification with sustainable farm technologies.

As rice export is dominated by few countries, it is expected that prices remain unstable because of production shocks or trade policy changes. Though rice is a major contributor to food security, most of the production is done by small farmers and the price is unstable in the market. Commercial farmers are attracted more towards high value agriculture produce than rice.

Per capita consumption of rice in Asian countries like: India, Vietnam and Indonesia is declining with rising income (Mohanty 2013). It is also the result of diet diversification. At the same time, it is anticipated that the consumption will not decrease dramatically in India because of the dominance of ovo-vegetarian population. In fact, it is expected that rice demand will rise continuously in coming years. According to the Food and Agricultural Policy Research Institute (FAPRI), the world's demand for the milled rice is expected to rise to 555 millions tonnes by 2035. Asians are expected to account for 67% of increase despite consumption is expected to decline in countries like India and China because of diversification in their diets.

Conclusion

Rice influences livelihoods and economics as this is one of the important staple food crops for more than half of the world's population. Asian countries are major producers and consumers of rice. In 2014, rice was cultivated approximately in 164 million hectares of land worldwide and around 740 million tonnes was produced, of which around 90% was produced in Asia. Most of the rice producers are small farmers. China and India are the world's largest rice producers producing annually around 193 million tonnes and 146 million tonnes respectively. Indonesia, Bangladesh and Vietnam are other big producers of rice. Global rice consumption can be expected to decline, if Asian countries follow diversification in diets.

Rice production and productivity is increasing, but the growth rate is declining in recent years. Since, area expansion is difficult, it is necessary to increase global rice yield. In developing world, yield increment is required continue at a faster rate to mitigate the pressure on rice lands from urbanization, climate change and competition with other high value agriculture. Rice consumption is increasing at a higher rate in Sub-Saharan Africa by displacing other staples. In Sub-Saharan Africa, Western Africa is the major rice producing region.However, most of the rice consumed in Africa is imported from Asia. In Latin America and the Caribbean, Brazil is the major producer.

Only 10% of the produced rice is traded internationally. India is the topmost exporter followed by Thailand, Vietnam, Pakistan and USA. Major importer of rice is China followed by Nigeria, Iran, Benin and EU. Rice being a critical crop for food security for more than half of the world population, attention is required in increasing investment for increasing rice yield.

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Rice Statistics from 1951 to 2015 in Nepal

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सारांश

नेपालका ७५ वटा जिल्लाहरूमध्ये मनाङ्ग र मुस्ताङ्ग बाहेक ७३ जिल्लामा खेती गरिने धान बाली उत्पादन, उपभोग तथा अर्थतन्त्र माथिको योगदानको हिसाबले पहिलो बाली हो भने संसारमै मकै पछिको दोस्रो प्रमुख बाली हो । संसारका धान खेती गरिने देश मध्ये नेपाल १८ औं स्थानमा पर्दछ । कृषि क्षेत्र तर्फको कूल राष्ट्रिय आयमा करिब २० प्रतिशत योगदान दिने धानले नेपालीको भान्सामा प्रयोग गरिने खानेकुरामध्ये करिब दुई तिहाई योगदान दिन्छ भने हामीले प्राप्त गर्ने क्यालोरीमा समेत करिब ३०% को योगदान दिएको छ । नेपालमा धानको उत्पादन मूलतः मनसुनको कारणबाट तलमाथि परिरहने भएतापनि हालका दिनमा यसको औसत क्षेत्रफल १४ देखि १५ लाख हे., उत्पादन ४० देखि ५० लाख मे. टन तथा उत्पादकत्व ३ देखि ३.३ टन प्रति हेक्टर रहेको छ । हालका दिनहरूमा देशभित्र उत्पादित धानले खान नपुग्ने भई ठूलो परिमाणमा भारत लगायतका देशहरूबाट समेत धान चामल आयात हुने गरेको छ ।

Summary

Paddy is the number two food crop of the world and number one food crop in Nepal in terms of area, production, value, contribution to GDP and AGDP as well as in Nepali people's food basket. Of the 75 districts, paddy is grown in 73 districts in the country contributing more than 50% among cereal crops and about 20% in all the crop and livestock products grown and produced in Nepal. Paddy is the most volatile crop in terms of weather which is largely based with the south west Monsoon system and vulnerable to climate change. The food basket of the Nepali people is dominated by rice average calorie contribution of about 30% which is the main product of paddy besides others. This article tries to explain the historical contribution of paddy in different aspects of economy and its importance in food security and food balance sheet with focus on statistical approach.

Keywords: AGDP, Cereals, Calorie, Food security, Paddy

Introduction

Nepal is predominantly an agrarian society, as it contribute about one third of the national economy and livelihood of more than 60% of the population (CBS 2014). About 21% of the land is cultivable, of which 54% has irrigation facilities with only 0.68 ha/household land holding. Paddy is the number one crop in Nepal in terms of coverage of area, production, contribution to GDP and AGDP as well as major source of dietary energy for the Nepali people. This article tries to present the situation of paddy in different scenario like, production at national and sub national level including districts, trade ie import and export scenario of paddy for the last few years, contribution of paddy in AGDP and food balance sheet as well as food consumption pattern in Nepal.

Rice area, Production and Yield trend of Nepal

It is believed that paddy is being grown in Nepal since last many years but the data officially available are from 1950 as explained in the tables below. The data received from the official reporting of the Ministry of Agricultural Development shows that the total area of the crop was about 1.295 million hectares with productivity of about 1.9 t/ha in 1950/51. The area increased gradually till 1960 and reached about 1.416 million hectares but the productivity remained almost constant.

The data on paddy area were revised on 1960/61 once the data were available from the first Census of Agriculture conducted by the Central Bureau of Statistics. There was a huge difference among the reported area by the Ministry and the results from the Agriculture Census. The area declined by about 23% and reported as 1.088 million hectares only. Since then, there was a small but gradual increment in paddy area, except few abnormal years like 1967/68, 1972/73, 1986/87, 1992/93, 2006/07, 2009/10, 2012/13 and recently in last year. The highest ever recorded paddy area was in 2000/01 reaching at the level of 1.56 million hectares.

The production level started from 2.46 million tonnes and reached highest to 5.072 million tonnes in the year 2011/12. The average yield rate of rice is also moving around 1.9 t/ha in 1950/51 to 3.394 in 2013/14. Regarding the trend over the last 65 years the average growth in paddy area is only 0.35% per annum and only about 1% growth per annum in production. Considering the population growth of about 2% in the last 5 decades and 1,35% in the year of 2001- 2011; the growth in paddy production is still far below than the average population growth indicating the decline in the per capita paddy availability (**Table 1**).

Table 1. National production trend of paddy for 65 years in Nepal

Year	Paddy				
	Area (ha)	**Production (tonnes)**	**Productivity (kg/ha)**	**Area growth (%)**	**Prod growth (%)**
1950/51	1295000	2460000	1900		
1951/52	1295000	2460000	1900	0.00	1.00
1952/53	1315000	2500000	1901	1.54	0.98
1953/54	1315000	2500000	1901	0.00	1.00
1954/55	1315000	2500000	1901	0.00	1.00
1955/56	1300000	2470000	1900	-1.14	1.01
1956/57	1295000	2460000	1900	-0.38	1.00
1957/58	1335000	2540000	1903	3.09	0.97
1958/59	1295000	2460000	1900	-3.00	1.03
1959/60	1416000	2690000	1900	9.34	0.91
1960/61	1088000	2108000	1938	-23.16	1.24
1961/62	1088000	2108000	1938	0.00	1.00
1962/63	1090000	2108000	1934	0.18	1.00
1963/64	1090000	2109000	1935	0.00	1.00
1964/65	1101000	2201000	1999	1.01	0.96
1965/66	1111000	2207000	1986	0.91	1.00
1966/67	1100000	2007000	1825	-0.99	1.09
1967/68	1154000	2119000	1836	4.91	0.95
1968/69	1162000	2178000	1874	0.69	0.97
1969/70	1173000	2241000	1910	0.95	0.97
1970/71	1182000	2305000	1950	0.77	0.97
1971/72	1201000	2344000	1952	1.61	0.98
1972/73	1140000	2010000	1763	-5.08	1.15
1973/74	1227000	2416000	1969	7.63	0.82
1974/75	1240000	2452000	1977	1.06	0.99
1975/76	1255795	2604751	2074	1.27	0.94
1976/77	1261619	2386272	1891	0.46	1.09
1977/78	1264060	2282430	1806	0.19	1.04
1978/79	1262650	2339280	1853	-0.11	0.98
1979/80	1254240	2059930	1642	-0.67	1.13

Year	Paddy				
	Area (ha)	Production (tonnes)	Productivity (kg/ha)	Area growth (%)	Prod growth (%)
1980/81	1275520	2464310	1932	1.70	0.82
1981/82	1296530	2560080	1975	1.65	0.96
1982/83	1264840	1832620	1449	-2.44	1.33
1983/84	1334200	2756980	2066	5.48	0.59
1984/85	1376860	2709430	1968	3.20	1.02
1985/86	1391040	2804490	2016	1.03	0.97
1986/87	1333360	2372020	1779	-4.15	1.17
1987/88	1423290	2981780	2095	6.74	0.77
1988/89	1450470	3283210	2264	1.91	0.90
1989/90	1432850	3389670	2366	-1.21	0.97
1990/91	1455170	3502160	2407	1.56	0.97
1991/92	1411810	3222540	2283	-2.98	1.08
1992/93	1262110	2584900	2048	-10.60	1.22
1993/94	1450449	3495589	2410	14.92	0.70
1994/95	1368423	2906184	2124	-5.66	1.18
1995/96	1496790	3578830	2391	9.38	0.79
1996/97	1511230	3710650	2455	0.96	0.96
1997/98	1506340	3640860	2417	-0.32	1.02
1998/99	1514210	3709770	2450	0.52	0.98
1999/00	1550990	4030100	2598	2.43	0.92
2000/01	1560044	4216465	2703	0.58	0.95
2001/02	1516980	4164687	2745	-2.76	1.01
2002/03	1544660	4132500	2675	1.82	1.01
2003/04	1559436	4455722	2857	0.96	0.92
2004/05	1541729	4289827	2782	-1.14	1.04
2005/06	1549447	4209279	2717	0.50	1.02
2006/07	1439525	3680838	2557	-7.09	1.13
2007/08	1549262	4299246	2775	7.62	0.84
2008/09	1556000	4524000	2907	0.43	0.95
2009/10	1481289	4023823	2716	-4.80	1.12
2010/11	1496476	4460278	2981	1.03	0.90
2011/12	1531493	5072249	3312	2.34	0.87
2012/13	1420570	4504503	3171	-7.24	1.12
2013/14	1486951	5047047	3394	4.67	0.89
2014/15	1425000	4788612	3360	-4.1	-5.1
Average				**0.35**	**0.99**

Source: MoAD 2015.

Paddy production at sub national levels

Nepal is physically divided into three ecological belts ie Mountain, Hills and Terai and politically divided into five development regions starting from east to west. There is a big difference among these belts and regions. Around 69% of the paddy area is in the Tarai region which contributes more than 71% in the total production. The Hills contribute to about 27% in area and 26% in production. Similarly the remote mountains also contribute about four percent of the total paddy area with 3% contribution in production.

Among the five development regions the contribution in area and production is lowest from far western development region which is about 12% in terms of area and 10% in terms of production followed by mid-western development region with contribution of 12 to 13% in terms of area and production, respectively. The highest contribution is from central development region which is about 27.5% for both area and production followed by eastern development and western development region with more than 20% contribution both in terms of area as well as production. The details are presented in the following **Table 2**.

Table 2. Production of paddy by ecological belt and development region in 2014/15

Devlopment region	2014/15			Contribution percentage	
	Area (ha)	Prod (tonnes)	Yield (kg/ha)	Area	Prod
Eastern	382867	1235963	3228	26.9	25.8
Central	391624	1318324	3366	27.5	27.5
Western	308090	1108932	3599	21.6	23.2
Mid western	172648	638668	3699	12.1	13.3
Far western	170117	486725	2861	11.9	10.2
Nepal	1425346	4788612	3360	100.0	100.0
Ecological belt					
Mountain	58438	143044	2448	4.1	3.0
Hill	382569	1230797	3217	26.8	25.7
Tarai	984339	3414771	3469	69.1	71.3
Nepal	1425346	4788612	3360	100.0	100.0

Source: Calculated from Statistical Year Book of Nepa:l MoAD 2015.

Paddy production by ecological belt and development regions

The ecological belt and development region can be categorized into 15 different domains in the country (**Table 3**). It has been observed that there is no cultivation of paddy in the western mountains is it so? Only in Manang and mustang there is no record of rice cultivation. There is a very high discrepancy among the ecological belts and region in terms of contribution in area and production of paddy. The highest area can be seen in the central Tarai followed by eastern and western, the same pattern is followed in terms of contribution in production as well. The contribution in area as well is production in mountain eco belts is around one percent while it is from two to nine percent in hills.

Table 3. Production of paddy by 15 ecological belt and development region in 2014/15

Belt/Region	2014/15			Percentage of contribution	
	Area (ha)	Prod (tonnes)	Yield (kg/ha)	Area	Prod
E. Mountain	19249	44861	2331	1.4	0.9
C. Mountain	16680	38723	2322	1.2	0.8
W. Mountain	0	0	0	0.0	0.0
MW. Mountain	7713	18067	2342	0.5	0.4
FW. Mountain	14796	41393	2798	1.0	0.9
E. Hills	81928	212301	2591	5.7	4.4
C. Hills	90043	364471	4048	6.3	7.6
W. Hills	123850	405912	3277	8.7	8.5
MW. Hills	47427	156242	3294	3.3	3.3

Belt/Region	2014/15			Percentage of contribution	
	Area (ha)	Prod (tonnes)	Yield (kg/ha)	Area	Prod
FW. Hills	39321	91871	2336	2.8	1.9
E. Tarai	281690	978801	3475	19.8	20.4
C. Tarai	284901	915130	3212	20.0	19.1
W. Tarai	184240	703020	3816	12.9	14.7
MW. Tarai	117508	464359	3952	8.2	9.7
FW. Tarai	116000	353461	3047	8.1	7.4
Total	1425346	4788612	3360	100.0	100.0

Source: Calculated from Statistical Year Book of Nepal MoAD 2015.

Production of paddy in districts

The paddy is grown in Nepal in 73 among 75 districts except Manang and Mustang. The major rice producing districts are Jhapa, Morang, Kailali, Kapilastu, Rupandehi, Bara, Bardiya, Parsa, Kanchanpur and Sarlahi all of them from the Tarai region. The lowest producing districts are mainly in the mountains namely Dolpa, Humla, Rasuwa, Mugu, Solukhumbu and others. From the **Table 4**, it can be seen that there is a significant change in terms of area, production as well as productivity of paddy for almost all the districts. The area in most of the districts has gone down which is obvious because of the crop diversification and urbanization process. The area in some other districts has gone up mainly due to increase in cropping intensity. The productivity in this table has been estimated as the ratio between production and area multiplied by 100, so we can see the sharp differences in terms of productivity increase or decrease.

The area, production and productivity over the last two periods 2004/05 and 2014/15 are presented in the following table.

Table 4. Production of paddy at districts in 2004/05 and 2014/15

Rank	District	2004/05			2014/15			% Change		
		Area	Prod	Yield (kg/ha)	Area	Prod	Yield (kg/ha)	Area	Prod	Yield
1	Jhapa	98000	321832	3284	83200	337792	4060	-15.1	5.0	23.6
2	Morang	96875	314844	3250	82550	313200	4500	-14.8	-0.5	38.5
3	Kailali	71232	177368	2490	70400	288925	3500	-1.2	62.9	40.6
4	Kapilbastu	69337	201077	2900	69840	209757	2980	0.7	4.3	2.7
5	Rupandehi	68500	127710	1864	69600	209520	3000	1.6	64.1	60.9
6	Bara	67000	201000	3000	60446	205000	4227	-9.8	2.0	40.9
7	Bardiya	61116	190807	3122	48500	182400	4000	-20.6	-4.4	28.1
8	Parsa	58000	141926	2447	45600	180300	4025	-21.4	27.0	64.5
9	Kanchanpur	57310	150540	2627	45600	161784	3600	-20.4	7.5	37.1
10	Sarlahi	53087	200940	3785	45500	156984	4300	-14.3	-21.9	13.6
11	Sunsari	50591	128186	2534	44940	156896	2596	-11.2	22.4	2.4
12	Nawalparasi	45507	137260	3016	44800	143704	3151	-1.6	4.7	4.5
13	Dhanusha	44636	114810	2572	44200	141440	3200	-1.0	23.2	24.4
14	Dang	43373	160612	3703	36508	127400	2800	-15.8	-20.7	-24.4
15	Siraha	40673	104165	2561	36000	112994	3722	-11.5	8.5	45.3
16	Saptari	37821	97196	2570	35000	103500	3520	-7.5	6.5	37.0
17	Banke	36630	114280	3120	32500	102375	3150	-11.3	-10.4	1.0
18	Rautahat	33465	93702	2800	30355	95300	2647	-9.3	1.7	-5.5

Rank	District	2004/05			2014/15			% Change		
		Area	Prod	Yield (kg/ha)	Area	Prod	Yield (kg/ha)	Area	Prod	Yield
19	Chitwan	31660	87223	2755	29400	95000	2714	-7.1	8.9	-1.5
20	Mahottari	29425	39212	1333	29400	90500	3078	-0.1	130.8	131.0
21	Kaski	18609	51890	2788	22025	83364	3785	18.4	60.7	35.7
22	Syangja	18110	54529	3011	16800	73762	4701	-7.2	35.3	56.1
23	Achham	17165	42449	2473	16500	60137	3580	-3.9	41.7	44.7
24	Bhojpur	16713	51496	3081	16093	50371	3801	-3.7	-2.2	23.4
25	Nuwakot	16228	47061	2900	15692	50369	4015	-3.3	7.0	38.5
26	Lamjung	16025	46473	2900	14930	47945	3962	-6.8	3.2	36.6
27	Sankhuwashava	15496	34091	2200	13650	45245	5706	-11.9	32.7	159.3
28	Surkhet	15438	47055	3048	13252	45144	3600	-14.2	-4.1	18.1
29	Sindhuli	14471	31966	2209	13000	41600	3200	-10.2	30.1	44.9
30	Illam	13627	32936	2417	12593	38995	3504	-7.6	18.4	45.0
31	Dhading	13300	38623	2904	12545	38587	3165	-5.7	-0.1	9.0
32	Tanahu	12440	34210	2750	12540	37327	2500	0.8	9.1	-9.1
33	Sindhupalchok	12300	29741	2418	12200	37009	3272	-0.8	24.4	35.3
34	Gorkha	12059	29275	2428	12192	35893	2230	1.1	22.6	-8.1
35	Khotang	11875	38340	3229	12161	34795	2109	2.4	-9.2	-34.7
36	Udayapur	10977	22349	2036	12100	33100	3840	10.2	48.1	88.6
37	Kavre	10645	30977	2910	11310	32660	2393	6.2	5.4	-17.8
38	Makwanpur	10388	20776	2000	11130	31230	2480	7.1	50.3	24.0
39	Doti	9987	22690	2272	10600	28217	2313	6.1	24.4	1.8
40	Gulmi	9470	23202	2450	10042	27950	2783	6.0	20.5	13.6
41	Ramechap	9435	26663	2826	9408	26755	2200	-0.3	0.3	-22.1
42	Panchthar	9025	19738	2187	9200	26523	6100	1.9	34.4	178.9
43	Parbat	8895	20275	2279	8835	26164	2781	-0.7	29.0	22.0
44	Palpa	8673	18742	2161	8620	26161	3149	-0.6	39.6	45.7
45	Dailekh	8600	20640	2400	8307	25386	3100	-3.4	23.0	29.2
46	Arghakhanchi	8300	19920	2400	8189	24942	3551	-1.3	25.2	48.0
47	Kathmandu	8100	46170	5700	7930	24804	5300	-2.1	-46.3	-7.0
48	Dhankuta	7700	13900	1805	7820	24738	2800	1.6	78.0	55.1
49	Terhathum	6959	18024	2590	7606	22769	3250	9.3	26.3	25.5
50	Salyan	6910	15270	2210	7024	22434	2869	1.6	46.9	29.8
51	Bajhang	6835	19753	2890	7006	22396	2113	2.5	13.4	-26.9
52	Baitadi	6750	16882	2501	7000	21902	3357	3.7	29.7	34.2
53	Pyuthan	6540	16252	2485	6525	20240	2200	-0.2	24.5	-11.5
54	Baglung	6520	13252	2033	5782	19000	3639	-11.3	43.4	79.0
55	Dadeldhura	6100	14030	2300	5221	17715	3064	-14.4	26.3	33.2
56	Rolpa	5930	10750	1813	4715	17494	2300	-20.5	62.7	26.9
57	Lalitpur	5580	12847	2302	4680	15680	2240	-16.1	22.1	-2.7
58	Darchula	4700	9160	1949	4480	12464	3200	-4.7	36.1	64.2
59	Okhaldhunga	4655	26068	5600	4355	12259	2600	-6.4	-53.0	-53.6
60	Bhaktapur	4503	27018	6000	4348	10812	2675	-3.4	-60.0	-55.4
61	Taplejung	4500	11900	2644	4074	10631	2373	-9.5	-10.7	-10.3

Rank	District	2004/05			2014/15			% Change		
		Area	Prod	Yield (kg/ha)	Area	Prod	Yield (kg/ha)	Area	Prod	Yield
62	Jajarkot	3570	8600	2409	4042	10310	2367	13.2	19.9	-1.7
63	Myagdi	3500	7900	2257	3895	9795	2750	11.3	24.0	21.8
64	Rukum	3260	6010	1844	3562	8637	2120	9.3	43.7	15.0
65	Bajura	3178	7633	2402	3310	7993	2415	4.2	4.7	0.5
66	Dolakha	3113	7938	2550	3180	7375	2500	2.2	-7.1	-2.0
67	Jumla	2850	4500	1579	2950	6996	2200	3.5	55.5	39.3
68	Kalikot	2080	2820	1356	2563	6671	2603	23.2	136.6	92.0
69	Solukhumbu	1850	5550	3000	1525	3564	2337	-17.6	-35.8	-22.1
70	Mugu	1500	3100	2067	1350	3510	2700	-10.0	13.2	30.6
71	Rasuwa	1317	2634	2000	1300	2551	1890	-1.3	-3.2	-5.5
72	Humla	550	840	1527	574	880	1533	4.4	4.8	0.4
73	Dolpa	190	228	1200	276	590	2138	45.3	158.8	78.1
74	Manang									
75	Mustang									

Source: Calculated from Statistical Year Book of Nepal MoAD 2004/05-2014/15.

Comparison of paddy with other cereals

The major cereals grown in Nepal are paddy, wheat, maize, millet, barley and buckwheat. The contribution of paddy in terms of area as well as production is highest among all other cereals grown in the country followed by maize, wheat and millet. The contribution of barley and buckwheat is less than one percent which is negligible at the national level but may be significant at the sub national level. The area and production of these cereals in the year 2014/15 with their overall contribution are listed in the following (**Table 5**).

Table 5. Contribution of paddy among other Cereals in 2014/15

Crop	2014/15		Contribution%	
	Area	Production	Area	Production
Paddy	1425346	4788612	42.2	51.7
Maize	882395	2145291	26.1	23.2
Wheat	762373	1975625	22.6	21.3
Millet	268050	308488	7.9	3.3
Barley	28053	37357	0.8	0.4
Buckwheat	10819	10870	0.3	0.1
Total	3377036	9266243	100	100

Source: Calculated from Statistical Year Book of Nepal MoAD 2015.

Trade scenario of paddy

It has been reported that Nepal used to export rice to India in the decades of 1970s but since last many years Nepal has become net food importer. The dependency of rice is increasing over the years. The **Table 6** highlights that the import of paddy and rice has increased from 271 thousand tonnes to 378 thousand tonnes in terms of quantity while the value has almost doubled from NRs 5 to 10 billion in last three years. The rice is mainly exported from India and occasionally from Thailand, US and Japan. There is a small and insignificant amount of paddy, which is also exported from Nepal (**Table 6**). The quantity and value exported among last three years are presented in the table. The rice is mainly exported to Peoples Republic of China.This should be noted that there is no official record of paddy export in the year 2014/15.

Table 6. Import and export of paddy in the last three years

HS Code	Description	2012/13		2013/14		2014/15	
		Quantity in kg and Value in NRs					
		Quantity	Value	Quantity	Value	Quantity	Value
10061000	Rice in the husk	254,465,823	4,756,467,679	167,100,819	4,499,675,116	338,512,058	9,012,426,867
10062000	Husked (brown) rice	818,880	51,701,023	930,379	57,958,987	1,254,425	71,652,889
10064000	Broken rice	15,583,040	293,136,229	32,354,920	642,686,510	37,856,348	967,734,543
	Total	270,867,743	5,101,304,931	200,386,118	5,200,320,613	377,622,831	10,051,814,299

HS Code	Description	2012/13		2013/14	
		Quantity in kg and Value in NRs			
		Quantity	Value	Quantity	Value
10062000	Husked (brown) rice			600	12,000
10063000	Semi milled or wholly milled rice, whether or not polished or glazed	123,152	8,297,305	874,685	27,740,852
10064000	Broken rice			200	25,000
	Total	123,152	8,297,305	875,485	27,777,852

Source: Trade and Export Promotion Centre 2012-2014, retrieved from www.tepc.gov.np.

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Rice Value Chain Study in Eastern Nepal

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सारांश

नेपालका कूल खाद्यान्न उत्पादनको करिब आधा हिस्सा धानले ओगटेको छ । धानको मूल्य शृंखला अन्तर्गत किसान, साना तथा ठूला व्यापारी, मिल संचालक, थोक बिक्रेता, खुद्रा बिक्रेता र उपभोक्ताहरू पर्दछन् । नेपालमा धानको बजारीकरणमा गाउँका व्यापारी, थोक बिक्रेता र चामल मिलवाला जस्ता बिचौलियाहरूको महत्वपूर्ण भूमिका रहेको छ । आर्थिक अभाव, बजार जानकारीको कमी, ढुवानी समस्या र भण्डारणको अभावले गर्दा गरिब तथा साना किसानहरू आफ्नो उत्पादन भित्र्याउने बित्तिकै बिचौलियाहरूलाई उनीहरूले भनेकै मूल्यमा बेच्न बाध्य हुन्छन् । धानको मूल्य शृंखला अन्तर्गत उत्पादनकर्ताले साना व्यापारी, थोक बिक्रेता, र प्रशोधनकर्ता गरी मुख्यतया तीन किसिमका खरिदकर्ताहरूलाई धान बेच्ने गर्दछन् । ठीक त्यसै गरी व्यापारीहरूले उत्पादनकर्ताबाट खरिद गरेको धान केही समयको भण्डारण पछि ठूला व्यापारी तथा मिलवालाहरूलाई बिक्री गर्दछन् । मिलवालाले प्रशोधन गरिसकेपछिको चामल थोक व्यापारी, खुद्रा व्यापारी तथा उपभोक्ताहरूलाई बिक्रि गर्दछन् । धानमा कृषकको फार्म गेट र खुद्रा मूल्यको अन्तर मध्यम प्रकारको धानमा रू. १.५, मोटो र मसिनोमा रू. २ र बासनादार मसिनोमा रू. २.५ पाइयो । चामलको मूल्य अन्तरधानको भन्दा अलि बढी पाईयो । मोटो चामलमा मिल र खुद्रा बिक्रेताबीचको मूल्य अन्तर रू. २ देखि रू. २.३३ पाईयो । मध्यम र मसिनो प्रकारको चामलमा मिल र खुद्रा बिक्रेता बीचको मूल्य अन्तर रू. २ देखि रू. ३ पाईयो । बासनादार मसिनो चामलमा यस्तो मूल्य अन्तर रू. २ देखि रू. ६ सम्म पाईयो । धानको मूल्य अभिवृद्धी गर्ने कार्यमा मुरही (भुजा) बनाउने, चिउरा बनाउने र भुटेको चिउराको फुरनदाना बनाउने कार्यहरू पर्छन् जसबाट थप रोजगारी सिर्जना भई आय आर्जनमा वृद्धी भएको छ । मूल्य शृंखलामा आपूर्तिकर्ताहरू एग्रोभेट, कृषि औजार बिक्रेता, सहकारी, मल बिक्रेता, नार्क, जिल्ला कृषि विकास कार्यालय, राष्ट्रिय बीउ बिजन कम्पनी लि. र कृषि सामग्री कम्पनी लि. को पनि महत्वपूर्ण भूमिका रहेको छ ।

Summary

Rice constitutes around half of the total cereal grains produced in Nepal. The rice chain actors involve: farmers, small and large traders, rice-millers, wholesalers, retailers and consumers. In Nepal, rice marketing is dominated by middlemen who might be village traders, wholesalers or rice millers. Poor and small farmers sell their produce to the middlemen, right after the harvesting low price due to lack of credit and transportation facilities, market information and good warehouses. In the rice value chain, primary producers sell their produce to three types of buyers: a small trader, a large wholesaler, or a processor. In the same way a trader may sell rice to big traders or directly to processors. After processing, rice millers sell their produce to wholesalers, retailers and finally to the consumers. The price spread of raw paddy between the farm gate and retailers was found to be NRs 1.5 in medium rice, NRs 2.0 in coarse and fine rice and NRs 2.5 in fine (aromatic) rice. The price spread of milled rice was found bit higher than the raw paddy. In coarse rice, the price spread between rice millers and retailers ranges from NRs 2.0 to 2.33. In medium and fine rice, the price spread between millers and retailers ranges from NRs 2.0 to 3.0. Similarly, in fine and aromatic rice, the price spread ranges from NRs 2.0 to 6.0. Value addition in rice involves making beaten rice, puffed rice and fried beaten rice. These diversified products of rice have created employment opportunities with increased income. Input suppliers like Agrovets, Agri-machinery suppliers, cooperatives, fertilizer dealers, NARC, DADO, National Seed Company Ltd, Agricultural Inputs Company Ltd. have important roles in the rice value chain.

Keywords: Diversified products, Income, Price spread, Rice, Value chain

Introduction

Rice, amounting to about half of the total cereal grains produced in the country, is Nepal's most important crop for food security. Nepal produced 4.79 million tonnes of paddy cultivated in 1.43 million hectares in the fiscal year 2014/15 (MoAD 2015). Rice is produced mainly in the Tarai region where various government support programs including rice mission and mechanization have been focused. However, growth in rice production has been low ie 1.4% per year over the last two decades (Karn 2014). Time series data shows that rice yield increased from 1967 kg/ha to 3394 kg/ha during the twenty year period since 1984/85 witnessing a sluggish growth with undulated pattern. A value chain is a sequence of target-oriented combinations of production factors that create a marketable product or service from its conception to the final consumption (Wilson 2015). The rice chain involves and includes: farmers, small and large traders, rice millers, wholesalers, retailers and consumers. Rice has a long value chain as it involves issues like grain quality and market price during harvest, milling and storage due to which many middlemen are involved in the chain who try to explore possibilities of making individual profits. Value addition to milled rice is in practice by preparing various products according to market demand and consumers' taste.

Harvesting

Harvesting is the process of collecting the mature crop from the field and storing in the appropriate place. Paddy harvesting activities include reaping, stacking, handling, threshing, cleaning, and hauling (IRRI 2013). These can be done manually or by using various kinds of machines such as reaper, thresher, combine harvester and hauler. In Tarai condition, there is an increasing use of combined harvester for harvesting rice and wheat as well. It is important to apply good harvesting methods to maximize grain yield, minimize grain loss and reduce quality deterioration. When rice is harvested, the grain contains up to 25% moisture. High moisture level during storage can lead to grain discoloration, encourages development of molds, and increases the likelihood of pest attacks. It can also decrease the germination rate of the rice seed.

Drying and storage

In Nepal, as in other south Asian and developing countries, traditional sun drying method is common for reducing the moisture content. Sun drying normally reduces the rice grain moisture from 25% to 10-11% within five to six sunny days. However, sun drying tends to be labor intensive and risk prone in changing weather conditions. Temperature control is not possible in this method and grain can easily overheat causing cracked grains, which lead to low milling quality.

The purpose of any grain storage facility is to provide safe storage conditions for the grain in order to prevent grain loss caused by adverse weather, moisture, rodents, birds, insects and micro-organisms like fungi. In general, it is recommended that rice for food purposes be stored in paddy form rather than milled rice as the husk provides some protection against insects and helps prevent quality deterioration. In Nepal, the estimated storage loss of rice commonly ranges from 10-15%, however, there is no authentic data about this storage loss.

Farm gate price and retail price of paddy

Fine and aromatic rice fetches higher price compared to other mediums and coarse type paddy (**Table 1**). It was due to low production but higher market demand caused by aroma and taste preference of the consumers. The highest price spread is found in fine and aromatic rice followed by fine (non aromatic), coarse and medium type rice.

Table 1. Average farm gate and retail price of paddy

SN	Paddy Type	Farm gate price	retail Price	Price spread
1	Medium	22.5	24.0	1.5
2	Coarse	20.0	22.0	2.0
3	Fine and aromatic	37.5	40.0	2.5
4	Fine (Non aromatic)	33.0	35.0	2.0

Source: Rice market survey in Sunsari district, 2016.

Average price of miller, retailer and consumer for different types of milled rice

The average price of the milled coarse rice increases by NRs 2 when it reaches the wholesaler and by NRs 2.33 when reaches the retailer. In case of medium type and fine type, the price of milled rice increases by NRs 2 at the wholesale level and by NRs 3 at the retail level. In case of fine and aromatic type, it increases by NRs 3 at the whole sale level and by NRs 6 at the retail level. It is interesting to note that the price of fine and aromatic type is about 50% higher than the fine (non aromatic) type. The average price of coarse type rice is less than half of the fine and aromatic type (**Table 2**).

Table 2. Average price of milled coarse, medium, fine and aromatic and fine

SN	Agent	Unit NRs/kg			
		Coarse rice	Medium rice	Fine and aromatic	Fine
1	Rice milled price	38.0	49.0	93.0	62.0
2	Wholesaler price	40.0	51.0	96.0	64.0
3	Retailer/Consumer price	42.33	54.0	102.0	67.0

Source: Rice market survey in Sunsari district 2016.

The average mill gate prices of rice bran, rice husk and broken rice are substantially high (**Table 3**) due to their multiple uses. Rice bran is used for livestock feed whereas husk is used as bedding material for poultry or fuel for various purposes. Broken rice is used in beverage preparation, feeding to poultry or home consumption after grinding it. In village, farmers usually go for traditional rice milling where they get milled rice that is mixed with bran and husk. After cleaning the milled rice, rice bran and ground husk are fed to livestock. In modern rice mill, there are separate outlets of rice bran, rice husk and milled rice.

Table 3. Average retail price of rice bran, husk and broken rice

SN	Rice product	Average price (NRs/kg)
1	Rice bran	24.0
2	Rice husk	5.0
3	Broken rice	27.0

Source: Rice market survey in Sunsari district 2016.

As a modern practice, broken rice is packaged in poly bag and branded for marketing. It has substantial demand in market for its multiple uses.

Marketing

In Nepal, rice marketing is dominated by the middlemen such as: village traders, wholesalers and rice millers. Poor farmers sell their produce to the middlemen, right after harvest, on their offer price due to immediate need of money and lack of storage facilities. Due to the lack of market information, good warehouses, transportation and credit facilities, farmers are compelled to sell their produce to the middlemen immediately after harvest at a low farm gate price. The middlemen later obtain high prices by floating in the markets and they are always blamed for taking higher profit margin. Rice millers, as middlemen, are one of the key players in rice marketing. They collect paddy from farmers, village traders, wholesalers and cooperatives. Market demand for rice is ever increasing in Nepal as the food habit of hill people is shifting towards rice. Most of the people in hilly region no more consume locally produced staple food such as corn and finger millet. As the household cash income is increasing mainly due to remittance, rice demand in rural markets has been fulfilled by importing and supplying the different brands of rice from India. Due to almost stagnant rice production over the years and increasing demand for rice in domestic market, rice import reached 25 billion rupees in the year 2014/15. Government of Nepal has taken various initiatives for increasing domestic production of rice by introducing direct and indirect subsidy policies in the Tarai.

For spring rice, the government has declared in its policy to provide five thousand rupees per hectare to the rice farmers who follow the practice of row transplant and additional five thousand rupees per hectare in the production.

Figure 1. Raw rice collected in a rice mill, Sunsari Goyal Rice Mill, Sunsari

There are many popular varieties including local cultivars, which fetch relatively higher price as compared to others. However, a few popular cultivars are less marketable as these are produced in confined areas with small volume. A good example of such cultivar having higher price but less marketability is a local cultivar namely Kalonunia in Jhapa. Due to low market volume of this rice, rice millers and other intermediaries usually do not buy this rice from farmers.

Nepal's rice import

Nepal's rice import increased by more than 4 times from 144042 tonnes in 2010 to 607690 tonnes in 2014 (**Table 4**). Rice Import continuously rises with the growth rate of 80.47% per annum, which also contains hybrid seeds from India and China. Rice imports from India remain more than 95% of total volume of transaction.

Table 4. Nepal's rice import from different countries (tonnes)

Year/Country	India	China	USA	Others	Total	Share of India%
2010	137564	20	6393	65	144042	95.50
2011	175985	147	8137	5	184274	95.50
2012	444666	202		7611	452479	98.27
2013	384401	122		14	384537	99.96
2014	607233	154		303	607690	99.92
Trend %	85.35	167.50	-25.00	91.54	80.47	

Source: ITC 2015.

Diversified products of rice

Beaten rice is popularly known as *Chiura* in Nepal. It can be taken in different forms like raw, fried, or with curd or milk. Beaten rice is made from paddy of different varieties. Most of the coarse varieties like Radha-12, Kanchi Masuli, Sona masuli, Swarna masuli and Chaite (Spring) rice are used to make beaten rice in Nepal. The average beaten rice recovery percentage is found to be 55-65%. Radha-12 gives the highest recovery percentage (62-65%) with higher quality, whereas *Chaite* (Spring) rice gives lower recovery percentage (55-60%) with lower quality. The average percentage of broken rice and husk are 6-7% and 20-25% respectively. Three types of beaten rice are found in the market: local (coarse type), special (fine) and fried beaten rice. The average miller's price of the beaten rice is found to be NRs 32-34, 38-40 and 52-54 per kg for local, special, and fried respectively. Fried beaten rice is mixed with other ingredients like peanut, potato chips, *bhujia* and spices to make a new product. *Furandana* that fetches higher price is a popular snack now-a-days among the new generation in Nepal. A packet of *furandana* (700 g) has a market price of 145 rupees, however, the price may vary based on their quality and brands.

Figure 2. Paddy soaking in water to prepare beaten rice beaten rice after processing

Puffed rice, known as *murhi* or *bhuja* is very popular in Nepal for cereal breakfast or consumed as alight food. It is a product from paddy rice as well as milled rice. In Nepal, most of the puffed rice millers import milled rice from India. The market price of puffed rice ranges from 55 to 60 rupees per kg based on the quality and brands.

Figure 3. Branded puffed rice after processing

Figure 4. *Furandana* made from fried beaten rice

The puffed rice recovery percentage from paddy and milled rice are found to be 55-57% and 85-87% respectively. The average miller's price of puffed rice ranges from NRs 52 to 58 per kg.

Value chain map of rice

The value of the product increases at each stage until it reaches the consumer in the value chain map. In rice value chain, primary producers may sell their rice in three ways: to a small trader, to a large trader, or to a processor. A trader may similarly sell to another trader, or directly to wholesaler, retailer or processor. Rice millers may buy rice directly from farmers or from traders, and sell the products to wholesalers or retailers and consumers. Every stage of the value chain relies on goods and services in order to reach its final stage. At various stages, goods and services include land, labor, machinery, input supplies, transport, energy and finance. The value chain map of rice shows the major functions, actors, and their relationship in rice marketing (**Figure 1**). The rice value chain is characterized largely by informal market system. A large number of market actors are involved in the value chain. Large traders and rice millers play a dominant role in this chain. They have the ability to buy large quantities of rice and store them for a long period of time. After milling, it is packed and marketed with different brands. There are different brands of basmati (fine and aromatic), medium and coarse type rice. Rice millers give different names to different varieties of rice.

Input suppliers

Farmers receive inputs required for rice production from local and district level input suppliers. Agro-vets, Agri- machinery dealers, cooperatives, fertilizer dealers, NARC, DADO, National Seed Company Ltd., Agricultural Inputs Company Ltd. are major input suppliers in the rice value chain. They supply inputs (seeds, fertilizers, pesticides, agricultural tools) and also provide technical advice to farmers. Seed is one of the important inputs in the rice value chain.

NARC and some DoA farms are involved mainly in early generation seed production (breeder and foundation seed). For later generation of commercial seed production, there are three prominent actors that include seed companies, cooperatives and Community Based Seed Production (CBSP) groups, which are mostly active in some Tarai districts.

Producers

Commercial production of paddy is concentrated in the Tarai region. Rice production is highest in Jhapa district followed by Rupandehi and Morang. The Tarai covers 68% of the total rice area in Nepal followed by hills (28%) and mountain (4%) (MoAD 2014).

Farmers grow different varieties of rice depending on land type (eg lowland or upland), access to seeds and their taste. After rice harvest, farmers usually keep some quantity for home consumption and sell the remaining quantity in the market. Some farmers use local storage facility and sell later at a higher price. Farmers generally sell their produce to small traders in village market or to large traders in district level market whereas some farmers sell directly to small rice millers. In most cases, small farmers do not have storage facility and sell their paddy at farm gate. There are no strong farmer groups, which can influence in market price determination.

Collectors: Small and large traders

Most of the small traders are permanent residents of their collection areas. In some cases they are also rice producers. They sell paddy to large traders and large millers as well as wholesalers/small millers. Small and large traders also provide loan to rice farmers with high interest rate. Large traders sell majority of their volume to large millers while a very small amount to wholesalers/small millers.

Processors

Large millers as well as small millers are the major actors for rice processing and marketing. Small millers can be found at the local level near village and village markets whereas large millers are usually found in towns and near to district headquarters. They perform various functions such as: drying, grading, storage, cleaning, husking, paddy separation, polishing, grading, weighing, packaging and branding. Of the total volume, they process: 66% is produced as white rice, 6.16% as bran, 25.16% as husk and 2.66% as broken rice. After Processing, they pack the products in poly bags and give different brand names. Rice recovery percentage depends on variety, moisture content, post-harvest handling, type of milling and storage time (APMDD 2013). Rice millers import Jeera Masino and fine quality rice from India.

Wholesaler

Wholesalers buy rice from large millers and sell it to retailers within and outside their respective districts. Wholesalers also directly sell to the final consumers. They perform transactions of large volume in big markets of Nepal and function as intermediary between millers and retailers.

Retailers

Retailers buy rice from large millers as well as small millers and sell in smaller quantities to the final consumers. They sell the milled rice to local people and their volume of transaction is relatively small. Retailers are usually the local residents and shop keepers, who also deal with other commodities.

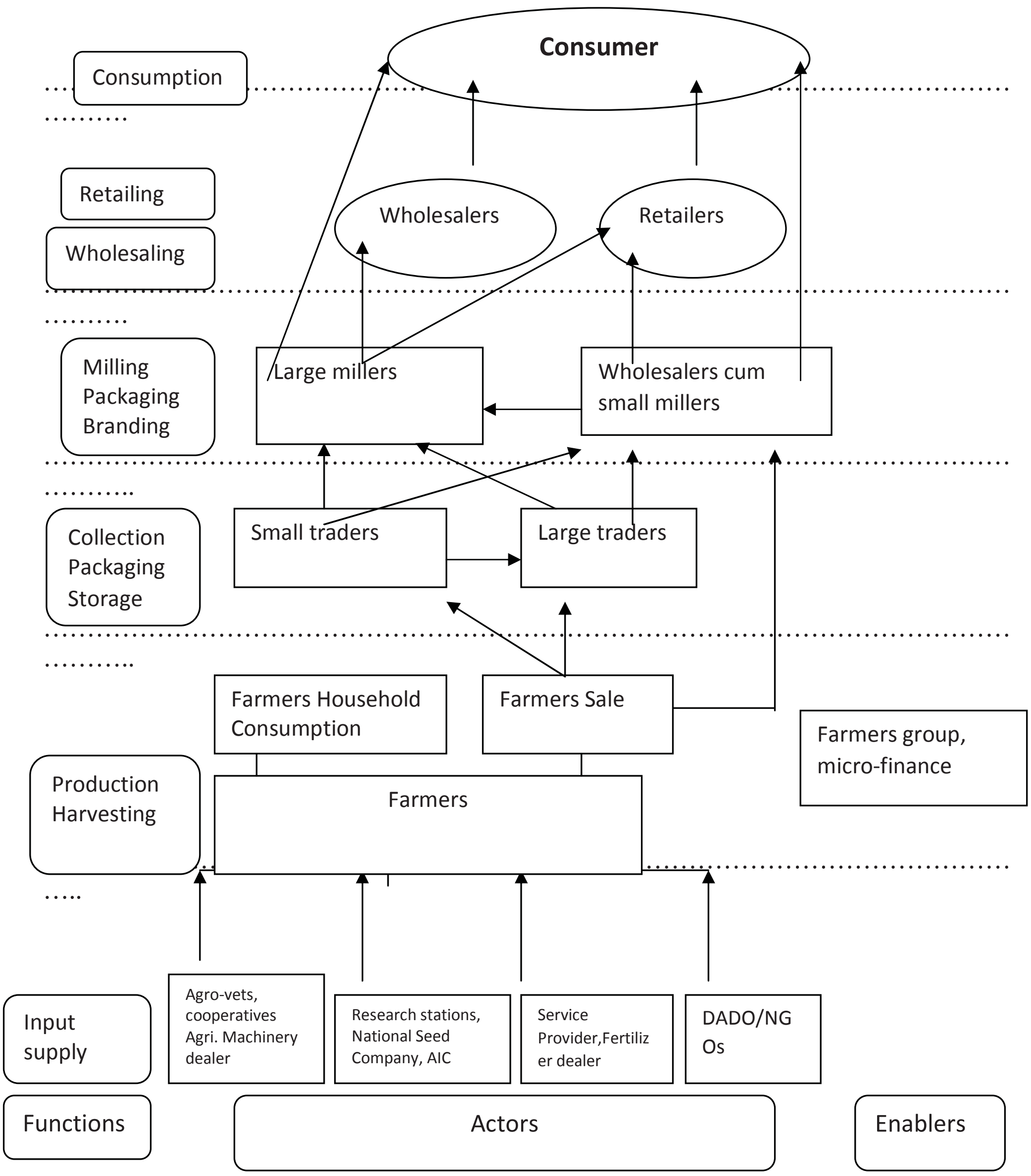

Figure 4. Value chain map of rice in Nepal

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Benefit Cost Analysis of Paddy in Different Ecological Zones of Nepal

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सारांश

उत्पादन लाभ र लागत बीचको तुलनाले उपयुक्त नीति निर्माणको साथै कृषि व्यवसायलाई जीवन्त राख्न सहयोग गरेको हुन्छ । विभिन्न बालीहरूको लाभलागत सम्बन्धी तथ्याङ्कको सहायताले कृषकलाई उपयुक्त बाली र व्यवसायको छनौटमा मद्दत गर्दछ । यो अध्ययन विगतमा बजार अनुसन्धान तथा तथ्याङ्क व्यवस्थापन कार्यक्रमबाट प्रकाशित लाभलागत अध्ययन सम्बन्धी तथ्याङ्कमा आधारित रहेको छ । लाभ लागत अध्ययन योजना निर्माण तथा बाली बीमाको लागि महत्वपूर्ण औजारको रूपमा रहेको छ । तराई क्षेत्रमा वि.सं. २०३२ देखि २०७१ सम्ममा धान बालीको लागत रू. ३,३३०.७५ बाट रू. ६८,२८९.८६ प्रति हेक्टर पाइएको छ भने कूल आम्दानी रू. ५१३०.७२ बाट रू. ८००८३.२४ प्रति हेक्टर पाइएको छ । धानको उत्पादन लागत प्रति किलोग्राम रू. ४.१५ बाट रू. १५.९६ पुगेको छ । यस अध्ययनबाट धान बालीको खुद आम्दानी तराईमा भन्दा पहाडमा बढी पाइएको छ । हालसम्मको ३८ वर्षको तथ्याङ्कले धान बालीको लाभ लागत अनुपात एकभन्दा केही बढी पाइएको छ ।

Summary

Comparing the benefit and cost of different crops are necessary to devise national policies for making the farm production viable. Data on cost of production can help farmers in their decision making process during the selection of profitable crops. This paper is prepared based on the secondary data. The data used for the analysis is taken from the previous 38 years of publications from market research and statistics management program of Department of Agriculture, Nepal. The cost and income from paddy production is vital for planning and serves as the basis for crop insurance. Total cost of paddy production was NRs 3,330.57 in 1974/75 but has increased to NRs 68,289.86 per hectare (Tarai) in 2013/14. The trend of gross income from paddy is NRs 5,130.72 per hectare in 1974/75 to NRs 80,083.24 per hectare in 2013/14. The production cost per kg of paddy has increased from NRs 4.15 to 15.96. The results showed that the net profit gained from paddy production was lower ie NRs 1800.15 in Tarai and NRs 2919.12 in the hills in 1974/75. The results showed the the benefit cost (b/c) ratio of paddy to be slightly greater than one.

Keywords: Benefit, Cost, Cost of Production, Gross Income, Price, Rice

Introduction

Profitability of the farm business is a pre-condition to attract farmers for increasing the agricultural production in the country. Comparing the costs and benefits of different crops is necessary during formulation of national policies for making the farm production viable. For judging the profitability of crop production and recommending policy measures for market interventions, sound information on the costs of production, yield rate and farm gate prices are necessary. Cost of production is an aggregate of fixed and variable costs incurred in crop production. Data on cost of production can help farmers in their decision making process during the selection of profitable crops. Farmers get knowledge of profitability in growing different crops suited to different agro climatic conditions by comparing the cost of production of different crops as well as other farming activities. Benefit cost ratio (B/C ratio) is the ratio of the output value including by-product and total cost of production on per hectare basis. If the value of B/C ratio is one, the farm business is neutral ie there is no profit or loss from production. Similarly, if the value of B/C ratio is greater than one, the farm business is profitable and vice versa.

The main objective of this paper is to analyse the trend of cost and gross income from paddy farming. This paper compares the cost of production, gross income and farm gate prices of paddy between the hilly and the Tarai region. This paper is prepared based on the secondary data. The data used for the analysis is taken from the reports from the past 20 years on cost of production gathered from market research and statistics management program and a recent publication on time series analysis of cost of production of cereal crops. This study compares the benefit cost (B/C) ratio among the ecological zones. Due to lack of data on paddy production in the mountains, this paper is unable to compare the benefit cost ratio of paddy in three ecological zones, and therefore it focuses mainly on the hills and the Tarai.

The cost and income from paddy production is vital for planning and serves as a basis for crop insurance. The four main factors of production: land, labor, capital and management are included for cost of cultivation calculation. The cost of production includes the fixed cost and the variable cost. Among the variable cost are: human labor and bullock/tractor cost, seed cost, manures and fertilizer cost, irrigation cost, plant protection cost, harvesting cost, interest, land leasing cost, management cost and miscellaneous cost. The fixed cost includes land tax, water tax, and depreciation of machineries. The gross income includes the income from main product and by-product. The benefit cost ratio would differ in different conditions of farming like irrigated and rain-fed conditions, use of local and improved varieties, System of Rice Intensification (SRI), seed production and hybrid production.

Trend analysis of paddy cultivation in different ecological zones from 1993/94 to 2013/14

The results showed that the trend of production cost of paddy was increasing from 1974/75 to 2013/14. The total cost was higher in the hills compared to the Tarai in the recent years but it was the opposite in the past. Total cost of paddy production was NRs 3,330.57 per hectare in 1974/75 and has increased to NRs 68,289.86 per hectare (Tarai) in 2013/14 (**Table 1**). Total cost has increased by around 1950.1% within the period of 38 years (1974/75 to 2013/14). The main reason behind the increment of the cost is the increase in price of the inputs used for paddy production like: labor, seed, fertilizer etc. Human labor and bullock/tractor shared around 60-65% of the total cost of production.

Table 1. Trend of total cost of production of paddy 1974/75-2013/14

Year	Tarai	Hill	National
1974/75	3330.57	3190.12	3260.35
1985/86	7641.85	7106.84	7374.35
1993/94	12760.32	10730.65	12187.30
1994/95	10488.69	9491.88	10183.00
1995/96	12556.75	13768.50	13058.50
1996/97	15589.47	18421.33	16890.50
1997/98	17031.02	19209.99	17420.70
1998/99	17762.06	18620.93	18615.70
1999/00	17826.11	27181.22	21537.10
2000/01	17954.83	35836.24	24540.20
2001/02	18841.71	22102.87	20473.50
2002/03	22484.74	31002.86	25673.40
2003/04	22879.32	28502.83	25691.08
2004/05	23206.06	23011.76	23108.98
2005/06	22259.31	20684.75	21472.03

Year	Tarai	Hill	National
2006/07	21370.72	25297.76	22710.50
2007/08	23624.75	25798.38	24711.57
2008/09	25377.76	26260.53	25453.30
2009/10	28611.59	30197.57	30056.90
2010/11	33189.6	40395.98	36939.80
2011/12	44424.76	54491.15	49079.60
2012/13	61006.79	58349.00	60154.40
2013/14	68289.86	67369.40	71132.30

Source : MRSMP 2014.

Trend of gross income (NRs/ha) from paddy production per hectare 1974/75-2013/14

The data showed the trend of gross income from paddy production is also increasing like the cost of production, from NRs 5,130.72 per hectare in 1974/75 to 80,083.24 per hectare in 2013/14. Until 2008/09, the gross income was found to be higher in hills in comparison to Tarai. But the gross income from paddy was higher in the Tarai than in the hills after 2008/09 (**Table 2**). The gross income from paddy production was much more in the hills compared to the Tarai. It is due to the higher farm gate prices of paddy in the hills compared to Tarai. Most of the farmers produce paddy for home consumption in hilly areas rather than for sale like in the Tarai.

Table 2. Trend of gross income from paddy production 1974/75-2013/14 (NRs/ha)

Year	Tarai	Hill	National
1974/75	5130.72	6109.24	5619.98
1985/86	9416.53	9604.43	9510.48
1993/94	13835.69	18766.84	16157.00
1994/95	13590.25	14547.41	13890.30
1995/96	15980.14	19802.38	17891.26
1996/97	18565.25	27085.78	21087.80
1997/98	19752.4	26532.06	21377.70
1998/99	21254.51	26055.41	22616.30
1999/00	24300.68	29843.59	26124.10
2000/01	23468.69	38214.81	29092.60
2001/02	24242.36	30174.59	26458.60
2002/03	28067.25	43904.95	32595.90
2003/04	27108.29	35403.86	31256.08
2004/05	30719.09	28101.41	29410.25
2005/06	39496.46	35954.4	37725.43
2006/07	48080.34	60481.28	51230.00
2007/08	49010.74	57890.14	53450.44
2008/09	52991.29	50680.89	52109.20
2009/10	58188.34	54907.69	56707.10
2010/11	54479.45	52351.08	53435.40
2011/12	61623.86	59549.19	61543.20

Year	Tarai	Hill	National
2012/13	65757.67	60528.44	65556.20
2013/14	80083.24	80944.71	80722.7

Source: MRSMP 2014.

Trend of production cost per quintal of paddy 1993/94-2013/14

The production cost per quintal of paddy was in increasing trend expect in the period from 2004/05-2009/10 (**Table 3**). The production cost per quintal of paddy has increased from NRs 415.48 to 1596.37 in 38 years. The production cost per quintal in hill was higher than in Tarai in 1974/95 and lower in 2013/2014. Tarai is suitable for mechanization compared to hills and farmers are using tractors to plough and harvest. Therefore, tractor replaces the bullock labor. Mechanization decreases the production cost by 40% (MRSMP, 2012). The reason behind low cost per quintal is the use of mechanized tools in cultivation and harvesting. The production cost per kg of paddy was NRs 1.82 in 1974/75 while it is NRs 17.40 now.

Table 3. Trend of production cost per quintal and kg of paddy 1993/94-2013/14

Year	Tarai	Hill	National (NRs/Qtl)	National (NRs/kg)
1974/75	178.48	185.26	181.87	1.82
1985/86	276.37	293.68	285.03	2.85
1993/94	415.48	473.19	445.70	4.46
1994/95	401.14	447.43	442.00	4.42
1995/96	455.63	486.66	471.15	4.71
1996/97	520.57	508.74	573.80	5.74
1997/98	525.04	576.44	622.60	6.23
1998/99	576.60	590.30	676.90	6.77
1999/00	594.94	630.35	724.80	7.25
2000/01	630.45	673.08	739.20	7.39
2001/02	656.49	711.46	704.80	7.05
2002/03	686.13	770.19	714.70	7.15
2003/04	706.82	738.24	722.53	7.23
2004/05	549.21	582.35	565.78	5.66
2005/06	534.75	541.28	538.02	5.38
2006/07	488.51	424.30	416.00	4.16
2007/08	523.48	578.92	551.20	5.51
2008/09	623.68	608.69	563.20	5.63
2009/10	666.09	672.39	606.30	6.06
2010/11	815.91	915.96	938.10	9.38
2011/12	1059.80	1142.96	1216.80	12.17
2012/13	1475.79	1401.21	1538.10	15.38
2013/14	1596.37	1555.84	1740.10	17.40

Source : MRSMP 2014.

Trend of net profit (NRs/ha) from paddy production 1993/94-2013/14

The results showed the net profit gained from paddy production was lower ie NRs 1800.15 in the Tarai and NRs 2919.12 in the hills in 1974/75 (**Table 4**). The net profit gained from paddy was increasing with greater fluctuation over the years. The net profit from paddy production was more during 2006/07 to 2009/10. The net profit was in decreasing trend during 2009/10 to 2013/14. It could be due to low farm gate prices of paddy compared to input prices.

Table 4. Trend of net profit from paddy production 1993/94-2013/14 (NRs/ha)

Year	Tarai	Hill	National
1974/75	1800.15	2919.12	2359.63
1985/96	1774.68	2497.59	2136.13
1993/94	1075.36	8036.19	3756.90
1994/95	3101.55	5055.53	3942.50
1995/96	3423.39	6033.88	4832.76
1996/97	2975.78	8664.45	6345.30
1997/98	2721.38	7322.07	6306.60
1998/99	3492.45	7434.49	6546.90
1999/00	6474.57	2662.37	8437.80
2000/01	5513.86	2378.57	7275.70
2001/02	5400.65	8071.72	5440.90
2002/03	5582.51	12902.09	8449.90
2003/04	4228.97	6901.03	5565.00
2004/05	7513.03	5089.65	6301.27
2005/06	17237.15	15269.65	16253.4
2006/07	26709.63	35183.52	30692.20
2007/08	25385.99	32091.76	28738.87
2008/09	27613.53	24420.36	27088.10
2009/10	29576.76	24710.11	26880.20
2010/11	21289.85	11955.10	17446.90
2011/12	17199.09	5058.04	13525.30
2012/13	4750.89	2179.44	8975.40
2013/14	11793.38	13575.30	8015.70

Source: MRSMP 2014.

Farm gate price (NRs/kg) of paddy

The data of farm gate prices of paddy in the Tarai was found lower than in the hills. The reason might be: better taste, flavor and long straw produced by local varieties than the commercial hybrids. Produced in the hilly region is generally used for home consumption rather than sale in the market. The farm gate prices of paddy in the hills and the Tarai was NRs 19.96 and 19.93 respectively in 2013/14 while they were NRs 1.98 and 2.24 per kg in 1985/86 (**Table 5**).

Table 5. Trend of farm gate price of paddy (NRs/kg)

Year	Tarai	Hill	National
1974/75	1.68	1.98	1.82
1985/86	1.98	2.24	2.11
1993/94	5.73	6.45	6.00
1994/95	5.72	6.42	5.90
1995/96	6.28	7.56	6.92
1996/97	6.85	8.20	7.30
1997/98	7.33	9.11	7.80

Year	Tarai	Hill	National
1998/99	8.11	8.90	8.40
1999/00	8.83	9.28	9.00
2000/01	8.69	9.90	9.10
2001/02	8.75	10.10	9.30
2002/03	8.75	10.75	9.40
2003/04	5.68	7.24	6.46
2004/05	5.29	6.92	6.11
2005/06	5.02	6.26	5.64
2006/07	10.02	10.28	10.20
2007/08	11.15	11.56	11.36
2008/09	12.04	12.11	12.10
2009/10	12.21	12.54	12.30
2010/11	14.06	13.99	14.00
2011/12	15.09	15.26	15.80
2012/13	16.26	15.69	16.90
2013/14	19.93	19.96	19.90

Source: MRSMP 2014.

Trend of benefit cost ratio of paddy 1993/94 to 2013/14

Enterprise with the B/C ratio more than one is generally considered to be earning the profit. The B/C ratio was found greater than one and was found fluctuating from 1993/94 to 2013/14. In some years, the B/C ratio was found above two, which means the benefit was double the cost of production.

Table 6. Trend of benefit cost ratio of paddy per hectare

Year	Tarai	Hill	National
1993/94	1.08	1.75	1.24
1994/95	1.30	1.53	1.30
1995/96	1.15	1.44	1.30
1996/97	1.19	1.47	1.25
1997/98	1.16	1.38	1.23
1998/99	1.20	1.40	1.21
1999/00	1.36	1.10	1.21
2000/01	1.31	1.07	1.19
2001/02	1.29	1.37	1.29
2002/03	1.25	1.42	1.27
2003/04	1.13	1.07	1.10
2004/05	1.19	1.24	1.22
2005/06	1.27	1.39	1.34
2006/07	2.25	2.39	2.26
2007/08	1.80	1.94	1.86
2008/09	2.09	1.93	2.00
2009/10	2.03	1.82	1.89
2010/11	1.64	1.30	1.45
2011/12	1.39	1.09	1.27

Year	Tarai	Hill	National
2012/13	1.08	1.04	1.09
2013/14	1.17	1.20	1.13

Source: MRSMP 2014.

Conclusion

This paper analyzes the benefit cost ratio in paddy cultivation. The results showed that the paddy cultivation is profitable because the b/c ratio of paddy is greater than one. Net profit gained from paddy was much lower than other commercial vegetables/crops. The farm gate prices of paddy in the hills was found higher compared to the Tarai. Most of the farmers in the hills grow local paddy for quality and aroma. They generally do not sale paddy in market. This in fact, has resulted in higher price of paddy in hills in comparison to Tarai. Mechanized tools and machineries can reduce the cost of production and increase the income level of farmers. During the rainy season, the land in the Tarai is covered by rain water and unfit for vegetables and other cereal production. The area for paddy cultivation during rainy season is almost utilized. So, we should attempt and plan for spring season paddy ie *chaite (*spring) paddy. The cost of production study and its final report is very useful because it is the basis for crop insurance and business plan in the future.

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Market Price of Paddy in Nepal: A Time Series Analysis, 1966 – 2014

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सारांश

कृषक तह मूल्य भन्नाले कृषकले कृषक थलोमा प्राप्त गरेको मूल्य भन्ने बुझाउँछ भने थोक मूल्य भन्नाले खुद्रा व्यापारीले थोक बिक्रेतालाई तिरेको मूल्य भन्ने बुझाउँछ । खुद्रा मूल्य भन्नाले उपभोक्ताले कुनै कृषि उपजको लागि तिरेको मूल्य बुझाउँछ । सामान्यतया, कुनै पनि कृषि उपजको माग र आपूर्ति जस्ता बजारका तत्वहरूले मूल्य निर्धारण गर्दछन् । कृषक एक्लैले उत्पादन, बजारीकरण, बिक्रेता जस्ता भूमिका निभाउन प्रायः असम्भव जस्तै हुन्छ । जसले गर्दा कृषि उपजलाई कृषकको खेतबारीबाट उपभोक्ताको भान्सासम्म पुर्‍याउन मध्यस्थकर्ता तथा व्यापारीहरूको भूमिका महत्वपूर्ण हुन्छ । धान तथा चामलको मूल्य प्रवृत्ति अध्ययन प्रकाशित पुस्तकहरूको तथ्याङ्कमा आधारित रहेको छ । इ.सं. १९६६ मा मोटा धान र चामलको मूल्य रू ०.९ तथा रू १.०५ प्रति किलोग्राम थियो भने इ.सं. २०१४ मा क्रमशः रू १९.९४ तथा रू ४२.८३ प्रति किलोग्राम पुगेको छ । यो ४९ वर्षको अवधिमा मोटा धानको मूल्य २११५.५% ले र चामलको मूल्य ३९७९.१% ले वृद्धि भएको देखिन्छ । ४९ वर्षको अवधिमा धानको मूल्य वृद्धिदर चामलको तुलनामा निकै कम रहेको पाइएको छ ।

Summary

Farm gate price is the price received by farmers by selling his produce. Wholesale price is the price paid by retailers while retail price is the price paid by consumers to get produce. The price is set by market forces, demand and supply. A farmer cannot play all the roles like: to produce, to transport up to market, to sell to consumer. The middleman/traders play as a bridge between farmer and consumer. The market and the middleman play key role to deliver produce from farmers' field to the hand of consumer. The price trend of coarse and fine paddy was analyzed through the data from secondary sources. The price of coarse paddy and rice was NRs 0.90/kg and 1.05/kg in 1966 while it reached to NRs 19.94/kg and NRs 42.83/kg in 2014. The price of coarse paddy increased by 2115.5% while the price of coarse rice increased by 3979.1%. The growth rate of price of coarse paddy was lower compared to rice in the period of 49 years.

Keywords: Coarse and fine rice, Demand and supply, Farm gate price, Growth rate, Market price, Rice

Introduction

The price is the economic value of any produce. Cost and price are two different terms. The amount of money you paid to produce a product is cost while the amount of money you paid to get a product is price. The prices are three types. Farm gate price is the price received by farmers by selling his produce, wholesale price is the price paid by retailers while retail price is the price paid by consumers to get produce. Generally, the price is set by market forces like demand and supply. A farmer cannot play all the roles like to produce, to transport up to market, to sell to consumer. The middleman/traders play as a bridge between farmer and consumer. The middleman/traders add value to the produce and sell to consumers according to their choice. In our marketing system, the marketing channel is quite long ie involvement of more agents and both parties' farmers get less profit but the consumer has to pay higher price. So, the involvement of middleman/agents should be minimized and farmers should get more profit and consumer has to pay reasonable price the produce. Most of the farmers are compelled to sell their produce right after harvesting due to lack of storage facilities, credit condition and main source of income.

The main objective of this paper is to analyze the trend of price (farm gate and retail) of the paddy before and after processing. This paper features the profit from paddy production and price growth rate and trend since 1966 AD (2022 BS). Price trend analysis is done based on the secondary data. The data used for the analysis is taken from the previous 49 years reports from Agribusiness promotion and marketing development directorate (ABPMDD 2015 and Mallick 1981). This study compares the farm gate price of paddy at raw form and retail price after milling.

National Farm gate price trend of paddy

The results showed the increasing trend of farm gate price of paddy from 1966-2014 (2022-2071 BS). Farm gate price of coarse paddy was NRs 0.90 and NRs 19.95 per kg in 2014 and 2014 respectively (**Table 1**). Farm gate price of paddy increased by 227.5% since 1995 (2052 BS). The farm gate price of paddy increased every year by 8.5%% which is very low as compared to labor price and seed price (MRSMP 2014 and Mallick 1981). The reason behind the low increment in farm gate price is that the farmers are the unable to fix their product price and the price is fixed by traders. The farmers are unable to get reasonable price of their produce due to lack of minimum support price announcement from government side.

Table 1. Trend of national average farm gate price of Paddy 1966-2014 (2022-2071 BS)

Year (BS)	Year (AD)	Average National farm gate price (NRs/kg)
2022	1966	0.90
2023	1967	1.13
2024	1968	1.07
2025	1969	1.10
2026	1970	1.20
2027	1971	1.31
2028	1972	1.26
2029	1973	1.41
2030	1974	1.65
2031	1975	1.76
2032	1976	1.79
2033	1977	1.74
2035	1979	1.82
2045	1988	2.11
2052	1995	6.09
2053	1996	6.07
2054	1997	6.55
2055	1998	7.52
2056	1999	8.22
2057	2000	8.50
2058	2001	9.05
2059	2002	9.29
2060	2003	9.42
2061	2004	9.75
2062	2005	8.22

Year (BS)	Year (AD)	Average National farm gate price (NRs/kg)
2063	2006	7.57
2064	2007	7.04
2065	2008	10.15
2066	2009	12.07
2067	2010	12.37
2068	2011	14.02
2069	2012	15.17
2070	2013	15.97
2071	2014	19.94

Source: Market Research and Statistics Management Program (MRSMP) 2014 and Mallick 1981.

Trend of different milled rice price during 1971-2014 (2027-2071 BS)

The retail price of milled coarse rice and fine rice (Mansuli) was found NRs 1.05 and 1.14 per kg in 1966 (2022 BS) while the retail price increased every year and after 49 years, the retail price reached NRs 42.83, 69.25 and 60.57 per kg in 2014 (2071BS) respectively (**Table 2**). The growth rate of coarse rice, basmati rice and flat rice was 7.6%, 8.08% and 4.87% since 1966 respectively. The price of coarse and basmati rice increased by 1714.81% and 2615.68% respectively from 1966 - 2014 (2022 - 2071 BS). The price of basmati rice increased in higher rate than coarse rice because basmati rice is preferred by rich consumers due to its aroma while coarse rice is purchased by poor people due to low income. Besides this, the production of basmati rice was very low compared to coarse rice. The parboiled rice is the rice packed after wet with hot water which is best for diabetes patient. The demand of parboiled rice is increasing nowadays too. The price data of parboiled rice is discontinued after 1996 because the marketed volume was very small and distribution is scattered throughout the country. The price is increased if the demand is higher compared to supply. Now, the consumer choice has shifted to fine rice from coarse rice due to increased income level. The government policy should focus to promote and produce fine rice to raise the income of the producer within the country. The annual national average change of price of paddy from 1966-1976 (2022-2032 BS) was 40% with coarse paddy, 52.3% in coarse rice and 16.7% with the fine paddy and 29.3% with the fine rice.

Table 2. Trend of processed paddy (milled rice) price 1966-2014 (2022-2071 BS)

Year (BS)	Year (AD)	Coarse rice	Basmati rice	Parboiled rice	Mansuli rice	Flat rice (Tarai)
2022	1966	1.05	-	-	1.14	-
2023	1967	1.81	-	-	1.35	-
2024	1968	1.96	-	-	1.29	-
2025	1969	2.15	-	-	1.23	-
2026	1970	2.08	-	-	1.26	-
2027	1971	2.36	2.55	2.00	2.20	3.66
2028	1972	2.24	2.84	1.83	2.25	3.65
2029	1973	2.74	3.13	2.32	2.70	4.13
2030	1974	3.04	3.57	2.78	3.06	4.67
2031	1975	3.40	4.19	2.85	3.83	5.33
2032	1976	3.42	4.00	2.68	3.86	5.82
2033	1977	3.03	3.84	2.55	3.17	5.28

Year (BS)	Year (AD)	Coarse rice	Basmati rice	Parboiled rice	Mansuli rice	Flat rice (Tarai)
2034	1978	3.14	3.83	2.62	3.46	4.74
2035	1979	3.39	4.24	2.71	3.71	5.02
2036	1980	3.45	4.20	2.79	3.84	5.00
2037	1981	3.81	4.70	2.92	4.15	5.95
2038	1982	3.94	4.94	3.25	4.47	6.53
2039	1983	5.03	6.22	4.10	5.90	8.10
2040	1983	5.87	6.79	4.66	6.44	8.43
2041	1984	5.28	6.64	4.33	6.14	9.10
2042	1985	5.40	7.26	4.73	6.63	9.15
2043	1986	6.56	8.25	5.77	7.77	10.32
2044	1987	7.00	9.20	6.90	8.63	11.71
2045	1988	7.65	10.36	7.15	8.19	9.51
2046	1989	7.73	11.03	7.40	9.20	11.67
2047	1990	7.70	12.57	7.39	9.09	13.18
2048	1991	9.81	14.18	9.30	11.71	14.76
2049	1992	11.41	16.57	10.77	13.57	16.45
2050	1993	11.54	17.99	12.01	14.09	16.90
2051	1994	12.45	19.11	12.79	12.19	18.55
2052	1995	13.99	21.09	12.26	16.30	19.81
2053	1996	14.71	23.69	-	17.32	21.42
2054	1997	15.78	24.41	-	18.00	21.83
2055	1998	17.42	26.71	-	19.49	23.49
2056	1999	20.51	34.17	-	24.07	27.23
2057	2000	17.97	34.54	-	22.23	24.13
2058	2001	17.07	33.56	-	21.03	23.97
2059	2002	17.20	32.93	-	21.78	22.53
2060	2003	17.88	36.02	-	23.48	23.99
2061	2004	18.13	34.36	-	22.94	23.11
2062	2005	29.90	40.35	-	27.08	26.86
2063	2006	22.63	43.83	-	28.18	27.15
2064	2007	25.51	45.85	-	30.99	30.34
2065	2008	29.79	52.50	-	36.10	37.98
2066	2009	31.57	61.09	-	40.97	40.66
2067	2010	36.55	69.30	-	46.70	50.43
2068	2011	34.45	63.72	-	43.40	47.86
2069	2012	36.54	69.25	-	46.78	50.50
2070	2013	40.53	70.10	-	47.24	53.13
2071	2014	42.83	70.84	-	47.98	60.57

Source: Agribusiness Promotion and Market Development Directorate 2014.

The profit was found NRs 536 and 564 per 100 kg for the brown and white rice marketing respectively compared to direct grain marketing in the nearby market. The profit margin gained by trader and middleman after value addition by deducting marketing cost was found 24-25% compared to paddy marketing. If we can minimize the profit taken by trader through rice marketing up to 10% which is reasonable in case of non-perishable commodity, the remaining 15% will go to either to consumers or producers. If producers get some more profit percentage, they will be encouraged to produce more with the use of high yielding varieties and modern technology. This will ultimately benefit consumers. This will ultimately benefit the poor people of the villages and improves the food security of the rural and urban poor consumer.

Table 3. Revenue comparison between paddy and rice marketing 2013

SN	Items	For 100 kg paddy			Value addition
		Quantity	Rate	Total	
1	Paddy grain	100	22.6	2260	
Brown rice marketing					
1	Brown rice	73.15	35.77	2616.6	
2	Broken rice	4.35	20.52	89.262	
3	Rice bran	22.50	18.22	409.95	
	Total revenues			3115.8	
1	Mill charge	100	1.2	120	
2	Transportation charge			50	
3	Packaging charge			150	
	Total costs of milling			320	
	Marketing margin			2795.8	536 (24%)
White rice marketing					
1	Milled white rice	66.2	43.5	2879.7	
2	Broken rice	3.4	20.52	69.77	
3	Rice bran	5.9	18.22	107.50	
4	Husks	24.5	1.92	47.04	
	Total revenues			3104.01	
1	Mill charge	100	0.8	80	
2	Transportation charge			50	
3	Packaging charge			150	
	Total costs of milling			280	
	Marketing margin			2824.01	564 (25%)

Source: MRSMP 2013.

Conclusion

Price is the key factor to earn profit from any business. If a farmer gets more profit, he/she will continue/enlarge the business/production otherwise, stops and changes the business. The price is generally higher than the cost of production. The farm gate price of paddy increased by around 227% since 1993 while the price of milled coarse and basmati rice increased by around 1700% and 2600% respectively. The growth percentage gap between farm gate and retail price was very high. This means farmers are getting lower price of their produce and consumers are compelled to pay more price. The higher margin is taken by the middleman due to long marketing channel. Besides this, the marketing of raw paddy provided low margin than milled rice. Therefore, the government authority has to play a bridging and intervention role to support the farmers, traders and consumers. The government should announce the minimum support price every year before planting the paddy and also prepare storage if the price goes down below the declared minimum support price. This strategy would encourage the farmers to cultivate both rainy (normal) and spring (chaite) paddy. The government should encourage the storage for few months and sell to market after milling/processing or marketing through cooperatives. The government has to play a key role to fix the farm gate price and retail price in future to encourage the production by small farmers.

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Pattern of Adoption and Farm Level Diffusion of Modern Rice Varieties in Nepal

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सारांश

आधुनिक उन्नत जातहरूले उत्पादन वृद्धि, खाद्य सुरक्षा र ग्रामीण कृषकहरूको जिविकोपार्जनमा महत्वपूर्ण भूमिका खेलेको हुन्छ । यो लेखको उद्देश्य नेपालमा धानका उन्नत जातहरूको कृषकस्तरमा अनुसरण र विस्तारको वस्तुस्थितिबारे हालै गरिएको अनुसन्धानको निचोडको जानकारी गराउनु रहेको छ । यस अध्ययनमा नेपालको २९ जिल्लाहरूमा अवस्थित ११६० कृषक घरधुरी, २७० बीउ उत्पादक र २४० बीउ व्यवसायीहरूको संलग्नताबाट उन्नत जात तथा बीउहरूको उपयोग, विस्तार र बजारीकरणबारे आवश्यक तथ्यांक तथा सूचना संकलनको साथै विगत ६ दशकको सरकारी तथ्यांकको विश्लेषण गरिएको छ । उन्नत जातहरूको विस्तार १९९०-२०१० को दशकमा द्रुत गतिले र हालको वर्षहरूमा सुस्त गतिले भएको पाइयो । उन्नत जातहरूको अनुसरण र विस्तार विशेषगरी तराईमा अत्याधिक (९७%), पहाडमा मध्यम (६५%) र उच्च पहाडी भेगमा न्यून (१२%) भएको पाइयो । तर कृषक स्तरमा हाल अनुसरण र विस्तार भएका धेरै जातहरूको विश्लेषण गर्दा पुराना पुस्ताका र १९९० दशक भन्दा अगाडि सिफारिस भएको पाइयो । बजारमा बिक्रि भएका उन्नत जातहरूको सर्वेक्षण बाट केही पुराना पुस्ताका र सिफारिस नभएका जातहरूको रहेको पाइयो । तसर्थ देशको आन्तरिक धान अनुसन्धान र विकासलाई सवल बनाउन आगामी दिनहरूमा नविनतम् उन्नत जातहरूको विकास र विस्तार गरी नेपाली जनताको खाद्य सुरक्षा र जिविकोपार्जनमा सुधार ल्याउनु पर्ने देखिन्छ ।

Summary

Modern rice varieties play important role in productivity growth, improve food security and livelihoods of rural farm households. This paper aims to assess the pattern and trend of adoption and farm level diffusion of improved rice varieties in Nepal. Evidence shows that initially MV adoption was slow and gradual and then it had a period of rapid growth after 1990 to until 2010 and is becoming stable in recent years (2011-15). Farm level adoption percentage of modern varieties was found very high in the Tarai (97%), moderately high (65%) in hills and very low (12%) in mountain region. Modern varieties have shown their popularity in specific regions and domains and those adopted in the fields were mainly varieties of older generation released before 1990s. Moreover, a fair proportion of area is under informally promoted varieties and hybrids. Market share of varieties estimated from seed sales data also showed similar findings. There is a need to improve efficiency of the domestic rice R&D system to develop, release and promote newer generation of farmer preferred varieties to increase productivity, ensure food security and improve livelihoods of the people in Nepal.

Keywords: Adoption, Diffusion pattern, Domestic R&D, Market share of MVs, New generation MVs

Introduction

Modern varieties are key drivers of agricultural growth and they have played crucial role in enhancing farm level adoptions, improving food security and reducing poverty in many developing countries (Evenson and Gollin 2003, Hazel 2008). An estimated 50% of the global increase in yields over the past fifty years has been derived from genetic progress and seed quality, in addition to agronomy improvement and phyto-sanitary product uses (FAO 2011). Adoption of newer generation modern varieties (MVs) can bring benefit over older ones, if agricultural research and development programs are able to develop, release and deliver varieties regularly and rapidly in the farmers' fields. This requires continuous replacement of older varieties with the more new and improved ones that have desired adaptability, maturity, yield superiority and preferred grain quality needs of the producers and consumers. A rapid rate of variety replacement rate (VRR) with improved high yielding varieties in farmers' fields leads to higher returns in public plant breeding research by reducing lag between variety release and adoption by the farmers (Brennan and Byerlee 1991).

Until 2014, the country has released and registered 91 modern varieties including hybrids for cultivation in different regions and domains of Nepal (SQCC 2015). As a result, a large proportion of rice area is covered by improved varieties. About 92% of the rice area is covered by these improved variety seeds (MoAD 2014). A most recent information from Crop Development Directorate (CDD) of MoAD indicates that area covered by high yielding improved varieties is 89.8% accounting 82.4% for improved rice varieties and 7.4% for hybrids (CDD 2015). However, information is scant about the farm level recent adoption trends and patterns of high yielding modern varieties (MVs) including those of the newer generation of MVs in Nepal.

Trend of rice MV adoption and diffusion

In the last 6 decades of rice research, several rice varieties were released, registered, promoted and adopted in the different parts of the country. The analysis of official aggregate data of adoption and diffusion trend of rice MVs over the last 55 years shows a sigmoid pattern of diffusion in Nepal (**Figure 1**). The adoption of MVs was slow and gradual in the beginning (1965-1990) and then it had a period of rapid growth after 1990 to until 2010 (91%) and becoming stable in recent years (2010-2014). Based on the official statistics of the Government of Nepal, the overall aggregate adoption of modern rice varieties in 2014 in Nepal was 92.48% (MoAD 2014). In the next few years once it reaches the plateau, it may eventually start declining. This sigmoid pattern is similar to the one hypothesized by Rogers (1995). CH-45 was the first officially released modern rice variety in 1959 followed by the Taiwanese varieties (Taichung-176, Chainung-242, Chainan-2 and Tainan-1) in 1967 and IR-8 from IRRI in 1968. These MVs were first planted on a significant area in Nepal in 1968-69, but slowed their spread gradually covering not more than 10% of the area until 1972-73 (Herdt and Capule 1983). The area under MVs gradually increased with the release of Mansuli in 1973 which remained a most popular rice variety until the late 1990s. By 1980 it was estimated that MVs may have covered 30% of Nepal's rice area, but the rate of increase was still slow (Herdt and Capule 1983). According to Upadhaya and Thapa (1994), modern varieties had covered about 40% of the area by 1990. After middle of 1990s, the area coverage of MVs increased rapidly due to development, release, seed multiplication and formal sector dissemination of seeds of promising varieties. The adoption and diffusion of MVs was triggered rapidly by the promotion program carried out by the National Rice Improvement Program since its establishment in 1972 through minikits distribution and by the Department of Agriculture through extension demonstration and dissemination in late 1970s to 1990s.

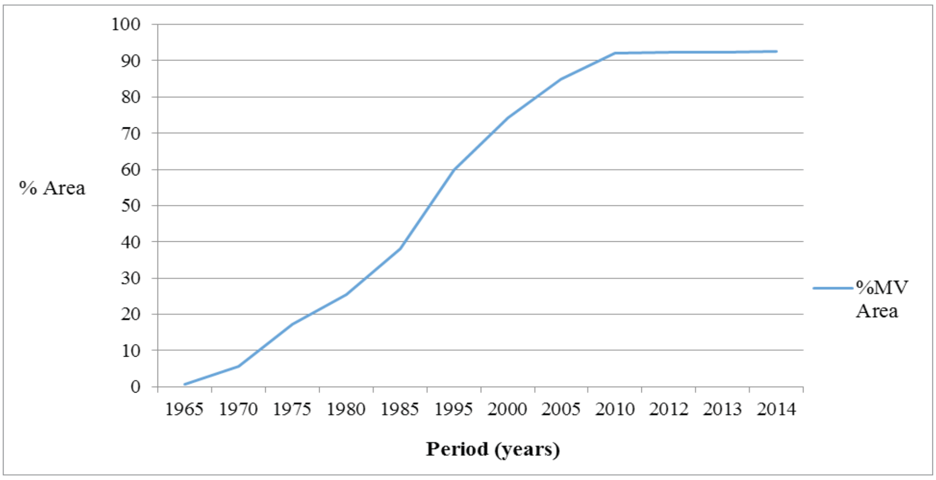

Figure 1. Trend in percent adoption and diffusion of MV rice varieties in Nepal (1965-2015)[1].

Source: Compiled from Nepalese Statistics in Agriculture of MoAD and various sources

1 In the sigmoid pattern, the diffusion (or spread) is slow at the initial stages of adoption as farmers learn about the technologies by adopting in small areas. The spread of technology accelerates overtime with more farmers adopting the technology and those who had already adopted expand the area under improved technologies. This process ultimately slows down later as most of the suitable areas are covered by the technology.

Since the beginning of 1990s, the speed of adoption and diffusion of MVs increased rapidly with the liberal economic policies of the government of Nepal in agriculture and seed sector development. Several public and private sector development particularly after the Ninth Plan (1997-2002), establishment of district level self-sufficiency program (DISSPRO) in 1998 and formulation of Seed Policy in 1999 played important role in this effort. The growth of seed sector in rice increased with the establishment of National Seed Company (NSC) in 2001 and rapid growth of private seed companies and other seed entrepreneurs (seed dealers, retailers) after the beginning of 2000s (Gauchan et al 2014). These initiatives and policies encouraged the private and community sector participation in the multiplication and marketing of rice varieties, which resulted in large scale dissemination across different parts of Nepal.

Pattern of farm level diffusion and adoption

More than a dozen rice varieties is dominant in Nepal (**Figure 2**). A recent study in Nepal indicated that Sonamashuli (a non-released Indian variety) was the number one rice variety being adopted in the largest proportion of area (13%) in Nepal mainly in central Tarai followed by Radha-4 (12%) in western and mid-western regions (Gautam et al 2013, Velasco et al 2013). Similarly, most recent study of CDD of DoA (CDD 2015) and previous study by Witcombe et al (2008) also indicated similar trend with Sonamashuli having the largest area under MVs in Nepal. Khumal-4 was commonly grown in altitude range of 900-1500 masl in upper mid hills and mountain regions. This variety covered 2% of the total MV area in Nepal and 9% MV area in mid hills and 7% in the high hills (Gauchan et al 2016).

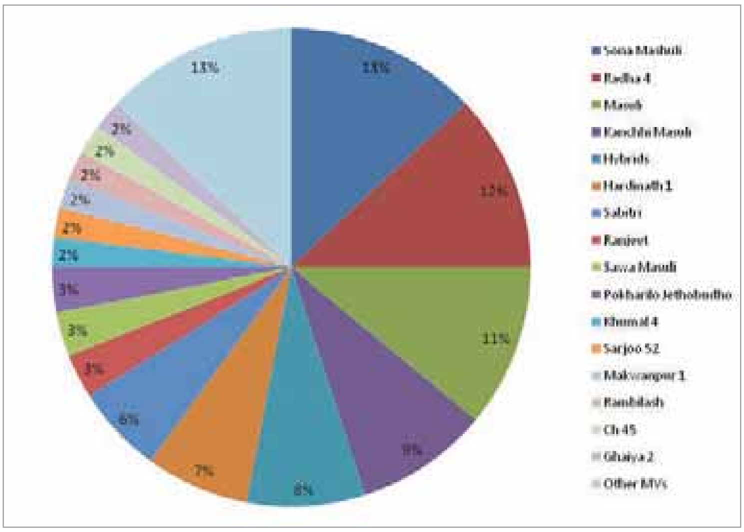

Figure 2. Varietal adoption pattern from household survey in 29 districts.

Sarjoo-52, Makawanpur-1, Rambilash, CH-45 and Ghaiya each also covered 2% of the total rice area in Nepal. The findings also showed that about 20 varieties were being adopted in more than 1% of total MV rice area in 2010-2012. About 13% of the total MVs area is covered by various other MVs that were released and pre-released ones. According to an expert assessment study conducted in 20 Tarai and one hill (Makawanpur) districts of Nepal in 2008, 10% of the rice area was covered by landraces and 90% by MVs (Witcombe et al 2008). The same study also showed that varieties released by the national programme covered half of the area in 21 surveyed districts.

Adoption of MVs by agro ecological zones

Area covered under improved varieties is a major indicator of adoption. A high variation exists in the extent and pattern of adoption of varieties in different agro ecological zones of Nepal (**Figure 3**). Adoption percentage of modern varieties was found very high in the Tarai (97%), moderately high (65%) in hills and very low (12%) in mountain region. Within the hill region, the adoption of MVs was very high in lower hills and irrigated valleys as compared to mid and upper hills. In lower hills and valleys (below >900 masl) the dominance of exotic hybrid was increasing. This is because presently, there are very few improved varieties released and registered for lower hills and river basins (>300-900 masl) and in high mountain region (>1500 masl). Those released and promoted are also not very much suited to harsh environments of high mountain region, rainfed lower hills and upland tars of the mid hills. Moreover, varietal and seed promotional programs from both public and private sectors are limited in the mountain region.

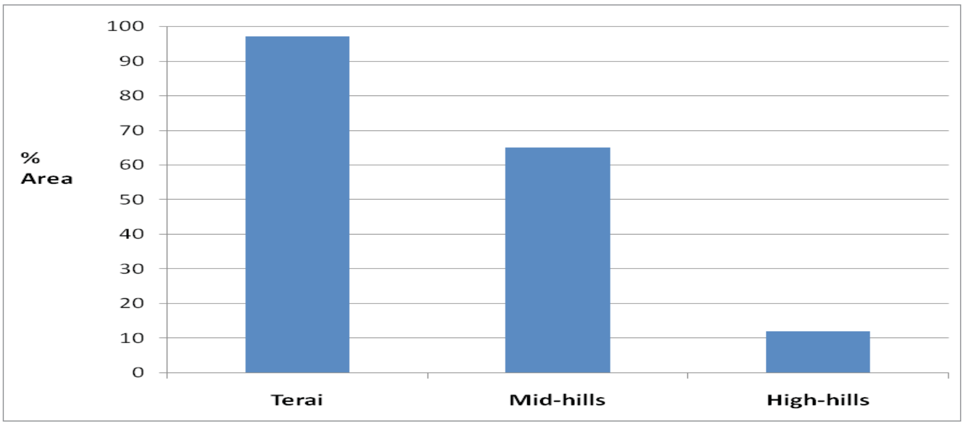

Figure 3. Adoption of MV rice in different agro ecological regions.

Adoption of new generation of MVs

Information on actual farm level adoption and diffusion of type and age of varieties is essential to understand the type of varieties that are available to farmers. New generation of varieties are those that are released recently after 1990 while older generation are those that are developed and released during the green revolution period, mainly before 1990 (Gauchan et al 2012). Adoption of new generation of rice varieties are limited in farmers' fields (Witcombe et al 2008, Joshi et al 2012, Gauchan et al 2012). The age of most of these commercially produced, marketed and distributed varieties are above 15 years, as they were released before the year 1990. Farm level adoption survey of 2011-12 indicated a prevalence of older varieties with 12 years of adoption lags and 18 years of weighted varietal age in Nepal (Gautam et al 2013, Velasco et al 2013). The dominant rice varieties in farmers' fields were Radha-4 (released in 1994), Sabitri (released in 1979), Sona Masuli (released in India in 1982), Masuli (released in 1973) and Khumal-4 (released in 1989). From earlier STRASA farm level adoption survey in 2010 also indicated that 60% of the varieties being adopted by farmers were older generation released before year 1990 (Gauchan et al 2012). Witcombe et al (2008) survey findings in 2008 also indicated that about half of the improved varieties adopted by farmers were more than 20 years old. The proportion of adoption of Indian varieties was significant covering about 30% of the area.

The seed sales data based on nationwide dealers' survey (Gauchan et al 2014) and source seed demanded in national balance sheet for the recent three years (2012, 2013, 2014) also indicate similar pattern (SQCC 2014). The average share of seed sale by seed dealers across the country for newly released varieties in rice in 2013 was about only 10% of the total sale indicating over 90% of the seed sold were of older generation released before 2000 (Gauchan et al 2014). Similarly, Joshi et al (2012) reported that 85% of all the foundation seeds demanded for rice in 2010 were varieties released before 1995. This happens since seed companies and most of the community sectors are producing and multiplying seeds of dominant old varieties because of their high market demand, high profit margin, low risk of marketing and poor access of new competent varieties in seed chain (Gauchan 2015). This predominance of old varieties in farmers' fields indicates inefficiency of research and extension system in developing and delivering new choice varieties to farmers.

Farm level adoption of varieties derived from foreign and local sources

Modern varieties promoted and being adopted at the farm level in Nepal come through both domestic and foreign sources. The details of area under improved rice varieties derived from foreign sources including those from informal cross border flow from India and local origin in Nepal is presented in **Figure 4**. As evident from data, 57% of the area under improved varieties is derived from foreign sources, mainly officially coming through IRRI, while 38% are derived from unofficial informal cross-border flow from India. Only 3% of the improved varieties that are developed, released and adopted from domestic genetic resources are from Nepal. The remaining 2% of the MV adopted area are derived from genetic resources that have 50% parentage from foreign sources and 50% from Nepal's own indigenous genetic resources (eg Khumal-4).

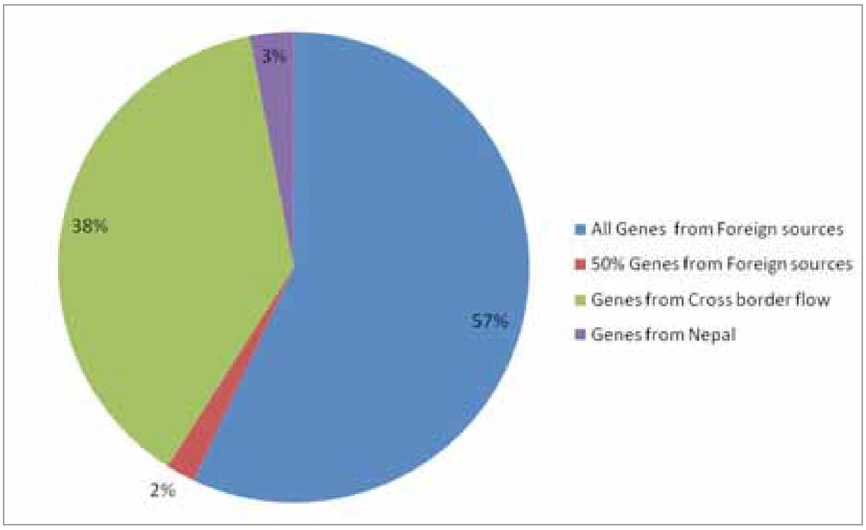

Figure 4. Farm level adoption of varieties derived from foreign and local sources

Source: Gauchan et al 2016.

This finding indicates that the source for origin of about 95% of the farm level adopted varieties are from foreign or foreign derived sources indicating huge dependence on foreign countries for improved varieties of rice (Gauchan et al 2016). The official foreign derived sources of varieties include popular varieties like Radha-4, Sabitri, Hardinath-1, Mashuli, Makawanpur-1, Ramdhan and Shambamasuri Sub-1. The varieties coming informally from India (un-official source) that are popular in Nepal Tarai include Sonamashuli, Kanchhimasuli, Sambamasuli, Sarjoo-52 and Ranjeet including some imported hybrids from India and China mainly in Tarai and lower irrigated hills and valleys.

Conclusion

Rice research directed for developing and delivering modern rice varieties in Nepal was initiated in the early 1960s to suit the needs of diverse ecosystems and population. Adoption of MVs was slow in the initial years but increased rapidly after 1990s until 2010 and remaining stable in recent years (2011-2015). The farm level adoption estimate is also close to aggregate official statistics. However, there is agro ecological differences in the adoption of MVs with very low farm level adoption in the mountains, modest level in the hills and higher level in Tarai (97%). The lower rate of adoption in the mountains is because of poor investment in rice R&D and the lack of availability of suitable cold tolerant rice varieties adapted to harsh mountainous region of Nepal. The higher adoption level of MVs is very high in Tarai because of its suitable agro-ecological conditions and the increasing focus of rice variety development, release and promotion in this region. The recent policies and programmes also encouraged the growth of the seed sector in Tarai and market accessible hills with increased private and community sector participation, which resulted in large scale dissemination and diffusions of MVs in Tarai. However, the genetic sources of the rice variety adopted at the farm level presently in Nepal mainly comes from foreign sources and informal cross border flow from India indicating poor performance and inefficiency of rice R&D system in developing, releasing and promoting farmer preferred locally adapted varieties in the country. Moreover, a large proportion of MV areas presently adopted by farmers are dominated by older generation varieties released before 1990s, most of them in early 1970s and 1980s. As a result, the increase in rice MV adoption and diffusion has not impacted much on rice yield and income of the farmers as compared to many countries of the neighboring Asia and the world.

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Employment Opportunities in Rice Based Industries of Nepal

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सारांश

धान नेपालको प्रमुख खाद्यान्न बाली हो । धानबाट विभिन्न प्रकारका परिकारहरू तयार गरिन्छ र यी परिकार तयार गर्न स्थानीय र राष्ट्रिय स्तरमा साना, मझौला र ठूला उद्योगहरू चल्दछन् । यी उद्योगहरूमा ठूला र साना पिठो कुट्ने मिल, चामल प्रशोधन गर्ने मिल, चामल पोलिश गर्ने मिल आदि पर्दछन् । यी उद्योगहरूले ठूलो संख्यामा रोजगारीको अवसर प्रदान सृजना गरेका छन् । यस बाहेक धान उत्पादन देखि बजारीकरण र व्यापार प्रक्रिया सम्ममा ठूलो संख्यामा जनशक्ती कार्यरत छन् तापनी यस क्षेत्रमा अपेक्षाकृत रूपमा रोजगारीको अवसर सृजना भएको छैन । यही विषयलाई सम्बोधन गरी रोजगारीका अवसर सृजना गर्न नेपाल सरकारले कृषि यान्त्रिकीकरण नीति ल्याएको छ । प्रस्तुत लेखले सरकारी तथा निजी क्षेत्रबाट धान र धान/चामलमा आधारित सेवाबाट सृजना भएका र गर्न सक्ने रोजगारीका अवसरहरू र सम्भावित क्षेत्रहरू स्पस्ट पार्न प्रयास गरेको छ ।

Summary

Rice is the major cereal crop of Nepal. Varieties of products are prepared from rice and to prepare these varieties, small, medium and large scale industries are run in local and national level. These industries include large and small flour mills, rice processing mills, rice polishing mills etc. These industries provide employment opportunities to large number of peoples. A part from this, large number of employees is employed in production process of paddy and trading of rice products but employed generation in this business has not observed as a marked progress. To support this, government has introduced new policy for mechanization of agriculture, which will create new areas of employment for farmers. In this context, this article is more focused on employment generation in rice business from production to trading process and it covers the potential sectors for employment generation in rice based industries focusing on government and private sector actions.

Keywords: Agriculture, Employment, Industries, Mechanization, Rice

Background

Rice is the staple food for the more than 80% population of Nepal. It is among the major product obtained from the paddy. Some other products of paddy besides rice are beaten rice, rice bran oil and rice flour. The business in rice is ever increasing in Nepal because of population increase and with the change in food habit towards consumption of rice also in the non-rice growing areas of the country. However, paddy processing business in Nepal since the last decade not progressed in significant manner due to the increasing import of processed rice from India and abroad. Consequently, paddy processing business growth has not gained the speed as was supposed compared to the demand growth. Ultimately employment generation in this business is also not observed as a mark of progress in Nepal. Government of Nepal has introduced new policy for the Mechanization of Agriculture in 2014. Now, regulations and strategy for the mechanization of agriculture implementation under this strategy is underway. Paddy plantation is still a manual job involving large number of men and women during the season. Mechanization of rice planting and other related farm business is still in the stage of infancy. Paddy farming is still a seasonal business in Nepal, where more women are involved as planters. Thus, women get rice farming related jobs during the monsoon time (June to early August) every year in the country. This article is more focused on the employment generation in the rice business apart from the farming, relevant industries related issues and potential remedial action from the perspective of the private sector.

Employment in paddy business

Agriculture sector engaged partially up to about 65 percentage of the total population in Nepal. Some of them full time and more on the seasonal employment basis. Consequently, paddy being a major crop in Nepal, it engages a majority of people as seasonal labors. Looking upon the value chain activities perspective, more people are involved in the production sector from farming to local post harvest.

Employment in Local small rice and flour mills

It was observed that small rice and flour mills located in the villages are providing 2-10 people as round the year employment. There are about 2500 small rice mills under operation in 65 districts of Nepal. Based on this it can be estimated that in an average about 12,500 people are employed as the year round employees. These mills are operated by small holders/farmers in the capacity of 5-10 tonnes per day and are still in primitive type of operations.

Employment during of processing of paddy

Post harvest handling of paddy is creating equally or more employment than paddy production. Flow of value chain is more on the post harvest processing business. Post harvest handling requires male labor force than in other activities. Transportation, milling and trade are the areas where males are much more involved than females.

Value added products derived from paddy are observed as below.

- Coarse rice produced from normal rice mills in the villages,
- Fine rice produced from modern rice mills including polishing and grading,
- Parboiled rice,
- Basmati and high grade fine rice,
- Rice flour,
- Bitten rice (*Chiura*) and
- Rice bran and rice bran oil.

According to the investment pattern and number of man power employed, milling business enterprises/rice mills are also categorized as below.

Medium to large scale industries- per day 160-200 tonnes milling capacity and above.

Small industries less than or around 50 tonnes per day milling capacity.

As estimated by the associations (Nepal Dal Chamal Sangh), the milling business provide employment at an average of 2-50 people in medium to large industries as full time employment and about 50-60 people as day labors in peak season in each industry.

Small industries established in the village and district headquarters employ about 10 people per industry as regular labors and about 15 people per day as seasonal labors during busy months of November to January, the heavy rice milling period in a year.

Employment generation in rice industry is more visible in the process of processing paddy for production of consumable items and its delivery to the consumers. At this stage, the value addition activities are creating almost equal to the number of employment as it generates for the production of paddy and its delivery to the processing units.

Stages of value addition in paddy processing business passes through the process flow of:

- Milling,
- Packaging in the retail packages eg different sizes 5 kgs. 20 kgs etc,
- Delivery through different means of transportation eg trucks, tractors and other means of transportation,
- Whole sale and retail selling outlets.

Small and medium scale rice industries are located in the city centers and district headquarters. In this type of industry, number of employees per industry varies from 3-15 people as permanent employees. And number of such industries as estimated by the Rice and Pulses Association are around 6000. Hence, the estimated number of employees would be 42000 people as direct employees and indirect employees involved in the transportation and business dealers would be around 48000 persons as partially employed. Based on the personal contact and discussion with some of the major rice dealers, (processors and traders) there are about 300 medium to large scale rice mills running in the Tarai regions of Nepal. Minimum capacity of milling in those industries is running by processing at the rate of 150-300 tonnes paddy per day. Regarding the official statistics on the employment in rice industry is not available to verify. The numbers of employment is based on the estimation and personal contact information only.

These types of industries are using more capital intensive technology; advanced milling technology for polishing, color separations etc. This category of industry employees around 10- 100 people per industry around the year in operation, this accounts for 60000 people as full time employees. In addition, the seasonal employees are about 100000 to 150000 persons per season. Milling business employee more men and only few females as around year employees.

This shows rice value chain more dominated by the small and medium farmers at the production stage whereas medium to large scale farmers are in the rice processing like milling and branding business.

Number of employment created in the rice business is just calculated at the stage of milling to whole selling business only. Retail sale business of rice is incorporated with other variety of food items as well. Hence, it would be not justifiable to isolate only rice business from other food items. Furthermore, employment generation is more significant in number in milling business than rest of other activities.

Employment in rice processing mills

An estimation of rice processing mills in the country is around 2000 scattered all over the county, mostly in rural areas. Roughly, 10-20 people are employed as labors and production scale of such mills is 50-60 tonnes per day. There are also 300 modern rice mills established in the semi-urban Tarai districs, which has been operating in the scale of 150-200 tonnes per day capacity. Value addition at this stage is estimated at 30-40% of the price of coarse rice.

Figure: 1 Small rice mills

Employment in rice trading

Number of traders, the whole sellers in the districts headquarters is in several numbers. Value addition in this segment of trade is up to 30% in the original rice price. Total estimated quantity on rice trade is around 5.6 million tonnes including 600000 tonnes imported from India. Trading of rice alone at the district and big markets involved around 150000 people. Official record of employment in this sector is not available and these figures are estimats based on the discussion with the traders/members of Dal Chamal Association. Rice mills and other agribusiness related companies are registered under the broader category of Agriculture and Forestry. Number of industries registered under this category is 16877 in the last ten years (**Annex 1**).

The statistical data from Ministry of Industries showed that in the last ten years, Agro based industries employment raised from 621 in 2002/03 to 30660 in the year 2012/13. Hence, it was found in increasing trend.(www.moi.gov.np). Informal data of the employment is calculated in this paper to get an impression of the present employment situation in Nepal from the rice and associated industries. No official data is available to verify the estimation. However, as we have been interacting with the different stakeholders involved in the paddy to rice business, these figures can represent at the most realistic situation of the employment in rice industry in Nepal. According to the list, total number of rice mills in Nepal has accounted as 92. Employment in those industries varied from 2 to 60 numbers of employees as direct employees/receiving around the year employment.

Employment in rice based hotels and restaurants in highway

Rice is the major component of everyday dietary intake in Nepal. Rice is the main course of meal at household kitchen, hotel, and restaurants. In the past, the consumption of rice was bit localized in plain areas. Having rice in the meal was considered pride in remote and inaccessible areas. However, the development of road access made it possible to transport from one place to another in the country and further increased its consumption. Now, anyone can purchase raw rice anywhere to prepare ones own meal or get cooked rice in the hotel or restaurants to fulfil his or her need. As a result, rice is the principal item in different forms of hotel or restaurant business. This is creating employment opportunities to a large number of people, categorically to the owners, cook, and cleaners employed in hotel or restaurant businesses.

Some issues to be addressed for creating more employment in rice business

There are some issues yet to be addressed in the promotion of rice production at the larger scale, which are mentioned below.

- Provision of contract and leasehold farming: Present act does not have any provision of legal right for farmers in the land act while farmers go on contract farming and the land lords to lease out farms for contract farming. This has resulted in adverse condition in rice business. Landlords prefer to be keep land barren and the lease farmers do not put more efforts to develop the farms as commercial farms. Still the farming for subsistence is persistent.
- Promote contract farming to scale up commercial farming of rice, for this sake the bill on Agribusiness Promotion Act, which is under the consideration in the parliament needs to passed and implemented soon.
- Promote Mechanization of farming business.
- Assure input supply including fertilizers and seed yet to be up scaled to reach in the wider farmers' community.
- Creation of conducive environment to attract private sector investment in agriculture like; tax incentive, subsidy and legal protection of the business till the long run. Introduce measures such as:
- Declaration of industrial area
- Speeding up of infrastructure development works like: power supply, road links, and water and sewerage system to the industrial area.
- Leasing out unused public land for productive farming.
- Promotion of Foreign Direct Investment (FDI) in Agriculture. It is not yet seen because of the unclear legal provisions. Agriculture sector needs to be prioritized for FDI and procedures need to be simplified and shortened.
- Provide soft loan to rice mills and tax holidays during initial years of operation.
- Abolish multilayer taxation in the transportation of paddy and rice from one district to another district, which promotes local processing of paddy and increases competitiveness of Nepalese industries enabling them to compete with Indian and imported rice.

Annex 1. List of some rice/wheat/flour/oil mills throughout Nepal

SN	Company Name	Address	Average annual employment in Nos.	City
1	Achyut Rice Mill	Kanchanbari	20	Biratnagar
2	Aman Rice Mill	Bhadrakali Chowk	12	Pokhara
3	Annapurna Maida Mills (P) Ltd.	Katahari	60	Biratnagar
4	Annapurna Rice Mill	Narayanghar	14	Bharatpur
5	Annapurna Rice, Oil Mills	Khanar	29	Biratnagar
6	Ashok Rice & Oil Mills	Katari	53	Biratnagar
7	Astha Food Industry	Bharatpur	6	Bharatpur
8	Baba Bishwokarma Chiura Udyog	Anandaban VDC	2	Bhairahawa
9	Baba Flour Mills (P) Ltd.	Siddhartha Chowk	5	Biratnagar
10	Bajrang Rice Flour & Oil Mill	Rangeli	12	Biratnagar
11	Balaju Dal Mill	Balaju	10	Kathmandu
12	Bce Mill	Pipara	5	Birgunj
13	Bhadrakali Rice, Oil & Flour Mill	Bhairahawa	6	Bhairahawa
14	Bhagawati Rice Mills	Narayangadh	5	Bharatpur
15	Bhagawati Rice Mills	Birta	5	Birgunj
16	Bhagawati Rice Mills	Bhadrapur	6	Jhapa
17	Bhairab Shelar Mill	Bhairab Tole	3	Pokhara
18	Bhawani Rice Mill	Adarsha Nagar	5	Birgunj
19	Bhawani Rice Mill	Lalitpur	2	Kathmandu
20	Bhawani Shankar Rice Mill	Bhadrapur	5	Jhapa
21	Bhubanesyari Rice Mills	Narayangadh	5	Bharatpur
22	Bhudeo Khadya Mills	Lal Bandi	15	Janakpur
23	Bijay Rice Mill	Hetauda	15	Hetauda
24	Bijaya Rice Mills	Majdiha Pipara	16	Birgunj
25	Binayak Food Industries	Surkhet Road	15	Nepalgunj
26	Birganj Khadya Udhyog Pvt. Ltd.	GPO: 20, Birgunj, Alkhiya Road	20	Birgunj
27	Birgunj Khadya Udyog Pvt. Ltd.	Parwanipur	15	Birgunj
28	Chandra Shiva Rice & Oil Mills	Adarsha Nagar	7	Birgunj
29	Chiranjibi Rice Mills	Bhadrapur	15	Jhapa
30	Chiranjibi Rice, Oil & Flour Mills	Narayangadh	5	Bharatpur
31	Deepak Flour Mills	Biratnagar	20	Biratnagar
32	Deepak Rice & Flour Mills	Adarsha Nagar	12	Birgunj
33	Dhan Rice Mill	Narayanghar	5	Bharatpur
34	Dhaulagiri Chewra & Oil Mill	Jogikuti	5	Bhairahawa
35	Dhiraj Rice Mills	Dhamboji	20	Nepalgunj
36	Dhrubatara Dhan Chamal Karkhana	GPO: 5802, Jyatha, Kathmandu	1	Kathmandu
37	Dhurba Rice Mills	Narayangadh	5	Bharatpur
38	Dil Durga Rice Mill	Biratnagar	5	Biratnagar
39	Dilip Rice Mills	Tinpaini	5	Biratnagar

SN	Company Name	Address	Average annual employment in Nos.	City
40	Dipendra Rice Mill	Chapapani	2	Pokhara
41	Durga Chiura Mills	Jhapa	5	Jhapa
42	Durga Modern Dal Mill & Durga Modern Oil Mill	Siddhartha Nagar	5	Bhairahawa
43	Durga Rice & Oil Mills	Main Road	5	Biratnagar
44	Durga Rice Mill	Galamandi	5	Bhairahawa
45	Durga Rice Mill	Chapkaiya	5	Birgunj
46	Durga Rice Mills	Narayangadh	5	Bharatpur
47	Ganesh Chewra Udyog	Naya Mill	5	Bhairahawa
48	Ganesh Himal Rice Mill	Manpur	12	Nepalgunj
49	Ganesh Khadhya Udhyog	Old Baneshwor	4	Kathmandu
50	Ganesh Modern Dal Mills	Manpur	10	Nepalgunj
51	Ganga Rice & Flour Mills	Biratnagar	15	Biratnagar
52	Ganga Rice Mill	Shrawan Path	10	Bhairahawa
53	Girija Rice & Oil Mills	Ram Mandir	45	Janakpur
54	Global Commercial Center (P) Ltd.	GPO : 13982, Kathmandu Sanepa	25	Kathmandu
55	Gokul Rice & Oil Industries	Dhamboji	15	Nepalgunj
56	Golchha Rice & Oil Mills	Biratnagar	15	Biratnagar
57	Gopal Oil, Dal & Flour Mills	GPO: 18, Biratnagar Bohara Niwas	15	Biratnagar
58	Gupta Dal & Oil Mill	Birgunj	15	Birgunj
59	Gupta Oil Mills	Adarsha Nagar	50	Birgunj
60	Gyanuka Seller Rice Mills	Dihiko Patan	15	Pokhara
61	Hajee Samsulhaque Rice & Oil Mills	Saro	15	Biratnagar
62	Himalaya Rice Mills	Bhadrapur	12	Jhapa
63	Hira Devi Automatic Rice Mills	Ward 8	6	Bhairahawa
64	Hira Rice & Oil Mills	Biratnagar	12	Biratnagar
65	Indra Rice Mill	Makawanpur	5	Hetauda
66	Indu Rice Mill	Rani Pauwa	5	Pokhara
67	Krishna Maskey Rice Mill	Bhanu Tole	5	Biratnagar
68	Krishna Rice Mill	Rani Pauwa	5	Pokhara
69	Laxmi Khadya Udyog (P) Ltd.	Dhangadi	15	Kailali
70	Laxmi Rice Flour & Cheura Mill	Rani Ghat	5	Birgunj
71	Lumbini Flour Mills P. Ltd.	Simra	15	Birgunj
72	Lumbini Flour Mills P. Ltd.	Thute Pipal	15	Bhairahawa
73	M. N. Rice Mills	Bhadrapur	15	Jhapa
74	Mahabir Rice & Oil Mill	Chapkaiya	15	Birgunj
75	Mahakali Rice Mill	Bhansar Road	15	Nepalgunj
76	Mahalaxmi Maida & Oil Mill (P) Ltd.	Main Road	15	Biratnagar
77	Mahendra Surya Rice Mills	Bindabashini	5	Pokhara

SN	Company Name	Address	Average annual employment in Nos.	City
78	Manorama Rice Mills (P) Ltd.	Gyaneshwor	10	Kathmandu
79	Mittal Rice & Oil Mill	Surkhet Road	20	Nepalgunj
80	Narayan Rice & Oil Mills (P) Ltd	Biratnagar	10	Biratnagar
81	Narayani Rice Mills (P) Ltd.	Chainpur	5	Birgunj
82	Naresh Rice Mill	Dhobighat	2	Kathmandu
83	Nepal Oil & Flour Mills	Rangeli Road	6	Biratnagar
84	Pashupati Rice Mills	Kadhaha	12	Biratnagar
85	Panchakanya Rice Mill (P) Ltd.	GPO: 2743, Kathmandu, Lalitpur	100	Kathmandu
86	Prem Narayan Rice Mills	Dhamboji	5	Nepalgunj
87	Rice Mill Pvt. Ltd.	Ittachen	2	Kathmandu
88	Sagarmatha Flour Mills	Main Road	5	Biratnagar
89	Shree Mahalaxmi Maida Mills (P) Ltd.	GPO: 648, Ktm, Khichapokhari	5	Kathmandu
90	Shree Shanker Rice, Oil & Flour Mills	Lahan-4, Shiraha	12	Siraha
91	Shree Shanker Rice, Oil & Flour Mills	GPO: 116, Biratnagar, Bhrikuti Chowk	15	Biratnagar
92	Vikash Flour Mill (P) Ltd	GPO: 1991, Kathmandu, Dillibazar	60	Kathmandu

Source: AEC/FNCCI 2016

Rice Mills, Milling Processes and Current Status in Nepal

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सारांश

परम्परागत रूपमा नेपालमा धान कुटानीको लागि ढिकी, जाँतो र पानी घट्टाको प्रयोग गरिन्थ्यो । तर प्रविधिको विस्तारसँगै धान कुटानी पिसानीको लागि आधुनिक, होलर मिल, सेलर मिलका तथा पोलीस मिलको विकास भएका छन् । नेपालमा हालसम्म २७५६२ वटा आधुनिक मिलहरू प्रयोगमा ल्याइएका छन् । हिमाल र पहाडको तुलनामा तराईमा बढी मिलहरू प्रयोगमा आएको पाइन्छ । हालैका वर्षहरूमा हलर मिलहरूको संख्या घट्दो रूपमा रहेको र सेलर मिलको संख्या बढ्ने क्रममा रहेको छ । सेलर मिलबाट प्रशोधन गरिएको चामल र ढुटोको गुणस्तर राम्रो भएकाले यसको लोकप्रियता बढ्ने क्रममा रहेको पाइएको छ । प्रस्तुत लेखमा नेपालमा धान कुटानीका लागि प्रयोग गरिने मिलको हालको अवस्था र धान मिलसँग सम्बन्धित अन्य विविध पक्षहरूबारे प्रस्तुत गरिएको छ ।

Summary

Use of water mills, *Dhikis* and *Jhanto* were some of the traditionally used equipment which are still prevalent techniques of milling rice in mostly rural parts of our country. However with advancement of technologies and rapid stride in industrialization, automated rice milling machines as rice pounder, rice polisher, sheller and huller are developed and used for rice milling. In the context of Nepal, altogether there are around 27562 rice mills established in different ecological regions and distribution of mills is highest in Tarai, followed by the hills and mountains. In recent years, use of sheller mills is increasing in comparison to huller mills. The sheller mills are getting popularity for their specialties to minimize grain breakage and for improved quality of rice and bran. This article attempts to assess the status of rice mills and rice milling processes in Nepal.

Keywords: Dehulling, Husk, Milling, Mills, Polishing, Rice

Introduction

Rice grain basically consists of a husk (or hull) and a grain of brown rice. Brown rice consists of a bran layer (including pericarp, seed coat, and aleurone layer), a germ and scutellum connected on the ventral side of the grain, and an edible portion or endosperm. Rice becomes edible after husk and bran are removed through milling. Rice kernels are often susceptible to breakage due to inefficient milling processes. Therefore, more efficient milling processes are recommended for better recovery ratio and quality rice kernel production. Rice milling involves the removal of the husk and the bran layer to produce the edible portion for consumption. Rice-milling process embraces two basic operations of removing husk to produce brown rice (dehusking or dehulling) and and removing bran layer from brown rice to produce polished/ white rice (polishing or whitening). Milling also removes the germ and a portion of the endosperm as broken kernels and powdery materials. It is also identified as one of the most important remedies for preventing post-harvest loss (Singha 2013).

A rice milling system consists of one to multi stage processes. In a one step milling process, husk and bran removal are done in one pass and milled or white rice is produced directly out of rice grain. In a two step process, removing husk and removing bran are done separately, and brown rice is produced as an intermediate product. In multistage milling, rice undergoes a number of different processing steps like: husking, husk separation, rice/paddy separation polishing and grading. Milling of the rice involves: removing the trash and then the huskfrom the rice, milling the bran off of the endosperm (leaving whiterice), and then removing broken kernels and other defects. In most of countries in the world, rice is generally milled in very small mills near the farm and stored in the form of milled rice until consumed. Sometimes it is stored as rice or brown rice and then milled fresh prior to consumption. In Nepal harvested rice is dried to appropriate moisture level and stored in different storage structures. Rice is generally milled in local rice mills in Nepal.

History of rice mills in Nepal

A rice huller or rice husker is an agricultural machine to automate the process of removing the chaff (the outer husks) of grains of rice. Throughout history, there have been numerous techniques to hull rice. Traditionally, it was method of pounding by using some form of mortar and pestle. An early simple machine in doing so is a rice pounder. Later even more efficient machinery was developed to hull and polish rice. These machines are most widely developed and used throughout Asia where the most popular type is the Engel berg huller designed by German Brazilian engineer Evaristo Conrado Engel berg in Brazil and first patented in 1885. During milling of rice through those huller. Through this machine more broken grains were produced and because of mixing of husk with bran, poor quality bran was obtained. These two effects were overcome by carrying shelling and polishing operations separately in different equipment (Pillaiyar 1980).

A rice polisher is a machine for buffing (or "polishing") kernels of rice to change their appearance, taste, and texture. Rice polishers are abrasive machines that use talc or some other very fine dust to buff the outer surface of rice kernels. The first fully automated rice polishing machine is believed to have been patented by the British engineer Sampson Moore in 1861 (https://en.wikipedia.org/wiki/Rice_huller).

Rice milling is the oldest and the largest agro processing industry of the country. Nepal, a landlocked mountainous country, having immense water resources has harnessed water power widely through the use of water mills, locally known as '*Ghatta*'.Similarly, traditional tools of *Dhikis* and *Jhantos* requiring human muscles have been used for centuries for rice milling. There are about 25,000 traditional water mills, comprising a major source of rural energy for agro-processing across the country (Shrestha 2012). They have been used for centuries by the communities in the hills and mountain regions of Nepal. Improved Water Mill (IWM) is also used in different parts of our country. It is an intermediate technology and increases the efficiency of the traditional water mill, resulting in increased energy output, thus helping both the millers and their customers. Two types of IWMs are in use: short-shaft, solely for grinding, and long-shaft,for grinding and other end uses such as rice/paddy hulling and -husking, rice polishing, sawmilling, oil-expelling, *lokta* processing (used for producing handmade paper),and for beaten rice or *chiura* among others. The history of development of IWMs in Nepal dates back to the early 1980s, after the Research Centre for Applied Science and Technology (RECAST), a research and development wing of Tribhuvan University (TU) developed a prototype of an improved version of water mill (Shrestha 2012). In the prototype, wooden paddles were replaced by hydraulically more efficient metallic blades, and a new bottom bearing was added. This prototype, with a closed chute and a covered chamber, was tested in a mill at Godavari, Lalitpur, Nepal. The technology was subsequently promoted among the farmers with involvement of a manufacturing company, the Kathmandu Metal Industries (KMI). In 2012, there were 22,676 traditional water mills spreading across 52 districts of the country. At the same time, there were 7,527 IWMs in the country. It is estimated that there are still at least 25,000 traditional water mills located mainly in the mid-hill areas from east to west in the country (Shrestha 2012). Similarly, history shows that the food grains trading business started along with the Kedia family when they used to collect food grains from every corner of the country and supply them to even remote areas that lacked transportation facilities. Later they established rice mills, dal mills and many more food grain factories including Nepal’s first modern rice mill, Bhagwati Rice Mill in Birgunj. From then different small and large rice mills have been established in different parts of our country (http://www.newbusinessage. com/Articles/view2492). As per the industrialists, there are 25 major domestic rice mills operating in Nepal (http://thehimalayantimes.com/business/plagued-by-problems/).

Figure 1. Traditional Water Mills and *Dhiki*

Modern milling process

Modern milling process involves the following series of steps.

Pre-cleaning

When rice comes into the mill, it contains foreign materials such as straw, weed seeds, soil, and other inert materials. If these are not removed before hulling, the efficiency of the huller and milling recovery will be reduced. The capacity of the rice/paddy pre-cleaner is normally 1.5 times the milling capacity. The rice/paddy is passed through coarse screens to remove all straw, stones, and other objects that are larger than the rice. The rice/paddy passes over fine screens to remove small weed seed, sand and dirt, stones, and other objects smaller than the rice. Air separation systems are sometimes used in this process.

Removing the husk (dehusking or dehulling)

Husk is a layer of cellulose protecting rice/paddy grain. Each rice grain has 2 "half husk" interlocking each other, so it is easier to break the interlock and release 2 half husks from rice grain.The husk is removed by friction as the rice grains pass between two abrasive surfaces that move at different speeds. This is most often done by passing the rice through two spinning rubber roles, one roll spinning faster than the other. The rubber rolls press tightly against the rice at the both sides and strip the husk off. After dehusking, the husk is removed by suction and transported to a storage dump outside the mill. Husk accounts for 20% of the rice grain weight and an efficient husker should remove 90% of the husk in a single pass.

Rice/paddy separation

The rice/paddy separator separates unhusked rice from brown rice. The amount of rice present depends on the efficiency of the husker and should not be more than 10%. Rice/Paddy separators work by making use of the differences in specific gravity, buoyancy, and size between rice grain/paddy and brown rice.

Whitening or polishing

White rice is produced by removing the bran layer and the germ from the rice grain. The bran layer is removed from the kernel through either abrasive or friction polishers. The amount of bran removed is normally between 8 and 10% of the total rice grain weight. To reduce the number of broken grains during the whitening process, rice is normally passed through two to four whitening machines connected in series.

Separation of white rice

After polishing, white rice is separated into head rice, large and small broken rice, and "brewers" by an oscillating screen sifter. Head rice is normally classified as kernels that are 75−80% or more of a whole kernel. To attain a higher degree of precision for grading and separation a length or indent grader is used.

Rice mixing

A good rice mill will produce 50−60% head rice (whole kernels), 5−10% large broken and 10−15% small broken kernels. Depending on country standards, rice grades in the market will contain from 5 to 25% broken kernels. If rice mixing is to be done properly, a volumetric mixer is necessary.

Mist polishing

Mixing a fine mist of water with the dust retained on the whitened rice improves the luster of rice (polishes) without significantly reducing milling yield. A friction type-whitening machine, which delivers a fine mist of water during the final whitening process, is used for "final" polishing before sale.

Rice weighing

Rice is normally sold in 50 kg sacks which must be accurately weighed and labeled. While most rice mills use a manual mechanical weighing system, very accurate and fast electronic systems are also available (http://www.knowledgebank.irri.org/step-by-step-production/postharvest/milling).

Comparison of milling out-turn by different milling process

History of development of rice milling industry describes the reason for improvements of milling industry from traditional methods, which is mainly due to food shortage in post war era. Milling process has significant effect on rice quality, percentage recovery of grains and grain composition. A research conducted in India shows that the percentage recovery of rice kernel from home pounding is 70-73% and the highest among other milling methods as huller type and Sheller type mills. The recovery of huller and sheller type mills is 68-69% and 69-70% respectively (NPCS). Despite having large percentage recovery, home pounding system of milling has decreased since it is labor intensive and time consuming technique.

Table 1. Percent recovery of mills

Type of milling	Percentage recovery of rice
Home pounding	70-73
Huller or Huller type mills	68-69
Sheller type mills	69-70

Source: Hand Book on rice Cultivation and Processing. NPCS Board of Consultants and Engineers, India

Factors influencing milling breakage

Milling of rice and the factors influencing it are important technological considerations in the processing of rice for the market. The pre-milling conditions mostly determine the milling quality than the type of mill. The yield of processed rice from during milling is determined by husk content of the variety, the degree of milling and the grain breakage. The husk content of rice/paddy varies from 14% (Baldi et al 1974) to 28% (Cagampang et al 1966), showing a difference in potential yield of 14 percentage options. The yield of milled rice varies inversely with the degree of milling, which ranges from 4-5% in India to 10% or more in most of other countries showing a difference in yield potential of at least 5 percentage points (Pillaiyar 1988). The husk content of rice is genetically controlled factor and the degree of milling is determined by custom or law of the country. Breakage reduces the economic value of rice and it lowers the milling yield since any breakage produces some fine broken which are lost during the seiving or aspiration stages of milling (Bhattacharya 1980).

Status of modern rice mills in Nepal

The rice milling industry has been established as one of the largest food industries in Nepal. A variety of indigenous milling equipment for shelling of rice and polishing of rice have been in use from time immemorial. Hand pounding of rice is still practiced in some parts of the country. Many types of tools as mortar and pestle and stone *chakkis* had been in used for a long time operated by womenfolk. As the time passed by, rapid industrialization has led to deployment of automation and introduction of different modern milling equipments. The total number of rice mills in Nepal in 2014 was 27562 with 17681 Huller and 9881 Sheller mills. Kapilvastu district of Nepal has the highest number of rice mills (1939) was found in Kapilvastu and the and lowest in Humla (1) as shown in table below.

Table 2. Lists of huller and sheller mills in Nepal

SN	District	Huller mills	Sheller mills	Total
1	Taplejung	41	2	43
2	Sankhuwasabha	171	0	171
3	Solukhumbu	30	0	30
4	Dolakha	205	13	218
5	Sindhupalchok	514	15	529
6	Rasuwa	20	10	30
7	Manang	0	0	0
8	Mustang	0	0	0
9	Dolpa	0	0	0
10	Mugu	3	0	3
11	Jumla	27	0	27
12	Humla	1	0	1
13	Kalikot	11	0	11
14	Bajura	21	0	21
15	Bajhang	9	2	11
16	Darchula	26	1	27
Mountain sub-total		**1079**	**43**	**1122**
17	Ilam	225	22	247
18	Panchthar	51	0	51
19	Tehrathum	100	0	100
20	Dhankuta	132	0	132
21	Bhojpur	103	0	103
22	Khotang	210	0	210
23	Okhaldunga	32	0	32
24	Udaypur	225	89	314
25	Sindhuli	65	35	100
26	Ramechhap	150	30	180
27	Kavrepalanchok	22	414	436
28	Kathmandu	30	70	100
29	Bhaktpur	345	31	376

SN	District	Huller mills	Sheller mills	Total
30	Lalitpur	398	12	410
31	Makawanpur	242	96	338
32	Dhading	223	360	583
33	Nuwakot	171	401	572
34	Gorkha	348	29	377
35	Tanahun	59	133	192
36	Lamjung	406	50	456
37	Kaski	347	421	768
38	Syangja	412	70	482
39	Parvat	296	44	340
40	Myagdi	234	5	239
41	Baglung	269	4	273
42	Gulmi	335	2	337
43	Arghakhanchi	335	0	335
44	Palpa	320	11	331
45	Rukum	42	0	42
46	Rolpa	102	0	102
47	Salyan	92	0	92
48	Pyuthan	266	0	266
49	Dailekh	140	0	140
50	Jajarkot	10	0	10
51	Surkhet	96	160	256
52	Doti	63	0	63
53	Baitadi	12	2	14
54	Achham	59	1	60
55	Dadeldhura	74	7	81
Hill sub-total		**7041**	**2499**	**9540**
56	Jhapa	906	131	1037
57	Morang	827	322	1149
58	Sunsari	607	125	732
59	Saptari	1200	142	1342
60	Siraha	951	65	1016
61	Dhanusha	672	68	740
62	Mahottari	978	46	1024
63	Sarlahi	475	132	607
64	Rauthat	789	167	956
65	Bara	143	387	530
66	Parsa	48	1000	1048
67	Chitwan	109	312	421
68	Nawalparasi	124	278	402
69	Rupendehi	40	658	698
70	Kapilvastu	519	1420	1939

SN	District	Huller mills	Sheller mills	Total
71	Dang	70	450	520
72	Banke	178	416	594
73	Bardiya	275	494	769
74	Kailali	506	371	877
75	Kanchanpur	144	355	499
Tarai sub-total		**9561**	**7339**	**16900**
Total		**17681**	**9881**	**27562**

Source: DADOs 2016.

Among the ecological regions, Tarai has the highest number of rice mills. It has 166900 (61.32%) rice mills followed by 9540 (34.61%) in the hills and 1122 (4.07%) in the mountain region. The reasons behind having higher number of mills in Tarai region could be large scale production of rice, easy access to infrastructures and presence of different agro-industries for utilization of rice by-products. Tarai, hills and mountains region has 9561, 7041, 1079 huller mills and 7339, 2499, 43 Sheller rice mills, respectively. In comparison to Huller mills, Sheller mills are getting popularity in Tarai region as rice milled through such mills increase the recovery percentage, minimizes the breakage of grains and ensures the quality of rice and bran. Currently, the huller mills account for 64.14% coverage while Sheller mills cover only 35.85%. But the trend of converting or replacing huller mills by sheller mills is increasing in recent years. So, the number of huller miller in Nepal is expected to decrease in the future by being replaced by Sheller mills.

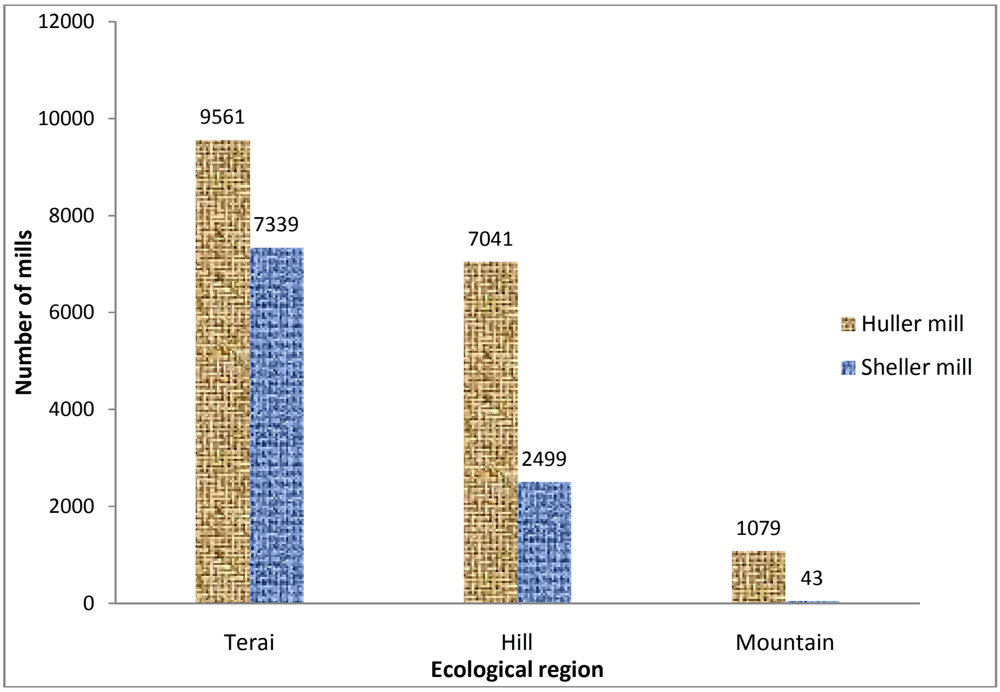

Figure 2. Distribution of rice mills in different ecological regions of Nepal.

Source: Information collected from DADOs 2014.

Conclusion

Efficient milling processes are highly recommended for better recovery ratio and quality rice grain production. In order to ensure quality of rice, it should be extracted following several steps of milling like: husking, husk and grain separation, polishing and grading. Among various milling equipment and machines, most appropriate would be the one that minimize the post harvest loss and maintains good quality grains. Currently, 27562 rice mills are in operation in Nepal with Tarai region retaining the highest number of rice mills in comparison to hills and mountain regions.

Acknowledgements

The authors would like to thank Mr. Dila Ram Bhandari, Director General of Department of Agriculture and Mr. Prakash Acharya, Senior Crop Development Officer for their valuable comments and suggestion during preparation of this article. Thanks also goes to officials working at District Agriculture Development Offices and Office of Small and Cottage Industries for providing relevant data.

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Rice Marketing in Nepal

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सारांश

कृषकलाई कृषि जन्य उत्पादनको उचित मूल्य प्रदान गर्न एवम् बजारमा सहज आपूर्तिको सुनिश्चिता कायम गर्न बजारीकरणको महत्वपूर्ण भूमिका रहेको हुन्छ । धान बालीको सन्दर्भमा यसको बजारीकरणमा खासगरी स्थानीय व्यापारी, थोक व्यापारी तथा धान मिलहरूको बर्चस्व रहदै आएको पाइन्छ । तसर्थ धान बालीको बजारीकरणमा बीचौलियाहरूको संलग्नता प्रचुर मात्रामा रहेको छ । नेपालमा सामान्यतया धानको बिक्री वितरण आश्विन/कार्तिकदेखि फाल्गुण/चैत्रसम्ममा हुने गर्दछ भने तराईका बढी उत्पादन गर्ने कृषकहरूले आषाढसम्म पनि धानको बिक्रि गरेको पाइन्छ । तराईमा गल्लावाला मार्फत बजारीकरण गर्ने प्रचलन व्यापक मात्रामा छ जुन पहाडी जिल्लाहरूमा देखिदैन । पहाडी जिल्लाहरूमा तराई क्षेत्रबाट तयारी चामल आउने प्रचलन बढेका कारण पहाडका स्थानीय धान/चामलको मूल्य कमी हुदै गएको पाइएको छ । पहाडमा सदरमुकामका व्यापारी र स्थानीय व्यापारी तथा तराईमा मुख्य गरी गल्लावाला र भारतीय व्यापारीले धान चामलको मूल्यमा असर पार्ने गरेको छ । नेपालमा धान भण्डारका लागि पर्याप्त संरचनाको कमी, भारतबाट कम मूल्यमा चामलको आयात, व्यापारीको मूल्यमा बर्चस्व तथा धान बालीको न्यूनतम समर्थन मूल्य नतोकिनु आदि धान/चामल बजारीकरणका सम्बन्धमा नेपालमा देखा परेका समस्याहरू हुन् ।

Summary

Agricultural marketing plays important role to provide remunerative price to farmer and ensures regular supplies of agricultural produces at reasonable prices. Rice marketing system in Nepal is mainly dominated by village trader, wholesalers and rice millers. Rice is generally marketed in Nepal through involvement of middlemen. Marketing of rice via wholesaler, village trader, rice miller and agricultural cooperatives is common phenomenon in Nepal. Seed dealers and retailers are the major channels through which hybrids are marketed in major market centers in Tarai and some market accessible regions of Hills. Rice marketing in Nepal starts from last week of Ashwin (September-October) to month of Falgun (February-March)/Chaitra (March-April). However, larger land lord in Tarai region sell the surplus remained after consumption during month Ashad (June-July) too. Common practice of sale of rice through involvement of traders (*Galla*) as seen in Tarai region does not prevail in hilly areas of Nepal. The trend of importing readymade fine rice from Tarai areas has increased tremendously these days. Common pricing practice is for the traders to give out loans to farmers during the planting season and agree on the price of rice in advance. However, in the eastern region, the gallawalas determine the price of rice after consultation with certain traders (millers), and circulate this information to the assembler for procuring rice from farmers. Lower price of imported rice from India and excessive influence of gallas (big traders at local level), open border situation, inadequate storage capacities, frequent strikes and Closure and unwillingness of government to announce MSP are some of the major problems associated with rice marketing in Nepal.

Keywords: Marketing, MSP, Price, Rice, Trader

Introduction

Rice is the staple diet of mankind, because rice is truly life, culture, tradition and a means of livelihood to millions. Rice is by far the most important crop in Nepal and contributes 51.6% of total cereal production. It continues to play vital role in the national food grain supply (MoAD 2015).

Agricultural marketing system plays a crucial role in achieving the twin objectives of providing remunerative prices to the farmers for their products and ensuring regular supplies of these products to the consumers at reasonable prices (Sidhu 1986). Sidhu (1986) in assessing the policies pertaining to agricultural marketing and input supply found that effective marketing, not only minimized losses but also motivated the farmers to produce more in order to maximize the returns from their farm. However in Nepal, institutionalized marketing systems have not yet been established (Dhital 2004).

The rice marketing system operated by the Ministry of Agricultural Development is in a preliminary stage. The major share of rice marketing is dominated by the middlemen such as village traders, wholesalers and rice millers. Poor farmers have to sell their production to the middlemen immediately after harvest on their offer price due to need of money and lack of storage facilities. The poor marketing system has been the main factor linked with rural poverty and food insecurity in Nepal. Rice marketing in Nepal has not been efficiently strengthened and upgraded which has created a serious problem in distribution of rice all over the country.

Figure 1. Rice after harvest

This situation has seriously prevented the improvement of farmer's income and, consequently, rice farming. Due to the lack of markets information, good warehouses, transportation and credit facilities, farmers are compelled to sell their products to the middlemen during the harvest time at a low farm gate price. These middlemen later obtain high prices by floating the grain in the markets. As a consequence, a chunk of the profit goes to the middleman rather than these original producers. Tewari et al (2006) mentioned that the education level of small holding farmers was found to be fairly low and they were unable to arrange credit facilities in time. Therefore, the poor marketing system has been the main factor linked with rural poverty in Nepal. The government of Nepal has been giving top priority to rice production and its appropriate marketing system. Improving the marketing system of rice is considered essential for poverty alleviation, national food security and the economic development of the country (Bahadur 1995). However, our rural marketing system is very poor compared with other south Asian countries. Our neighboring country specifically India has improved the food security and poverty situation by changing rural marketing policy in agricultural sector.

Inefficient marketing practices hurt both producers and consumers even though such practices may benefit traders to a certain extent in the short run. However, all the parties in the market loose in the long run due to overall marketing inefficiency. The price of rice mainly depends on the price determined by local large millers and traders, and the prices in the bordering Indian markets.

Rice marketing policies in Nepal

Nepal is the 85th most food insecure country in the world despite the fact that 65.5% of its population is dependent on agriculture, according to the global food security index 2015. Half of the small and marginal farmers and majority of landless agriculture workers are below the poverty line. The government has launched mega program and has policies in place to overcome hunger/malnutrition. However, benefits of such provisions hardly reach the beneficiaries (Kathmandu Post 2016-5-20).

The legal framework pertaining to agriculture and agricultural marketing is quite extensive, with over 60 laws—and additional rules, regulations, orders, and bylaws- of direct concern. Having gained WTO membership in 2004, this existing framework will continue to be strengthened, either with new or amended legislation, in order to better align it with WTO recommendations. Despite this existing framework, it is important to note that there is neither a policy to ensure that producers and traders compete freely nor to prohibit connivance and cartels in the domestic market. The latter is evident in today's practice of rate fixing by transport syndicates.

Nepal has been a net rice importer for the last two decades, importing mainly from India despite the recent export bans by India. The country's government policies and interventions in agricultural markets were geared toward the supply of adequate food grain through importation (Tobias et al 2012). Rice is a critical crop for food security and a mainstay for the rural population in Nepal. Because only a relatively small volume of rice production is traded internationally, high level of self-sufficiency is generally pursued as the preferred strategy to secure adequate supplies, especially in those countries relying on rice as the main staple. Successive governments have accordingly supported the sector, through research in new varieties and the provision of irrigation, subsidized credit, basic inputs and extension (FAO 2003). Rice is one of the few food commodities still subject to widespread domestic marketing restrictions and to government wholesale or retail price controls. Over the past two years, there was a tendency to further deregulate post-harvest activities and efforts made to shift some functions traditionally carried out by government organizations, such as stock holding, to the private sector. Furthermore, governments moved to concentrate their food distribution programmes on vulnerable and special population groups (FAO 2003). As per the current 14^{th} plan (2016/17-2018/19), government has made a provision to maintain stocks of food grain as 1500 tonnes in buffer stock and 4000 tonnes in SAARC Food Bank as an strategy for country food security (MoF 2016).

Rice marketing channel in Nepal

Rice marketing system is purely private based except the distribution of processed rice through National Food Corporation (NFC) and is totally dominated by private traders. The most widely seen channel for rice marketing includes private as well as the government institutions. **Figure 2** describes the possible marketing routes through which rice is channeled. Rice is generally marketed in Nepal through involvement of middlemen. **Figure 3** describes the possible marketing routes through which rice is channeled. Marketing of rice via wholesaler, village trader, rice miller and agricultural cooperatives is common phenomenon in Nepal. Small land holding farmers with small quantities of rice often sell directly to the agricultural cooperatives and rice mills. Such farmers have less surplus and high home consumption. Rice millers are one of other key players as middlemen in rice marketing. They collect rice from farmers, village traders, wholesalers and cooperatives. Rice millers are rice traders serving as an intermediary. Each miller announces the price levels of milled rice considering the milling charge and based on the prevailing prices. The market share of rice brokers is uncertain because it is not a legal distribution channel and therefore, this kind of market channel is also called as rice smuggler. Sometimes, they supply rice to India, actively working near the Indian border area. Rice is distributed to consumer through all the intermediary actors.

Figure 2. Rice ready for sale

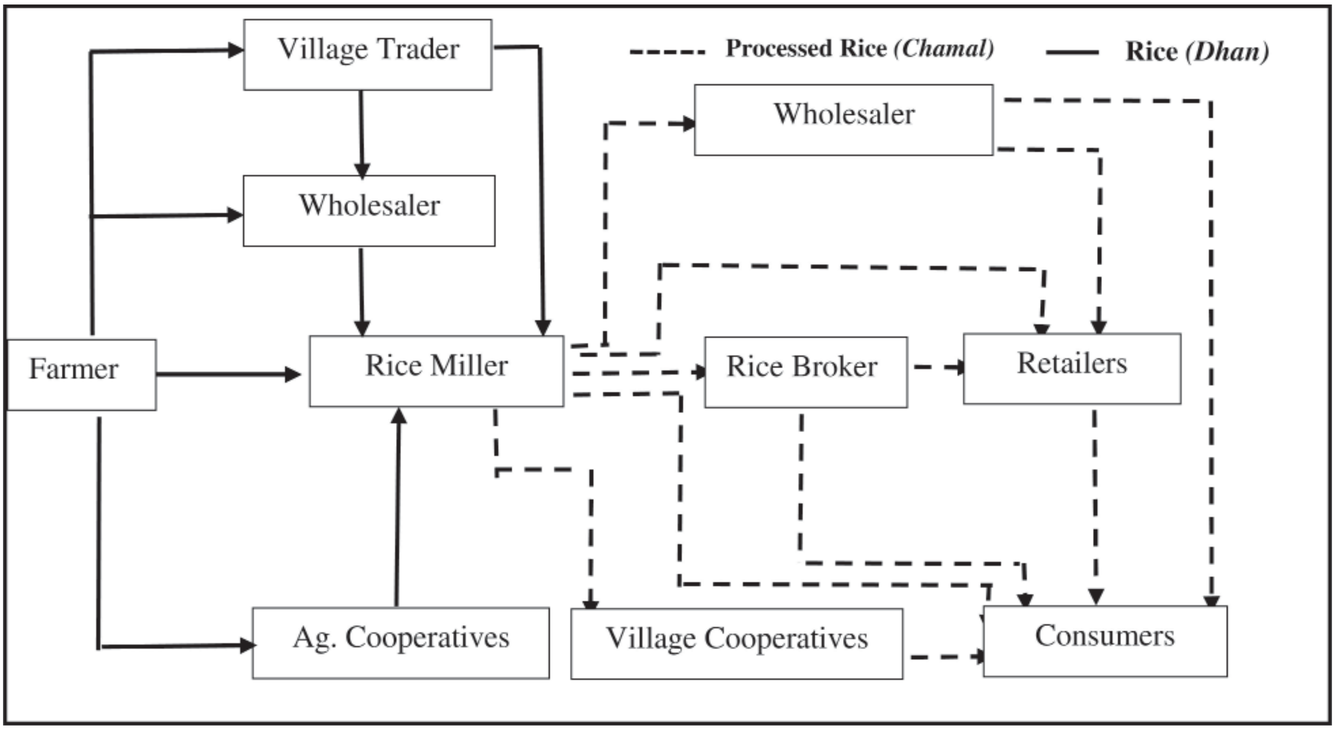

Figure 3. Rice marketing system in Nepal

Institutions involved in rice marketing and price comparison

Rice (processed and unprocessed) marketing is mainly dominated by private sectors in Nepal. As mentioned earlier most of traders (wholesalers, retailers, rice mills) involved directly in rice marketing are from private sector. Besides them, NFC and Salt Trading Corporation (STC) are some of the major public institutions engaged in rice marketing. STC is one of the largest business organizations in Nepal established as an experiment of the utility of Public Private Partnership (PPP) for a developing country under PPP act of Government of Nepal. With the proportion of 79:21 investment from private- public (state owned National Trading Limited), STC is managed by joint effort of state (Government) and private (shareholders). Both of these institutions are directly involved in contributing supply of rice in market. Similarly, NFC is one of the major government owned institutions that mainly aims in making rice and other agricultural products available in remote areas of country.

Generally, the price of rice fixed by the both institutions is generally lower than the retail market price for rice as shown in the table below. Moreover, government has promulgated rules for Operating Low Prices Cooperative Shop (*Supath Mulyaka Sahakari Pasal Sanchalan Sambhandi Niwamaoli 2065*) in 2nd March 2009. This regulation mainly focused in ensuring supply of agricultural products (especially cereals including rice) in reasonably lower price. Few years ago, Ministry of Agricultural Development had also provided NRs 1 lakhs to agricultural cooperatives to run low price shops (Supath Mulya Pasal) that sell agricultural products (including rice) and agricultural inputs. However, due to weak regulation and implementation, these low price shop could not run as expected. However, some them are still in operation in some parts of the country.

Table 1. Price of various types of processed rice in NFC, STC and retail market

SN	Types of processed rice	Price at NFC	Price at STC	Retail Price at market
1	*Aruwa Mota Chamal*	40.70		
2	*Aruwa Makawanpur Chamal*	41		

SN	Types of processed rice	Price at NFC	Price at STC	Retail Price at market
3	*Aruwa Madhyam Chamal*	43		
4	*Aruwa Sona Masuli Chamal*	45		
5	*Aruwa Gorakhnath Chamal*	50		
6	*Aruwa Jeera Masino Chamal/Jeera Masino*	60		60-70
7	*Aruwa Basmati Chamal*	95		
8	*Usina Sona Masuli/Sona Masuli Chamal*	37	41.33	
9	*Usina Mota Chamal*	35		
10	*Bangladeshi Usina Chamal*	35		
11	Brown Sona Masuli *Chamal*	40		
12	Brown *Basmati Chamal*	95		
13	*Makhhan Masuli Chamal*			60
14	Basmati *Chamal Ne/E*			85-100
15	*Pokhreli Chamal*		65.75	70
16	*TNT Basmati*		102.0	
17	*Bhansa Ghar Chamal*		59	
18	*Sonam Mangalam Chamal*		65.6	
19	Local *Jeera Masino*		88.0	

Source : STC 2017, NFC 2017, Kirana Byapari Sangh 2017.

Marketing practices, mode of transportation and payment of rice in Nepal

Rice marketing in Nepal starts from the last week of Ashwin (September-October) to the month of Falgun (February-March)/Charitra (March-April). However, larger land lord in Tarai region sell the surplus remained after consumption during month Ashad (June-July) too. However, major transaction in rice occur from second week of Kartik (October-November) to last week of Mangsir (2nd week of December) in Nepal. In western Tarai, especially in Bardia, farmers are found to keep 1-1.5 tonnes of rice for household consumption. In an average, more than 50% of household sale two to five tonnes of rice each season (Mahatra 2017, personal communication). Whereas in hilly areas, the quantity of sale is lower than that of Tarai region. In mountain region, most of people bring rice from hilly or Tarai districts. In Tarai, after harvesting and threshing of rice, farmers sell rice to local traders (generally called as Galla) or roaming traders for rice (*Firante* trader) or a trader who has previously lent money to farmers.

Figure 4. Traders arriving for purchase of rice

Somewhere Indian traders reach at the rice field of farmers and purchase all their produces. Immediately after harvest, farmers are forced to sale rice at lower price because of the higher moisture. Price of coarse rice increases from NRs 16000/ton in Ashwin (September-October)/Kartik (October-November) to 20000/ton in Falgun (February-March)/Charitra (March-April). Similarly, price of medium and find rice increases from NRs 18000/ton and NRs 21000/ton in Ashwin (September-October)/Kartik (October-November) to NRs 22000/ton and NRs 29000/ton in Falgun (February-March)/Charitra (March-April). When traders reach at rice field to purchase rice, they generally set price at NRs 1000-1500/ton lower than the market price. In such situation farmers have to pay NRs 80-90 for each sack provided by traders for bagging. Price of rice generally depends on price of rice in India. National Food Corporation also purchase rice from Tarai district and distribute them to hilly districts of Karnali districts and remote areas. Price of rice is found to increase after NFC announces its price. However, by that time, most of farmers are already found to have sold rice to local traders or India traders. In Bardia, local traders generally sell rice to nearby wholesalers or big traders (Like K.L.Dugad, Prativa Rice Mill of Golchha Group, Ganga Kadhya Udhyog, Nandani Rice Mills etc). Some of them sell rice to rice mills around Nawalparasi and Rupendehi to make beaten and puffed rice. In some places, people directly purchase rice from mills because they believe that they can get quality rice that is free from any kind of adulteration (Mahatra 2017, personal communication).

Figure 5. Rice brand available in market

Marketing practices followed in the mid hill region of Nepal is quite different from Tarai. Most of farmers are found to grow local varieties of rice in mid hills region. Common practice of sale of rice through involvement of traders *(Galla)* as seen in Tarai region does not prevail in hilly areas of Nepal. In many cases farmers keep most of the quantity produced for household consumption. Some farmers pack rice in sack and sale them in local market or district headquarter themselves. This tradition of sale of rice, in fact, has lowered the bargaining power of farmers and price per unit in the market. The change in consumption behavior of people to consume fine rice from coarse rice has forced farmers to keep their produce (coarse rice) unsold. Farmers find it very easy to sell fine rice in comparison to coarse rice in hilly districts. Trend of importing readymade fine rice from Tarai areas has increased tremendously these days. The movement of traders from mid hills district to Tarai region for rice purchase still prevails in these days too. Moreover, farmers are found reluctant to sell rice because of low price per unit in hilly districts of Nepal. Farmers feel that branding of local rice would fetch good price and also would create huge demand of local rice throughout the country (Adhikari and Regmi 2017, personal communication).

Farmers need to make arrangement of transportation themselves to deliver rice to store of traders and Nepal Food Corporation. Larger farmers use tractor for transporting rice whereas smaller farmers generally use mini tillers and bullock drawn cart. Transportation cost differs in use of means of transportation. Generally, a tractor takes NRs 800-1200/trip (for 3.5 – 4.0 tonnes) and bullock drawn cart takes NRs 500-700/trip (2.0-2.5 tonnes) to deliver rice to destination. In western Tarai region, especially in Banke, Bardia, Kailali and Kanchanpur, payment for sale of rice is made in three ways. First, farmers shall receive the total payment for sale of rice from trader (*Sahu/Mahajan*) by deducting amount of loan taken. Secondly, trader will make payment within 10 days when farmers suffer from immediate need of cash. Third mode of payment would be based on trust between farmers and traders. In this mode of payment farmers will deliver rice to traders and receive the payment at higher price during Falgun (February-March)/Charitra (March-April) (Mahatra 2017, personal communication).

Because of change in consumption behavior of Nepalese people, demand for fine rice is increasing at a rapid rate in Nepal. Various types of rice with different brand names (even in Nepalese brand) are found in market indicated as fine rice (eg *Jeera Masino*). However, none of them specify the variety of rice in the package. This, in fact, creates problem in assessing the place of cultivation of the rice, packaging and processing of rice.

Rice price determination in Nepal

The interaction of demand and supply forces in the market at a given time determines the price of commodity. Shrestha and Pandey (2011) stated that the common pricing practice is for the traders to give out loans to farmers during the planting season and agree on the price of rice in advance. However, in the eastern region, the *gallawalas* determine the price of rice after consultation with certain traders (millers), and circulate this information to the assembler for procuring rice from farmers. At the producers' level the traders determine rice price whereas at the wholesalers' level, the price was determined by wholesalers themselves. In the retail market, price is determined by retailers. This indicates the dominant role of traders (miller/wholesaler) in determining the price of rice in the market.

If we look at the annual average price of raw rice there is discrimination in the price based on the quality as like as coarse, medium and fine. On an average the price of raw rice medium is 1.2 times higher than raw rice coarse whereas the price of raw rice fine is 1.9 times higher than raw rice coarse and 1.5 times higher than the raw rice medium. The price of raw rice coarse was NRs 17.07/kg in 2001/2 and reached to 42.83 in 2014/15 by 151% increment. Similarly, price of raw rice medium increased by 160% from NRs 21.03/kg in 2001/2 to NRs 54.63/kg in 2014/15. Likewise, price of raw fine rice increased by 152% from NRs 33.56/kg in 2001/2 to NRs 84.41/kg in 2014/15 as shown in **Table 2**. The study conducted by Mishra et al (2016) found that any change in the Indian rice price is transmitted to Nepal and thereby affects the demand and supply scenario in Nepalese rice market.

Table 2. National annual average price of raw rice from 2001/02-2014/15 in NRs/kg

Fiscal year	Raw rice coarse	Raw rice medium	Raw rice fine
2001/02	17.07	21.03	33.56
2002/03	17.2	21.78	32.93
2003/04	17.88	23.48	36.02
2004/05	18.13	22.94	34.36
2005/06	29.06	27.08	40.35
2006/07	22.63	28.18	43.83
2007/08	25.51	30.99	45.85
2008/09	29.96	36.01	52.5
2009/10	31.58	40.95	61.06
2010/11	34.93	43.72	65.28
2011/12	34.45	43.4	63.72
2012/13	36.54	46.78	69.25
2013/14	40.53	51.31	79.0
2014/15	42.83	54.63	84.41

Source: MoAD 2015.

Constraints of rice marketing in Nepal

Lower price of imported rice from India and excessive influence of *gallas* (big traders at local level) and other traders to control on price of rice are the major problems faced by farmers of Tarai region with reduced farm gate price. Because of open border situation with India, the flow of cheaper rice from India to Nepal has often been raised by farmers as a serious issue in rice marketing in Nepal. This problem is faced at all level of marketing ie from wholesaling to retailing. The market price of rice is generally announced by traders. They generally keep the price of rice lower at the peak season of production and higher when the grains are out of stock at the farmers' level. This has mainly resulted due to lack of adequate storage facilities at farm level. Rice farmers in Nepal often do not have option of alternative markets to sell their produce. So, they are forced to sell their produce at the price set by traders. The influence in price of rice due to cross border flow is also a serious concern from the perspective of wholesalers and traders in Nepal. Issues of mixing of poor quality rice imported from India with Nepalese rice is also heard around the border area of Nepal. Frequent strikes and *bandas* (closure of transportation and market) have also appeared as major problems for rice marketing in Nepal. Majority of traders argue that they have been forced to give donation and taxes at various places while marketing of rice. Similarly, lower bound tariffs for processed rice (8%) and unprocessed rice (5%) has allowed border flow of lower priced rice from India to Nepal, resulting in distortion of domestic market in Tarai region. Lower quality of rice due to mixing up of stones and other materials, inappropriate packaging, loss in weight of rice in comparison to the quantity they pay for are some of the problems being faced at retailer's level during rice marketing in Nepal. As MSP of rice have not been announce for many years, Nepalese farmers always face the problems in marketing of rice after crop harvest. Lack of infrastructural facilities (eg transportation and storage) and financial resources are some of the other constraints in rice marketing in Nepal.

Conclusion

Marketing function of rice is mainly dominated by the activities of intermediaries like '*gallawalas,*' millers and other stakeholders involved in product moving, who act as a price maker and grab the major share of the consumer price. On the other hand, farmers are less benefitted by the consumer price. Considering these facts time has come to make a difference in the area of rice marketing in Nepal. It is apparent that shorter the channel, lower is the marketing margin and associated cost. This in turn would safeguard the producer's share and consumer sovereignty. There is a need to reduce the price spread and increase the farmers' shares. It can be achieved either by reducing the number of intermediaries or by improving the functions and creating enabling environment like subsidies, extension services, infrastructures and trade promotion activities. Among these, reduction of intermediaries' number could be the best one. Some of the policy suggestions for promotion of rice marketing in Nepal could be:

- Farm productivity enhancing policies, which include a broad range of policies such as irrigation, research and extension that would result in higher yields and consequently an upward shift of the supply curve.
- Transportation infrastructure policies, which would reduce transportation costs of major transportation corridors connecting the five regions of Nepal.
- Import control policies that lift the explicit or implicit restrictions on international trade.
- Standards and quality control policies, which include policies that would regulate the quality standard of rice varieties and/or affect the degree of mixing between rice varieties.
- Rice based industries strengthening policies, which include market information, taxes and tariffs, product development
- PPP model strengthening policies, which include creation of enabling environment for the establishment of public limited company for rice marketing.
- Execution of minimum support price (MSP) for the protection of rice farmers and to minimize the informal flow of rice to India.

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Product Diversification and Use of Rice By-Products

(वस्तु विविधिकरण तथा उप-उत्पादनको उपयोग र प्रयोग)

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Rice Products Diversification in Context of Nepalese Culture

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सारांश

धान नेपालको प्रमुख खाद्यान्न मात्र नभई सांस्कृतिक प्रक्रियासँग जोडिएको मुख्य अन्न हो । प्राचीनकालदेखि नै जन्म विवाह लगायत अन्य उत्सव तथा मृत्युमा समेत धानको विभिन्न उपयोग हुने गर्दछ । चिउरा, सेलरोटी, कसार, भुजा, जाँड, रक्सी आदि परम्परागत खाद्य पदार्थहरूका साथै केक, चाउचाउ, तयारी भात आदि आधुनिक खाद्य वस्तुहरू समेत उत्पादन गर्न सकिने यस अन्नको समाजका विभिन्न वर्गहरूमा अनिवार्य उपयोग हुने गर्दछ । भात लगायत चामलको अन्य परिकार बनाई खानुलाई प्रतिष्ठाको विषयसँग जोडेर हेरिने हाम्रो समाजमा पछिल्लो समयमा यसको सांस्कृतिक र खाद्य परिकारमा विविधताको अवस्था भने घट्दो छ । यसै सिलसिलामा धानसँग सम्बन्धित तिनै खाद्य वस्तुहरूको नयाँ पुस्तामा पहिचान नगुमोस् भन्ने हेतुले सामान्य प्रशोधन प्रविधि तथा तस्बीरहरू यो लेखमा प्रस्तुत गरिएको छ ।

Summary

Rice is major cereal crop of Nepal and is linked with culture, religion and food habits of Nepalese. Since ancient time, it was used in different forms in ceremonies like birth, death, marriage and festivals. Beaten rice, *Sel roti*, Puffed rice, *Kasar* and drinks like *Jand, Raksi* are major food products prepared from rice. Besides this, cakes, noodles, ready made rice and other products are also prepared from it and consumed widely in different parts of country. Consumption of rice and rice products is taken as a matter of dignity, but its use in religious purpose is declining day by day. So, to inform about about importance of rice and its products to new generation, this article explains about varieties of products prepared from rice, their importance, processing methods and their linkage with our tradition and culture.

Keywords: Culture, New generation, Processing, Products, Religion, Rice

Introduction

Nepal is a country of multi-ethnic communities. Every ethnic tribe has its unique culture, traditions, languages and food habits. Thus, Nepal is paradise for people with discerning palate. Although some of the foods in Nepal have been influenced from its neighboring countries but many others have their unique taste because of the importance given to the locally produced spices and ingredients. Geographical diversity has aided a lot in bringing variations in taste of Nepal. Nepalese foods are not only rich in taste but also possess higher nutritional value. In fact, food in Nepal are far more hygienic than most of other Asian foods since they rely more on herbs and spices rather than on oil and fat. Even the people who do not eat rice as their main diet said that they ate *Bhat,* which strictly implies to rice. Eating rice is prestigious compared to other foods. Hence, rice is culturally and socially associated to Nepalese society and role of rice is more important from cradle to crave of Nepalese ethno-culture. A set of *Dal, Bhat and Tarkari* is the most popular food of Nepal in which *Bhat* (boiled or steamed rice) is served along with *dal* (cooked lentil or blackgram) and *Tarkari* (curry) (Poudel 2011). Other foods have hybrid Tibetan, Indian and Thai origins. Declining per capita consumption of plain cooked rice in Asia has accelerated national research and development on rice processed products to help maintain rice consumption levels. The processing of rice and the eating quality of the product are influenced by a number of functional properties, which derive from the rice composition.

The ratio of amylose to amylopectin in starch as indexed by apparent amylose content (AC) of milled rice is the chief influence on processing and eating quality. Most tropical non-glutinous varieties have 20% or higher amylose. Processed rice products were surveyed, with emphasis on Asia. Glutinous rice is used in desserts, cakes and sauces, low AC rice in baby foods and breakfast cereals, intermediate AC rice in canned soups and fermented rice cakes, and high AC rice in rice noodles.

Indigenous rice products in context to Nepal

In Nepal, various indigenous products are prepared from rice and consumed regularly or occasionally. Some of these food items with their preferred traits have been presented in following table.

Table 1. Typical indigenous food items prepared from rice in Nepal and their preferred traits

Rice food items	Rice varieties	Preferred traits
Sel roti	Bihari*, Manamuri*, Radha-17, BG 1442	Tasty, puffiness
Chiura	Yekhattar, Sabitri, Radha-4	Long, wide grain and tasty
Khir	Mansuli, Sabitri	Tasty
Bhat	Basmati*, Poteli*, Malaysia, Sabitri, Radha-1	Softness, tasty
Latte	Anadi*	Stickiness
Puwa	Any irrigated fine rice variety	
Siramla	Anadi*	Tasty, sweet
Dahi chamal	Any irrigated fine rice variety	
Pulaw	Any irrigated fine rice variety	
Jhilaya	Mansuli, Manamuri*	Softness
Anarasa	Mansuli, Manamuri*	Softness

*Local rice varieties (Pandey 2005)

Bhat (Plain boiled rice)

Ingredients: 2 Cups or 400 Grams of Common Rice, 2 Cups or 500 ml of water

Preparation: Wash the rice and soak it in water for about 10 minutes. Put the rice inside 3 Liter Pressure Cooker and add 2 cups or 500 ml of fresh drinking water. Close the lid of cooker tightly and start heating it until the first whistle comes. After the first whistle, reduce the heat and cook the rice for another 1 minute. Turn off the heat and leave the cooker to cool naturally. Hot serve.

Figure 1. paddy, brown and polished rice, measuring water, cooking rice and *Bhat* (clockwise)

Chiura (Beaten rice)

A popular traditional food of Nepal made from paddy. It is made by soaking, draining, roasting and flaking the paddy followed by removing of the husk. It is one of the items mainly consumed in special occasion typically in *Ashad* 15 (National Rice Day) with *Dahi* (fermented milk product). Beaten rice or rice flake is a very popular snack item in Nepal. It is pre-cooked, having crispy texture and is in ready to serve form. It is eaten as a snack or as full meal with milk, yoghurt, pickle, meat, eggs, cooked legumes, etc. It is also consumed in other Southeast Asian countries. It is popular among different ethnic communities of Nepal especially in Newar, Bramhin, Chhetri, Rajbanshi, Choudhary, etc. Special coarse varieties of rice such as Taichung-176, Radha-12, etc are suitable for *Chiura* preparation. *Chiura* is considered an essential item in occasions like marriage ceremony, festivals, picnic and similar functions. Researches show that in *Chiura* making there is a significant loss of minerals like calcium and iron. There have been some studies on the fortification of *Chiura* with these minerals for compensating the loss. In traditional approach, the tools *Okhli* or *Dhiki* are used to prepare *Chiura*. In modern milling system, power mills are used to flake the paddy to convert in *Chiura*.

In modern milling, the process commences with the selection of clean and robust paddy grains. The selected grains are packed in jute bags and soaking in potable water for 24 to 48 hours. The soaked paddy is then drained and roasted with sand till puffing started. Roasted rice immediately screened to separate sand and passed between heavy iron rolls for the flaking. The husk and broken rice are separated by winnowing followed by screening. Ready rice flakes is cooled and packed in plastic bag for the storage up to 3 months. When molasses is mixed with beaten rice it is called as *bheli-chiura*.

Figure 2. Soaked and drained paddy, roasting, hand pounding and *Chiura* (clockwise)

Sel roti

Selroti is a ring shaped deep fried rice confection. Generally, it is prepared in festive occasions and rituals like: *Tihar*, *Maghe sankranti*, *Swasthani-Pooja* and during funeral ceremonies. It is generally consumed as breakfast snack in major cities including Kathmandu valley. The major ingredients for the *sel roti* preparation are: rice flour, sugar, ghee and refined oil. The process of making *sel roti* differs slightly with the availability of minor ingredients and culture. Generally, fenugreek, ripened banana, butter, yoghurt, *kaulo* (bark), baking soda etc are used as enhancer. Selected rice varieties (*Anandi*, Taichung-176 etc) are used to make *sel roti*.

Ingredients: Three cups basmati rice (soaked for a few hours), 3 cups soft butter, 1 cup sugar, 1 teaspoon vanilla extract, one tablespoon ground cardamom, $^1/_4$ cup almond nuts, $^1/_4$ cup cashew nuts, two tablespoons grated coconut, three cups chilled whole milk, one teaspoon salt, one liter cooking oil.

Preparation: Rice is soaked for two hours and drained properly. Soaked rice is grinded and screened to separate fine and coarse flour. Ground rice flour is aged for 1-2 days for better texture and flavor of *selroti*. Fine and coarse ground rice flour (4:1) are mixed with ghee or butter and sugar each 8 to 10%. Improving agents are mixed (as preference) properly and finally water is added (50-60% of flour) and whipped manually or mechanically for 15-20 minutes continuously to make viscous batter. Around 50 g of batter is poured uniformly in ring shape in to the boiling refined oil on frying pan. Deep frying is carried out till the ring turns yellowish brown and is turned upside down with the help of skewer. Prepared *sel roti* is then drained and assumed better if hot served. *Sel roti* are prepared in bulk and can be stored for a week at room temperature. *Sel roti* are often sent as souvenir to family members and relatives.

Babar: For the *Babar* preparation, first rice flour is mixed with water and making it like paste (or residual batter of *Sel roti* can also be used) and pour in fry pan with ghee or in vegetable oil by making flat round shape. It is cooked on both sides till brownish red crust. It is mostly common during the time of fasting (*brata*) or in *Tihar* festival.

Figure 3. Ingredients, batter, deep frying, *Sel roti* (ring shape) and *babar* (flat shape) (clockwise)

Pulao

Pulao is fried rice with spices and condiments. Rice is soaked in water. Spices and condiments such as coconut, date, palm, resin, cardamom, cloves, cinnamon, green pea, ground nut are dip fried and then soaked rice is added with stirring till slight brown coloration. Hot water is added for final cooking. Similarly, vegetable *pulao* is also popular in Nepal. It is served during the parties and events. It has flavor of turmeric and cumin to it.

Figure 4. soaking rice, spices, vegetables, plain *pulao* and vegetable *pulao* (clockwise)

Bhuja (Puffed rice)

Bhuja **(**puffed rice) is a type of puffed grain made from paddy, commonly used in breakfast cereal or snack foods, and served as a popular street food in South Asia. It is also famous as other names as "*Murai*" or "*Golfuki.* "Traditionally, *Bhuja* preparation includes soaking of paddy (2-3 days), draining the water and lightly roasting in earthen pot though the method of manufacture varies widely. Puffed rice is formed by the gelatinization of starch when heated within the shell of the grain. Unlike popcorn, rice kernels are naturally lacking in moisture and must first be conditioned with steam.

Figure 5. Earthen pot for roasting, *Bhuja*, puffed rice balls made with Jaggery (clockwise)

In modern method, 10% salt solution is sprinkled in rice in the ratio of 1:25 followed by overnight heaping for the conditioning. The conditioned rice obtained from both processes is dried in sunny place for 4-6 hours. Puffed rice can be prepared by roasting the dried conditioned rice kernels either with sand or oil or heating in an oven. Rice puffed in this way is crispy and slightly salty in taste.

Puwa

Puwa is the traditional sweet made from Rice. *Puwa* preparation involves the roasting of small broken rice (*kanika*) or flour in *Ghiu* (ghee) until it becomes brown red. A little water is sprinkled and steamed for short in certain intervals of roasting. About 10% of sugar and spices as preference are added as flavor.

Figure 6. Broken rice (semolina), roasting *puwa,* ready *puwa* (clockwise)

Chamre

Chamre is a type of fried rice. Rice is soaked in water for about 15 minutes and then fried in ghee or oil. It will be given color by adding turmeric powder along with some salt. *Chamre* is generally served with *sandeko gundruk* (pickle prepared from fermented mustard leaves).

Figure 7. *Chamre, sandeko gundruk and latte* (clockwise)

Latte

Food prepared from sticky rice (landrace: *Anadi*) is called *latte*. Rice is soaked in water and then fried in ghee adding sugar or molasses and cooked in slow fire until it gains sticky.

Yomari

Yomari is the special dish of Newar community. It is prepared by filling the dumpling of rice flour which is shaped in the form of divine conch (*Shankha*) with mixture of molasses and sesame seeds. Although *yomari* was traditionally prepared especially in *Yomari Punhi* (the full moon night of Poush month of Nepali calendar). These days, *yomari* is available in all Newari hotels in Kathmandu. It is the Newari sweet dish that is best served hot. *Yomari* is steamed in an earthen pot called *Potasi* and molasses can be substituted by lentil paste or milk solids called *Khuwa*. ***Ingredients*****:** Four cups rice flour, one cup sugar, water, one cup sesame seed, one table spoon ghee or oil

Preparation**:** About two cups of water is boiled. Ghee is put in the boiled water. Rice flour is kneaded well and wrapped in a piece of cloth. Sesame seeds are fried lightly in an ungreased pan till they begin to jump. Fine blending is carried and mixed with sugar. Some water is added to make medium thick batter. A handful of kneaded flour is taken and shaped like egg and reshaped to oval. From one side, a hole is made using finger tip by gradually pressing the dough. Sesame paste with *chaku* is added and close giving pointed shape. After making several pieces, put into a steamer for steaming and serve hot. This *Yomari* has very special value. It is made on the full moon day festival in the month of December. It is believed that it gives hotness to the body. On auspicious occasions when a baby boy or girl attends 2 or 4 years of age, *Yomari* is compulsory and the child is garlanded with *Yomari* pieces stitched in a thread numbering his/her age.

Figure 8. Dough for *Yomari*, Enrobing *Chaku*, Steaming *Yomari*, Ready *Yomari* (clockwise)

Fini roti

Fini is served at special or ceremonial functions as part of traditional rituals. They are very popular during *Dashain, Tihar* (Laxmi puja and Bhai Tika). As ingredients, for the *Satho* (to create the layers in the *Fini*); 200 g ghee (clarified butter), 1 and 1/2 cup fine rice flour. For the *Fini* dough; one kg white flour, 50 g ghee (clarified butter), two cups water, permissible food color, one cup sugar, one liter oil for deep frying.

Preparation: For the *Satho*, add the rice flour and ghee in a dish and mixed till smooth texture. For the *Fini* dough, first prepare white dough with flour, oil and water to soft dough. Divide the dough into 2 or 4 equal parts (if you are not confident about rolling the dough, then make 4 parts). Using a rolling pin, flatten it out in a long rectangular shape. It should be about 1/2 inch thick. Using a butter knife or spoon, evenly spread generous amount of "*Satho*" all over the flattened dough. The *Satho* helps to creates multiple layers in the *Fini* once it is cooked.

Figure 9. Dough from rice flour, deep frying of *fini and r*eady *fini* (clockwise)

Gently roll the dough into a tight roll ensuring the dough and the *satho* stick as it is rolled the dough. Cut the roll into 2 inch size pieces. Flatten and roll out each dough piece with a rolling pin. Using a sharp knife, make 3 equally spaced slits on the rolled dough. Heat sufficient oil in a pan and deep fry each *Fini* individually. The *Fini* should be fried for 2-3 minutes and should be crispy. *Fini* is served cold and can be stored for 2 weeks.

Kheer (Rice pudding)

Kheer or rice pudding is a sweet dish prepared by adding rice, dried fruits, cinnamon powder and cardamom powder to the boiling milk and leaving it on the neat for about an hour. It is the customary practice to eat *Kheer* on the date of 15th Shrawan (last week of July).

Ingredients: 200g basmati rice or *Sabudana,* one litre whole milk, four tablespoons slivered almonds or shredded coconut, six slightly crushed cardamom pods, six tablespoons sugar

Preparation: Rice is soaked in water for 30 minutes. Milk, sugar and cardamom pods are placed in heavy based pan and bring to boil. Drained rice is added and heated in low flame simmer one hour. Add almonds and or shredded coconut. Cooking until it has consistency of porridge by frequent stirring. Serve warm or cold.

Figure 10. Ingredients for *kheer* preparation, cooking *kheer* in *karahi* and ready *kheer* (clockwise)

Siramla

Siramla is prepared from local rice variety called *Anadi*. The paddy is soaked in water overnight then roasted and dehusked. If it is be kept for long time, it will change into hard. When *Siramla* is fried or roasted in small fire we can get puff rice called *Khatte*. It is the popular breakfast in hilly areas of Nepal. It is made from rice mainly from brown rice obtained from *Dhiki* (a special Nepalese manual flaking instrument) but white or polished rice can also be used.

Anarasa

Anarasa is a type of rice cookie. It is generally made during festivals. It is offered as *Prasad* to god too. *Anarasa* is made mainly during Deepawali. *Anarasa* is made of a mixture having an equal proportion of rice flour and sugar; hence it is sweet enough to call *Mithai (sweets)*. The sesame seeds on the top adds different flavor to it. Ingredients such as: rice flour, sugar and ground dry fruits are mixed and left overnight for a proper blending. Making of *Anarasa* is a two day process, and can be prepared at home.

Ingredients: Rice soaked for a few hours - 3 cups, ghee (Melted unsalted butter) -1 cup, sugar - 3 cups, cardamom (ground) - 1 tablespoon, almond (ground) - 1/4 cup, cashew nuts (ground) - 1/4 cup, ghee (Melted butter for frying) - 2 cups, lemons: 4 to 5, white sesame seed- half cup

Preparation: On the first day, grind soaked rice and sugar, add ground cardamom, cashew and almond and mix it well, the mixture is put as it is to stay overnight, the mixture gets moist next morning. On the second day, draw lemon juice in a bowl, take a plate and spread some sesame seed and some dried ground rice on it. Take a small ball out of the moist mixture, dip your figures into the lemon juice, gently spread the ball (in the plate of sesame seed and rice) into the shape of a cookie. Heat oil in a big pan until it starts steaming (make it real hot). Drop *Anarasa* cake into the oil and change sides and let it fry one at a time until it becomes golden brown. Take the *Anarasa* out and stack it one on top of other to drain excess oil. Place it to be cool and enjoy it.

Figure 11. Mixing ingredients, flattening dough, frying *Anarsa* and ready *Anarsa* (clockwise)

Kasaar

Kasar is a special traditional sweet of Nepal made from rice flour and melted jiggery with ball shape of radius 4-6 cm. Basically it is served in wedding ceremony, *Brata bandha* and other cultural activities specially in Bramhin and Kshetri communities.

Figure 12. Roasting rice with ghee, shredded coconut, melted jaggery, mixing ingredients and *Kasar* (clockwise)

Bagiya and *Chichar*

Both dishes are special to *Tharu* community. *Bagiya* (rice flour dumpling) is a healthy and delicious dish eaten during the *Shukrati* (Deepawali) festival in eastern Tarai of Nepal. It needs some rice flour, lentils, spices and a pot of boiling water to prepare it. The rice is soaked in water milled in dhiki, shifting the flour and fried on iron cauldron (avoid to burn the flour). Warm water is added and kneaded enough to prepare tender dough. Steamed lentils, spices, ginger, mustard oil and salt are mixed. Round dumplings are made out of the dough. A hole is bored, put the mixture of lentils and spice and flatten it with the palms at the middle and leave both the ends protruding out. Steam the dumplings over a clay pot of boiling water. Serve the steamed *bagiya* with *chutney* (pickle) or vegetable curry. While Tharus in the eastern Nepal prefer flat *bagiya* with lentils but in westerns prepare *bagiya* of tubular shape, without lentils.

Chichar is prepared from steamed sticky rice (*Anadi* variety) and is mostly eaten with fish at the time of *Maghi*. *Tharu* women used to make *poka*. To make a *poka*, handful of *chichar* is wrapped in the leaves of *bhorla* (wide leafed wild creeper) and tied tightly with ropes. The *poka* is used to roast in firing place before consumption.

Bhakka

It is also special to Tharu community. The rice is soaked in water and milled in *Dhiki* (traditional wooden mill), sift the flour and make a cake like structure using bowl or plate by pressing on it. Steam the cake over a clay pot of boiling water. Serve the steamed *cake (Bhakka)* with the pest of salt and chili or chutney.

Figure 13. Rice flour, steaming, keeping warm and *bhakka* with salt-chilly (clockwise)

Chatamari

Chatamari, also known as Nepali pizza, is the pancake like Newari dish made up of rice flour. *Chatamari* is a compulsory dish of Newar in festive occasions like Dewali or Degudeopuja which falls in April or May. It can either be eaten the plain *chatamari* or taste can be enhanced by topping with eggs, meat or vegetable.

***Ingredients*: For the base:** 3 cups rice flour, black lentil paste, 1 cup water (depending on consistency), 1 cup ghee or butter, salt to taste. **For Toppings;** ½ lb chopped/minced chicken or any other meat, ½ cup finely chopped onions, ½ cup diced tomatoes, one tea spoon minced garlic, one tea spoon minced ginger, ½ tea spoon freshly ground black pepper, three tea spoon cooking oil/butter, salt to taste.

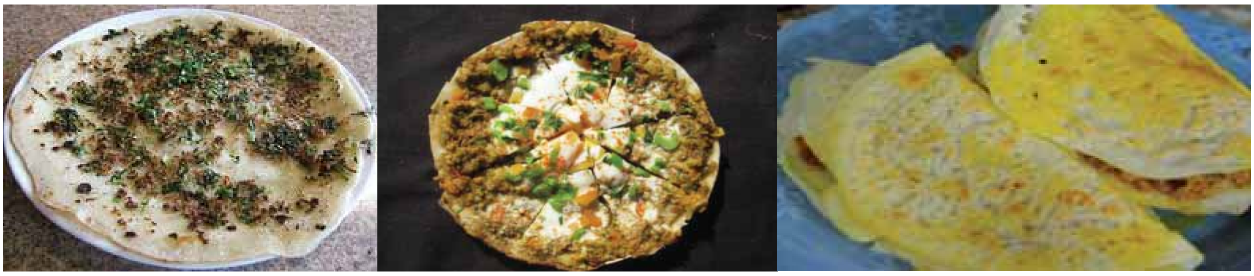

Figure 14. *Chatamari* with fried seasonings, vegetable toppings and veg. sandwich (clockwise)

Preparation**:** *For the base,* first of all, soak black lentil in water and remove the black coating. Mix the lentil paste with the rice flour and make a thin paste. Now, heat a flat pan and put the paste on the hot pan. Roll it while you pour it and make sure it turns as thin as a paper sheet. Then, put the toppings on the paste and cook it until the paste is done. The *Chatamari* is ready to serve. For topping, heat oil in a pan and fry onion, garlic and ginger until they turn light brown, add minced meat, salt and pepper. When it is about to be done, add tomatoes and cook it until the meat is ready. Make sure to mix everything well.

Jaulo

Jaulo is prepared when soaked rice is fried in oil with fenugreek for a while and, water is added to the extent that rice will dip in water then we put salt and turmeric powder. Rice will be cooked in small fire and is taken out before drying all water. A semi solid thick mass is obtained when cooling. *Jaulo* is generally served to weaned children and post operative patients.

Poko

It is rice based alcoholic beverage characterized by creamy color, soft, and juicy, sweet and sour taste with slightly alcoholic and aromatic flavor. It is special to Newari community and prepared using starter culture *manapu* in cooked rice, packed in wide leaves and allowed to ferment at ambient condition. There is a traditional belief that *Poko* promotes good health, nourishes the body giving good vigor and stamina. Their production is confined to home scale only.

Jand and *raksi*

It is the traditional alcoholic beverage of Nepal. *Jand* is a fermentation product of cereals preferably finger millet and other cereals such as rice, maize, wheat and cassava among others. *Raksi* is major traditional alcoholic beverage of Nepalese community. *Raksi* is an unaged generic spirit obtained by pot distillation of the slurry of *Jand*, the fermented millet or rice or wheat or maize or their combination. The distillate is called *raksi*. *Raksi* made from rice is called *chamal ko raksi*. The product resembles whisky and has highly varying alcohol contents.

Figure 15. *Poko, Jand, Jand* pouring for distillation, distilling *raksi* and ready *raksi* (clockwise)

Product diversification in context to modern technology

Rice noodles

The rice needs to soak in water for a day. The rice water sits in bags, and as the water drains out, the rice congeals or forms into clumps. The clumps are mixed with potato flour and water in a mixer. The mixture is ladled out onto a cotton cloth, which is stretched over boiling water. The steam from the water cooks the rice mixture (kind of like a crepe or flat pancake). The water is boiled over a fire and the fire is fueled by rice husks, so every part of the rice is used in the process. The flat rice pancakes are pulled off the cloth with a bamboo pole and dried on a bamboo mat for 4-5 hours. The sheets are then cut with a machine to make rice noodles and packaged for sale. A device can be use to cut the noodles.

Figure 16. Rice clumps, thin sheet of rice paste dried on bamboo mat over a muslin cloth, cutting dried sheet of rice flour, steamed rice noodles and seasoned rice noodles (clockwise).

Rice cake

The origin of rice cake seems to be in Korea. Selected rice variety (depending on stickiness, expansion potential and taste) is soaked in water until the right moisture level is attained. The rice is gravity-fed from the hopper into the popping machine. The mold is heated to hundreds of degrees and a slide plate opens to impose a vacuum on the moist rice mass. After 8 to 10 seconds of exposure to heat at this pressure, the lid of the mold expands, creating an even greater vacuum on the contents. In the last few seconds of heating, the mixture explodes to fill the given space. If the rice forms a large proportion of the exploded mass, it will be more satisfying, have a better texture and be full of natural flavor.

After the cake has exploded in the popping machine, the cooking head opens and the cake falls gently on a conveyor belt. The belt carries the cake where spraying heads sprays salt and the flavoring agents. Natural flavors are preferred by consumers and include everything from strawberry, caramel, apple cinnamon, blueberry and almond. The conveyor, now carrying flavored cakes, passes through a tunnel dryer where the moisture added by the flavor sprayers is driven off. The conveyor moves to the bagging area, where the rice cakes are removed from the conveyor by hand, inspected for any breakage and stacked, sealed in shrink wrap and packaged in an overwrap bag printed with the product identification and sealed. The bags are then packed in cartons for bulk sale

Glutinous rice (sweet rice)

It is popular in Japan and other Asian countries. This type of short-grain rice is not related to other short-grain rice. Unlike regular table rice, this starchy grain is very sticky and resilient, and turns translucent when cooked. Its cohesive quality makes it suitable for *yomari* and cakes. Thaichung-176 is glutinous rice popular in Kathmandu valley to make *chiura* and *jand*. Anadi is another popular glutinous rice of western Nepal and used to prepare *siramla*, *kheer* etc.

Figure 17. Rice cakes (hard type), soft cake of rice, glutinous rice and products (clockwise)

Instant rice

Instant rice is ready to serve food after rehydration. For the processing, it commences with steaming rice for 15 minutes followed by draining and drying. The drying is achieved in cabinet drier at 65ºC for 4-6 hours then cooled and packed in the laminated packaging material. It is stable for 6 months if stored in cool and dry place. The steamed and dried peas, leafy vegetables, mushroom etc also can be incorporated in sachet as vegetable and flavorings in the package. The rehydration can be done by using hot water of equal volume at the time of serving.

Figure 18. Instant rice after dehydration, dried carrot and peas, rehydrated plain and vegetable based instant rice products (clockwise)

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Production, Supply and Consumption of Beaten Rice (*Chiura*) in Nepal

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सारांश

धानलाई भिजाई वा उसिनेर नफुट्दै कुटानी गरी थेप्चो बनाइएको एक खाद्य वस्तुलाई चिउरा भनिन्छ । चिउरा नेपालमा अत्यन्तै लोकप्रिय औद्योगिक वस्तु हो, जसलाई आम नेपालीले हरेक दिन, हरेक चाडपर्वमा उपभोग गर्नुका साथै विभिन्न होटल, समारोहमा समेत खाद्य वस्तुको रूपमा प्रयोगमा आउने गर्छ । नेपाली कृषकहरू र मजदुरहरूले खाजाको रूपमा यसको उपयोग गर्ने गर्छन् । यो लेखले बाह्य र सहायक सन्दर्भ सामग्रीको आधारमा नेपालमा चिउरा सम्बन्धी विश्लेषण गर्ने प्रयास गरेको छ । चिउरा उत्पादनका लागि लोकप्रिय रहेका धानका जातहरू जस्तैः ताइचुङ-१७६, मकवानपुर-१, राधा ४, हर्दिनाथ १, चैते, सि.एच.-४५ र घैया आदिको धान चिउरामा रूपान्तरण हुने अनुपातको आधारमा चिउराको कूल उत्पादनका आँकडा निकालिएको छ । नेपालमा कूल ९९८,४२६ मे.टन चिउरा उत्पादन हुने गरको छ । ५४,१८९ मे.टन धानबाट ३०,४९२ मे.टन चिउरा उत्पादन हुने अनुमान गरिएको छ । चिउरा उपभोग गर्ने जनसंख्या र प्रति दिन आवश्यकताका आधारमा चिउराको खपतको आँकडा निकाल्ने गरिन्छ । नेपालमा १६ देखि ५६ वर्ष उमेर समूहका २६ प्रतिशत जनताले औसतमा ६१ ग्राम चिउरा प्रति दिन उपभोग गर्दछन् जुन ३२,२७९ मे.टन हुन आउँछ । प्रस्तुत विश्लेषणले नेपालमा वार्षिक मागको तुलनामा १,७८६ मे.टन चिउरा न्यून हुने देखाएको छ । नेपालमा चिउराको माग अत्याधिक रहेको भएतापनि चिउराको लागि धानको जातीय विकास र प्रविधिमा कृषि अनुसन्धानको ध्यान अपेक्षाकृत जान सकेको छैन भने सचेतना अभिवृद्धि तथा चिउरा उत्पादनका उपयुक्त धानका जातहरूको प्रवर्द्धन र प्रविधि प्रसारमा कृषि प्रसार प्रणालीले गति लिन सकिरहेको छैन । यसका साथै कृषक, चिउरा उत्पादन गर्ने मिल संचालकहरू र व्यापारीहरू बीचको सम्बन्ध अत्यन्तै कमजोर तथा मूल्य श्रृखंलामा आवद्ध हुन नसकेको अवस्थाले गर्दा वर्तमानमा चिउराको अपेक्षाकृत प्रवर्द्धन हुन सकिरहेको छैन ।

Summary

Beaten rice is boiled and de-husked rice which is flattened into flat light dry flakes. It is one of the most popular industrial products of rice in Nepal and popularly known as *"Chiura"* which is incorporated into everyday life, festivals, hotels/restaurants, rituals, wedding and more importantly is a common snack among farmers and laborers. Analysis of beaten rice in this article is primarily based on the secondary data and rational assumptions. Total *Chiura* production has been estimated through the total production of popular *Chiura* producing rice varieties such as Taichung-176, Makwanpur-1, Radha 4, Hardinath 1, Chaite, CH-45, *Ghaiya*, etc and assumptions on rice to *Chiura* conversion ratio. Total production of *Chiura* producing rice varieties has been estimated at 998,426 tonnes. It has been estimated that 30,492 tonnes *Chiura* was produced form 54,189 tonnes rice. Estimate of *Chiura* consumption was made based on the population consuming *Chiura* and average consumption per day, in the three ecological zone and five regions. It has been estimated that of the total population age between 16-56 years (14,079,720 people), about 26% people on average consume 61 g *Chiura* per day, require 32,279 tonnes *Chiura* per year. The analysis shows that there is net deficit of 1,786 tonnes of *Chiura* per year from the domestic production. Despite huge demand of *Chiura* in the country, Nepalese research system has not focused much on varietal development and the best bet technologies for *Chiura* producing rice varieties. Consequently, agriculture extension system is also lagging behind in creating awareness and promotion of *Chiura* producing rice varieties and production technologies. Linkage between rice producer, *Chiura* millers and traders is also very weak or not in a complete value chain system.

Keywords: *Chiura*, Consumption, Extension, Linkage, Research, Rice, Varieties

Introduction

Beaten rice (also called flattened rice) is de-husked rice which is flattened into flat light-dry flakes. It is one of the most popular industrial or processed products of rice in Nepal and popularly known as

'Chiura'. *Baji* is the term commonly used for *Chiura* by the *Newari* people in the Kathmandu Valley of Nepal. *Chiura* is incorporated into everyday life, festivals, hotels, restaurants, rituals and is a common snack among farmers and laborers. It is also a low-cost wholesome food with good nutritional value and is mostly preferred by the medium and low income class families. During major Nepalese festivals like *Dashain* and *Tihar, Chiura* is a special snack or dish in every house, which is incorporated with different pickles, meat and veggies. *Chiura* has been adapted to different Nepalese cultures and eating preferences differs accordingly. For example, Tharu communities prefer eating *Chiura* with fish and meat, while Madhesi communities prefer to eat *Chiura* mixing with *Dalmot.* Additionally, *Chiura* is served with yogurt, curry, sugar, saccharine and other ingredients in different parts of Nepal. Often *Chiura* is paired with tea as a mid-morning snack while working in the fields. More importantly, *Chiura* holds an important place in the traditional Nepali wedding ceremony.

Methodology

This analysis is primarily based on the secondary data and rational assumptions. Total *Chiura* production has been estimated through the total production of popular *Chiura* producing rice varieties and realistic assumptions on rice to *Chiura* conversion ratio. Commonly grown rice varieties for *Chiura* production in Nepal are: Taichung-176, Makwanpur-1, CH-45, Radha-4, Hardinath-1, Chaite and Ghaiya series. It is evident that not all rice volume is used for *Chiura* production and this also differs with variety. It has been assumed that about 2% of the total production of Ghaiya series rice reaches to the mills and Makwanpur-1 reaches about 10%, Radha-4 about 5%, Hardinath-1 and Chaite 2% each and CH-45 about 5%. Rice variety Taichung-176 is primarily cultivated for *Chiura* and it is assumed that about 70% of it is used for *Chiura* production alone. However, few *Chiura* mills around *Chiura* producing areas also surveyed to collect production capacity of each mill. Not all rice varieties have same paddy to *Chiura* conversion ratio. Based on the key informants' information, paddy to *Chiura* conversion ratio has been assumed 50% for Ghaiya series, Radha-4 and spring season rice varieties, 60% for Makwanpur-1, and 70% for Taichung-176 variety.

Population consuming *Chiura* and average consumption per day is not similar throughout the country. It is mainly due to *Chiura* consumption habit of people, availability, and affordability by ecological zone and regions. Accordingly estimate of *Chiura* consumption was made based on the population consuming *Chiura* and average consumption per day, by 3 ecological zones (mountain, hill and Tarai) and 5 regions (eastern, central, western, mid-western, far-western). It has been estimated that about 26% people of the total economically active population (age between 16-56 years) consume 61 g *Chiura* per day on average. Similar proportion for different age group people has also been assumed. About 17% people of age between 16-30 years consume 48 g *Chiura* per day, about 35% people of age between 31-45 years consume 67 g *Chiura* per day and about 34% people of age between 46-56 years consume 67 g *Chiura* per day.

Production and supply

In rural communities of Nepal traditionally *Chiura* is produced at home by soaking paddy overnight in hot water, then drained, roasted in mud-made utensil (*Handi*) and is flattened using locally made wooden beams (called *Dhiki*) and accessories. This method is normally practiced to meet household requirement of *Chiura* during festivals. However, for commercial purpose *Chiura* is produced in mills, following a series of sequential production process (**Figure 1**). Paddy is thoroughly cleaned and graded to remove off-size grains and inert materials and then it is soaked in hot water for about 30 to 45 minutes. After drying it is roasted to make flakes. These flakes are then passed through sieves to remove uneven and broken materials. The recovery rate (conversion factor) of even sized flakes ranged from 50-70% and remaining is used as bran for animal feed and wastage (about 10%). The *Chiura* making process in the mills and its marketing is presented in the following flow chart.

There is no authentic published data on *Chiura* production in Nepal. It is very difficult to estimate total production mainly because of difficulty to count each *Chiura* producing household and quantity produced by traditional way and also due to difficulty to reach each *Chiura* mills scattered across the country. Most of millers are operating without registration, despite the rule that such mills should have been registered either in small cottage industries and/or private company. *Chiura* can be prepared from many rice varieties. However, conversion ratio, taste, preference, quality and storability of *Chiura* are major concern from producer and consumer point of view. In Nepal, most popular *Chiura* producing variety is Taichung-176. This was introduced in Nepal from Taiwan in 1966 and can widely be grown in mid-hills of the country. Other popular varieties for *Chiura* production are Makwanpur-1 and some *Ghaiya* varieties. Additionally, some other coarse varieties are also used for *Chiura*.

Figure 1. Production process of *Chiura* in the mills

Total production of *Chiura* producing popular varieties has been estimated to be 998,426 tonnes (**Annex 1**). Applying the proportion of paddy (as explained in the methodology) used for *Chiura* production for each variety, about 54,189 tonnes is used for *Chiura* production. Similarly, by using the paddy to *Chiura* conversion factor, about 30,492 tonnes of *Chiura* is produced, which comes to be about 56% of paddy that is used for *Chiura* production. Retail price of the *Chiura* is determined by various factors such as appearance, mix of other materials, color, taste etc. Based on the sample farm-gate price (NRs 50/kg for *Ghaiya*, NRs 60/kg for Makwanpur-1, spring rice varieties like Hardinath-1, Chaite, CH-45, Radha-4 and NRs 70/kg for Taichung-176), total value of the *Chiura* comes to be NRs 1,926 million.

The commercial supply of *Chiura* in Nepalese market is primarily by the major wholesalers. The wholesalers collect *Chiura* form the mills and distributes to retailers and thereby to consumers. Assuming 10% trading losses, about 27,443 tonnes of *Chiura* is being supplied in the market through various channels.

Consumption

Chiura being the low cost wholesome food with good nutritional value, it can be taken in different forms such as raw, fried, with curd or milk and therefore has huge demand. Additionally, due to changing food habit and preferences of Nepalese people, it is becoming one of the major food items. Its preparations can be made at a short notice and hence it is very common and convenient food item in household, restaurants, other eateries, hostels and so on. People of all age groups from all sections like it and thus it is a mass consumption item. *Chiura* has special characteristics of long storability.

It has been estimated that of the total population age between 16-56 years (14,079,720 people) about 26% people on average, consume 61 g *Chiura* per day, require total 32,279 t/year. The analysis of *Chiura* requirement by age group shows that 1,275,904 people of age between 16-30 years (17% of this age group) consume 48 g *Chiura* per day which requires 8,213 t/year. Similarly,1,583,489 people of age between 31-45 years (35% of this age group) consume 67 g *Chiura* per day which requires 16,590 t/year; and 731,138 people of age between 46-56 years age group (34% of this age group) consume 67 g *Chiura* per day which is equivalent to 7,476 t/year. The summary of *Chiura* requirement by ecological zone and age group is presented in **Annex 2** and detail analysis in **Annex 3**.

Conclusion

Despite huge quantity of *Chiura* demand in the country Nepalese research system has not focused much on varietal development and better-bet technologies for *Chiura* producing rice varieties. Consequently, agriculture extension system is also lagging behind in creating awareness and promotion of *Chiura* producing varieties and appropriate production technologies to farmers. Linkage between rice producer, *Chiura* millers and traders needs to be strengthened. Meaning, initiative should be focused in a complete value chain model. A such, establishing efficient and effective backward and forward linkages among *Chiura* value chain functions and functionaries is of utmost importance.

This analysis is primarily based on the secondary data and rational assumptions. However, few millers around *Chiura* producing areas were also contacted by telephone to collect production capacity of each mill. To have minimum errors of the estimates, the study should be carried-out by sample survey in representative areas. Nevertheless, this attempt will also give some indications of *Chiura* market in Nepal.

The analysis shows that there is net deficit of 1,786 tonnes *Chiura* per year (supply 30,492 tonnes and requirement 32,279 tonnes) from the domestic production, assuming 10% supply loss there is a deficit of 4,836 t/year. To maintain market equilibrium, there must have been import of *Chiura*. However, there is no authentic information about imports. To have minimum errors of the estimates, the study should be carried out by sample survey in representative areas. Nevertheless, this attempt will also give some indications on *Chiura* market in Nepal.

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Annex 1. Area and production of major beaten rice producing rice varieties and estimate of beaten rice production.

Agro-ecological Zone	Paddy Area (ha)*	Yield (t/ha)*	Paddy Production (tonnes)	% of paddy used for *Chiura* production (Estimate)	Paddy used to produce *Chiura* (tonnes) (Estimate)	Estimated Rice to *Chiura* Conversion factor (%)	*Chiura* Quantity production (tonnes) (Estimate)	Farm gate selling price (NRs/t) (Estimate)	Total value (Million NRs)
	a	**b**	**c=(a*b)**	**d**	**e=(d% of c)**	**f**	**g=(f% of e)**	**h**	**i=(g*h)/million**
Ghaiya-2	69	3.4	235	0.02	5	0.50	2	50,000	0.1
Makwanpur-1	3,219	4.8	15,451	0.10	1,545	0.60	927	60,000	55.6
Radha 4	3,576	3.2	11,443	0.05	572	0.50	286	60,000	17.2
Mountain Total	**6,864**		**27,129**		**2,122**		**1,215**	**170,000**	**73**
Ghaiya-2	1,723	3.4	5,858	0.02	117	0.50	59	50,000	32
Makwanpur-1	26,055	4.8	125,064	0.10	12,506	0.60	7,504	60,000	450.2
Taichung-176	1,744	7.9	13,778	0.70	9,644	0.70	6,751	70,000	472.6
Radha 4	22,672	3.2	72,550	0.05	3,628	0.50	1,814	60,000	108.8
Hill Total	**52,194**		**217,250**		**25,895**		**16,127**	**240,000**	**1,064**
Ghaiya-1	521	3.4	1,771	0.02	35	0.50	18	50,000	0.9
Makwanpur-1	1,331	4.8	6,389	0.10	639	0.60	383	60,000	23.0
Radha 4	103,472	3.2	331,110	0.05	16,556	0.50	8,278	60,000	496.7
Tarai Total	**105,324**		**339,271**		**17,230**		**8,679**	**170,000**	**521**
Spring Rice									
Hardinath-1	62,957	5	314,785	0.02	6,296	0.50	3,148	60,000	188.9
Chaite -2	16,345	4.8	78,456	0.02	1,569	0.50	785	60,000	47.1
CH-45	6,153	3.5	21,536	0.05	1,077	0.50	538	60,000	32.3
Spring Total	**85,455**		**414,777**		**8,942**		**4,471**		**268**
Grand Total	**249,837**		**998,426**		**54,189**		**30,492**		**1,926**

Annex 2. Summary of *Chiura* requirement by ecological zone and age group

Agro-ecological zone	16-30 Years of Age			31-45 Years of Age			46- 56 Years of Age			Total *Chiura* requirement (t/year)	Total Population	Total Population consuming *Chiura*
	Total Population	Population consuming *Chiura*	Total consumption (t/year)	Total Population	Population consuming *Chiura*	Total consumption (t/year)	Total Population	Population consuming *Chiura*	Total consumption (t/year)			
Mountain Total	445,978	40,769	112	276,819	51,731	233	149,525	29,244	134	480	872,322	121,744
Hill Total	3,239,515	524,805	2,803	1,933,881	629,285	5,430	964,421	308,428	2,583	10,816	6,137,817	1,462,518
Tarai Total	3,703,463	710,331	5,298	2,340,471	902,473	10,927	1,025,647	393,466	4,759	20,983	7,069,581	2,006,270
Grand	7,388,956	1,275,904	8,213	4,551,171	1,583,489	16,590	2,139,593	731,138	7,476	32,279	14,079,720	3,590,531

Source: CBS (2011)

Annex 3. Analysis of *Chiura* requirement by ecological zone and age group

Agro-ecological zone	16-30 Years of Age						31-45 Years of Age					
	Total Population	% of population consuming *Chiura* (Esti.)	Population consuming *Chiura*	Rate of *Chiura* consumption (g/person/day) (Esti.)	Consump tion days in a year (Esti.)	Total *Chiura* consumption (t/year)	Total Population	% of population consuming *Chiura* (Esti.)	Population consuming *Chiura*	Rate of *Chiura* consumption (g/person/day) (Esti.)	Consumption days in a year (Esti.)	Total *Chiura* consumption (t/year)
Eastern Mountain	101,699	0.10	10,170	40	55	22	60,465	0.20	12,093	56	63	43
Central Mountain	128,097	0.15	19,215	50	73	70	85,603	0.30	25,681	70	84	151
Western Mountain	5,752	0.15	863	40	73	3	4,410	0.30	1,323	56	84	6
Mid-Western Mountain	99,311	0.05	4,966	30	55	8	58,502	0.10	5,850	42	63	15
Far-Western Mountain	111,119	0.05	5,556	30	55	9	67,839	0.10	6,784	42	63	18
Total Mountain	**445,978**		**40,769**			**112**	**276,819**		**51,731**			**233**
Eastern Hill	423,809	0.15	63,571	50	73	232	255,359	0.30	76,608	70	84	450
Central Hill	1,428,135	0.20	285,627	60	110	1,877	864,577	0.40	345,831	84	126	3,658
Western Hill	736,987	0.15	110,548	50	91	504	440,571	0.30	132,171	70	105	971
Mid-Western Hill	438,467	0.10	43,847	40	73	128	250,433	0.20	50,087	56	84	235
Far-Western Hill	212,117	0.10	21,212	40	73	62	122,941	0.20	24,588	56	84	116
Hill Total	**3,239,515**		**524,805**			**2,803**	**1,933,881**		**629,285**			**5,430**
Eastern Tarai	1,055,316	0.15	158,297	60	110	1,040	703,426	0.30	211,028	84	126	2,232
Central Tarai	1,247,695	0.25	311,924	70	128	2,789	823,752	0.50	411,876	98	147	5,930
Western Tarai	600,837	0.20	120,167	60	128	921	355,813	0.40	142,325	84	147	1,756
Mid-Western Tarai	431,622	0.15	64,743	50	91	295	253,903	0.30	76,171	70	105	560
Far-Western Tarai	367,993	0.15	55,199	50	91	252	203,577	0.30	61,073	70	105	449
Tarai Total	**3,703,463**		**710,331**			**5,298**	**2,340,471**		**902,473**			**10,927**
Grand	**7,388,956**		**1,275,904**			**8,213**	**4,551,171**		**1,583,489**			**16,590**
% share			17%						**35%**			
Average		0.14		48.00	85.17	654.59		0.28		67.20	97.94	1,309.03

Agro-ecological zone	46- 56 Years of Age						*Chiura* requirement (t/year)	Total Population	Total Population consuming *Chiura*	% of total
	Total Population	% of population consuming *Chiura* (Esti.)	Population consuming *Chiura*	Rate of *Chiura* consumption (g/person/day) (Esti.)	Consumption days in a year (Esti.)	Total *Chiura* consumption (t/year)				
Eastern Mountain	36,763	0.20	7,353	56	63	26	91	198,927	29,616	
Central Mountain	50,772	0.30	15,232	70	84	90	311	264,472	60,127	
Western Mountain	2,304	0.30	691	56	84	3	12	12,466	2,877	
Mid-Western Mountain	27,174	0.10	2,717	42	63	7	31	184,987	13,533	
Far-Western Mountain	32,512	0.10	3,251	42	63	9	36	211,470	15,591	
Mountain Total	**149,525**		**29,244**			**134**	**480**	**872,322**	**121,744**	14%
Eastern Hill	152,545	0.30	45,764	70	84	269	951	831,713	185,943	
Central Hill	370,894	0.40	148,358	84	126	1,569	7,104	2,663,606	779,815	
Western Hill	261,108	0.30	78,332	70	105	575	2,051	1,438,666	321,052	
Mid-Western Hill	121,521	0.20	24,304	56	84	114	478	810,421	118,238	
Far-Western Hill	58,353	0.20	11,671	56	84	55	232	393,411	57,471	
Hill Total	**964,421**		**308,428**			**2,583**	**10,816**	**6,137,817**	**1,462,518**	24%
Eastern Tarai	328,023	0.30	98,407	84	126	1,041	4,313	2,086,765	467,732	
Central Tarai	347,807	0.50	173,904	98	147	2,504	11,223	2,419,254	897,703	
Western Tarai	162,105	0.40	64,842	84	147	800	3,478	1,118,755	327,335	
Mid-Western Tarai	106,407	0.30	31,922	70	105	234	1,089	791,932	172,836	
Far-Western Tarai	81,305	0.30	24,392	70	105	179	880	652,875	140,664	
Tarai Total	**1,025,647**		**393,466**			**4,759**	**20,983**	**7,069,581**	**2,006,270**	28%
Grand	**2,139,593**		**731,138**			**7,476**	**32,279**	**14,079,720**	**3,590,531**	26%
% share			**34%**						**26%**	
Average		0.28		67.20	97.94	599.58				

Source: CDD 2015.

Production, Consumption and Marketing of Puffed Rice (*Bhuja*) in Nepal

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सारांश

नेपालमा लोकप्रिय रहेको यस खाद्य वस्तुलाई मुरई वा भुजा भनेर चिनिन्छ । यसलाई मानिसले खाजा वा नास्ता, चटपटे, लड्डु, चाटको रूपमा खाने गर्दछन् । कम मात्रामा क्यालोरी, फ्याट र सोडीयमबाट मुक्त रहेकाले पनि भुजा स्वास्थ्यको लागि फाइदाजनक मानिन्छ । मोटोपन भएका मानिसका लागि भुजा सुरक्षित खानाको रूपमा उपयोगी हुन्छ । सांस्कृतिक तथा धार्मिक महत्व रहेको भुजालाई नेपालीहरूले मकर संक्रान्ति, दशैं, तिहार, छठ, इद् जस्ता चाडपर्वहरूमा समेत उपयोग गर्दछन् । भुजा उत्पादनका लागि आवश्यक तयारी ७० प्रतिशत धान भारतबाट आयात गरिएको पाइएको छ । नेपालमा केही स्टिम प्लान्ट भए पनि उपयोग गर्न सक्ने अवस्थामा नभएकाले संचालन गर्न सकिएको छैन । वर्दमान, कोलकत्ताबाट नेपालको पूर्वी र मध्य नाकाहरूहुँदै उसिनेको धान भुजा बनाउने प्रयोजनका लागि आयात हुने गर्दछ । नेपालमा रजिष्टर नभएका सोना मसुली, माला, रत्ना जस्ता धानका जातहरू भुजा बनाउनका लागि प्रयोग भएको सर्वेक्षणबाट पाइएको छ । सूचनाको अभाव, भुजा उत्पादन प्राथमिकतामा नपर्नु, भुजा उत्पादनको लागि उपयुक्त धानका जातहरूको विकासका लागि पर्याप्त अनुसन्धान नहुनु, तथा भौतिक पूर्वाधारहरूको कमी आदिका कारण नेपालमा भुजा उत्पादन तथा बजारीकरणले गति लिन सकेको छैन ।

Summary

Puffed rice is a valuable commodity that is increasingly getting popular in Nepalese community and occupies an integral place in Nepalese cuisine. It is also called *murai or bhuja* in Nepal and is a popular food item made from puffing of rice. People use it in different form in Nepal as breakfast, as snacks and others dishes such as *chatpate, laddu, chaat.* Puffed rice is hygienic product from rice with low content of calories, free from fat and sodium. It has been widely used as safe food where obesity is major problem. In Nepal, it has cultural and religious values and eaten during *Makarsakrati, Dashai, Tihar, Chaat and eid* etc. Ready rice for making puff are produced in India. Fewer number of steam plants for producing boiled rice has been setup in the country, they are not functional. Traders import boiled rice from Bardaman, Kolkata, India through eastern and central boarder of the country (Biratnagar and Birgunj) which is distributed to the puffed rice factories across the nation. Major varieties for producing puffed rice are: Sona Masuli, Mala, Ratna which are not registered in Nepal. Seventy percent of rice for this factory comes from India. Most of the factories are located in Tarai region which supplies puffed rice to neighboring districts. Because of lack of substantial information, studies and priority on puffed rice and lack of steam plants, we are completely dependent on India for rice varieties suitable for producing puffed rice. With the increasing demands of puffed rice we are not able to keep up with technological advancement. Research work developing suitable rice varieties for puffing quality is yet to materialize in Nepal.

Keywords: *Bhuja*, Boiled rice, Cultural and religious value, Puffed rice

Introduction

Puffed rice is a whole-grain puffed product obtained from pre-gelatinized milled parboiled rice, generally prepared from preconditioning of grains by hydrothermal treatment, followed by drying and milling. The milled grains are treated with salt water to an optimum moisture content, which is then subjected to puffing by sand roasting method (FDA 2016). Puffed rice also known as *murai* or *bhuja* in Nepal is a popular food item made from puffing of rice. *Murai* rice is similar to pop-corn in maize. It is a processed product from rice. The puffing of rice makes it less perishable and easily digestible. People use it in different form in Nepal as breakfast, as snacks and others dishes such as *chatpate, laddu, chaat*. The different communities in Nepal have their own uses of puffed rice. As puffed rice is light and completely cooked, it has no side effects and has been recommended for patients as well. Puffed rice is increasingly becoming more popular and demand for puffed rice is high as well.

Importance of puffed rice

Puffed rice is used in snack foods and breakfast cereals, and is also a popular street food in some parts of the world. It is also used in temples and *gurudwaras* as *prasad*. Absence of gluten provides additional benefit and makes rice particularly suitable as an alternative either in full form or as replacement of wheat in bakery products especially suitable for the celiac subjects (Prasad et al 2010). Further on the process of roasting the rice starch gets damaged, gelatinized and subsequently a portion of it is retrograded, which ultimately leads to the formation of resistant starch. This changed form of rice starch in resistant starch may be nutritionally important fraction as dietary starch, which may thus pass unaffected during digestion and absorption in the small intestine. Also, if it goes to large intestine in unaffected form it may serve as nutrient for the gut microflora. The roasted or toasted form of rice as puffed rice may thus also be considered as pre-biotic foods apart from the conventional and nutritious low cost easily reach food to masses.

Figure 1. *Chatpate* from puffed rice

Puffed rice is low in calories, fat-free and sodium-free. It is however, not a very good source of protein or fiber, or a significant source of any vitamin or mineral but being low in calories and voluminous, it has been widely used as safe food where obesity is major problem.

Table 1. Nutritional content of puffed rice (per 100 g)

Calories	% Daily Value*
Total Fat 0.5 g	0%
Saturated fat 0.1 g	0%
Cholesterol 0 mg	0%
Sodium 3 mg	0%
Potassium 113 mg	3%
Total carbohydrate 90 g	30%
Dietary fiber 1.7 g	6%
Protein 6 g	12%
Vitamin A, C, B-12, calcium	0%
Iron	176%
Vitamin B-6	5%
Magnesium	6%

**Percent Daily Values are based on a 2,000 calorie diet.*

Production

Puffed rice is produced by heating the steam-conditioned kernels in an oven. Puffed rice is formed by the reaction of starch and moisture when heated. Another method of puffing rice is "gun puffing", where grain is conditioned to the correct level of moisture and pressurized to around 200 PSI. When the pressure is suddenly released, the pressure stored inside the kernel causes it to puff out. This method produces puffed rice which is spongy in texture. For commercial purpose for large production puff rice is produced in industry by using steaming, shelling and roasting machine. While in local method, paddy is steamed till become soft and is allowed to dry in the sun and thereafter is used *Dhiki* or *sheller* to shell the paddy to get rice which is roasted in a *karai* or pan to allow puff formation from the rice.

Modern "Puffed Rice" is attributed to an American, Alexander P. Anderson, who, stumbled across "puffing" while trying to ascertain the water content of a single granule of starch, introduced the first puffing machine at the World's Fair in Saint Louis, Missouri in 1904.

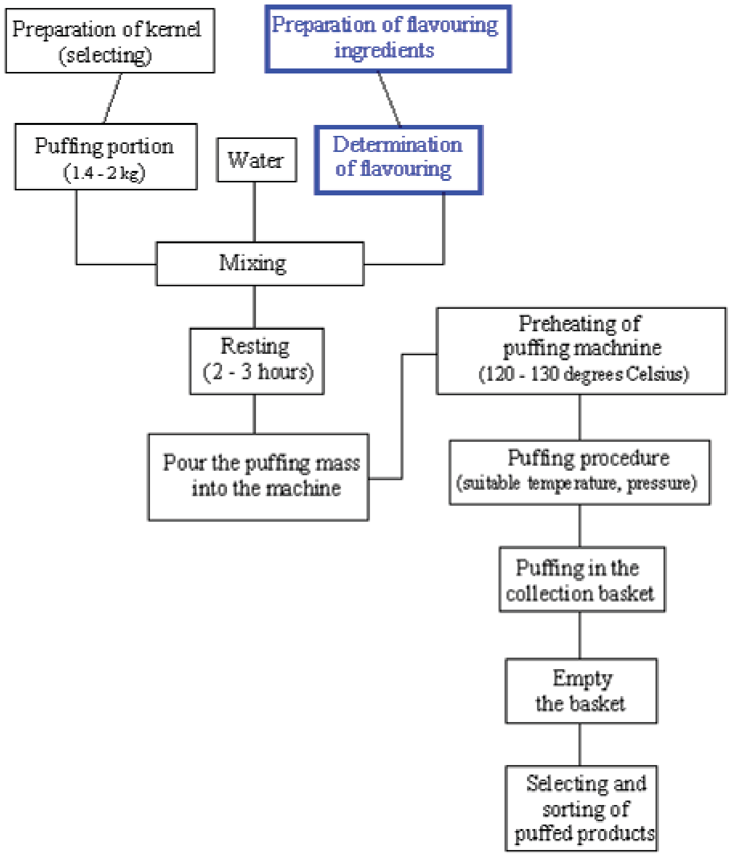

Figure 2. Puffing process

The production process, however, varies from place to place. General survey and interviews with the proprietor or related traders conducted by the authors and the District Agriculture Development Offices found that almost of the ready rice for making puff are produced in India. Although 2 or 3 steam plants for producing boiled rice has been setup in the country, they are not functional. Few major traders import boiled rice from Bardaman, Kolkata, India through eastern and central boarder of the country which is distributed to the puffed rice factories across the nation. The rice variety suitable for producing puffed rice are: SonaMasuli, Mala Indian, Ratna which are not registered in Nepal. Most of the traders are not aware about the variety but two types of grains are generally used for producing puffed rice, Sona (small, golden and coarse grain) and Lalat (long grain). Most of the puffed rice factories are roasters only but so far Rajesh Rathi, proprietor of Mahesh Food Industries, Biratnagar-3 is the trader who has his own steam plant as well as roaster. According to Mr. Rathi, suitable rice varieties for preparing puffed rice are: Sonamasuli, Radha-12, Swarna and Indian varieties 10010 and 4094. 70% of rice for his factory comes from India. With reference to personal communication with the proprietor of Hari Foods, Kailali the company is taking 5 trucks (17 ton each) annually to meet their raw materials. The raw material is produced in India and imported by some agency in Biratnagar and Birgunj (S. Khatiwada, personal communication). These companies are making their order of raw materials from Biratnagar and Birgunj. Puffed rice conversion rate from boiled rice is 85-90%. The boiled rice is fed into the roaster along with some calibrated portion of brine. Brine solution is generally used because salt in it helps to fully expand rice grain into puff. About 500-600 tonnes of boiled rice is imported daily from India and about 600 tonnes of puffed rice is produced across the country (G. Panthi, personal communication).

Consumption

Puffed rice is basically the common snacks for people in Tarai whereas it is also now more common among the *Pahadi* (hill people) community than Madhesi (Tarai people) community. The demand for puffed rice in mid-hills has also increased due to changing food habits of people and increased supply to those regions. It is the likes of all people irrespective of the age. Moreover, it is healthy food that can even be recommended to patients and elderly people. It can be consumed in various forms such as plain, with milk or tea and it is an important or in fact an obligate component of most of snacks in the country (with meat, pickles, vegetables etc). Maximum consumption of puffed rice is in: homes, hotels and restaurants where it seems to replace beaten rice as snacks. This is one of the items of breakfast for labors in Tarai similar to *chiura* in the hills. Puffed rice is also used for making different delicious sweets mixing with jaggery and sometime with sesame also. For Hindus it is of cultural and religious values and eaten during *Makarsakrati*, *Dashai*, *Tihar*, *Chaat* and Muslim during *Eid* festival. The consumption of puffed rice is increasing in one or other forms. Puffed rice is used in diverse range of products such as *laddu, chaku,* peanut-puffed rice cake, *masala bhuja,* mix *bhuja, chatpate* etc. It holds an important place and is a regular presence in every occasion and event in the form of one or more special dish.

Figure 3. Making of puffed rice

Marketing

Almost all the raw materials (boiled rice) comes from India and there is not much information on the Nepali varieties being suitable for producing puffed rice. The available puffed rice factories in the country either import their raw materials from India or buy from trader. Boiled rice is imported from Birgunj and Biratrnagar boarders and the trader supplies it to puffed rice factories. The factories either further process puffed rice and pack on their own or directly sell it to the different entity as a whole seller. The boiled rice after being roasted can be processed into different products or packed as it is. Most of the factories are located in Tarai region which supply puffed rice to neighboring districts. In Rupandehi only, about 50-60 tonnes of puffed rice transactions occur daily. Puffed rice is supplied to: Baglung, Pokhara, Syangja, Dang, Palpa, Nawalparasi, Gulmi, Arghakhanchi and different parts of Rupandehi itself. Apart from plain puffed rice, the wholesaler process puffed rice to various value added products such as: *Masala bhuja, mix bhuja, bhujaladdu* etc. The plain puffed rice is packed into sack of 20-30 kg.

Figure 4. Puffed rice ready for sale

Table 2. Prices of whole rice grain, boiled rice and puffed rice

Rice	Price per quintal (NRs)
Rice	2500
Boiled rice	4500
Puffed rice	5500

Table 3. The available lists of the industries involved in selling puff rice in Nepal

SN	Name of industries	Name of proprietor	Production capacity/day	Consumption within districts/year	Consumption outside of districts/year	District
1	Ma Kankali Rice mill, Khaireni	Shri Prativa Shrestha	0.5 tonne			
2	Rajesh Rice Mill, Khaireni	Shri Rohini Devi Shrestha	1 tonne			Chitwan
3	Sunder Rice Mill, Khareni	Shri Shiva Prasad Pandey	1 tonne			
4	Tiwari Chawal tatha chiura udhyog, Geetanagar	Shri Bishnu Tiwari	0.5 tonne			
5	Shri Ram Food Industry, Jitpur Bara	Rambabu Prasad Gupta	4 tonnes	286 tonnes	1144 tonnes	
6	Baba Food Industry, Jitpur Bara	Roshan Prasad Gupta	3 tonnes	110 tonnes	935 tonnes	
7	Remon Food Industry, Bara	Rabi Shankar Agrawal	0.5 tonne	185 tonnes	185 tonnes	Bara
8	Lalmati Rice Industry, Bariyarpur, Bara	RamlakhanSahani	-	6 tonnes		
9	Mainali Enterprises, Nijgadh -9, Bara	Nawaraj Mainali	1.5 tonnes	305 tonnes	100 tonnes	
10	Narsingh Adhunik Udhyog, Kathari-9	Hari Prasad Sah	20 tonnes			Morang
11	Mahesh Food Industry, Baijanathpur-3	Rajesh Rathi	1.5 tonnes			
12	Terupathi Food Products, Biratnagar-18	Ashok Yadav	3 tonnes			
13	Dinesh Agro	-				Kailali
14	Hari Foods	-				
15	Pashupati Bhuja Udhyog	Govinda Panthi	0.95 tonne	300 tonnes		Rupandehi
16	Tirupati Bhuja Udhyog					
17	Lumbini Bhuja Udhyog					

Source: Personal Communication with S Regmi, B Gyawali, S Khatiwada, N Regmi 2016.

Constraints

We are completely dependent on India for rice varieties suitable for producing puffed rice. With the increasing demands of puffed rice we are not able to keep up with technological advancement, and the bitter truth at present is that we have only one steam plant that is functional. Another constraint in puffed rice production is load shedding due to which factories cannot run with full potential. Shortage of skilled as well as unskilled labor has confronted in puffed rice production in Nepal. Due to under developed marketing channels, delivery system is not authentic as the raw materials needs to be transported all the way across from eastern part of country to far west. There is no report of Research work carried out in puffed rice in Nepal although there is a high demand of developing suitable rice varieties for puffing quality and taste. Likewise, the extension services are also not found to be involved in the market extension and documenting the status of puffed rice in Nepal.

Conclusion

Puffed rice is a valuable commodity that is increasingly getting popular in Nepalese community and occupies an integral place in Nepalese cuisine. There is a tremendous scope of improvement in developing puffed rice industry in Nepal. This sector needs priority for upliftment and it cannot remain concealed from the view point of the concerned authority.

Acknowledgements

The authors are highly grateful to Mr. JitendraYadav, senior agriculture development officer and crop development officers Sudip Khatiwada, Nirmal Regmi, Binod Gyawali, Sudip Regmi, for providing and compiling data. Thanks also goes to Mr. Achyut Mishra (Food Science and technology Division, NARC) for providing valuable information. Congenial efforts from Mr. Amit Karna and Hari Panthi are highly acknowledged.

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Use of Rice By-products in Livestock Industries of Nepal

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सारांश

खाद्यान्न बालीको उत्पादन गर्दा ती बालीहरूको पर्याप्त परिमाणमा उप-उत्पादनहरू उत्पादन गर्ने गर्दछन् जसको कृषक वर्गको लागि सामान्य तथा कम आर्थिक महत्व हुन्छ । धान बालीको उत्पादन गर्दा समेत पराल, ढुटो, डिवेल्ड केक आदि बाइप्रोडक्टहरू उत्पादन हुने गर्दछन् । प्रस्तुत लेखले धान उत्पादन गर्दा उप-उत्पादनको रूपमा आउने पराल, भुस, ढुटो आदिको दाना उद्योग र अन्य पशुपालन क्षेत्रमा कसरी प्रयोग भइरहेको छ भन्ने बारेमा प्रकाश पार्न खोजेको छ । सामान्यता पराल र भुस कुखुरा पालन व्यवसायमा सोत्तरको रूपमा प्रयोग गरिने गरिएको छ भने पराल गाइवस्तुलाई आहारको रूपमा समेत खुवाउने गरिएको छ । ढुटो प्रयोग नेपाली कृषकले घरमै गाइवस्तुलाई खुवाउने तथा दाना उद्योगमा समेत प्रयोग भएको पाइएको छ । ढुटोले प्रति के.जी. ३२५० किलो क्यालोरी र ११ प्रतिशत क्रुड प्रोटिन प्रदान गर्ने पाइएको छ । नेपालका पशु तथा कुखुराको दानामा करिब ७१ करोड बराबरको ३९ हजार ३ सय ९६ मे. टन आन्तरिक उत्पादन हुने ढुटोको प्रयोग भएको पाइएको छ । नेपालमा ढुटो र परालको उच्च मूल्य रहेको छ । नेपालमा दानाको चर्को मूल्यका कारण पशुपालन व्यवसायमा उत्पादन लागत बढेको सन्दर्भमा पराल, ढुटो आदिको पशु दाना उत्पादनमा प्रयोग गर्न सके पशुपालन व्यवसाय थप नाफामुखी हुन जाने देखिन्छ ।

Summary

Food crop production generates large volume of by-products and the failure to properly utilize them can lead to less economic return to farming communities. The rice industry is chief farming activity in Nepal which yields large quantities of by-product such as: straw, husk, bran, de-oiled cakes and broken rice. The aim of this article is to present a review of the use of these by-products in livestock industries. We performed theoretical research about the utilization of rice by-products in various areas within livestock industries. The findings point to proper utilization of all rice by-products in lucrative area. Rice straw and husk is popularly used as livestock bedding material especially in poultry farms. Rice straw is also used as feeding material for large ruminants with or without certain physical and chemical modifications. Other high energy by-products like rice bran/rice polish are used in livestock feed. Rice polish provides energy of 3250 Kcal/kg and 11% of Crude Protein (CP). In Nepal, 39,396 tonnes of bran/polish have been used in poultry and animal feed formulation that worth about NRs 71 million. These by-products also have high market price and have least share in import figures compared to other feed ingredients that can be worthwhile for nation's economy. As feed cost is high and replacing expensive ingredients with fairly less expensive rice products will cause substantial benefit for livestock industry. Moreover, yearly increase in use of rice by-products in livestock industries indicates its prospect.

Keywords: Bran, Husk, Livestock industry, Nepal, Rice by-products, Straw

Introduction

Livestock plays a crucial role in supporting the livelihoods of farming communities in the context of crop livestock integrated farming system in Nepal. In spite of several efforts in the past, productivity of livestock has remained at a low level mainly due to shortage of feed along with other lacking such as breeds and health management (Devkota et al 2014). Nepal is an agrarian country with typical crop livestock mixed farming system in majority of the part of the country. Livestock is an integral part of Nepalese farming system that shares about 26% to the agricultural gross domestic products (MoAD 2013).

Feed is the major input cost in animal agriculture, accounting for 65-70% of the total rearing cost. Poor nutrition of animals has been identified as the major constraint to animal production across the developing world (FAO 2000). Due to variety of reasons, the tropical world is largely faced with the problem of acute shortage of feed resources. Crop by-products which are important feed supplements in ruminant feeding include: rice bran, wheat bran, flaked rice bran, rice polishing, maize bran, mixed cereal bran, grain legume by products and oil seed cakes such as mustard cake, soybean cake, cotton seed cake, and ground nut cake. These by products are normally supplements to dairy rations and used as raw materials for commercial feeds. Annually three million tonnes of dry roughage as crop residues are produced in the country. About 70% of crop residues are used by ruminant livestock as feed and remaining 30% is used as roofing and bedding materials (Shrestha et al 2014)

Cereal straws are major source of bulk and energy for ruminants. However, since last few years, even the straws have become an expensive commodity (1994-NRs 1/kg, 2004-NRs. 2/kg, 2014- NRs 4-5/kg). The feed deficit in hilly region and Tarai region is- 56%, - 42% whereas there is 26% feed surplus in mountain region. 60% of livestock feed requirement comes from low quality crop residues. Thus, most of the livestock in Nepal has to depend on crop residues and by-products (Forage seed production area mapping 2002). The situation is by no means as hopeless as projected. Our country has many other resources that can sustain livestock which have ability to digest coarse materials. Rice straw, rice bran and rice polish are some of the available rice based feeding materials for livestock in Nepal.

Figure 1. Straw storage structures

The trend of using concentrate feed has become popular in commercial rearing. Rice and rice by-products are second most important feed ingredient after maize while formulating animal feed. In rural areas, rice polish and bran (from local rice mills) are mainly used to feed ruminants as feed supplements (Yadav 2014). In Nepal, only 10.8% of total grain requirement (464 million t/year) is available for feeding livestock (Yadav 2014).

Technologies for use of rice straw for animal feeds in Nepal

Dry roughage, particularly crop residues, such as rice straw, wheat straw, corn stover, oat hay, residues of millet and buckwheat, residues from oil seed crops etc are important sources of animal feeds. Among them, rice straw is one of the most important sources of bulk and energy for ruminants. Rice straw is used in various ways to feed animals in Nepal. Some of the technologies to use rice straw as source of animal feed in Nepal are discussed below.

Bailing of straw/hay

There are three main types of bales that can be made for feeding livestock: small bales, large square bales and large round bales. Large round bales are quite popular among many livestock producers. Large round bales (LRBs) are made up of by a tractor with round straw baler (Pandey 2014).

Chopping/chaffing of straw

Some benefits of chopping or chaffing straw are increment in palatability and digestibility, ease in handling fodder quantity. Traditional and multifunctional chaff cutters are in practice to chaff the straw in Nepal (Pandey 2014).

Urea treatment of straw

Treating with urea is based upon its transformation into ammonia. In order for the treatment to succeed, most of the urea must first be hydrolyzed into ammonia and then this must diffuse correctly so fixing itself to the forage and modifying it chemically. One must therefore ensure favorable conditions for both good ureolysis and good ammonia treatment, in the knowledge that these two processes take place simultaneously within the forage matter. Efforts have been made to reduce urea application rates to 2 or 3% by mixing it with lime, $Ca(OH)_2$ which favors the urea hydrolysis and above all, the alkaline reaction. Work concerning this aspect is still at an experimental stage (Pandey 2014).

Common procedure of urea treatment

Polythene sheet should be spread over on selected site. The one fourth paddy straw will be spread over the polythene sheet. The water urea solution (4 kg urea/40-liter water/100 kg straw) is sprinkle over the paddy straw and mixed properly. Then, next one fourth paddy straw is spread over and again urea solution is sprinkle till completion of the straw. The treated straw is kept for 21 days under air tight condition (Pandey 2014). Owen and Jayasuriya (1989) reported higher milk yield in treated condition (2.97 kg/day mild yield) in comparison to no treatment (2.17 kg/day)

Straw blocks

To meet the challenges during emergency situations, straw blocks have generally the composition of 80 parts straw, 10 parts molasses, 2 parts mineral mixture, 1 part urea and 1 part salt, which could meet the maintenance requirement of the animals. The proportion of straw feeding should be reduced to 60, 50 and 40% for animals yielding 5-10, 10-15 and 15-20 kg milk per day respectively (Pandey 2014).

Complete feed

Complete feed is a homogenous mixture of feed ingredients (concentrates and roughages), which contains nutrients (proteins, carbohydrates, fiber, fat, minerals and vitamins) and also meets the dry matter requirement of animals. Complete feed is more balanced feed and can be fed as per requirement of the animals. The technology of straw based densified complete feed as blocks or pellets could play an important role in providing balanced rations to livestock in during green forage scarcity. A concentrate mixture using maize grain, soya bean meal, ground nut cake, rice bran, mineral mixture and common salt in the ration 40, 20, 20, 17, 2 and 1% respectively could be used along with the roughages source to make a complete feed block (Pandey 2014).

Wafering

Wafers are about ten times the size of pellets having sizes of rectangular wafers of 25X25 mm and cylindrical wafers of 8-30 mm diameter. After milling and addition of concentrates, chemical additives and other minerals, the straw is wafered to increase the nutrient value, intake and digestibility. The wafered feed is not only easy to transport, to store, and to feed, but also very convenient for marketing due to its high density. Wafers can be prepared from chopped straw alone or with 40 kg/ton molasses or with sodium hydroxide (Tingshuang et al 2002)

Role of rice by-products in livestock industries

Traditionally the major feed resources are crop residues and by-products, forest, seasonal grazing land, and non-cultivated areas. Agricultural land provides about 60% of the total annual feed supply, mainly in the form of low quality crop residues, whilst 40% comes from forest and grazing land (TLDP 2002). Crop residues constitute large parts of animal feeds in almost all ecological zones. Crop residues either processed or unprocessed dominates the ruminant feeding in Nepal. Approximately 40% TDN is supplied by crop residues. Rice straw meets about 32-37% of total digestible nutrients required for several million livestock units, especially during scarcity of green fodder (CDD 2015). Other residues or crop co-products include wheat straw, grain legumes, *chunnis* etc. In addition to stall feeding of crop residues, animals are also grazed in the agricultural fields after harvesting of food/cash crops. This type of feed resource is temporary in nature and available for limited period but widely prevails all over the country (Yadav 2014). Rice polish (1.6 million t/year) is major energy source of rice by products available in Nepal. It provides energy of 3250 Kcal/kg and 11% CP. Rice polish could be used as readily available energy source for rumen microbes while feeding urea treated rice straw for ruminant animals (Upreti and Shrestha 2006). Bastakoti et al (2009) and Upreti et al (2010) reported the average cost of milk production through feeding of rice straw and commercial feed was lower than concentrate based feeding and higher than forage based feeding.

Share of rice by-product in animal feed composition in Nepal

Rice polish/bran and rice straw are major sources of feeding materials for livestock in Nepal. Rice polish/bran (including de-oiled) constitute 9% in animal and poultry feed composition. In Nepal, domestic production of rice polish/bran have been used in animal and poultry feed composition. Import of rice polish/bran through official source have not been recorded yet.

Table 1. Ingredients used for animal and poultry feed formulation

SN	Feed ingredients	Quantity (tonnes)	Inclusion %	Import %
1	Rice polish/bran	39396	5	0
2	Deoiled rice bran	31517	4	30
3	Wheat	31517	4	0
	Wheat bran	7879	1	0
4	Yellow Maize	409726	52	55
5	Soybean meal	126070	16	99
6	Tilcake	23639	3	90
7	Sunflower cake	23639	3	90
	Nystard cake	39397	5	00
	Mineral vitamins/feed additives			
8	Bonemeal	7879	1	85
9	Dyster Shell	7879	1	98
10	Limestone	15759	2	0
11	Feed supplements/additives	7879	1	80
	Total	787935	100	

Note: The feed formula is only a typical example and it can vary between manufacturers depending upon the price and availability of feed grains.

Source: Bhattarai and Chapagain 2014.

Industrial uses of rice by-products in livestock industries in Nepal

In the current scenario, there are about 120 registered feed companies in Nepal. About 80% of egg production and 65% of broiler production cost incurs in feed procurement. At present, 92% of the total feed is used only for poultry, 5% and 3% for cattle and pig respectively (NFIA 2012).

The number of feed industries affiliated in AEC/FNCCI has reached 94. The total of 2200 tonnes of feed per day is produced by Nepalese feed industries as poultry, cattle and pig feeds. The percent of use of rice by product like bran constitute around 10% (Silwal 2017, personal communication). Exact data regarding amount of rice bran and other such rice by-product in feed is lacking in recent years. However, amount of rice polish/bran and deoiled rice bran used in livestock feed was 27,500 tonnes and 10,784 tonnes respectively in 2006 which increased to 39396 tonnes and 31517 tonnes in 2014 (Bhattarai and Chapagain 2014). Rice bran is generally used for feeding cattle and buffalo in Nepal. In Nepal, 5.9 kg and 22.5 kg bran is obtained that accounts NRs 107.50 and NRs 409.95 (at NRs 18.22 per kg) from 100 kg of milled white rice and brown rice, respectively (MRSMP 2013). With this rate, transaction of rice polish/bran for feed industries in Nepal accounts NRs 717.795 million (Calculated based on **Table 1**). Rice husk is generally used as bedding materials (litters) for poultry industries in Nepal. 24.50 kg of rice husk is extracted from 100 kg of paddy (MRSMP, 2013). A total of 1,173,209 tonnes of husk is produced from 4,788,612 tonnes of paddy at the rate of 24.5% husk recovery (MoAD 2015) annually amounting NRs 5866.45 million at the rate of NRs 5.0 per kg (DP Kaphle 2016, personal communication).

Conclusion

Animal husbandry is the chief occupation after crop production in Nepal. Rice straw is the major forage or residue which is used for animal feeding in small farms and bedding materials in winter. Farmers' preference to grow tall varieties with high straw yield is to provide feed to livestock. Rice bran and deoiled rice cakes are other rice by-products which are major part of commercial livestock feed. Adoption of technologies like ensiling and urea treatment can enhance nutrient availability from otherwise less nutritive rice straw. Thus, use of rice by-product in livestock industry has better prospects for Nepal.

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Use of Rice Straw in Cottage Industry of Nepal

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सारांश

वि.स. २०७२ मा परालमा आधारित घरेलु उद्योगबाट उत्पादन हुने विभिन्न वस्तुहरूको पहिचान, बजारीकरण यसका फाइदाहरू तथा आइपर्ने समस्या सम्बन्धी अध्ययन गरिएको थियो । अध्ययनको लागि आवश्यक जानकारी भक्तपुर जिल्लाको सुकुलढोका क्षेत्रमा एक मामला अध्ययन तथा तीन मुख्य सूचनादाताबाट संकलन गरिएको थियो । सुकुल, गुन्द्री, चकटी, कुर्सी, जुत्ता, चप्पल प्रमुख उत्पादनहरू धानको परालमा आधारित रहेको पाइयो । ती वस्तुहरूको उत्पादन परम्परागत ज्ञान तथा सीपको आधारमा गरिएको पाइयो । गाउँघरतिर सुकुल, गुन्द्री तथा चकटीलाई कार्पेटको रूपमा प्रयोग गर्दै आइरहेको अवस्था छ, तर हाल आएर बिस्तारै आधुनिक कार्पेटले प्रतिस्थापन गरिरहेको छ । मुडा तथा कुर्सीहरू त्यति प्रचलनमा आइरहेका छैनन् । तर जुत्ता तथा चप्पलहरूको प्रयोग हिन्दु धर्मालम्वीहरूको धार्मिक प्रयोजनको लागि बढ्दै गइरहेको छ । सुकुल उत्पादनको लाभलागत अनुपात ०.८२ भएको र कम फाइदा हुँदाहुदै पनि रोजगारको अर्को उत्तम विकल्प नभएका कारणले सुकुल उत्पादनमा संलग्न भएको पाइयो । यी वस्तुहरूको उत्पादन तथा बजार साँगुरिएको भएता पनि गाउँघरतिर फुर्सदको समय सदुपयोग गरी आयआर्जन गर्ने व्यवसायको रूपमा रहेको तर अन्य आयआर्जनका राम्रा विकल्प भएमा यो व्यवसाय प्रतिस्थापन हुने देखिएको छ ।

Summary

A study was carried out in 2016 to identify different products of rice straw based cottage industries in Nepal, and assess their constraints and benefits. The information was generated with the help of a case study and three key informant interviews. Sukuldhoka cluster of Bhaktapur district was selected for the study. The study found that rice straw based cottage industries produce *sukuls, gundris, chakatis,* stools, chairs, and sandals. These were made using traditional knowledge and skills. *Sukuls, gundris* and *chakatis* are used as carpets in some rural areas which are being replaced by modern woollen and synthetic carpets. Stools and chairs made traditionally are also not used commonly. However, as rice straw sandals are considered holy in Hindu mythology, its demand among people performing religious Hindu rites, is increasing. An analysis of sukul making showed that benefit cost ratio at market price was 0.82 for its preparation. Rice straw is also used as thatching material in some cases. Although market is shrinking for most of the products, rice straw based cottage industries are providing income to people by utilizing their leisure time.

Keywords: Benefit cost ratio, Cottage industries, Market, Rice, Straw

Background

Rice straw is the above ground vegetative part, except grain, of the rice plant (*Oryza sativa* L.) (Kadam et al 2000). It is a crop residue derived from rice production (Upreti et al 2007). The production of rice straw depends on several factors such as crop varieties, working environment etc. IRRI (2016a) reported that the production quantity of rice straw is 1.5 times the weight of rice grain. In Asia, about 620 million tonnes of straw was produced in 2008 and it is increasing each year (IRRI 2016b). In Nepal, quantity of rice straw produced was 7.18 million tonnes in 2014/15 (MoAD 2015). Most of rice harvesting is done manually in Nepal. During rice harvesting, the rice plant is cut at half feet to one feet above the ground, threshed and

Figure 1. A *Kunyau* of *paral*

grains are separated. The straw is then sun dried, bundled and heaped in shed or in open space with a cover to prevent the straw from decomposing. Heap of stored *paral* is called *Kunyau* (**Figure 1**).

Rice straw has several uses. It is used in animal feeding, basketry, biofuels, biogas, biomass, construction materials, crafts, shoes, erosion control, thatching, mulching etc. Recently, it has been gaining popularity for its medical value. Desouky et al (2015) reported that it is rich in antioxidant compounds which can be used to improve human health.

Published literatures in rice straw used in small and cottage industries is grossly lacking in Nepal. This study was carried out in 2016 and highlights different uses of rice straw in country's cottage industries.

Utilization pattern

Paral is used for different purposes in industries and in cultural and religious practices. It is generally fed to livestock, used as bedding material for animals, and also used as a source of fuel for cooking food, especially in Tarai areas to supplement the fuel wood demand. In Tarai, people burn paral, called *ghoor* in local language, gather around it to keep their body warm especially in cold waves in winter. It is also used, along with firewood, in cremation by *Hindus*. Its use in cottage industries has been discussed here.

Use of paral in cottage industries in Nepal

Paral is used in preparing different goods. Among them, *sukul* (**Figure 2**) and *gundri* (**Figure 3**) are most common in rural society prepared by using traditional knowledge and skills. These

Indigenous products are used as carpets and more demanded in winter season in rural areas. Small sized *sukul* is called *Chakati*. As the opportunity cost of rural labor is virtually absent, leisure is used in preparing these products and selling in adjoining marketplaces. Here, a case of Binu Maharjan, a native from old city of Bhaktapur has been illustrated in Box 1. In recent days, demand of *sukul* is decreasing due to growing consumers' preference of higher quality woollen and synthetic carpets over *sukuls and gundris*.

Besides *sukul*, *paral* is used in making shoes (**Figure 5**), chairs and stools (**Figure 6**). *Paral* shoes is considered holy by Hindu religion, and put on by *Kiriyaputris*, meaning sons and wives of dead people, performing final rites. *Paral* is also spread and used as bed for *Kiriyaputris.*

Other uses include as thatching material in rural houses (**Figure 7**) and cottage restaurants in urban areas in Nepal to add value by providing a traditional outlook. These days, thatched houses are very rarely found in rural areas as they are replaced by zinc sheets or concrete structure. Demand of cottage type of restaurants is high. Moreover, *paral* is used as a raw material in booming mushroom production in peri-urban areas of Kathmandu, Pokhara, Biratnagar and other cities in Nepal.

Figure 2. A roll of *sukul*

Figure 3. *Gundri*

Figure 4. Straw mat for drying paddy

Figure 5. *Paral* shoes

Figure 6. *Paral* stool

Figure 7. Traditional thatched house in rural area of Nepal

Box 1: Case Study: Use of rice straw for *Sukul* making

Figure 8. *Sukul* making

Binu Maharjan, a resident of Sanagaun village in Lalitpur district has been involved in *Sukul preparation* using rice straw in her free time. She has been using straw from their half ropani of land. She lives with her husband and two kids. Her husband had gone to Malaysia for overseas employment and came back due to different problems there. After the return of her husband, she had difficulties in maintaining her lifestyle as before because of the lack of financial support that her husband provided. She is making 40-50 s*ukuls* per year. About 14 *Kalli paraal* is required to prepare one 25 square feet *Sukul. Kalli* is the unit of *paraal* measurement and is a small bundle of around one kg. The average price of one Kalli *paraal* is NRs 10. The average wages for female in her area is NRs 350 (per day). Then the total cost of one *sukul* comes to be around NRs 490. However the price of one *sukul* ranges from NRs 350-450 depending on season. Its price is higher in winter season compared to summer. From this figure it seems that the *sukul* making is not a profitable enterprise, however due to absence of other better options (due to very less opportunity cost), she is continuing this business to support her family. Traders come to collect the products from the village. sometimes she also receives pre-order. She is also planning to drop this business if she gets any other opportunity in nearby areas which can sustain her family.

Conclusion

Products from rice straw based cottage industries are quite common in rural areas of the country. These products are specially made in leisure time for supporting rural livelihoods. Economic analysis in market price does not show encouraging results. Most of the products are being replaced by modern synthetic and woollen materials with the rise of per capita income of people. Producers are those who value leisure less than earning a lot from making rice straw products. Straw use as base material for mushroom production and sandals has good demand in the country. Along with the promotion of these two, other alternative uses have to be explored including extracting different useful compounds as in other countries to make this industry more attractive.

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Rice Straw as a Substrate for Mushroom Cultivation in Nepal

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सारांश

च्याउ विभिन्न माध्यमहरूमा उत्पादन गरिन्छ र माध्यमको छनोट यसको उपलब्धता र मूल्यमा भर पर्दछ । पराल धानको उप–उत्पादन हो । परालला‌ई पोषणयुक्त र औषधी मूलक उच्च महत्वको खाना जस्तै च्याउ उत्पादन गर्नको लागि प्रयोग गर्न सकिन्छ । गहुँको छ्वालीबाट भन्दा धानको पराल प्रयोग गरी च्याउ उत्पादन गर्दा १० प्रतिशतभन्दा बढी उत्पादन हुने गर्दछ । धानको परालको सेलवाल मुख्यगरी सेलुलोज, हेमिसेलुलोज र लिगनिन भन्ने पदार्थबाट बनेको हुन्छ । यी पदार्थहरूलाई च्याउको त्यान्द्राबाट निस्केको ईन्जाईमले टुक्र्याउने काम गर्दछ । च्याउखेतीको माध्यमबाट यी अनुपयुक्त पदार्थलाई पुनः प्रयोग गरी कृषिको क्षमता बढाउन सकिन्छ तसर्थ धानको पराल मुल्यवान रेसा र च्याउमा परिवर्तित भई थप आम्दानी बढाउन सकिन्छ । यो लेखले च्याउको उत्पादनमा धानको परालले पार्ने प्रभावको बारेमा विशेष जोड दिएको छ । नेपालमा परालको औसत उत्पादन ३.९ मे.टन प्रति हेक्टर छ भने करिब १,५३१,४९३ हेक्टर धान खेतबाट वार्षिक ५९७२८२३ मे.टन पराल उत्पादन भैरहेको छ । कन्ये च्याउ खेतीको लागि वार्षिक करिब १०५००० मे. टन पराल खपत भैरहेको छ । सामान्यता १ के जी परालबाट ७०० देखि ८०० ग्राम च्याउ उत्पादन हुने गरेको छ । नेपालका व्यवसायिक कृषकहरूले विशेष गरी कन्ये च्याउ खेती गर्नको लागि धानको पराल माध्यमको रूपमा प्रयोग गरेको पाईन्छ । कृषकहरूले गोब्रे च्याउको खेतीको लागि बनाईने कम्पोष्टमा पनि धानको पराल प्रयोग गर्ने गरेका छन् । च्याउ खेती कृषकको लागि आम्दानीको राम्रो स्रोत हुन सक्छ र ग्रामिण भेगमा भएको मानवश्रमको राम्रो उपयोग समेत गर्न सक्छ । च्याउ उत्पादन गरिसकेपछिको परालला‌ई खेतमा मलखादको रूपमा समेत प्रयोग गर्न सकिन्छ ।

Summary

Mushrooms are grown on a great variety of substrates and the choice of substrate depends on availability and cost. Rice straw can be used as potential resources for production of nutritiously and medicinally high value food like mushroom. Rice straw yields about 10% more mushroom than wheat straw. Rice straw consists predominantly of cell walls, comprised of cellulose, hemi-cellulose and lignin. These components are broken down by mushroom hyphae secreting large amounts of extracellular enzymes. Recycling of these unfavorable materials through mushroom culture can increase agricultural efficiency and enhance degradation process of ligno-cellulose sources. Thus rice straw is transformed to valuable roughage and mushrooms provide an additional income. The average yield of straw in Nepal is 3.9 t/ha. It is estimated that 105000 tonnes of rice straw has been using annually for oyster mushroom production and commercial farmers use only rice straw as substrate for oyster mushroom cultivation in Nepal. In general, 1 kg dry straw produces 700-800 g oyster mushroom. The common field mushroom and many other types of mushroom grow well on compost made from rice straw. The organic matter left over after mushrooms harvest can also be used in cropland as organic fertilizer.

Keywords: Organic matter, Oyster mushroom, Rice straw, Substrates

Introduction

Mushroom cultivation can help to reduce poverty and strengthen livelihoods through the generation of a fast yielding and nutritious source of food and can be reliable source of income. Since it does not require access to a huge swate of land. Mushroom cultivation is a viable and attractive activity for both rural farmers and peri-urban dwellers. Commercially cultivated five species of mushrooms are *Agaricus bisporus* (Lange) Imbach, *Pleurotus* spp, *Lentinus edodes* (Berk.) Pegler, *Volvariella volvacea* (Bull Fries) Singer and *Ganoderma lucidum*(Curtis) P. Karst.

Diversified and wide range of climate across the country has gifted a lot of varieties of mushrooms naturally (760 species) in Nepal. Some170 species of the have been proven as edible mushrooms (Poudel and Bajracharya 2011). The demand of mushroom has been mounting day by day due to population growth, market expansions and changing of consumer behavior. Rice straw is the principal substrate for oystermushroom, straw mushroom and common mushroom cultivation in Nepal (Manandhar 2005). Hence, this paper highlights the use of rice straw on mushroom production.

Substrates for mushroom cultivation

Mushrooms can be classified as three categories by their tropic patterns: saprophytes, parasites or mycorrhizae. The most commonly grown mushrooms are saprophytes, decomposers in an ecosystem growing on organic matters, decomposers such asoyster mushroom and enokitake that have lignocellulosic enzymes. On the other hand, secondary decomposers like button mushroom or straw mushroom require substrate degraded by bacteria or other fungi.

Figure 1. Use of straw for mushroom production

Rice straw is abundant in most Asian countries where rice is a major crop, and can be purchased for a reasonable price. The widely used substrate that is used in Nepal is rice straw (Devkota and Bhandari 2014). Rice straw can be used as the basic material for mushroom cultivation. Mushrooms are capable of breaking down organic material that other microorganisms cannot decompose. The main function of rice straw is to provide a reservoir of cellulose, hemicelluloses and lignin which is utilized during the growth and fructification of mushroom. The common field mushroom and many other types of mushroom grow well on is the compost made from rice straw. The organic matter left over after mushrooms harvest can be recycled onto cropland as organic fertilizer.

A substrate is an important substance for growing mushrooms. Usually, a wide range of diverse cellulosic substrates are used for cultivating mushrooms. Different agricultural and/or industrial straw wastes can be used for cultivation of mushrooms. Various agricultural byproducts are being used as substrates for the cultivation of oyster mushrooms, including banana leaves, peanut hull, corn leaves, mango fruits and seeds, sugarcane leaves, and wheat and rice straw. In Asia, rice straw is widely used as the substrate for cultivating oyster mushroom (Thomas et al. 1998) and is also considered the best substrate for higher protein content and yield of mushroom.

Table 1. Key mushroom species and their corresponding cultivation medium

Growing medium	Mushroom species
Rice straw	Straw (*Volvariella)*, Oyster (*Pleurotus*), Common (*Agaricus*)
Wheat straw	Oyster (*Pleurotus*), Common (*Agaricus*), Straw (*Volvariella*), Roundhead (*Stropharia*)
Coffee pulp	Oyster (*Pleurotus*), Shitake(*Lentinus*)
Saw dust	Shiitake (*Lentinus*), Oyster (*Pleurotus*), Lion's Head or PomPom (*Hericium*), Ear (*Auricularis*), Ganoderma (*Reishi*), Maitake (*Grifolafrondosa*), Winter (*Flammulina*)
Saw dust-straw	Oyster (*Pleurotus*), Roundhead (*Stropharia*)
Logs	*Nameko* (*Pholiota*), Shitake (*Lentinus*), Whitejelly(*Tremella*)
Sawdust-rice bran	*Nameko* (*Pholiota*), Ear (*Auricularis*), *Shaggy Mane* (*Coprinus*), Winter (*Flammulina*), Shiitake (*Lentinus*)
Corn cobs	Oyster (*Pleurotus*), Lion's Head or Pom Pom (*Hericium*), Shitake (*Lentinus*)
Paper	Oyster (*Pleurotus*), Roundhead (*Stropharia*)
Horse manure (fresh or composted)	Common (*Agaricus*)
Molasses waste from sugar industry	Oyster (*Pleurotus*)
Water hyacinth/Waterlily	Oyster (*Pleurotus*), Straw (*Volvariella*)
Bean straw	Oyster (*Pleurotus*)
Cotton straw	Oyster (*Pleurotus*)
Banana leaves	Straw (*Volvariella*)

Source: Beetz and Kustudia 2004.

Rice straw can be used as the main substrate for mushroom cultivation. In case of cultivation of common mushroom first, it should be composted. The rice straw is prepared by composting. The substrates developed for Button mushroom cultivation by Plant Pathology Division are as follows (PPD 1999):

Compost A: Rice straw: 1000 kg, Urea:5 kg, Ammonium sulphate:20 kg, Triple super ,phosphate: 7 kg, and Agri lime: 30 kg

Compost B: Rice straw: 1000 kg, Complexsal, (20:20:0): 23 kg, Urea: 4 kg, Gypsum (Plaster ofaris): 40 kg

Compost C: Rice straw: 1000 kg, Urea: 15 kg, Ammonium sulphate : 15 kg, Gypsum: 35 kg, Agrilime: 25 kg and Rice bran: 25 kg

Compost D: Rice straw: 1000 kg Or Straw- 500 kg and Wheat straw- 500 kg, Chicken manure

Up to now Nepalis practicing *Agaricus bisporus, Pleurotus species* and *Volvariella volvacea* in rice straw (Devkota and Bhandari 2014).

History of use of rice straw as substrate for mushroom cultivation in Nepal

Mushroom cultivation was initiated by the Division of Plant Pathology, Nepal Agricultural Research Council (NARC) in 1974. The growing technology for white button mushroom was developed during that early period and extended to general farmers starting in 1977. It utilized the synthetic media of paddy straw, which is harvested twice a year in Kathmandu. The technology to grow oyster mushroom using chopped straw packets was introduced to the farmers in 1984, and since then mushroom cultivation has become more popular among farmers (Manandhar 2005).

In 1981, scientists of the Plant Pathology Division introduced the cultivation technology of straw mushroom and conducted research on different substrates for its cultivation. Based on their research, paddy straw + gram powder was found the best substrate for the cultivation of straw mushroom (Parajuli 2014). The Centre for Agricultural Technology (CAT) introduced straw mushroom (*Volvoriella volvacea*) cultivation using rice straw in the Tarai districts since 2001 (Manandhar 2005).

Biochemical composition and nutritive value of rice straw

Mushrooms require carbon, nitrogen and inorganic compounds as their nutritional sources and the main nutrients are carbon sources such as cellulose, hemicellulose and lignin. The biochemical composition of rice straw is characterized by a typical composition of an agricultural-based lingo cellulosic residue. It contains on an average 30 – 45% cellulose, 20 – 25% hemicellulose, 15–20% lignin, as well as a number of minor organic compounds. Rice straw and wheat straw are poor in nitrogen, but relatively high in inorganic compounds, often referred to as ash (www.ecn.nl/phyllis). Rice straw consists predominantly of cell walls, comprised of cellulose, hemicellulose, and lignin. To break down these components cellulase, hemicellulase and ligninase are required (Schiere and Ibrahim 1989). These enzymes are not produced by the animals themselves. Huge quantities of agro-industrial biomass including about 900 million tonnes of rice straw are produced worldwide annually, more than 90% being produced in Asia (Jahromi et al 2011). Mushroom hyphae secrete large amounts of extracellular enzymes which bring about the degradation of macromolecules such as cellulose, hemicellulose, lignin and protein in the substrates (Kuforiji and Fasidi 2008). Adenipekun and Okunlade (2012) investigated the potential of *Pleurotus ostreatus* in degradation of rice straw maize stovers and rattan wood. Recycling of these unfavorable materials through mushroom culture can increase agricultural efficiency and enhance degradation process of ligno-cellulose sources. The increase in the yield of mushroom in paddy straw is due to easier way of getting sugars from the cellulosic substances (Ponmurugan et al 2007).

Availability and use of rice straw for mushroom cultivation in Nepal

Rice straw is a crop residue derived from rice production. It serves as a major feed for ruminants. According to CDD (2015) average yield of straw in Nepal is 3.9 t/ha. Annually a total of 5,972,823 tonnes of straw is produced from 1,531,493 hectares rice fields amounting NRs 7,167,387,240 at the rate of NRs 1.2/kg. It is estimated that the large ruminants such as cattle and buffalo consume 82.4% of the straw. The remaining 17.6% rice straw is available for other uses (Pandey 1997). If this surplus straw could be used for mushroom substrate, it will substantially reduce the substrate scarcity problem in the country. Nepalese farming is dominated by smallholders and residue burning is a traditional practice. Farmers mainly burn to reduce the labor costs of preparing their fields for the next crop. In southern Nepal, it is common practice to dispose crop residue (such as rice straw) by burning it in the field. This causes many environmental problems because biomass burning contributes to smoke, black carbon and greenhouse gases. In this context rice straw as a substrate for mushroom cultivation can be effectively used to stop small-scale farmers from burning rice straw stubble and other biomass and the re-use of this agricultural waste will be economically profitable not only for the farmer but also for the agriculture at large.

Mushroom farming in Nepal is becoming popular among Nepali farmers for its new way of farming . Now there are many commercial mushroom farms in Nepal that produce different variety of mushrooms. Since a long past, wild mushroom has been collected and accepted (eating) socially and culturally by certain ethnic groups. But now-a-days due to urbanization and awareness on the health benefit of mushroom, its consumption is increasing. Currently about five species of mushroom are cultivated at commercial scale. Among five very popular mushroom species, the white button mushroom (*Agaricus bisporus*) and oyster mushroom (*Pleurotus* sp.) have a higher commercial value (DOIE 2013). Straw mushroom is also being cultivated in Tarai region which is tropical climate and it is mainly grown in rice straw. Oyster mushrooms may be grown on rice straw, sawdust, wheat straw and a variety of high cellulose waste materials. It can be cultivated on pure substrate or combination of different substrates but now it is commonly grown in rice straw. Due to availability, quick decomposition, affordability, easy handling and more yield, almost all producers use rice straw for the production of *P. osteratus* (Sharma et al 2013). In general, 1 kg dry straw produces 700-800 gram of oyster mushroom. Published data regarding rice straw volume used for mushroom production do not exist. At present there are about 5000-6000 mushroom farmers in Kathmandu alone (Poudel and Bajracharya 2011). Over 10000 farmers (commercial and small holder) are involved in mushroom cultivation. Nearly 105000 tonnes of rice straw of NRs 52500000 at the rate of NRs 5/kg has been used annually for oyster mushroom production and commercial farmers use only rice strawas substrate for oyster mushroom cultivation in Nepal. Without use of rice straw commercialization of straw mushroom, oyster mushroom and common mushroom is impossible (Adhikari 2016, personal communication).

Growth and yield of mushroom on different substrates

Suggested that the utilization of insoluble ligno-cellulosic substrates by edible mushrooms depends on the production of the enzymes such as cellulases, hemicellulases, ligninases which bring about hydrolysis of the macro molecules of cellulose, hemicellulose and lignin components of the substrate, thereby liberating the low molecular weight nutrients essential for mushroom growth. Comparing rice straw with wheat straw, rice straw yielded about 10% more mushroom than wheat straw under the same cultivation conditions (Zhang et al 2002). Mushrooms have been recognized as a high potential converter of cheap celluloses into valuable protein. The rapid growth and the ability to utilize various lingo cellulosic substrates make different mushroom species cultivation possible in different parts of the world. Substrate type is one of the major factors affecting the yield and quality of oyster mushroom. A substrate in mushroom cultivation may be defined as a kind of lingo cellulose material which supports the growth, development and fruiting of mushroom. Most of all edible mushroom species can utilize various kinds of substrate materials depending on availability in different places. The nutrient composition of substrate is one of the factors limiting the saprobiotic colonization of cultivated mushrooms. The growth of microorganisms as well as quantitative and qualitative yield of the desired product depends on the utilization of nutrients and physiochemical environment in the medium or substrate. The yields of mushroom on different substrates were: 151.8 g, 111.5 g, 87.8 g, 49.5 g, 23.5 g, 13.0 g and 0.0 g per kg substrate for rice straw, banana leaves, maize stalk, corn husk, rice husk, fresh sawdust and elephant grass respectively and rice straw give the best yield (Kimenju et al 2009).

A research conducted in Nepal regarding cultivation of oyster mushroom on different substrates such as: rice straw, rice straw + wheat straw, rice straw+ paper, sugarcane bagasse and sawdust of alder revealed that, the effects of various substrates on mycelia growth, colonization time, primordial appearance time, mushroom yield, biological efficiency (BE), size of the mushroom and chemical composition, rice straw (control) was found the best substrate with yield of 381.85g and BE of 95.46% followed by rice plus wheat straw and rice straw plus paper waste for the production of mushroom. The nutritional composition was also better from mushroom fruit grown on rice straw (Sharma et al 2013).

International scenario

In Asia, rice straw is widely used as the substrate for cultivating oyster mushroom (Thomas et al 1998) and is also considered the best substrate for yield and high protein content. Wheat straw is commonly used as a substrate in Europe and sawdust is commonly used as a substrate in Southeast Asian countries for the cultivation of oyster mushroom. Button mushroom was the only mushroom cultivated on a large scale, using composted wheat straw as the substrate. In China, oyster mushrooms are cultivated mainly on sawdust and cotton seed hull. Demand for sawdust and cotton seed hull is increasing following the increasing expansion in the poultry industry and mushroom cultivation, thus making it difficult and expensive for commercial mushroom growers to get sawdust and cotton seed hull. If rice straw and/or wheat straw can support the growth of oyster mushroom, then it would be one of the solutions to transform these inedible wastes into an accepted edible biomass of high market value, and serve as a cheap source of substrate for mushroom grower (Wang 2010).

In several countries of the Asia-Pacific region mushroom cultivation is integrated into rice farming. In China and Vietnam millions of rice farmers integrate rice farming and rice straw mushroom cultivation. After rice harvest the straw waste is used as the substrate for growing *Volvariella volvacea*. Rice straw can also form a component of the substrate used for growing other species of mushrooms (FAO 1999).

Conclusion

In Nepal, rice straw is widely used as substrate for cultivating oyster mushroom and white button mushroom and is also considered the best substrate for higher protein content and yield of mushroom. Rice straw consists predominantly of cell walls, comprised of cellulose, hemicellulose, and lignin. To break down these components cellulose, hemicellulose and ligninase are required. Mushroom hyphae secrete large amounts of extracellular enzymes which bring about the degradation of macromolecules such as: cellulose, hemicellulose, lignin and protein in the substrates. Recycling of these unfavorable materials through mushroom culture can increase agricultural efficiency and enhance degradation process of ligno-cellulose sources.

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Industrial Uses of Rice By-Products in Nepal

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सारांश

धान काटेपछि चामल बन्ने प्रक्रियासम्म आइपुग्दा पराल, भुस र ढुटो आदि उप-उत्पादन (वाइप्रोडक्ट) को रूपमा प्राप्त हुन्छन् । यसरी प्राप्त हुने उप-उत्पादनहरू मध्ये पराल गाईवस्तुलाई खुवाउनका साथै औद्योगिक प्रयोजनका लागि समेत प्रयोग हुन्छ । पराल हाते झोला तथा ह्यांगर बनाउनका साथै साना घरेलु उद्योगमा स्टुल, कुर्ची, गुन्द्री आदि बनाउन समेत प्रयोग हुन्छ । पराल पल्पको स्रोतको रूपमा कागज कारखानामा र च्याउ उत्पादन गर्ने माध्यमको रूपमा समेत प्रयोग भइरहेको छ । औषतमा ३.९ मे.ट. पराल १ हेक्टर धान खेतबाट प्राप्त हुने गर्दछ । त्यसैगरी धानको भुस चिउरा तथा भुजा मिलहरूमा धान उमाल्न वा पकाउनका लागि उर्जाको स्रोतको रूपमा साथै मल्चिंग, भकारोमा सोत्तर तथा कुखराको खोरमा लिटरको लागि समेत प्रयोग हुने गर्दछ । औसतमा १०० किलो धानबाट २४.५ के.जि. भुस प्राप्त हुने गर्दछ । उप-उत्पादनको रूपमा प्राप्त हुने ढुटो सामान्यतया गाईवस्तुलाई पशु आहाराको रूपमा खुवाउने गरिन्छ । तथापि, नेपालमा प्रयाप्त भौतिक पूर्वाधारको अभावमा ब्रान वेल (तेल) र वायो उर्जा निकाल्न सकिएको छैन । प्रस्तुत लेखमा धानबाट प्राप्त हुने उप-उत्पादनहरूको नेपालको औद्योगिक क्षेत्रमा उपयोगको अवस्थाबारे संक्षिप्त जानकारी पस्कने प्रयास गरिएको छ ।

Summary

Straw, husk and bran are the major by-products of rice obtained in the process of harvesting to milling. Rice straw is used as major forage for livestock in rice-producing areas. It has also the industrial uses in various rice straw based industries. Rice straw used in handicraft industries for making hand bags and wall hangings. It is also used in cottage industries to make straw mat, stools, shoes etc. Moreover rice straw is used as source of pulp in paper industries and as a substrate for mushroom production. Yield of 3.9 tonnes straw is produced from one hectare of paddy in Nepal. Rice husk is used for production of thermal energy using various types of furnaces. Husk is also used as soil mulch, poultry litter, insulation material, packing material and source of heat energy in puffed rice mills in Nepal. On an average, 24.5 kg of husk is produced from 100 kg of paddy. Rice bran is an important feed ingredient of the concentrate ration for the livestock. However, due to limited and inadequate infrastructures, Nepal has not become able to extract rice bran oil and make use of rice by-products to generate bio-energy. This article, intends to throw lights on rice by-products and their industrial uses in Nepal.

Keywords: Bran, By-products, Husk, Infrastructures, Rice, Straw

Background

Rice straw, husk and bran are the major by-products of paddy in Nepal. These by-products are obtained in the processing of rice from paddy harvesting to milling. Before rice grains enter into the milling process, the main by-product is the rice straw constituting more or less equivalent to weight of the rice grain. The main yield of rice milling is the edible endosperm constituting around 69.6%. MRSMP (2013) reported that other by-products of rice ie husk and rice bran are around 24.5% and 5.9%, respectively. The percentage of rice by-products varies with milling rates, type of mill and type of rice (Hoed et al 2006, Wells 1993, De et al 1996). Traditionally the rice by-products had no or little commercial value and simply used as animal feeds, roofing materials, cooking fuels, medium for mushroom production, fertilizers and sometimes source of energy by burning the straw and husks. Nevertheless, there have been remarkable innovations for industrial utilization of rice by-products ranging from biomass energy to medicines for curing numerous human diseases. In Nepal, rice by-products have been used in farm and industries.

Rice straw is produced after harvesting of paddy. Straw comes from what is left on the plant after it is harvested and the grains are threshed. Rice husks or hulls are generated during the first stage of rice milling, when rough rice or paddy rice is husked. Rice bran is produced during the second stage of milling, the whitening or polishing process, when the bran layer is removed from the brown rice kernel. This process can be shown in the figure below.

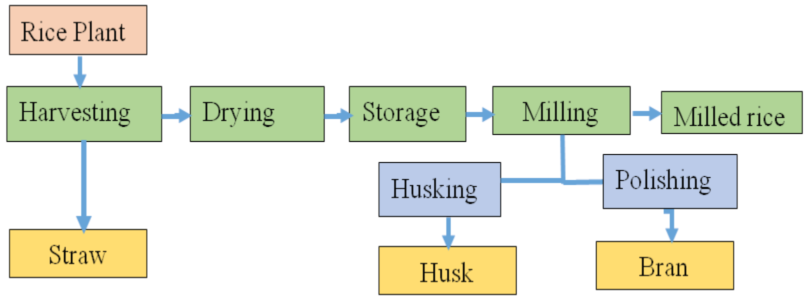

Figure 1. Process of formation of rice by-products

The rice by-products with their characteristic features have been presented in the **Table 1**.

Table 1. Description of rice by-products

By-products	Description
Straw	Stem and Leaf of the rice plant, separated during harvesting or threshing, has multi facet uses, an attractive and potential source of energy.
Husk	Outer covering of the grain, de-husked during milling and separated from the endosperm, major by-product of rice
Bran	Inner covering of the rice grain, removed from the endosperm through whitening or polishing, rich in oil and other ingredients like vitamins, minerals, amino acids, carbohydrates, protein.

Rice by-products and their industrial uses in Nepal

Rice Straw

CDD (2015) has estimated the average yield of straw in Nepal to be 3.9 t/ha producing about 6 million tonnes of straw with monetary value of around NRs 7100 millions. In Nepal, straw is mainly used for following purposes.

Straw at farmers level

Rice straw is major forage or residue which is used for animal feeding in small farms. Rice straw meets about 32-37% of total digestible nutrients required for several millions livestock units, especially during scarcity of green fodder (Basnet 2008). Rice straw may be fed to their livestock or burned or left on the field before the next ploughing, ploughed down as a soil improver (Kadam et al 2000). It is estimated that the large ruminants such as cattle and buffalo consume 82.4% of the straw. The remaining 17.6% rice straw is available for other uses (Pandey 1997). This surplus straw could be used for mushroom substrate. Nepalese farmers also use straw for thatching. The woody portion of straw is used as fuel. Sometimes a portion of the straw is ploughed back in to the soil to be reused as bio-fertilizer.

Straw at industrial level

In Nepal, rice straw is used for several industrial purposes. Some of the uses of straw in industries are given below.

Straw in handicraft industry: Rice straw is used in making certain fancy products like bags, wall hanging, etc.

Straw in paper industries: In Nepal, some paper manufacturing industries use rice straw as raw material.

There are about 10 big paper manufacturing factories in Nepal (http://www.directoryofnepal.com), using rice straw along with other fibrous materials to prepare pulp for making boards and papers.

Straw in cottage industries

Products from rice straw based cottage industries are quite common in rural areas of the country. These products are specially made in leisure time for supporting rural livelihoods. *Sukul* and *gundri* (kinds of sitting mat) are most common in rural society prepared by using traditional knowledge and skills. Rice straw is used in making shoes, chairs and stools. Other uses include as thatching material for cottage restaurants in urban areas in Nepal to add value by providing a traditional outlook.

Straw as a substrate for mushroom production

Rice straw can be used as potential resources for production of nutritiously and medicinally high value food like mushroom. In general, 1 kg dry straw produces 700-800 g oyster mushroom. Nearly 105,000 tonnes of rice straw of NRs 52,500,000 at the rate of NRs 5/kg has been used annually for oyster mushroom production and commercial farmers use only rice straw as substrate for oyster mushroom cultivation in Nepal. Without use of rice straw, commercialization of straw mushroom, oyster mushroom and common mushroom is impossible (Adhikari 2016, personal communication).

Straw for bio-energy

Rice straw can either be used alone or mixed with other biomass materials in direct combustion, whereby combustion boilers are used in combination with steam turbines to produce electricity and heat. The energy content of rice straw is around 14 MJ per kg at 10% moisture content (https://www.bioenergyconsult.com). However, production of electricity from rice straw has not been initiated yet in Nepal.

Rice husk

The rice husk, also called rice hull, is formed from hard materials, including silica and lignin, to protect the seed during the growing season. 24.50 kg of rice husk is extracted from 100 kg of paddy (MRSMP 2013). A total of 1,173,209 tonnes of husk is produced from 4,788,612 tonnes of paddy at the rate of 24.5% husk recovery (MoAD 2015) annually amounting NRs 5866.45 million at the rate of NRs 5.0 per kg (DP Kaphle 2016, personal communication). Rice husk is used for production of thermal energy using various types of furnaces. Some other uses of husk are as soil mulch, poultry litter, insulation material, packing material and source of heat energy in puffed/beaten rice mills, noodles factory and soap industries in Nepal.

In some countries, silica present in rice husk are used for producing several value added products like abrasives in metal cleaning, carrier for fungicides, insecticides and catalysts, floor sweeping aid, light weight refractory bricks, lime silica bricks, sodium silicate, etc. However, this is not in practice in Nepal.


Figure 2. Rice husk being packed in bags for poultry industries at Nayamill Rupandehi

Rice bran

Rice bran is the inner layer of rice grain in between the endosperm and husk. Milling of paddy yields two main by-products of economic and nutritional importance, namely husk and bran. In Nepal, 5.9 kg and 22.5 kg bran is obtained with the revenue of NRs 107.50 and 409.95 (@NRs 18.22 per kg) from 100 kg of milled white rice and brown rice, respectively (MRSMP 2013). Rice bran is an important feed ingredient in the concentrate ration of livestock. Rice bran oil can also be extracted from the hard outer brown layer of rice underneath the husk. Cereal grains are considered as source of carbohydrate but they can also contain oil which is of considerable economic value.

Conclusion

Rice by-products like rice straw, husk and bran have several industrial uses in Nepal. These by-products, with their industrial uses, have some share of contribution in economy of the country. Rice straw has been used in cottage industries to make chairs, stools, shoes and mats. Similarly, paper factory, handy craft industries have been using rice straw for industrial purpose. Rice straw is used as a substrate for mushroom production in various parts of country. Similarly, rice husk is being used as source of thermal energy and also as mulching materials and bedding materials (in poultry). Rice bran is generally used as feeding materials in livestock sectors. Rice bran oils and bio-energy can also be extracted from rice straw, which is in practice in some of the foreign countries. Urgent need is felt for infrastructural development to make use of rice by-products in Nepal.

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Chapter III
(अध्याय ३)

3. Policy Arrangements, Coordination, Problems and Challenges

(नीतिगत व्यवस्था, समन्वय, समस्या तथा चुनौती)

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Policy Review of Paddy Production in Nepal

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सारांश

कृषि विकासकालागि योजनावद्ध विकासको सुरुवात केही दशक अगाडिदेखि भएतापनि धान उत्पादन र उत्पादकत्व वृद्धिमा अपेक्षाकृत प्रगति हासिल गर्न सकिएको छैन । आवधिक योजनाका दस्तावेजहरू अध्ययन गर्दा विभिन्न योजनाहरूले राखेको धान उत्पादन लक्ष्य पहिलो, दोश्रो र छैटौ योजना बाहेक अन्यमा हासिल भएको देखिदैंन । मध्यम र दीर्घकालीन योजनाहरूमा खाद्यान्न बालीलाई प्राथमीकता दिइएको भएतापनि धानकै लागि किटान गरिएका कार्यक्रमहरू तेह्रौ योजनाभन्दा अघिको अवधिमा खासै पाइएको छैन । दीर्घकालीन कृषि नीति र कृषि विकास रणनीति कृषि विकास लागि नेपाल सरकारले कार्यान्वयन गरेका रणनीतिक दस्तावेजहरू हुन् जसमा धान प्रवर्द्धनका कार्यक्रमहरू समेत समावेश गरिएका छन् । समग्र धान लगायतका बालीहरूको बीउ क्षेत्रलाई मार्गनिर्देश गर्ने बीउ बिजनको दीर्घकालीन राष्ट्रिय सोच कार्यान्वयन भइरहेको छ । बृहत्तर धान उत्पादन कार्यक्रम, मसिना तथा बासनादार उत्पादन कार्यक्रम, प्रधानमन्त्री कृषि आधुनिकिकरण परियोजना आदि कार्यक्रमहरू धान बाली विकासको लागि हाल नेपाल सरकारबाट संचालन भइरहेका कार्यक्रम तथा आयोजनाहरू हुन् । मूल्य नियमनका नीतिमा एकरूपता नहुनु, अनुसन्धान र विकासमा अपर्याप्त बजेट विनियोजन, प्रभावकारी कार्यान्वयनमा भन्दा कागजी विकासमा बढी जोड, धान बालीको उत्पादन प्रवर्द्धनका ठोस कार्यक्रम नहुनु आदि योजनावद्ध विकासका नीतिहरूमा धान बालीसँग सम्बन्धित समस्याहरू रहेका छन् । प्रस्तुत लेखमा नेपालमा धान बाली उत्पादन प्रवर्द्धनका लागि कार्यान्वयनमा रहेका नीतिहरूको विश्लेषण गर्ने प्रयास गरिएको छ ।

Summary

Despite the planned development efforts in agriculture for decades, tangible achievements in paddy growth rate for production and productivities have not been achieved. The production target of paddy production in periodic plans was not achieved except for the first, the second and the sixth plan. The policy documents, however, have given due emphasis on cereal crops including promotion of paddy. Specific programs for promotion of paddy production were rarely stated in most of the mid and long term periodic plans until thirteenth plan. APP and ADS are the major long term strategic documents that have focused in promotion of cereals and paddy in Nepal. National Seed Vision (2013-2025) has been formulated and executed to guide overall seed sector of the country focused on increasing productivity of paddy. Recently, government has been implementing specific rice promotion programs like fine and aromatic rice production, mega rice production, community seed banks and PMAMP. Inconsistencies in policies regarding price regulation, inadequate investment in research and extension, loose commitments rather than effective implementation of rice related programs, inadequate specific programs on promotion of rice production in Nepal are some of the bottlenecks for paddy production in the country. This paper makes an attempt to review rice related policies by the Government of Nepal and their implementation status.

Keywords: ADS, APP, Cereals, Effective implementation, Paddy, Plan, Policies

Background

Nepalese economy is dominated by agriculture which contributes 31.7% to the total gross domestic product (MoF 2015).Within agriculture sector, cereal crops have the highest contribution (47.10%) with rice making 16.33% of the AGDP (MoAD 2015a). Nepalese dietary system is cereal based and dominated by rice. Rice fulfills the major nutritional demand, especially the carbohydrates. NLSS (2011) reported that Nepalese dietary intake reveals per capita per year consumption of rice as 122 kg in 191 kg total food grains intake.

Among cereals, paddy occupies the first position in terms of area (42.2%) and production (51.7%) out of all cereal crops (MoAD 2015a). However, paddy production has not been increased satisfactorily to meet the demand of increasing population. Population over last five decades has increased at annual growth rate of 1.74% (CBS 2012) while during the same period paddy production has increased only by 1.62% (FAOSTAT 2016). This has ultimately led to increase of paddy imports. Though the country has recognized the importance of agricultural sector, area of the cultivated land has been decreasing in recent years. This is more prevalent in paddy production. According to Agriculture Census 2011, rice cultivation area has decreased by more than 129 thousand hectare in last ten years. Similarly, paddy farming households have decreased from 76% in 1996 to 72.3% in 2011 (NLSS 2011).

Since the ancient time rice has stayed as staple and important food crop in Nepal. Various plans, policies and programs have been formulated and implemented to promote rice production. However, the implementation aspects of programs related to rice have become always a challenge. The following sections attempt to throw light on policies formulated and implemented for rice production and promotion in Nepal.

Policies/Programs formulated by GoN for promotion of rice production in Nepal

GoN has continuously paid attention in increasing production and productivity of paddy through formulation of various policies, acts, regulations, programs and projects. These policies have given impetus for the promotion of paddy production in Nepal. Since the beginning of the planned developmenteither five year or three years, plans are still being formulated in the country. The status and achievements in paddy production during periodic plans of Nepal is discussed below.

First plan (1956-1961)

Any clear cut policies and programs of agriculture were not mentioned in a specific manner. Yet, the plan sought to increase the agricultural output. Equal emphasis were laid down actually to collect the proper agricultural statistics in order to formulate future plans in a realistic and applicable ways. However, some attentions were given for the development of middle level technicians by setting training institutions. Besides, establishment of crop protection center and livestock center during the period paved the foundation for agricultural development. The plan had focused to promise the introduction of land reform in the country. To overcome the food shortage the plan had intended to facilitate the irrigation to increase agricultural output. The plan included the following programs such as:

- Reconstruction of the JudhaNahar and Jagadishpur in order to provide irrigation facilities for the command area of 9000 acre of paddy crops in Tarai.
- Completion of seven irrigation programs which could be facilitated for the 75000 acres of land
- Construction of new irrigation canal to provide for irrigation facility for 20000 acre of land

Second plan (1962-1965)

The second plan had estimated to increase agricultural output especially for food grains by 4.85%. This plan had laid greater emphasis on irrigation and agricultural extension programs for the development of agriculture. These programs had stressed on the use of improved seeds, fruits cultivation, preservation and some diversification of agricultural production activities towards the vocational subjects.

Production of paddy increased from 2102 to 2201 thousand tonnes from year 1962 to 1965 which equals to an increment of 4.7%. Not more than 50,000 kg of improved seed were used for not more than 1,000 hectares annually during this period. Twenty eight districts were selected for the intensive food grains production during the Second Plan period. These districts were: Jhapa, Morang, Sunsari, Saptari, Dhanusha, Sarlahi, Bara, Parsa, Rautahat, Chitwan, Makwanpur, Nawalparasi, Rupandehi, Dangdeukhuri, Banke and Kailali as Tarai and inner Tarai districts, and Ilam, Dhankuta, Kavre, Kathmandu, Bhaktapur, Lalitpur, Kaski, Syangja, Tanahun, Palpa, Doti and Dadeldhura as Hills and Valley districts. Further, it had targeted 2% annual growth rate of rice and 16% increment for the cereal crops production. The production achievements of paddy at the end of first and second plan are shown in **Table 1**.

Table 1. Paddy production at the end of first and second plan (1961/62 and 1964/65) ('000 t)

Crop	1962	1965	Percent increase
Paddy	2102	2201	4.7
Food grains	3145	3271	4.0

Source: NPC 1965.

Third plan (1965-1970)

The third five year plan had placed primary emphasis for accelerating agricultural development. Due emphasis was given for an integrated agricultural development program based upon specific objectives rather than piecemeal projects and programs. Some policies relating to adoption of new and improved agricultural techniques such as improved seeds, fertilizer and reasonable agricultural pricing policies had been envisaged. Policy to establish agricultural supply corporation was mentioned in the plan. The plan had envisioned to purchase food grains from surplus and transfer them to deficit zones. The plan had also mentioned to create department of land administration for land reform programs. Thirty percent of the total fertilizer use target was set only for paddy. GoN had given priority for construction of godowns during this period (NPC 1965). The target of paddy production in third plan and achievement is presented in **Table 2**.

Table 2. Target and progress of paddy production in third plan ('000 t)

Crop	Production target and achievement		Target achievement gap in percentage	Percentage change over the level of 1965 (second plan)
	Target for 1970	Achievement in 1970		
Paddy	2386	2241	-5.4	1.8
Food grains	3776	3426	-9.3	4.7
Productivity of paddy (t/ha) in 1970		1.91		

Source: NPC 1965-1970 , DFAMS 1978.

Fourth plan (1970-1975)

The agricultural sector got overriding importance in the fourth five year plan. It was given the first priority. Supply of an adequate amount of agro industrial raw materials and provide greater exports through increased production were major objectives set in the plan. In the fourth plan, the agricultural policies were to divide the country into major agricultural areas according to the potential for food grain production, cash crop production, horticultural production, livestock development, dairy products, fishery, etc. Emphasis was given to the adoption of appropriate rent and land tax policy in order to generate additional savings and to broaden the tax base in the agricultural sector. To increase the agricultural exports to India and to overseas countries the adequate markets and price incentives and other subsequent encouraging factors for production were in the plan as well. Sixteen districts were selected for intensive cultivation of crops. To meet the target of increased cereal grain production by 16% during the Fourth Plan period, the plan highlighted the necessary arrangements for increasing the supply of improved seeds. The "Corridor" concept of agriculture development was introduced to foster cereal and cash crops in Tarai, horticulture and livestock in hills and mountains. The average paddy production in comparison to the end of the plan was increased by 9.4%. The plan had achieved the satisfactory results in the food grain sector. The target achievement of paddy production during fourth plan is presented in **Table 3**.

Table 3. Target and progress of paddy production during fourth plan ('000 t)

Crop	Production target and achievement		Target achievement gap in percentage	Percentage change over the level of 1970 (Third Plan)
	Target for 1975	Achievement in 1975		
Paddy	2599	2452	-5.7	9.4
Food grains	4279	3776	-11.8	10.2
Productivity of paddy (t/ha) in 1975		1.98		

Source: NPC 1970-1975, DFAMS 1978.

Fifth plan (1975-1980)

The fifth plan accorded topmost priority to the agricultural sector. The objectives of the fifth plan were basically the same as in the fourth plan. The fifth plan recognized the need to increase agricultural productivity as well as to provide productive employment in the agricultural sector.

The fifth plan included the intensive development of cereals and cash crops in the Tarai belts. Priority was given for the use of chemical fertilizers in the areas with transportation facilities and increase the use of compost and organic manure. The plan had stated to establish optimum size of fertilizers and insecticides factory within the country in the next 10 years, considering the economic and technical feasibility. The plan also had the objective to assist in increased agricultural production by increasing the productivity of land by encouraging multiple cropping pattern through an efficient irrigation system (NPC 1975).

In order to ensure that farmers fully cooperate in the drive to raise production, the year 1976 was declared as **"Agriculture Year".** During the plan period, the production of food grains and paddy remained below the level of 1975 (NPC 1975). Frequent drought and adverse climatic conditions were the major impediments for under performance of cereals and paddy.

The Integrated Cereal Project (1977-82) was initially designed to increase the production and productivity of food grain through cropping systems, improvement to assist in national objectives to increase food grain production, improve income distribution and raise the nutritional status. The project was funded by USAID. Later on, the project was extended for three years up to 1985. National Rice Improvement Program was launched and headquarter was established at Parwanipur, Bara. The overall target and achievement of paddy production during the fifth plan is presented in **Table 4**.

Table 4. Target and progress of paddy production during fifth plan ('000 t)

Crop	Production target and achievement		Target achievement gap in percentage	Percentage change over the level of 1975 (Fourth Plan)
	Target for 1980	Achievement in 1980		
Paddy	2800	2058.93	-26.4	-16.0
Food grains	4550	3196	-29.8	-15.6
Productivity of paddy (t/ha) in 1980		1.64		

Source: NPC 1975-1980.

Sixth plan (1980-1985)

In line with its importance in the country's economy, agriculture development had been given high priority. For the sixth five year plan 31% of the total expenditure was earmarked for this sector. The plan envisaged the different approaches to crop production for the development of agricultural product at the national level and thereby to improve the consumption level of the people. The plan strategy emphasized food grain production in hills to meet the local requirements. Crop intensification in irrigated land was given emphasis in Tarai belts. Production of food crops for both domestic consumption and for export was one of the major focuses in the plan. The target of food grain production was set at 4.346 million tonnes. But achievement did not exceed 4.289 million tonnes. This means 98% of the plan target was achieved. Among food crops the production of paddy was found to exceed the target of the sixth plan.

Table 5. Target and progress of paddy production during sixth plan ('000 t)

Crop	Production target and achievement		Target achievement gap in percentage	Percentage change over the level of 1980
	Target for 1985	Achievement in 1985		
Paddy	2740.357	2756.59	5.2	33.39
Food grains	4346.013	4288.98	-1.3	34.19
Productivity of paddy (t/ha) in 1985		2.07		

In 1982, The Block Production Program was introduced in two Tarai districts, Bara and Parsa under USAID funded project, ICP. Later the government owned this program and expanded to the entire Tarai and to some hill districts with government financial support. Originally, the block was defined as the adjoining plots of 1,000 hectares while later changed to 100-ha sub-blocks when the pre-requisites were not possible for 1,000 hectares blocks. For the hill regions the sub-blocks were even smaller in size of 20 hectares.

Seventh plan (1985-1990)

Agriculture was accorded the top priority in the seventh plan. Supply of food grains was considered as the most important aspect to fulfill the basic needs of people. The plan emphasized on agricultural programs to be launched as a campaign by prioritizing food grain and by dividing the arable lands into production blocks for fulfilling the needs of the increasing population. Accordingly, production services and other facilities made available to the production block for encouraging the farmers. The plan focused on making availability of certified seed through the institutional arrangement and extending breeding program to make supply of improved seeds among farmers. Paddy production program was mentioned in separate headings in the plan. The plan primarily focused on increasing productivity of paddy. The target for production to *chaite/bhadaiya* and summer paddy was fixed at 3.40 million tonnes from an area of 1.334 million hectares for both crops. From this paddy production was estimated to be increased by 667,000 tonnes as compared to the base year. For attaining this target the overall productivity of 2.01 tonnes of paddy/ha was estimated to be raised to 2.50 t/ha.

The plan focused in implementing the paddy production program by dividing the areas into major irrigated area, minor irrigated area, partial irrigated area or the area dependent on monsoon water sources and other areas dependent on weather into special, pocket and general areas respectively. Special emphasis was given on increasing productivity. During the Seventh Plan period in areas of special program productivity of 3.56 t/ha was estimated to be increased to 4.00 t/ha. In areas of pocket program, productivity of 2.77 t/ha was estimated to increase to 3.40 t/ha; and in areas of general program, productivity of 2.14 t/ha was estimated to be increased to 2.60 t/ha. Seven hundred tonnes of foundation seeds production of paddy was set target for the government farm stations during the plan period. The plan focused in using chemical fertilizers in the areas with irrigation facility.

Thus 560,000 tonnes of paddy under special programs, 595,000 tonnes under pocket programs and 839,000 tonnes under general programs were expected to add up to 1,994,000 tonnes from the areas covered by those programs with 1,406,000 tonnes. Other areas of paddy production were not directly influenced by those programs. This ultimately set the target of producing 3,400,000 tonnes of paddy in the period (NPC 1985).

Table 6. Target and progress of paddy production during seventh plan ('000 t)

Crop	Production target and achievement		Target achievement gap in percentage	Percentage change over the level of 1985 (Sixth plan)
	Target for 1990	Achievement in 1990		
Paddy	3400	3392	-0.23	23.05
Food grains	5361.085	5663	5.63	32.03
Productivity of paddy (t/ha) in 1990		2.35		

Source: NPC 1980-1985.

Eight plan (1992-1997)

The eighth plan had objectives to contribute to the national economy through increased agricultural production based on geographical specialization. It primarily focused on in increasing agricultural production and productivity to meet the growing domestic food demand. The plan focused on intensive paddy production program in the hills, in areas with a warm climate and low altitude (up to 900m), such as rainfed lowlands and river valleys which are capable of yielding two paddy crops a year. The total paddy area in the country was expected to reach 1,564,000 hectares in the final year of the plan. Thus, with the additional production of 1,060,000 t, the paddy production level was expected to reach 4,452,000 t by the end of the plan. It was targeted to increase the paddy yield to 2.846 t/ha from the average productivity of 2.346 t/ha of the base year (NPC 1992). The target and progress of paddy production during the eight plan is presented in **Table 7**.

Table 7. Target and progress of paddy production during eighth plan ('000 t)

Crop	Production target and achievement		Target achievement gap in percentage	Percentage change over the level of 1990 (Seventh Plan)
	Target for 1997	Achievement in 1997		
Paddy	4452	3699	-16.91	9.05
Food grains	7486	6395	-14.57	12.92
Productivity of paddy (t/ha) in 1997		2.46		

Source: NPC 1992 - 1997.

Ninth plan (1997-2002)

Agriculture was prioritized even in the ninth plan. The APP stressed on food security through increased production and income as well as women's participation were major focus in agricultural sector. The plan intended to increase the use of chemical fertilizer in crop sector by 49 kg/ha at the end of the Ninth Plan with gradual increase from 18 kg/ha in FY 1996/97 (NPC 1997). But the achievement for use of fertilizer was achieved to be 31 kg/ha (NPC 2002). The plan intended to increase the annual average production of major food grains by 5.18%. The incremental production of 1.847 million tonnes during the plan period was targeted (NPC 1997). However, there was incremental production of 852 thousand tonnes in the period (NPC 2002) as presented in **Table 8**. The irrigated area was estimated to be increased by additional 1,55,000 hectares. The plan stated seed production program to be implemented in irrigated pocket areas of five mountain and ten Tarai districts of five development regions. The five mountainous districts were assumed to produce improved seed necessary for the nearby districts of mountains and high mountains (NPC 1997). During ninth plan, DISSPRO was approved from DoA in 1998 (CDD 1998) and DISSPRO gave farmers source seed at 25% subsidy and 100% transport subsidy up to their respective Service Centre as provisioned.

The growth rate for food grains remained 2.89% against the target of 5.18%. In the ninth plan, it was aimed to increase annual production growth of paddy by 6.21%. However, achievement was much lower than the target ie 2.25% this was mainly attributed to the deteriorating situation of peace tranquility in the country. Paddy production status in this period has been shown in **Table 8**.

Table 8. Target and progress of paddy production during ninth plan ('000 t)

Crop	Production target and achievement		Growth rate	
	Target for 2001/02	Achievement in 2001/02	Achievement%	Target%
Paddy	5000 Source: NPC 1997-2002	4136 Source: Bhandari 2002	2.25 Source : Bhandari 2002	6.21 Source : Bhandari 2002
Food grains	8242 Source: NPC 1997-2002	7254 (Food grains) Source: NPC 1997-2002	2.89 Source : Bhandari 2002	5.18 Source : Bhandari 2002

Source: NPC 1997-2002 ,Bhandari 2002.

Tenth plan (2002-2007)

Reduction in poverty by increasing production, productivity and income in the agricultural sector and contributing to food and nutritional security was one of the sectoral objectives related to food grains in the tenth plan. The plan expected an annual growth rate of the agricultural sector by 4.11% from the present 3.3%. However, 2.67% of average annual growth rate was achieved at the end of plan. It was 0.7% in the final year of the tenth plan (NPC 2007). The plan set the target of food grain availability per person per year from 264 kg to 269 kg (NPC 2002). The achievement was more than the target ie 280 kg/person/year (NPC 2007). The plan emphasized on production technology for hybrid and aromatic variety of paddy which give higher yield and are suitable to the climate. The plan focused on implementing the programs as per APP by declaring the tenth and eleventh Plans as the agriculture decade (NPC 2002). Onwards the Tenth plan separate target for paddy production was never mentioned in periodic plans of the government which was one of the setbacks for rice production in the country. The target and achievement for food grain in the plan duration is presented in **Table 9.**

Table 9. Target and progress of food grain production during tenth plan ('000 t)

Crop	Production target and achievement		Percentage change over ninth plan
	Target for 2006/07	Achievement in 2006/07	
Paddy	NA	3680.838	-11.0
Food grains	8700 (Av annual growth 3.7%)	7329	1.03
Per capita food grain availability	269 kg/person/year	280 kg/person/year	

Source: NPC 2002-2007, MoAD 2015d.

Eleventh plan (Three years interim plan: 2007/08-2009/10)

The interim plan had specific sectoral objectives of increasing agricultural production and productivity and maintaining food sovereignty by ensuring food security. The plan emphasized to achieve these objectives through promotion of food grains in Nepal.

The plan targeted 3.6% of an annual growth rate of the agricultural sector by (NPC 2008). However, 3.2% of average annual growth rate was achieved at the end of plan, which is 0.4% less than the target (NPC 2010). The plan emphasized in seed promotion and quality control programs in all districts (NPC 2008). The food grain availability reached 272 kg/person/year at the final year of the plan (NPC 2010). Government of Nepal through Budget Speech of FY 2008/09 spelled out for establishing Community Seed Bank to improve access of quality seeds to the farmers in FY 2008/09. Target and progress of food grain production during tenth plan is presented in **Table 10**.

Table 10. Target and progress of food grain production during 11th plan ('000 t)

Crop	Production target and achievement		Percentage change over Tenth plan
	Target for 2009/10	Achievement in 2009/10	
Paddy	NA	4023.823	9.31
Food grains	7778 (Av annual growth 2.0%)	7762	5.90

Source: NPC 2008-2010, MoAD 2015d.

Twelfth plan (Three years plan 2010/11-2012/13)

Agriculture was given second priority in the three year plan. The plan targeted 3.9% annual growth rate of the agricultural sector (NPC 2010). However, 3.4% of average annual growth rate was achieved at the end of plan, which is 0.5% less than the target (NPC 2014) (**Table 11**). However, the growth rate of agriculture in the final year of the plan was 1.1% only (NPC 2014). The plan targeted the per capita food production to be 320 kg/person/year. The plan focused on provision of subsidy on production materials like seeds and fertilizers, and extension of irrigated area through community managed irrigation projects to enhance the food grain production (NPC 2010).

Table 11. Target and progress of food grain production during 12th plan ('000 t)

Crop	Production target and achievement		Percentage change over Eleventh plan
	Target for 2012/13	Achievement in 2012/13	
Paddy	NA	4504.503	11.9
Food grains	9561	8738	12.57

Source: NPC 2010/11-2012/13, MoAD 2015d.

Thirteen plan (2013/14-2015/16)

The plan expected an annual growth rate of 4.5% for agricultural sector. (NPC 2014). However, 2.2% of average annual growth rate was achieved at the end of plan (NPC 2016). Agricultural growth rate remained at 1.33% for the final year of the plan (NPC 2016). The plan mainly focused on increment of production and productivity of crops (including rice and other food crops) through provision of subsidy on improved seeds, organic fertilizer, irrigation, machineries and equipment, chemical fertilizers and subsidy in premium for insurance of various crops. The plan mentioned the separate projects like Fine and Aromatic Rice Promotion Program in 20 districts and Mega Rice Promotion in 15 districts (NPC 2014). GoN also formulated the National Seed Vision (2013-2025) to guide the overall seed sector of Nepal (National Seed Vision 2013-2025).

Table 12. Target and progress of food grain production during 13th plan ('000 t)

Crop	Production target and achievement		Percentage change over Twelfth plan
	Target for 2015/16	Achievement in 2015/16	
Paddy	NA	4299.078	-4.56
Food grains	8738	10881	24.52

Source: NPC 2013/14-2015/16.

In fiscal year 2015/16, government, through budget speech, declared to develop paddy production pockets in 12 Tarai districts and also mentioned to provide irrigation facilities to those areas within 5 years. The programs of fine and aromatic rice promotion and mega rice production were part of budget speech in FY 2015/16. Likewise, the speech planned to declare pocket areas for major food grains including paddy. The budget speech of 2016/17 has announced PMAMP project that aims to make a nation self-reliant in paddy production in two years. Similarly, extension of mega rice production program to 35 districts, continuation of fine and aromatic rice and commitment to declare MSP for paddy were some of the major highlights related to paddy production in budget speech of 2016/17 (MoF 2016). Jarailo Basmati Rice has been included in ODOP and OVOP programs for Doti district of Nepal.

Constitution of Nepal

The constitution of Nepal has protected its citizen by stating right to food as the fundamental right (article 36). In the same article, the constitution mentions that every citizen shall have the right to food sovereignty as provided for in law. Constitution has protected the rights of farmers through the right to access to land as provided for in law for agricultural purposes, along with the right to choose and preserve traditionally adopted and used endemic seeds and agricultural species (in Right to Social Justice as fundamental right). In its section titled, Policies and Responsibilities of State, the constitution has emphasized in increasing produce and productivity through land plotting and by discouraging absentee land ownership.

Agricultural perspective plan (APP)

In 1997, the 20 years APP was approved with the major objectives to alleviate poverty and achieve significant improvement in the standard of living through accelerated growth and expanded employment opportunities. Similarly, it had envisioned transforming the subsistence-based agriculture into a commercial one through diversification and widespread realization of comparative advantage. APP focused on the priority inputs as irrigation, fertilizer, rural roads and electrification, technology and priority outputs as livestock, high value commodities, agribusiness, forestry. It aimed at returning Nepal to cereal exporting country. APP had focused on high growth rates set of technology and inputs for expanded research and extension efforts on major field crops as rice, wheat, maize and potato. APP strategy- technology based green revolution in agriculture was taken as the crucial engine for accelerated growth. The strategy in the Tarai package was on production on food grain however priority was given to irrigation, fertilizers, agricultural roads and rural electrification but not on seeds. The field crop subsector was treated as supply driven subsector. The major crops of the Tarai were rice along with wheat, potato and maize (APP 1995). During the plan period, the road network had considerably expanded and irrigation cover had increased as well. In almost all agriculture subsectors (crops, livestock, fishery, and forestry) there had been progress in terms of production or/and productivity. However, cereals sector (particularly paddy) in general did not perform well, partly because of the deficiency in availability of inputs such as improved seeds and timely, quality, and affordable chemical fertilizers (MoAD 2015b).

National agricultural policy 2004

National Agricultural Policy, 2004 is the major policy document for agricultural development in recent years. This policy also has not directly quoted about rice but has focused certain activities that can contribute to paddy production. This policy has mentioned about land, human resources, farm mechanization and investment issues differently. The policy has mentioned about the scientific land utilization system to discourage the use fertile land in non-agricultural activities. Similarly, it has categorized that the farmers with less than four hectares of land will be identified and classified as resource poor to provided specified facilities. It has also mentioned about establishment of Land Bank and provides information and loan to the land traders in coordination with local bodies. Similarly, this policy has envisioned about the Large Production Pockets to provide integrated supports of technology, loan and physical facilities. However, policy does not state the specific programs related to paddy production promotion (MoAC 2004).

National celebration day for rice in Nepal

National Rice Day is regularly celebrated in *Asar* 15 (June last week). There are separate programs of the celebration by MoAD, NARC, DoA, CDD, DADO and various other governmental and non-governmental organizations. Nepalese people have the culture of eating beaten rice mixed with curd/yoghurt while transplanting rice in the flocculated mud by almost every Nepali on this very day and is considered a huge cultural phenomena in Nepal. Like National Rice Day, World Food Day is also celebrated annually under the theme of UNFAO declaration in October 16 in honor of the establishment of FAO in 1945. This is celebrated worldwide since 1981 concerned with food security. MoAD translates the theme of UNFAO to the Nepali situation and celebrates with the programs like school level essay competition in all 75 districts and felicitation to more than 100 farmers under different crop categories. Among others, highest yielding rice farmers are awarded during the World Food Day in Nepal.

National Seed Vision (2013-2025)

National Seed Vision has also put major thrust for the cereal crops as a whole. The Seed Vision aims to increase crop productivity, raise income and generate employment opportunities through food self-sufficiency, import substitution and export promotion of quality seeds. The vision has projected the area of the improved seed to cover in 6,368 hectares and formal sector seed production 19,450 t by the end of 2025. This vision also projected the production of 6,103,552 t rice with productivity of 3.80 t/ha of paddy by the year 2012. Similarly, the vision has projected that the released varieties of rice would be 100 and out of that 13 would be hybrids. In order to achieve the food production target, this vision has aimed at increasing the seed replacement rate of rice from 9% to 25% by 2025.

Special agriculture production program (2012 to date)

Distribution of improved seeds through subsidy was initiated by the government of Nepal under Special Agriculture Production Program in 2012. This program has been given continuation to date (2016). National Seed Company Limited has got the major responsibility for the implementation of this program. After the government decided to control use and selling of chemical fertilizer, this program started gaining some momentum. Under this program, subsidized chemical and organic fertilizers are distributed to farmers through AICL. This distribution is mainly targeted to the food grains. Similarly, improved seeds of rice, wheat and maize are distributed through NSCL. The government subsidy program in rice seed subsidy program has remained very effective for private sector seed companies and seed traders, because it ensures the market of seeds produced by the private sectors (MoAD 2011).

Agriculture development strategy (ADS: 2015-2035)

With the vision of moving towards “aself-reliant, sustainable, competitive, and inclusive agricultural sector that drives economic growth and contributes to improved livelihoods and food and nutrition security”, government of Nepal has formulated and implemented a 20 year Agriculture Development Strategy (2015-2035). ADS was formulated after the completion of APP in 2015 that resulted in the mixed performance during implementation period. This document has identified cereals, lentil, dairy, vegetables and tea as the priority commodities. The strategy has assumed the area of rice will not be increased, but will decrease slightly (-0.1%) annually over the base year area. However, yield is targeted to increase by 1.7% annually so that per capita rice availability will be increased by 0.2% (MoAD 2015b) as presented in **Table 13**.

Table 13. ADS target of paddy production

Indicator	Unit	Baseline 2015/16	Assumed growth rate	Short term (5 year)	Medium term (10 years)	Long term (20 years)
Area	Thousand hectares	1,425	-0.10%	1,418	1,411	1,397
Production	Thousand tonnes	4,768	1.60%	5,097	5,518	6,468
Yield	kg/ha	3,300	1.70%	3,591	3,906	4,694

Source: MoAD 2015b.

ADS keeps target of achieving 0 to 5% trade surplus in food grain. It also focuses on effective implementation of existing seed policies including Seed Vision 2013- 2025 through sufficient investment in resources and capacity building. It targets a range of mechanization options accessible to farmers through the private sector that will be made available. ADS assumes availability of food production will grow faster than population growth and therefore assure food self-sufficiency. The objective is to ensure that a landlocked country like Nepal could assure sufficient food grains to its population at all times (MoAD 2015b). The ADS target of per capita availability of gross paddy is presented in **Table 14**.

Table 14. Rice grain availability per capita

Item	Indicator	Unit	Baseline 2015/16	Assumed growth rate	Short term (5 year)	Medium term (10 years)	Long term (20 years)
Population	Total Number	Thousand	28038	1.40%	29,669	31,394	35,153
Gross paddy availability per capita	Production per capita	kg/cap	168	0.20%	170	171	175

Source: MoAD 2015b.

Agricultural mechanization policy 2014

Government of Nepal has formulated the agriculture mechanization policy 2014 to contribute to reduction in poverty and achievement of sustainable development through agricultural mechanization in Nepal. Mechanization policy has envisioned facilitating, supporting and regulating role of the state and active participation and role of private sector in mechanization. It has focused to support small scale mechanization and commercialization of agriculture in the context of geographical, social and small-scale farming. Agriculture mechanization could help solve labor shortage in farming. One the one hand agriculture land continue to remain untended due to labor shortage while on the other hand there is a heavy import of food commodity through the remittance of toil. Mechanization will result in the use of power tiller, mini tiller, thresher and other machineries in paddy production, processing and marketing that have been increased over the years in Nepal (MoAD 2014).

Rice development program and guidelines for promotion of rice production from the Government of Nepal

Food security aspect has been given high priority by the government of Nepal. MoAD has tried to enhance the food security situation of country through the implementation of various rice related programs. To support the program implementation, various guidelines have also been formulated. Some of the rice related programs, guidelines and donor assisted projects run by MoAD to promote rice and food grains are discussed below.

Mega rice production program

Mega Rice Production Program was introduced in 15Tarai districts in FY 2015/16 with the special focus for productivity increment and area expansion to contribute to become self-reliant in rice production. The program has targeted to expand the area of spring rice to 3,00,000 hectares from the base year area 1,11,000 hectares while the productivity would be increased to 5.0 t/ha from 4.0 in base year (CDD 2015). The target of extending spring rice area was set 5400 hectares in 2015/16. However, achievement was only 2542 hectares (CDD 2016). The target of extending area under spring rice for the current fiscal year 2016/17 has been set 6900 hectares in 35 districts (CDD 2016). The mega rice production program is a typical output based facilitation program that provides NRs 5000/ha cash incentive after the farmers/farmers' group/cooperatives grow spring rice in a line and ensure their crop via crop insurance program. The program also aims in promoting mechanization in rice field. The program has been implemented as per Mega Rice Production Program Implementation Guidelines, 2015.

Fine and aromatic rice production promotion program

Ministry of Agricultural Development in FY 2014/15 started Fine and Aromatic Rice Production Promotion program in 20 districts as per the Fine and Aromatic Rice Production Promotion Program Implementation Guidelines, 2014. The program set objectives to increase production and productivity of local/improved fine and aromatic rice with the increased access to technology; to assist in supply of raw materials for fine and aromatic rice processing industries; to gradually replace imports of fine and aromatic rice; to register and conserve, utilize and promote local varieties of fine and aromatic rice. Major activities of the program includes distribution of source/improved seed: azolla, Dhaincha, zinc sulphate, and so on in a subsidized system (CDD 2014). Support to farmers group/cooperatives/seed companies for seed storage, treatment, packaging and truthful leveling of seeds were some of the other programs to promote fine and aromatic rice production in Nepal. The government had set target of extending area under fine and aromatic rice in 10000 hectares in fiscal year 2016/17. The program is being implemented in 20 districts of Nepal.

Prime minister agriculture modernization project (PMAMP)

The PMAMP has vision to commercialize agriculture with specialized production center development also known as Pocket, Block (24 in 2016/17, coverage, 100 ha each), Zone (5 in 2016/17, coverage: 500 ha each) and Super-zone (one in 2016/17 coverage: 1000 ha) as per their commercial feasibility. The project aims in making country self –reliant for rice in three years.

Under this project, super-zone for rice is being implemented in Jhapa district. The major activities of the super zone and zone are:

- Custom hiring centers at blocks and super zone,
- Minilab establishment for soil, seed, crop protection, fishery, food quality control,
- Organic fertilizer and bio-pesticide production factories establishment support,
- Agriculture institutes,
- Post-harvest centers at blocks, pockets, zones and super zones,
- Performance based incentives allowance to the concerned employee.

Organizations involved in rice research in Nepal

NARC is the sole public organization in Nepal that conducts rice research based on public financing in the country. Rice research is also done by LIBIRD (Local Initiatives for Biodiversity Research and Development) and FORWARD (Forum for Rural Welfare and Agricultural Reform for Development) through the funds and resources they obtained mainly from bilateral donors and international research agencies but not through public funding from Nepal. The Institute of Agriculture and Animal Sciences (IAAS)/Tribhuvan University and Agriculture and Forestry University (AFU) have mandate for mainly teaching, and research on rice is not a regular phenomenon through public funding. International Rice Research Institute (IRRI) is the pioneer institute in rice research. IRRI and the Government of Nepal started working together and IRRI-Nepal office was established in 2005 (Gauchan and Pandey 2011).

Food grain related periodic projects of the government in Nepal

With the principle aim of strengthening research, extension and development of agriculture sector in Nepal, government of Nepal has launched several foreign aid supported projects in Nepal. The some of the completed and on-going projects related to food grains projects are listed in **Table 15**.

Table 15. List of projects related to food grains production

Name of the project	Duration	Source of funding
1. Gandaki *Anchal* Agriculture Development Project (GAADP)	1963-1981	GTZ (Germany)

Name of the project	Duration	Source of funding
2. Agriculture Extension and Research Project (AERP)	1885-1994	World Bank
3. The Integrated Rural Development Project	1970-1980	
4. Integrated Hill Development Project (IHDP)		Swiss Development Corporation (SDC/N)
• First phase	1975-1980	
• Second phase	1980-1985	
• Third phase	1985-1990	
5. Rasuwa Nuwakot Integrated Rural Development Project, (Two phases)	1976-1992	UNDP
6. The Tuki Extension System (Dolakha and Sindhupalchowk)	1977-1990	Swiss-assisted
7. Training &Visit Extension System(19 dist.in Tarai and 4 in Midhill)	1975-1989	World Bank
8. Agriculture Research and Production Project (ARPP)	1985-1990	USAID
9. Janakpur Agriculture Development Project (JADP)	1971-continue	Japan (KR2 Fund)
10. Integrated Cereal Project (ICP)	1977-1985	USAID
11. Agriculture Research and Extension Project (AREP)	1997-2002	World Bank
12. Mahakali Hills Integrated Rural Development Project (MIRDP)	1979-1987	World Bank
13. Seti Zone Rural Development Project (SZRDP)	1986-1995	ADB
14. Karnali Bheri Integrated Rural Development Project (K-BIRD)		Canadian
• First phase	1981-1984	
• Second phase	1985-1989	
15. Rapti Integrated Rural Development Project		USAID
• First phase	1980-1987	
• Second phase	1987-1995	
16. Koshi Hill Area Rural Development Project (KHARDP)	1979-1984	UK
17. Block Production Program (28 dist.)	1982-	USAID
18. Mechi Hills Irrigation and Related Development Project (MHIRDP)	1987-1991	(SNV/NEPAL)
19. Sagarmatha Integrated Rural Development Project (SIRDP)	1978-1988	ADB
20. BhairahawaLumbini Ground Water project (BLGWP)	1980-2001	World Bank
21. Hill Food Production Project (HFPP)	1981-1991	World Bank
22. Agroenterprize and Technology System Project (ATSP)	1990-1996	USAID
23. SINKALAMA (4 dists.) Sindhupalchok, Kavre, Lalitpur, Makawanpur		
24. Upper Sagarmatha Agriculture Development Project	1992-2002	ADB
25. Lumle Agriculture Center (LAC)		
26. Pakhribas Agriculture Center (PAC)		
27. Farming Systems Research and Extension Approach	1985-1990	DFID
27. Seed Sector Support Project (SSSP)	1997-2002	UK (DFID)
29. Market Access Rural Development Project (MARD)	1996-2002	USAID
30. Hill Agriculture Research Project (HARP)	1997-2004	UK9DFID)
31. KarnaliAnchal Special Agriculture Development Project	2000-2006	ADB

Name of the project	Duration	Source of funding
32. Nepal Irrigation Sector Project (NISP)	1997/98-2001/02	World Bank
33. Second Irrigation Sector Project (SISP)	2000/01-2002	ADB
34. Hill Maize Research Program (HMRP)	1999-2014	SDC
35. Sustainable Soil Management Project (SSMP)	2007-2010	SDC
36. Agriculture Training and Extension Improvement Project (AEITP)	2004-2009	JICA
37. Integrated Pest Management Phase II	2008-2013	Norway
38. Social Safety Net Project (SSNP)	2008-2013	WB
39. Emergency flood Damage Rehabilitation Project	2009-201	NORAD/FAO
40. Commercial Agriculture Development Project (CADP)	2005-013	ADB/Japan
41. Agriculture Perspective Plan Support Program (APPSP)	completed in 2009	DFID
42. Secondary Crops Development Project	1989-1997	ADB
43. Crop Diversification Project	2002-2007	ADB
44. GulmiArgakhanchi Rural Development Project (GARDP)	1988/89-2002/03	European Community (EC)
45. Integrated and Water Resources Management Project (IWRMP)	2008 – 2018	World Bank
46. PACT (Project for Agriculture Commercialization and Trade (PACT)	2009 – 2018	IDA Grant
47. High value Agriculture Project (HVAP)	2010 –2017	SNV - IFAD AEC
48. Rising Income for Small & Medium Farmer Project (RISM-FP)	2011 – 2017	DoA, NRB
49. Agriculture and Food Security Project (ASFP)	2013/14 -2018/19	GAFSP, GoN
50. Kisan Ka Lagi Unnat Biu Bijan Karyakram (KUBK)	2012/13-2018/19	IFAD, GoN
51. Rani JamaraKularia Irrigation Project	2012/13-2018/19	World Bank
52. Community Managed Irrigated Agriculture Sector Project (CMIASP)	2005/06-2018/19	ADB
53. World Food Program (WFP), Nepal Kadhya Surakshya Anugaman Pranali (NeKSAP)	2009-2016	WFP

Conclusion

Rice is the largest agricultural sector in terms of employment, share to gross domestic product and raw materials supply to the existing agro-based industries. Therefore, the growth of paddy is intimately related to the overall growth of agricultural sector in Nepal. Although due emphasis is on since a few decades to flourish and foster paddy sector at a faster rate, the achievements gained in paddy sector remain unsatisfactory. Nepal, a paddy exporting country in the past is now a net importer of it. Every development plan and policy has directly or indirectly stated the importance of paddy in national economy. However, inconsistencies in policies regarding price regulation, inadequate investment in research and extension, rhetorical commitments rather than effective implementation of rice related programs, lack of specific integrated programs on promotion of rice production are some of the shortcomings in policies for agricultural development in Nepal.

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Price Policy for Paddy in Nepal

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सारांश

कृषि मूल्य नीति कृषिजन्य वस्तुहरूको मूल्य स्थिरीकरण गरी उत्पादक र उपभोक्ता दुवैलाई न्यायोचित मूल्य उपलब्ध गराउन सरकारले लिने नीति हो । कृषकलाई सहुलियत मूल्य उपलब्ध गराई उत्पादन वृद्धि गरी खाद्य संकटग्रस्त स्थानहरूमा उपयुक्त मूल्यमा खाद्यान्न उपलब्ध गराउनु तथा मूल्य स्थिरीकरण गर्नु कृषि मूल्य नीतिका उद्देश्यहरू हुन् । न्यूनतम समर्थन मूल्य तथा खरिद मूल्य निर्धारण नेपालमा धान बालीलाई लक्षित गरी ल्याईएका कृषि मूल्य नीतिहरू हुन् । नेपालमा सन् १९६० को दशकमा अप्रत्यक्ष हिसाबले कृषि मूल्य नीति अवधारणागत रूपमा सुरु भएको थियो । नीतिगत हिसाबले सन् १९८० को दशकसम्म खाद्यान्नको मूल्य राज्य नियन्त्रित थियो भने नब्बेको दशकको अन्त्यतिर आंशिक रूपले खुल्ला हुँदै नयाँ शताव्दीको प्रारम्भ सम्ममा पुरै खुल्ला बजार निर्देशित थियो । नेपालमा सरकारी तवरबाट खरिद तथा बिक्री हुने वस्तु तथा सेवाको न्यूनतम समर्थन मूल्य, खरिद मूल्य र बिक्री मूल्य सम्बन्धी निर्णय लिने सबैभन्दा माथिल्लो निकाय मन्त्रीपरिषद् हो । औपचारिक रूपमा धानको न्यूनतम मूल्य तोक्ने कार्यको सुरुवात सन् १९७६/७७ मा भएको थियो भने सन् १९९९ पश्चात् यो कार्य स्थगन भयो । हालसालै यो कार्यलाई पुनः सुरुवात गरिएको छ । हाल कृषि विभाग अन्तर्गतको कृषि व्यवसाय प्रवर्द्धन तथा बजार विकास निर्देशनालयले उत्पादन लागत, थोक मूल्य र भारतको न्यूनतम समर्थन मूल्यलाई आधार बनाई न्यूनतम समर्थन मूल्य हिसाब गर्छ र कृषि विकास मन्त्रालयमा सिफारिस पठाउँछ । मन्त्रालयले यसै को आधारमा आपूर्ति मन्त्रालयमा सिफारिस गरी पठाउँछ र त्यहाँबाट आवश्यक निर्णय लिनका लागि मन्त्रीपरिषद्मा प्रस्ताव पठाइन्छ । धानको खरिद बिक्रीमा न्यूनतम समर्थन मूल्य लागू गर्ने आधिकारिक सरकारी निकाय नेपाल खाद्य संस्थान हो । न्यूनतम समर्थन मूल्य बजार मूल्यभन्दा कम तोकिनु, भौतिक तथा प्रशासनिक पूर्वाधारको अपर्याप्तता, आर्थिक अभाव तथा भारतसँगको खुल्ला सिमाना जस्ता कुराहरू नेपालमा न्यूनतम समर्थन मूल्य कार्यान्वयनका दौरान देखा परेका मुख्य सवालहरू हुन् । न्यूनतम समर्थन मूल्यको प्रभावकारी कार्यान्वनका लागि सरकारले धान बाली लगाउनु अगावै समर्थन मूल्य तोक्ने तथा नेपाल खाद्य संस्थानको क्षमता अभिवृद्धि गर्नु पर्ने देखिन्छ ।

Summary

Agricultural price policy is a government's intervene to stabilize prices of agricultural goods to ensure a reasonable price to consumers and producers. Major objectives of agricultural price policy in Nepal are: to make food grain available in food deficit districts at reasonable prices; to stabilize the prices of food grains; and to increase the agriculture production by providing price incentive to producers. For paddy and other food grains, declaration of minimum support price and fixation of procurement price are included under agricultural price policies in Nepal. The agricultural price policies, which virtually began in 1960, were largely regulated by the state until the middle of the 1980s, partially liberalized until the late 1990s; and almost fully liberalized since the turn of the century. The apex body responsible for making decisions on the MSP, PP or Sales prices of goods and services in public sector undertaking is the cabinet. The government of Nepal started announcing minimum support price for rice since 1976/77 and continued until 1999. The MSP was not announced thereafter. This practice has been recently reintroduced. These days, Agribusiness Promotion and Market Development Directorate under the Department of Agriculture calculates the MSP on the basis of cost of production, wholesale price and MSP in India and recommends it to the Ministry of Agricultural Development. The ministry recommends it to the Ministry of supply, which submits the proposal to the cabinet for making decision. Nepal Food Corporation (NFC) is the sole institution to implement MSP in buying and selling of paddy. The announcement of MSP lower than the market price, inadequacy of physical and administrative infrastructures, financial constraints, and open border with India are some of the issues associated with ineffective implementation of MSP for paddy in Nepal. For the effective implementation of MSP, the government needs to announce it before the planting season and strengthen the capacity of NFC.

Keywords: Agricultural price policy, Cabinet, MSP, NFC, Paddy, PP, Stabilization

Background

Agricultural price policy means a policy to determine, regulate and control the prices of agricultural products. Agricultural prices, on the one hand, determine farmers' income and on the other hand affect the living standard of the people engaged in the other sectors of the economy, as agricultural commodities form part of wage goods. Thus, changes in agricultural prices affect the transfer of income between the agricultural and the non-agricultural sectors. Agricultural Price Policy plays an important role in achieving growth and equity in the Nepalese economy in general, and the agriculture sector in particular. Subsidies in chemical fertilizers, improved seeds, deep and shallow tube-well installations and provision of minimum support prices are some of the government intervention to regulate agricultural prices in Nepal. Government of Nepal virtually introduced agricultural price policies in 1960s. The government started regulating the prices of agricultural commodities through the provision of minimum support price for rice and wheat from 1976/77. Since then, several changes have taken place in price policies of the government. The practice of declaring minimum support price of rice was reintroduced recently after a gap for about a decade.

Objectives of agricultural price policy

Price is responsible for the resource allocation in a market economy. The price policy plays an effective role to systematically divert the factors of production towards sectors aimed by the plan thereby leading to systematic growth of production and ultimately to speedy economic development. Specific objectives of price policies in Nepal are:

- to make food grains available at reasonable prices for poor in food deficit districts,
- to stabilize food grain prices and
- to increase the agriculture production by providing price incentives to producers.

Importance of agricultural price policy

Price policy of the government for agricultural produce seeks to ensure remunerative prices to growers for their produce in order to encourage higher investment and production and also for safeguarding the interests of consumers by making available food supplies at reasonable prices. The price policy of the country also seeks to evolve a balanced and integrated price structure in keeping with the overall needs of the economy. In order to achieve this end, the government announces minimum support prices (MSPs) and also organizes purchase operations through the state owned institutions (For example NFC during mid-1970 to 1980s). In order to safeguard the interest of both producers and consumers a comprehensive agricultural price policy must be formulated. The price policies in paddy and food grains not only assist in increasing production but also increase the level of income and stabilize the market price. Minimum support prices (declared by government normally at the beginning of sowing season for not letting price of paddy to fall below certain level) are the major forms of regulatory instrument to protect paddy producers in Nepal. Price policies in Nepal are very important to regulate the prices of paddy and food grains considering the context of landlocked situation, open border with India, climate change, and world trade.

History of agricultural price policy for paddy in Nepal

The agricultural price policies, which virtually began from 1960 were largely regulated by the state until the middle of the 1980s, partially liberalized until the late 1990s; and almost fully liberalized since the turn of the century. Now there is virtually no direct government control in agricultural prices. Beginning of agricultural slump coincides with the introduction of the agricultural price policy. Agricultural price policy was not under consideration till the beginning of the sixth plan.

The consideration of agricultural price policy as an instrument of policy planning is of recent origin. The establishment of department of Rice Milling and Sales in 1949 marked the beginning of public sectors' intervention in the distribution of subsidized food grain in the country. Main responsibility of this office was to look after food distribution in Kathmandu valley. The food grain, especially rice used to be produced by the land owners in the Tarai as BEGHATTI (a kind of levy) and transported to Kathmandu valley to the army personnel, public servants and if available, to general public. With the political change in 1951, the BEGHATTI system was abolished and Department of Food was established at the center with regional food control offices in different regions to procure rice in the Tarai and dispatch it to Kathmandu for distribution. In 1957, these units were merged to create a new Food Office. Agents were also appointed to distribute food grains and control consumer prices. Distribution activities of new Food Office, however, were limited to the Kathmandu valley only. In 1965, Food Management Corporation (FMC) was established under the Corporation Act to replace the Food Office. The functions and scope of the FMC were more or less same as of the Food Office. This corporation remained functional till 1972 (Gautam 1987).

The drought followed by excess rain in 1971/72 in the hilly and remote regions of the country gave rise to a series of pressure, which led the then His Majesty's Government to realize the need of an effective organization to handle food grain procurement and distribution at the national level. This realization resulted in the creation of Agricultural Marketing Corporation by merging Food Management Corporation and Agricultural Supply Corporation. Later in 1974, Nepal Food Corporation was formed to work solely on the procurement and distribution of food grains. In addition, six Paddy and Rice Exporting Companies were also created in 1974/75 with an objective of institutionalizing the rice export. The number of these companies was increased to eight. These companies used to procure some of the rice directly from farmers either through cooperatives or by establishing temporary procurement centers during the post-harvest period. All these exporting companies were closed in 1980 leaving the job of procurement, processing and export of rice to the private sector. Thus, it is evident that the fundamental objective behind the development of institutional facilities leading up to the creation of NFC was to stabilize consumer prices especially in the Kathmandu valley (Gautam 1987).

To announce the MSP of paddy, Government of Nepal had formed Central Food Management Committee in the beginning. After the formation of Ministry of Supply in mid-October 1983, the ex-officio chairmanship of this committee was shifted to the Minister for Supply. From November 1984, the Minister for Agriculture became the ex-officio chairman of this committee. The committee was renamed as Food Grain Management, Prices and Export Policy Formulation Committee in 1984 with broadened terms of reference. Form early 1986, the chairmanship of this committee was again moved to the Minister for Supply (Gautam 1987). Currently, Ministry of Supply has the mandate of submitting proposal to the cabinet for the announcement of MSP and the NFC has the whole-sole responsibility of buying and selling paddy. NFC by and large procures rice from millers. Thus, farmers have to sell their rice to millers and traders.

In addition to MSP, the cabinet also takes decisions on the fixation of purchasing price and sales price of agricultural goods and services transacted through the public sector undertakings. The cabinet may delegate its decision making authority to different agencies and bodies. Normally, the executive head of the implementing agency takes the initiative of framing the price level. Before 1992, Department of Food and Agricultural Marketing Services was the institution under the Ministry of Agriculture to take initiatives for recommending minimum support price for paddy. Market Development Directorate was made responsible for this job after DFAMS was dissolved. These days a technical committee formed by Agri-business Promotion and Market Development Directorate of the Department of Agriculture recommends the minimum support price of Paddy to MoAD. The ministry forwards this recommendation to the Ministry of Supply. The proposal prepared by this ministry with the recommendations of MoAD is then submitted to the cabinet for making final decisions on minimum support price for paddy.

Agribusiness Promotion and Market Development Directorate plays a vital technical role and takes following matters into considerations while deriving the recommended price.

- Estimated average cost of production of the crop in question,
- General state of food grain production in the country,

- Prices prevailing in the Indian market centers and adjoining main production areas in Nepal,
- Market price prevailing in the main producing areas in the country and its tendency,
- Transport and other associated cost from the main producing areas to the adjoining Indian market centers,
- MSP fixed by the Government of India (If announced),
- Past MSP's and their trend,
- Seasonal variation in the aggregate domestic prices,
- Spatial price analysis (Mainly eastern and western Tarai),
- Purchase policy of Government of Nepal.

Review of price policies for food grains and paddy in periodic plans

Use of agricultural price policy as an instrument to encourage production and consumption was not explicit at the macro level until the fifth periodic plan. The government started announcing MSP for paddy since 1976/77 as per the recommendations of periodic plans.

First and second plan (1956-1961 and 1962-1965)

The First Plan (1956-61) did not mention anything about the prices of food grains. However, the Three Year Plan (1962-65) highlighted the need for stabilizing consumer prices (HMG 1963).

Third plan (1965-1970)

The Third Plan (1965-70) acknowledged the need for a well-conceived price policy. However, the document was silent on the nature, scope and objective of this policy.

Fourth plan (1970-1975)

The fourth Plan (1970-75) emphasized on improving the bargaining power of farmers. Provisions for the establishment of "Agricultural Marketing and Warehousing Corporation" with an allocation of NRs 7.8 million was made for the purpose of improving storage facilities and to improve marketing of agricultural products (HMG 1970).

In this plan period, Agricultural Marketing Corporation was established in 1972, which was bifurcated into two independent agencies two years later. The corporation was created to deal with food grains and fertilizers to minimize food problems in many parts of country. The aim of its establishment was also to create infrastructure base for the implementation of future agricultural price policies in order to foster agriculture production. The primary objective of this corporation was to stabilize consumer prices as well as to promote the use of production inputs such as chemical fertilizers and seeds of high yielding varieties of paddy, maize and wheat.

Fifth plan (1975-1980)

The emphasis of the Fifth Plan (1975-80) was on the stabilization of prices of development and consumer goods (NPC 1975). However a comprehensive and well-conceived price policy was not designed and implemented till the end of this plan (NPC 1980).

The plan apart from analyzing the past price trend and describing the policy and its elements at some length also envisaged action program (Ibid p.160). Among others, it envisaged fixing the minimum support and procurement prices to stimulate the production of crops such as paddy, maize, wheat, pulses, millets, cotton, jute, oilseeds, tobacco, sugarcane, potato, ginger, and cardamom. The plan assured the procurement of certain crops, which were grown for export promotion and import substitution (NPC 1980).

Sixth plan (1980-1985)

From the point of view of realization of the role of comprehensive price policy in general and agricultural price policy in particular, sixth plan document compared to its predecessor was relatively more progressive.

However, some of the activities could not come into implementation. Financial and infrastructural constraints apart from its weakness in assessing resource required in implementing the tasks envisaged might have contributed to this situation. Geographic reality was not explicitly considered in fixing prices in reality during the plan period. The plan gave emphasis in fixing minimum support price in paddy, wheat, maize, pulses, millet and cash crops to increase the production of those crops. The plan also stated the gradual implementation of guaranteed system of procurement policies. While fixing the minimum support prices of cereals and cash crops, the following factors were taken into considerations.

- Cost of production
- Parity price with competing crops. If a given crop production target is of higher priority, the price of such crops will be fixed higher than the competing crops.

The plan intended to eliminate the supply of food gradually by Nepal Food Corporation except in food deficit districts, where the private sector cannot supply (NPC 1980)

Seventh plan (1985-1990)

The role of effective agricultural price policy had been realized in this plan as well. The achievement experienced during the Sixth Plan might have led to the realism. For agricultural price purpose, emphasis was on the creation of a responsible agency to effectively implement price policy apart from the establishment of an advisory body. The need for such body has been felt in view of the past instability and adhocism in deciding the MSP and PP (NPC 1985).

Eighth plan (1992-1997)

The plan intended to encourage the involvement of private sector through gradual reduction in price and transport subsidy of improved seeds. The plan targeted to form an agricultural price commission to monitor the border and international prices, to analyze the cost of production of various agro products and to make recommendations for fixing reasonable support prices. The plan intended to encourage farmers through effective price and market information services for attaining marketing efficiency of agricultural commodities. Subsidy on sales price of seed was thought to be discontinued to encourage the private sector in seed business. However, the plan intended to continue support on the price of source seeds to encourage their use. Conduction of agricultural marketing and price management program for providing reasonable prices to the producers was another aspect of the plan. In order to relieve farmers from the anxiety of probable price reduction, the plan stated fixing of a minimum support-price for major food and cash crops before their plantation. Even in essential commodities like foodstuff, Nepal Food Corporation adopted the policy of stabilizing the price by controlling supply of goods through its stocks not by declaring the price itself. This was helpful in increasing the role of private sector in various economic activities (NPC 1992).

Nineth plan (1997-2002)

The plan encouraged farmers by declaring minimum support price of agricultural products, such as paddy, rice, and sugarcane at appropriate time. Emphasis was given in the supply of good quality seeds by developing resource centers, where seeds would be produced in farmers' field. Price fixation was left upon the responsibility of District Seed Production Committee, which includes seed producers. Gradual reduction in providing subsidy on chemical fertilizer was stated in this plan. The plan continued supporting farmers by declaring the minimum support price of major agricultural products, such as paddy, rice, and sugarcane. Provision of subsidizing 25% on the price of foundation seeds was also included. Commitment was made to create necessary arrangements to determine the minimum support price of food products. The plan included the provision of taking recommendations by the Government from Price Determination Advisory Committee to determine the prices of commodities (NPC 1997).

Tenth plan (2002-2007)

The plan emphasized strengthening the system of price fixation through market system. There was a target to set up medium sized store houses to help farmers to store their products for certain duration and get higher prices later (NPC 2002). As the production of food items remained negative due to unfavorable weather condition in the last three years of the Plan period, there was overall price rise of the food products (NPC 2008).

Eleventh plan (2007/08-2009/10)

The plan stated to adopt the system of market price determination of goods and services being supplied by publicly owned corporations. Strengthening the distribution system so as to make food available at cheaper prices and preparation of a basis for the determination of minimum acceptance price were major aspects of the 11th plan to maintain reasonable prices of agricultural commodities in the market (NPC 2008).

Twelveth plan (2010/11-2012/13)

The plan emphasized promoting agricultural insurance. The plan also focused on reducing transport subsidy on food grains gradually in the districts with road access (NPC 2010). Since the production of food grains (including paddy) is weather dependent in Nepal, their prices remained ups and down during the plan period (NPC 2014).

Thirteenth plan (2013/14-2015/16)

Increasing subsidy on agriculture and livestock was the major aspect of this plan to maintain the prices of agricultural goods and services at the reasonable level. Some of the innovative programs, like fine and aromatic rice production and mega rice promotion programs were initiated as a proxy measure to regulate the prices of paddy in Nepal (NPC 2014).

Support price for paddy

The Government practiced announcing the MSP for paddy and sometimes for wheat although it was discontinued for few years in the past. The prices for both coarse and find paddy were announced till 1982/83. The MSP for paddy was uniform except in 1982/83 when it was applicable only in four districts of far western Tarai region of Nepal. Regional differences were instituted for 11 hill districts in 1985. The declaration of MSP could not be of much help to farmers in taking cultivation decision since the date of announcement tended to coincide more with the date of harvesting rather than the planting time (Gautam 1987).

Approaches followed in determining the MSP has to be aligned with the process followed by the Government of India. A comparison of MSP for paddy indicated that there was no marked difference in the price level especially to check the movement of grains across the border. Time series data on farm gate prices were not available on this matter. Available data suggested that the farm gate price was sometime higher than MSP. The details of MSP announced by the Government of Nepal are presented in **Table 1**.

Table 1. Minimum support price for rice in Nepal

Crop season (Beginning in June/July)	MSP (NRs/t)		Remarks	Source
	Coarse	Fine		
1976/77	1125			Gautam (1989)
1977/78	1125		21th December 1977	Gautam (1989)
1978/79	1125		January 1978	Gautam (1989)
1979/80	Not Announced			
1980/81	1425		31th October 1980	Gautam (1989)

Crop season (Beginning in June/July)	MSP (NRs/t)		Remarks	Source
	Coarse	Fine		
1981/82	1500		15th April 1981 (Applicable for 4 districts only: Banke, Bardia, Kailali and Kanchanpur)	Gautam 1989
1982/83	1780	1850		Gautam 1989
1983/84	1800	2000	4th October 1983	Gautam 1989
1984/85	1970	2070	16th December 1984	Gautam 1989
1985/86	1970	2070	5th February 1985	Gautam 1989
1986/87	2400	2500	8th October 1986	Gautam 1989
1987/88	NA			
1988/89	NA			
1989/90	NA			
1990/91	Not announced			
1991/92	3800			Paudel 2008
1992/93	4400			Paudel 2008
1993/94	5000			Paudel 2008
1994/95	5450			Paudel 2008
1995/96	6200			Paudel 2008
1996/97	6500			Paudel 2008
1997/98	8040 (Proposed but not announced)			Paudel 2008
2016/17	Proposal was made @NRs 22300/t (Medium rice) and @NRs 20700/t (Coarse rice) in November 2016 (for mainseason rice). But, cabinet did not announce MSP for Paddy and directed NFC to undertake buying and selling activities giving due consideration on producers' welfare and existing market prices.			

Issues and challenges related to price policies in paddy and food grains in Nepal

Despite the fact that agricultural price policies for paddy and food grains stabilize the prices by protecting both producers and consumers, several issues and challenges have been faced in price determination. Physical infrastructure, like transport, communication, storage and processing facilities are inadequate in Nepal creating difficulties to maintain the stable prices of paddy. Similarly, the NFC, which is a public sector organization and is responsible to implement MSP in buying and selling of paddy, does not have adequate storage capacity. The quantity and quality of information that is required to administer the price policies effectively along with the manpower required for generating and analyzing such information is still inadequate. Due to the lack of appropriate road networks and geographical remoteness, the distribution of paddy from Tarai to Hill and Mountain districts is difficult. As a result of this, paddy produced in Nepal is sold across the border creating a problem of regulating the price in Nepal. The factor, which has been instrumental in determining the level of performance, is the lack of financial resource of the institutions involved particularly in the case of NFC (for the purchase of food grains including paddy) and AICL (for the purchase of chemical fertilizers). The effective price that the government can fix and administer will always have to be in a given range. Consideration should be given whether this range implies economic efficiency or not. Regulation and deregulation of fertilizers and minimum support price for paddy also created problems in stabilizing the prices of paddy in Nepal.

Consequences of MSP for paddy in Nepal

To restore production incentives, minimum support prices were introduced, but these remained ineffective due to various reasons. Firstly, the MSP was fixed normally below the market price level in such a way that the government did not have to procure food grains at announced price. Secondly, these prices were announced at the time of harvest and not before planting season and did not keep producers motivated to increase production. Thirdly, there was an extreme overturn in policy, which became instrumental in eroding little competitiveness that the Nepali agriculture had in the past. The Government realized only two advantages from the revision in policies – i) savings in national budget as a result of savings allocated for subsidies in agriculture; and ii) some improvements in balancing nutrient elements in soil due to the withdrawal of heavy subsidy in nitrogenous fertilizers (FAO 2010).

Finally, financial constraints faced by the NFC resulted that it could not purchase sufficient amount from farmers and enforce the Government's price announcement. The Government has not announced minimum support price for paddy publicly since 1997/98. Whether the Government should continue a price support policy for food grains in the future remains questionable. During the period when MSP was announced, the production of paddy over the years did not show encouraging results. The production in comparison to the base year of periodic plans was found to be increased marginally except in the fifth plan. However, the production target of paddy was never achieved except in the sixth plan. Thus, it is very difficult to justify that the MSP announced for paddy has direct effect in increasing production.

Table 2. Target and progress of paddy production during MSP announced plans (‘000 t)

Periodic plan	Production target and achievement		Target achievement gap in percentage	Percentage change
	Target	Achievement		
Fifth plan	2800	2058.93	-26.4	Percentage change over the level of 1974/75: -16.0
Sixth plan	2740.357	2756.59	5.2	Percentage change over the level of 1979/80: 33.39
Seventh plan	3400	3392	-0.23	Percentage change over the level of 1984/85: 23.05
Eighth plan	4452	3699	-16.91	Percentage change over the level of 1989/90: 9.05

Source: Calculated from periodic plans of NPC 1975-1997.

Conclusion

Rice, being the staple food crop, supplies more than 30% of calorie requirement of Nepalese population. Therefore, the ups and downs in paddy production directly influence the food security situation of the country. Currently, Nepal has become the net importer of rice. Import of several thousand tonnes of rice has also resulted increasing the price of rice in Nepal. Thus, increasing production to meet the increasing demand for rice and to stabilize the price is an urgent need at present. On the other hand, the need is also to protect producer farmers by adopting appropriate price measures. Appropriate price policy can play a pivotal role to fulfill these needs. Fixation of minimum support price or procurement price for paddy could be a component of price policy. However, there is not a pleasant history of MSP for paddy in Nepal because of discontinuation in the fixation of MSP for a long duration in the past 40 years. Moreover, the MSP announced for paddy was most often lower than the market price. Thus, learning from the past experience the Government should not make any delay in protecting paddy producers and stabilizing the price to ensure consumer welfare through appropriate policy measures. The announcement of MSP before planting season and strengthening the capacity of NFC could be possible way out for effective implementation of price policies for paddy in Nepal.

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Pattern of Investment in Rice Research and Development in Nepal

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सारांश

प्रस्तुत लेखमा तथ्याङ्क र सूचनाहरूको आधारमा धान अनुसन्धान र विकासमा लगानी सम्बन्धी पक्ष एवम् धान अनुसन्धान र विकासमा वैज्ञानिक योजना तर्जुमा र स्रोतको परिचालन सम्बन्धी जानकारी पस्कने प्रयास समेत गरिएको छ । कूल ग्राहस्थ उत्पादनमा धान बालीले करिब २० प्रतिशत योगदान पुऱ्याएको भएता पनि हाल धान अनुसन्धानमा कृषि अनुसन्धानको कूल बजेटको २-४ प्रतिशत मात्र लगानी गरेको पाइएको छ । अन्य लगानीका अनुमानित उपलब्ध उपायहरूको आधार (धान अनुसन्धानमा पूर्णरूपमा संलग्न वैज्ञानिकको संख्या, वर्षेनी सिफारिस भएका धानका नयाँ जातहरूका संख्या, बजारमा देखिने र बिक्री भएका उन्नत जातका बीउहरूको मात्रा) लाई विश्लेषण गर्दा हाल धान अनुसन्धान र विकासमा न्यून लगानी भएको देखिन्छ । सरकारी क्षेत्रबाट उन्नत पैत्रिक जातहरूको विकास र स्रोत बीउ उत्पादनमा बढी लगानी गरेको देखिन्छ भने निजी क्षेत्रबाट बाह्य हाईब्रीड जातहरू विदेशबाट आयात पश्चात् परीक्षण र सूचीकृत गराई बीउ बिक्री वितरणमा बढी लगानी गरेको पाइन्छ । हालको न्यून लगानीको अवस्थामा सुधार गरी धानबाट प्राप्त कूल राष्ट्रिय आयको न्यूनतम १ प्रतिशत धान अनुसन्धान र विकासमा लगानी गरेमा नेपाललाई धान उत्पादन र उपभोगमा आत्मनिर्भर बनाउन सकिने प्रशस्त सम्भावनाहरू रहेका छन् ।

Summary

Actual investment in rice research is very low with a share of 2-4% of the total agricultural research budget despite rice accounts for half of the total food production and contributes about 20% of the AGDP. Current investment in rice R&D is also low in terms of investment in full time equivalent of scientists (FTE) in rice research, number of varieties released and registered per annum as well as seeds sold and type of varieties promoted in the market. Public sector currently has larger investment in inbred variety development, release and source seed production while private sector has sole contribution in hybrid variety introduction, registration and supply. The current focus of investment is more on introduction, testing and promotion rather than domestic breeding and promotion. As a result, investment in domestic hybrid R&D as well as research in locally adapted variety is very weak. The current pattern of underinvestment on research calls for increased funding for rice R&D making investment at least 1% of the value of rice output. The paper concludes with a need for long-term increased investment in rice to reduce import and make country self-reliant.

Keywords: Domestic breeding, Private investment, Public research, Rice R&D, Underinvestment

Introduction

Production of rice is not adequate to meet food needs of increasing population. Rice yields are still low and hovering around 3 t/ha as compared to global average of 4 t/ha (FAOSTAT 2014). As the possibility for further physical expansion of rice area in Nepal is presently limited, the only remaining option to enhance rice production in the future is through increases in rice yield and cropping intensity. In this context, technology development and delivery is critical for which increased investment in rice research is essential. Furthermore, increased investment in rice research and development (R&D) is essential to ensure national food security, reduce poverty and save scarce foreign exchange that are being used in importing rice from India[1]

Past investment in rice research and development has benefitted globally. According to Hossain et al (2003) annual gains from adoption of improved rice varieties in Asia stood about US$ 10.8 billion. The amount was nearly 150 times higher than annual investment made in rice research by International Rice Research

1 Official sources indicate that Nepal spent about 2600 million NRs in importing rice from India in 2014/15

Institute (IRRI) and National Agriculture Research Systems (NARS) together. A recent Australian Centre for International Agricultural Research (ACIAR) impact study (Brennan and Malabyabus 2011) indicated that rice varietal yield improvement research from 1985-2009 from IRRI supplied germplasm in three east Asian countries (Philippines, Indonesia and Vietnam) indicated a high economic rate of return with average yield gains of 11.2% per annum that was possible mainly from investment in rice research targeted to development and promotion of high yielding rice varieties. The economic value of that yield improvement was estimated to be of US$ 1.46 billion averaged per year across the three countries (Brennan and Malabyabus 2011).

A recent study in Nepal also provides evidence of estimates of benefits of an investment made in the development and adoption of rice variety Khumal-4 recommended for mid hills of Nepal. The finding shows that Khumal-4 is annually providing a benefit of NRs 1 billion (US$ 11 million) after the year 2000 in 2014 price (Gauchan et al 2016). Despite the importance of investment in rice in national economy, food security and livelihood of the people in Nepal, we have limited review and analysis of the overall investment pattern in rice research and development (R&D).

Pattern of investment in rice R&D

The current investment on rice research is only about 0.05% of the value of rice output. If investment in agricultural extension and overall development is accounted for, it comes around 0.1% of the value of rice output. This is very low as compared to the value of rice output which accounts for about 20% of the AGDP.

Past evidences show that the actual amount of operational budget allocated to rice research was hovering around NRs 5-7 million in NARC from 2003-2010 with 2-4% of the total research budget, even though it was higher during 1998-2002 (Gauchan and Pandey 2011, Shrestha 2014). After 2010, the actual amount of rice research budget had increased hovering about NRs 30-40 million. For instance in 2012-13, the actual budget allocated to National Rice Research Programme (NRRP) was NRs 26.89 million out of total NARC budget of NRs 1750 million (NARC 2015). Similarly in the same year, about NRs 20 million of budget was estimated to be allocated in Regional and Area specific Agricultural Research Stations (R/ARS) and central disciplinary Divisions at Khumaltar, where rice research is carried out. This aggregate of the total was NRs 46.89 million which accounted for 2.6% of the total research budget allocated to NARC as block grant from the Government of Nepal. Despite actual amount of rice research budget increased in recent years, the proportionate share to total agricultural research budget remained same to date. However, in early 1970s and 1980s, the proportionate share of rice research budget in total crop budget was much higher than in the 1990s (Upadhyay and Thapa 1994). In the year 2000-2001 also, the actual share of rice research was higher accounting 5.7% of total agricultural research budget (Shrestha 2014). But this proportionate investment declined after 2002 despite increased actual budget after 2010 in NARC from the Government of Nepal. The current trend of investment in rice research over the years indicate that it is made in *ad-hoc* way with limited scientific and economic principles adopted in allocating research resources across the crops, production environments and agro-ecological zones.

Research investment in by full time equivalent (FTE) researchers

The investment of research through estimation of full time equivalent (FTE) scientist is a standard global practice (Byerlee and Morries 1993, Pandey and Pal 2007, Beintema and Stads 2010, Gauchan and Pandey 2011). The estimation of full time equivalents (FTEs) through surveys is a standard practice in the literature (Beintema and Stads 2010) when there is a lack of other alternative satisfactory ways of reliably estimating these research investments. We used a proxy measure for research expenditures, namely, the total scientific time invested in rice research on a full-time equivalent (FTE) basis, because the disaggregated data on actual value of research expenditures on rice research activities are currently not available.

At present, NARC has a uniform level of research support across agro-ecological regions and ecosystems even on a per FTE basis; hence, the expenditures with a unit of researcher time remain constant over Nepal.

Gauchan and Pandey (2011) made estimation of per scientist expenditure in rice research per FTE basis in 2010 which was about US$5,930 at 2010 price. This amount was quite low as compared to the per scientist resource allocated for rice research in a neighboring developing country India which was estimated to be $15,780 for eastern India and $21,110 for the rest of India in FY 2000 (Pandey and Pal 2007).

Country's engagement of scientific manpower (human resources) is also a measure of research investment. Human resource capacity in rice research in Nepal is currently limited, even though NARC has a fairly good number of researchers in total. Among 332 researchers of NARC in 2013/14, 115 researchers in rice were working partly or fully with 43% of their full time share. This accounted 38.75 researchers on full time equivalent (FTE) basis (Shrestha 2014). The earlier study by Gauchan and Pandey (2011) estimated relatively lower to this value because of fewer people working on rice in 2009/10 as compared to 2013/14 where some new recruitments and increased resource allocations were made after 2010 from the Government of Nepal particularly after the learning of food crisis in 2008.

Variety release and registration: A proxy measure of research investment

Status of varietal development and recommendation by the national agriculture research and development system is an indicator of public investment made in research as well as making available varietal options for seed producers, suppliers and farmers in the country. Improved varieties are released rapidly by national seed board as a measure of their success of the program (Evenson and Gollin 2003). Until 2014 the public R&D system in Nepal has developed, tested and officially released and registered a total of 91 rice varieties with release of 73 varieties and registration of 17 hybrids and one inbred variety (SQCC 2015). Out of the release list, 12 rice varieties are denotified[2] resulting in a total of 79 varieties (61 release and 18 registered) presently in use. Denotification was done for old and obsolete varieties that were not in demand in addition to being high disease and insect susceptibility. This indicates that annual average release and registration in the last 55 years (1960-2014) is 1.65 per annum indicating low research investment with less than 2 rice varieties available per year in Nepal for total rice area of about 1.5 million hectare. **Table 1** presents both public and private sectors release and registration of rice varieties and annual rate of variety notification for the last 55 years (1960-2014) with specific analysis for a recent 10 years (2005-2014) with the private sector involvement.

Table 1. Release and registration of crop varieties (1960-2014)

Public and p rivate sector in rice	Total varieties	Inbred	Hybrids	Annual average rate of release & registration (1960-2014)	Annual average rate of release & registration (2005-2014)	Share (%) in total varieties	Proximate share (%) of investment
Rice	91	74	17	1.65	4.1		
Public sector	70	70	0	1.33	2.4	77	77
Private sector	21	4	17	0.20	1.7	23	23

Source: Compiled and estimated from SQCC 2015.

The data show that when both public and private sector released and registered varieties are aggregated for the last 55 years, the annual rate of variety released/registered is about 2 for rice.

The pace of notification of crop varieties has surged in the recent decade (2005-2014) with the private sector involvement contributing in making availability of 4 varieties per annum in recent decade (2005-2014). Out of 91 varieties notified until 2014, 70 varieties were from public sector while 21 were from private sectors (agribusiness firms, seed companies including NGOs). Hybrid registration was sole contribution of the private sector contributing 17 hybrids registered until 2014. Registration of hybrids are mainly initiated since 2010 through private sector efforts. Some of them are becoming popular in farmers' fields particularly

2 These include four IR series (IR 8, 20, 22 and 24), Jaya, Chandina, Durga, Laxmi, Mallika, Khajura-2, Parwanipur-1 and Barkhe-2.

in market accessible and irrigated domains of Tarai, inner Tarai, lower hills and river basins. The share of public sector in total released and registered varieties is 77% while that of private sector is 23% implying presently three-fourth of the share of investment accounted from public sector. Hybrid varieties are solely the contribution of private sectors. In recent decade (2005-2014) a high average rate (4.1 per annum) of variety notification (release and registration) is due to private sector participation in the registration of hybrids mainly after the year 2010, where 17 hybrids were registered in a single year in 2010. This indicates that in recent years there is an increase of investment from private sector.

Trend of rice varieties released over the period

The pattern and trend of variety released for the last 55 years (1965 to 2014) is presented in **Figure 1**. The country has released an average of 14 varieties per decade in the last 55 years' period since the beginning of first variety release in 1966. A highest number of releases of 24 varieties have occurred during the recent period "between 2005-14" followed by 18 varieties in 1985-1994 period.

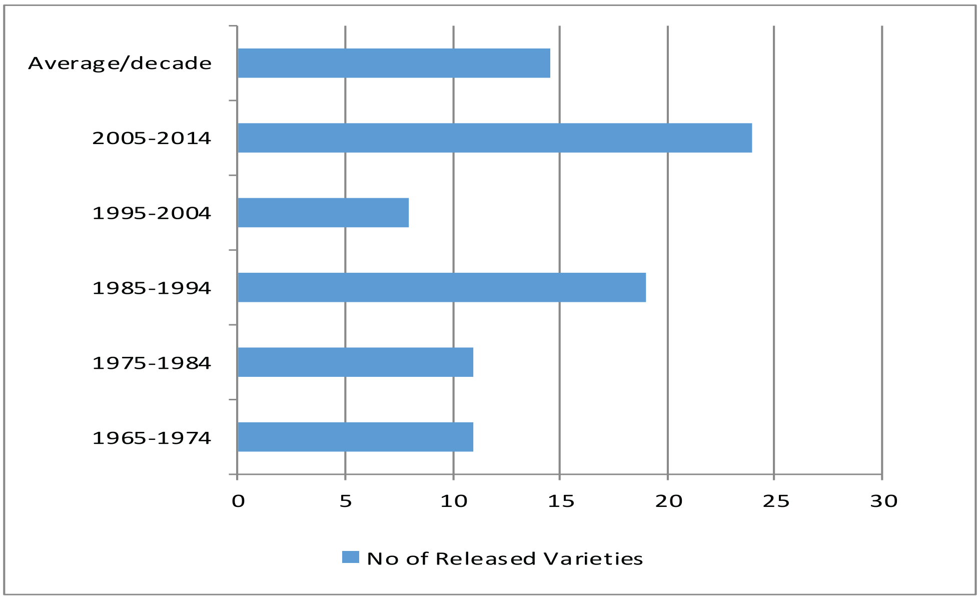

Figure 1. Trend of rice varieties released per decade (1965-2014)

After the year 1990 with new liberal economic policy, the country has released about 40 varieties in the period of 24 years (1991-2014) which is more than double to total number of releases after 1965 to 1990 (26 years). The highest rate of release of rice varieties occurred in a recent period (2005-2014) and in early 1980s to mid 1990s (1985-1994), which indicates higher research investment for rice in these periods. The real data of expenditure also indicates that real investment of budget and human resources in rice research was higher during early 1980s to mid-1990s and in the recent 5 years after 2010 (Upadhyaya and Thapa 1994, NARC 2015).

Private sector seeds sales as proxy for the private investment

Estimates of seed sales through market survey

Estimate of seeds sales in the market is a proxy indicator for the market demand and availability as well as investment made in seed business. Several private sector actors such as seed companies, seed dealers, cooperatives and community based seed producer (CBSP) groups are engaged in seed sales and distribution in the country. A recent nation-wide survey of seed dealers in rice in 2013 indicated that there are ten varieties that are most popular with the highest seed sales in 2013/14 (Gauchan et al 2014). The dominant varieties marketed by seed dealers in 2013 is presented in **Figure 2**. The largest seed sales obtained from survey was Radha-4 followed by Sabitri and then US-312 (hybrid). Ramdhan and Hardinath-1 varieties ranked fourth and fifth, Gorakhanath hybrid 6th and Makawanpur-1 in 7th postion. Similarly, recently released Shamba mashuri Sub-1 variety ranked eighth. Among 10 important ranked varieties, 3 hybrids (US-312, Gorakhnath and Arise-6464) were rencently registered in Nepal. Sarjoo-52 a variety from India which is not released or registered in Nepal was also being marketed and widely adopted in far western region of Tarai (eg Kailali, Kanchanpur) and partly in western Tarai. Pedigree record and analysis of marketed seeds of these top 10 varieties indicate that all most of these varieties sold in the market have their origins in foreign sources and not being developed in the counry.

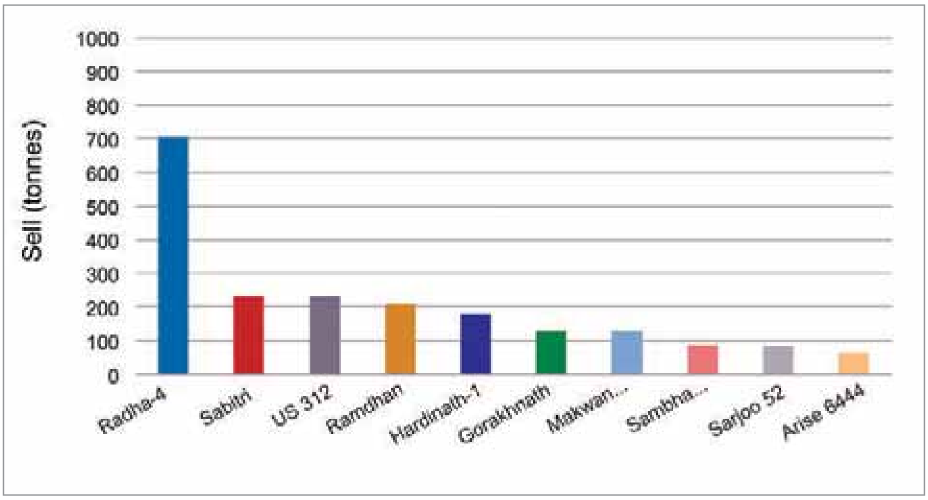

Figure 2. Dominant varieties marketed by seed dealers in 2013

Source: Gauchan et al 2014.

The overall analysis of country of origin of Nepalese total released varieties also showed that the only 68% rice varieties released to date are from foreign sources indicating high dependence of the country in foreigin germplasm for varietal development (Joshi et al 2016). These evidences infer that investment in R&D for domestic breeding of popular market preferred variety is presently very much limited in Nepal.

Market shares of improved domestic inbred and hybrid varieties

The proportion of modern variety (MV) seeds sold in the market or market share is also proxy indicator for the investment in rice R&D.Presently both modern inbred varieties and hybrids make significant share of market share of MV rice seeds (**Figure 3**).

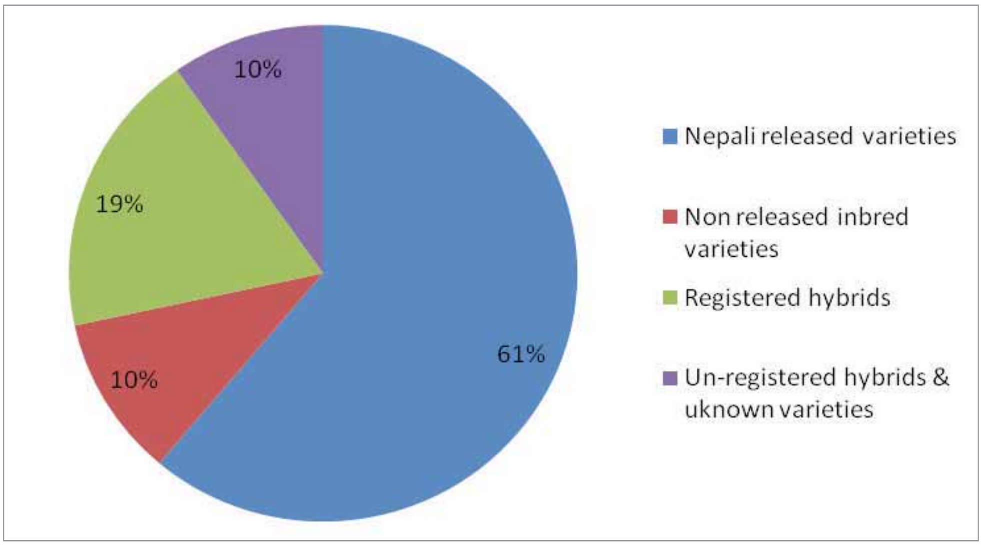

Figure 3. Market share of rice varieties and hybrids in Nepal (Gauchan et al 2014)

Survey of seed dealers cum retailers (Agrovets) selling different improved rice varieties in 2013 in Nepal indicated that about 61% market share is covered by domestically developed modern inbred rice varietes, 19% by registered exotic hybrids, 10% by unreleased inbred and 10% by unregistered hybrids in Nepal. This indicated that there are still a bigger share (about 40%) varieties sold in the market that are not being developed and notified from investment made in the country.

Conclusion

Presently investment in rice R&D is low in terms of investment in full time equivalent (FTE) scientists in rice research, number varieties released and registered per annum as well as varieties promoted in the market. Public sector currently has larger investment in inbred variety development, release and source seed production while private sector has sole contribution in rice hybrid variety introduction, testing, registration and production and supply of commercial exotic hybrids in the country. Public sector mainly NARC provides technical supports for testing and evaluation of hybrid varieties imported by the private sector. Even though there has been a surge in registration of exotic hybrids recently after favourable policy shift, the registration and promotion of local farmer adapted varieties (landraces) is very much limited from both public and private sectors. The evidence of seed sales data and share of popular varieties marekted in the country indicate that most of them are introduced, exotic and released and registered but not bred and improved in Nepal. This indicate that investment in domestic plant breeding research in the country is weak. Moreover, investment in domestic hybrid R&D as well as research in local variety is very weak or absent as all of the presently registered and marketed hybrids are exotic and not being developed in Nepal.

The current pattern of underinvestment on research calls for increased funding for rice research and development making investment at least 1% of the value of rice output rice in Nepal. Considering the very diverse agroecology, heterogeneous farming systems and socioeconomic needs of the population, more varieties need to be released and registered annually in the country. Emphasis should be given for long-term investment in rice R&D specifically focusing on rice value chain development to reduce import of rice and make country self-sufficient.

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Rice Research Linkage Between NARC and Other Organizations in Nepal

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सारांश

नेपालको भूपरिवेश सुहाउँदा उपयुक्त प्रविधिहरूको विकास गरी बाली वस्तुहरूको उत्पादन र उत्पादकत्व वृद्धि गर्ने उद्देश्यले एक स्वायत्त संस्थाको रूपमा नेपाल कृषि अनुसन्धान परिषद्को स्थापना भएको हो । परिषद्ले सञ्चालन गर्ने अनुसन्धानात्मक क्रियाकलापहरूमध्ये धान बाली अनुसन्धान पनि एक हो । धान बाली अनुसन्धानका खातिर प्राविधिक सहयोग, जर्मप्लाज्म संरक्षण तथा आदानप्रदान, जातीय विकास, प्रविधिहरूको प्रमाणीकरण आदि कार्यका लागि परिषदले अन्तर्राष्ट्रिय धान अनुसन्धान संस्था (इरि), अन्तर्राष्ट्रिय मकै तथा गहुँबाली अनुसन्धान केन्द्र (सिमिट), नेपाल सामाजिक सुरक्षा संजाल, जैविक विविधता, अनुसन्धान तथा विकासका लागि स्थानीय पहल (ली-बर्ड), फरवार्ड, विभिन्न कृषि विश्वविद्यालय, कृषि विभाग आदि संस्थाहरूसँग सहकार्य र समन्वय गरिरहेको छ । नेपाल कृषि अनुसन्धान परिषद् र अन्य विभिन्न संस्थाहरूसँग हुने साझेदारी अझ प्रभावकारी बनाई संस्थागत सुदृढीकरण, क्षमता अभिवृद्धि, धान अनुसन्धानमा लगानी वृद्धि आदिमा समेत सम्पूर्ण साझेदार संस्थाहरूको क्रियाशीलता बढाउन सकेमा धान बालीको विकासमा टेवा पुग्ने देखिन्छ ।

Summary

Nepal Agricultural Research Council (NARC) is an autonomous organization established to undertake agricultural research activities for increasing agricultural production and productivity by generating appropriate agro-technologies suitable to various agro-ecological zones in Nepal. Rice research is one of the priority research areas of NARC. In coordination and collaboration with various national and international organizations, NARC has been continuously involved in various rice related researches. Knowledge updates, technical assistance, germplasm conservation and exchange, varietal development, verification of technologies are some of the research activities that NARC is doing in collaboration with various organizations like International Rice Research Institute (IRRI), International Maize and Wheat Improvement Centre (CIMMYT), Local Initiatives for Biodiversity, Research and Development (LIBIRD), Forum for Rural Welfare and Agricultural Reform for Development (FORWARD), Agricultural Universities, Department of Agriculture (DOA), etc for rice research in Nepal. Collaboration between the partners in institutional strengthening, capacity building, investment in rice research, etc should be strengthened for sustained rice development.

Keywords: Agro-ecological zones, Collaboration, National and international organizations, Rice

Background

Nepal Agricultural Research Council (NARC) is an autonomous organization established under Nepal Agricultural Research Council Act 1991 to undertake agricultural research activities for increasing agricultural production and productivity by generating appropriate agro-technologies suitable to various agro-ecological zones. The fundamental functions of NARC are: conducting studies and researches on different aspects of agriculture; providing research and consultancy services to the clients and coordinating, monitoring and evaluating the agricultural research activities in Nepal. Research on diversified crops like: cereals, grain legumes, oilseeds, cash/industrial crops, horticulture (fruits and vegetable crops), livestock, swine, avian and fisheries are the thematic areas of NARC to conduct agricultural research in Nepal.

Under NARC, National Rice Research Program (NRRP) is responsible for coordinating and generating rice production technologies in collaboration with universities and other agencies. Besides this, Agriculture

Botany Division (ABD) is the leading rice breeding activities for hills and high hills of Nepal. National Agriculture Genetic Resources Centre (NAGRC) is currently holding 2300 collections of rice landraces collected from different parts of the country which are easily available to the breeders of NRRP and other institutions. In addition to conservation, national genebank also started pre-breeding activities and screened landraces tolerant to different biotic and abiotic stresses. These technologies are verified at farmers' fields in the outreach sites of each research station in collaboration with government and non-government organizations along with other stakeholders. R/ARSs verify technologies at the farmer's fields in the form of coordinated farmer's field trial, participatory varietal trial, farmer's acceptance test (minikits) and other location specific crop management on-farm trials especially in outreach research (OR) sites. Sometimes, such promotional activities are conducted at other sites where these are required based on feedback from farmers, extension personnel and related stakeholders. Other activities like stakeholders' meeting, farmer's field day, training, joint monitoring to OR sites, village level workshops, regional technical working group meetings are periodically organized to deliver take home message, create awareness about the technologies, collect feedback, prioritize the future plans and ultimately build up close linkages with all rice stakeholders. Research stations also organize training to SMSs, field staff and progressive farmers about the recently developed rice production technologies. Leaflets in Nepali and English, annual reports, proceedings, etc are also published and distributed to the respective stakeholders.

Technology dissemination aspect of agro-technology in wider perspective comes under Department of Agriculture (DoA), Department of Livestock Services (DoLS) and community based organizations (CBOs). Memorandum of Understanding (MoU) of NARC with Universities (TU, AFU, PU, KU) and CTEVT helps to strengthen capacity building, technology generation and verification through multidisciplinary academic researches. NARC and universities have close collaboration for undertaking agricultural research studies, especially for higher degree research studies, for the last couple of decades.

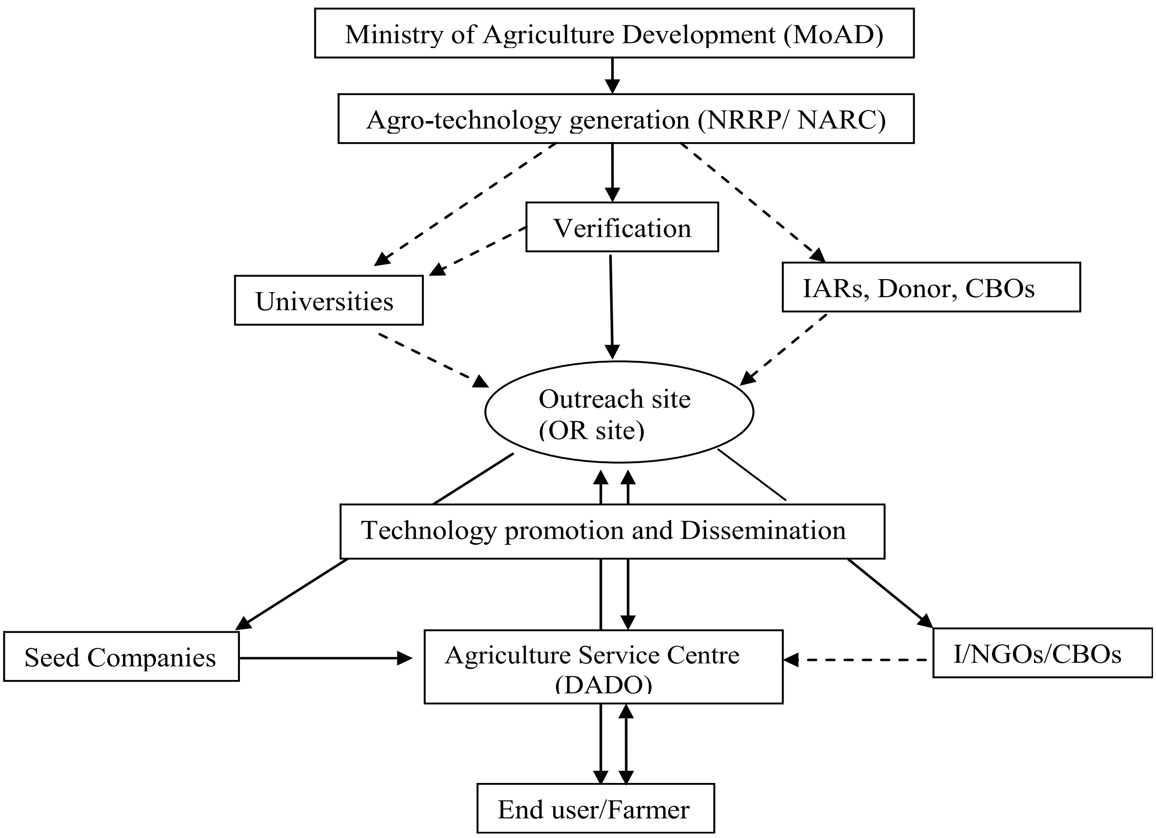

Figure 1. Schematic representation of rice research linkage in Nepal

Collaboration with IRRI

International Rice Research Institute (IRRI) was established in 1960 in Philippines. The flow of material from IRRI for research activities in Nepal started in 1996 (NARC 1997, Bhandari 1995) and it started working with Nepal in 1985. It has been providing different international observation nurseries through International Network for Genetic Evaluation of Rice (INGER). The nurseries consist of abiotic especially cold tolerance and ecosystem wise nurseries, biotic such as diseases and insects related nurseries. IRRI has been also helping for sharing information and capacity building in terms of short term and long term trainings. In addition to training to researchers and extension workers, it also provides opportunity for exposure visit to policy makers. Memorandum of Understanding (MoU) for scientific and technical cooperation in research and training on rice between NARC and IRRI was first signed in January 2001 at IRRI, Philippines. Afterward, IRRI-Nepal office was established in Kathmandu, Nepal in January 2005. It was established to strengthen collaboration and extend linkages with all the government and non-government organizations engaged in rice research and development in Nepal. Knowledge update and technical assistance from IRRI are being received through print, electronic media and website to researcher and extension workers on rice research and development.

IRRI has been playing a key role in hybrid rice development, improvement in genetics of rice, disease management, various abiotic and biotic stress resistance/tolerance, various ecosystem based rice lines, fine and aromatic rice variety development in Nepal. IRRI-Nepal office coordinates with NARC for various rice research projects. The objectives of coordinating project are: for germplasm sharing for - climate resilience, biotic and abiotic stress tolerance; hybrid development, enabling seed polices and facilitating exchange of information and germplasm. Likewise, coordinating project assembles the researchers, academicians, extension personnel, private seed companies and farmers in the same platform for rice research and development in Nepal.

Collaboration between IRRI and Nepal is more than 50 years old. So far, Nepal has released 78 rice varieties including 30 IRRI-bred varieties. Nearly, 2800 Nepalese rice landraces are preserved in IRRI's genebank. Recently, 8 drought and 2 submergence tolerant rice varieties have been released after collaboration with IRRI. Nepal has been a member in steering committee of many consortiums coordinated by IRRI like: Consortium of Unfavorable Rice Environment (CURE), Consortium of Cold Tolerance Rice Research and Development, Consortium of Hybrid Rice Research and Development and Consortium of Rice Research in Asia. Hybrid rice research has been initiated in Nepal since 2002 with testing of international hybrid rice observation nursery through INGER.

The ongoing projects in collaboration with IRRI are as follows:

- Stress tolerant rice for Africa and South Asia (STRASA),
- Accelerating the Adoption of Stress-Tolerant Rice Varieties by Smallholder Farmers in Nepal (USAID-ASTV),
- TA8441- Development and dissemination of climate resilient rice varieties for water shortage areas of South Asia and South East-Asia,
- EC-IFAD funded collaborative project,
- Cereal System Initiatives in South Asia (CSISA),
- International Network for Genetic Evaluation of Rice (INGER),
- Managing rice landscapes in the marginal uplands for household food security and environmental sustainability: IRRI/IFAD,
- Developing and disseminating water saving rice technologies in South Asia: IRRI/ADB.

Collaboration with CIMMYT

International Maize and Wheat Improvement Centre (CIMMYT) works for maize and wheat crops research and development worldwide. In addition, CIMMYT also conducts on-farm trials to mitigate effects of climate change scenario through validating and transferring rice based farming systems technologies to increase crop productivity per unit land per year for improvement of livelihood of the people in Nepal. NARC has been working with CIMMYT under different projects for improving rice production and productivity. Officially, CIMMYT became partner with Nepal in 1985. A long-term experiment was conducted at National Wheat Research Program (NWRP), Bhairahwa in 1988 to study the effects of mineral fertilizers and/or manure on soil fertility in rice-wheat cropping systems. CIMMYT provides fund and technical assistance to promote agronomy trials and more specifically conservation agriculture using modern mechanical tools.

CIMMYT funded for testing and evaluation of different methods of rice transplanting in Rupandehi during 2002/03 (Khan et al 2004). Similarly, CIMMYT and RWC-IGP supported to Rice-Wheat system research in Nepal for on-farm and on-station evaluation of systems of rice intensification (SRI) for increased production of rice (Tripathi et al 2004a). RWC-IGP supported to evaluate the performance of direct seeding (DSR) with different resource conservation technologies (RCTs) over conventional TPR in rice-wheat cropping system during 2002/03 and 2003/04 in Rupandehi district (Tripathi et al 2004b). Survey of boro rice in Nepal during 1997-98 was financially supported by CIMMYT and rice genotypes were also made available from India to conduct yield trials. Some scientists from NARC also participated in observation tour on boro rice to India funded by CIMMYT. The first workshop on boro rice on the occasion of International year of rice was held at RARS, Parwanipur on the 4th Oct 2004 funded by CIMMYT, Nepal (Bhurer et al 2007). Several rice scientists, extension personnel and farmers participated in the workshop and shared information regarding boro rice.

An ACIAR funded and CIMMYT led 4 year (2014 to 2018) project "Sustainable and Resilient Farming Systems Intensification in Eastern Gangetic Plains (SRFSI in EGP)" in Nepal, participated in by Bangladesh and India has been undertaken. In Nepal, project is executed by NARC in partnership with DoA and International Development Enterprise (IDE-Nepal). Under NARC, RARS, Tarahara and NRRP, Hardinath are working in project sites, Sunsari and Dhanusha districts, respectively. The project is supposed to address declining soil fertility, decreasing rainfall pattern, higher cultivation cost and labor shortage during peak agricultural activities. Conservation agriculture project of CIMMYT aims at increasing the productivity of food crops in the Eastern Gangetic Plains with minimum tillage through use of farm machineries and supplementary groundwater irrigation practices along with sustaining the soil fertility in rice based cropping system.

Collaboration with LIBIRD

Local Initiatives for Biodiversity, Research and Development (LIBIRD) is a national non-governmental organization and works with NRRP/NARC on: participatory plant breeding (PPB), participatory varietal selection (PVS), client oriented breeding (COB), wild and wild relatives, rice landraces, germplasm collection, and conservation and utilization activities in rice. NARC started collaboration with LI-BIRD in 1997 through in-situ conservation of agro-biodiversity at different locations (Bara, Kaski and Jumla). The project covered several crops including rice in order to initiate conservation of endangered crop species for future use in Nepal. NRRP closely worked for rice and prepared the list of endangered landraces of rice. The project collected the landraces through diversity fair and maintained rice diversity block at Kachorwa, Bara. Several crosses were made using popular traditional rice varieties with selected donors to improve agronomic performance of the local varieties and conserve the diversity (Chaudhary et al 2004).

PPB was first initiated to develop cold tolerance rice variety for high altitude (Sthapit 1996) and *Chhomrong Dhan* is its first output. PPB was employed through in-situ conservation project in collaboration between LI-BIRD and NRRP (NARC) since 1999. Several landraces: *Jethobudho*, *Bayerni*, *Biramful, Panhele,* *Kariya Kamod and Lalka Basmati* were enhanced through project by improving blast tolerance, lodging tolerance, post-harvest quality traits, good yield and market potential because of their popularity among the farmers. *Jethobudho* and *Lalka Basmati* are outputs of in-situ conservation project through PPB approach in collaboration between NRRP and LI-BIRD. LI-BIRD has its own breeding program and generates rice lines for different ecosystems. It conducts on-farm trials in the form of PVS (participatory varietal selection), mother and baby trials in collaboration with DoA. It also shares rice lines with NRRP for testing in multi-location trials (Chaudhary et al 2007) and for multiplication of breeder and foundation seeds.

Linkage of NARC with educational institutes like IAAS, AFU, HICAST

NARC maintains a close coordination and linkage with educational institutes for agriculture. NARC has signed an agreement with IAAS, especially for practical works and research activities of the students. NARC has assisted in providing research materials and research venues for post graduate and doctoral students of IAAS, AFU and HICAST. Moreover, scientists from NARC also support students of these institutes by supervising the research work.

Linkage with other Organizations

- Forum for Rural Welfare and Agricultural Reform for Development (FORWARD), in collaboration with LI-BIRD, DoA and NRRP, promoted new rice and legume varieties developed from client oriented breeding in Dhanusha, Mahottari and Rupandehi district since 2008.
- Diffusion of boro rice technology was implemented in Bara under IFAD project in collaboration with AIRC, Ranighat, Birgunj, NARC (Bhurer et al 2007).
- SMCRSP, Cornell, USA provided the funding for study on competitive ability of rice cultivars against weeds in mid-hill ecology during 2001 and 2002 summer season (Ranjit et al 2004).
- German Academic Exchange Service (DAAD) provided scholarship for higher studies to researchers and also provided fund to carry out experiment. DAAD funded to carry out study in floodwater chemistry of lowland rice in mid-hill region of Nepal (Tuladhar 2004).
- Overseas Development Administration (ODA) of the British Government funded for studies on inheritance and selection of field tolerance to sheath brown rot disease in rice during the summer of 1993 in the research command area of the Lumle Agricultural Research Center (Sthapit et al 1995).
- Development of cold tolerant parental lines and analysis of cold tolerance genes supported by Rural Development Administration (RDA), Korea.

Conclusion

NRRP/NARC has been making efforts for generating rice varieties and associated production technologies in collaboration with national and international agencies, institutions and donors. So far, 78 improved rice varieties have already been released and 30 hybrid varieties have been registered. Several GOs, NGOs, universities and international partners have been working closely to meet the objectives of rice research and development in Nepal. Faster promotion and dissemination of improved rice production technologies to wider areas demand the strong development methodologies and increased collaboration and linkage among all the stakeholders, especially researchers and development workers in the future. All the partners need to work together for the betterment of rice research and development of Nepal.

The linkage among organizations (GOs, NARC, I/NGOs, IARS donor, universities) has to focus on policy issues, investment, institutional strengthening, capacity building, technology generation tools and promotional activities to mitigate food and nutritional insecurity and climate change. Exchange of materials and information are necessary for biodiversity conservation and utilization in order to promote the materials and technologies in participatory approaches for rice research and development in the future.

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International Rice Research Institute (IRRI) Support on Human Resource Development for Rice Promotion in Nepal

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Collaboration between IRRI and Nepal which started in 1966 is more than 50 years old. The direct collaboration started in the beginning of January, 2005 after the establishment of IRRI-Nepal Office in Kathmandu. Government of Nepal has recognized IRRI office in Nepal to be of international standard.

International Network for Genetic Evaluation of Rice (INGER) is a consortium of National Agricultural Research and Extension System (NARES) of rice growing countries and International Agricultural Research Centers (IRCs), which was established in IRRI in 1975. INGER is the global model for exchange, evaluation, release and use of genetic resources under the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), which uses Specific Material Transfer Agreement (SMTA) to facilitate access and benefit sharing. INGER has released 667 rice varieties in 62 countries of the world with the economic benefit of 1.4 to 1.6 billion US dollar. More than 50% rice varieties released by the Government of Nepal comes from IRRI through INGER and other projects of IRRI. IRRI has included Nepal in the Steering Committee Members of different rice consortiums (Consortium of Rice Research in Asia, Consortium of Unfavorable Rice Environment, Consortium of Temperate Rice Research, Consortium of Hybrid Rice Research and Development) for sharing experiences of rice research and development in the international forums.

A total of 313 Nepalese scholars completed their studies and short training courses from 1996 until the end of 2015, where 54 completed their Doctoral Degree (Ph.D.), and 47 finished their Master's Degree, 10 were on-the-job trainees, and 201 attended various short courses. In addition to this, different exposure visits to Scientists and Government Officials of Nepal were organized in the IRRI Head Quarter, Philippines and different countries of the world. In this way, IRRI has helped Nepal for developing technical manpower in rice research and development.

Different rice technologies for control of diseases, insects, plant nutrients management, resource conserving technologies and conservation of agricultural technologies on rice in Nepal were jointly developed by IRRI, Nepal Agricultural Research Council (NARC) and Department of Agriculture (DoA). IRRI and Nepal Agricultural Research Council (NARC) have initiated Hybrid Rice Research in Nepal since 2013 by bringing CMS lines and R lines from IRRI. IRRI has been strengthening seed-net in Nepal by organizing different regional, national and international meetings/workshops as well as by providing technologies for quality seed production. IRRI programs have also contributed in effective marketing of seed to seed companies, cooperatives and farmers' seed producers' groups. Some financial and technical supports have been provided to different research centers of NARC for breeder seed production and validation of rice technologies as well as to different District Agricultural Development Offices (DADOs) of DoA for the promotion and dissemination of improved rice varieties in farmers' fields.

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History of Tenancy System and its Present Status in Nepal with Reference to Rice Farming

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सारांश

नेपालमा विशेष गरेर धान खेतीमा मोहियानी प्रथाबारे ऐतिहासिक तथ्य र घटनाहरू बटुल्नु यो लेखको अभिप्राय हो । यसका लागि केही पुराना अध्ययनहरूका साथै कृषि गणना र जानकार व्यक्तिहरू आधार बनेका छन् । नेपालमा मोहियानी प्रथा प्राचीनकाल किरात युगमा घुमन्ते खेतीको सुरुवातसँगै भएको हो । त्यतिबेलाको मोहियानी व्यवस्थापनमा मनुस्मृति र कौटिल्यको अर्थशास्त्रको प्रभाव परेको थियो । लिच्छवीकालमा राजपरिवार र धार्मिक संस्थाहरूको जग्गा कमाउनेले कुत बुझाउनु पर्दथ्यो, जसलाई पिण्डक भनिन्थ्यो । कुत शब्द सर्बप्रथम मानदेवको पालामा आएको हो । राजा अंशुवर्मा मोही व्यवस्थापनमा कौटिल्यको अर्थशास्त्रबाट प्रभावित थिए । मध्ययुगमा जयस्थिति मल्लले केही सुधार गरे । मोहियानी प्रथाको विकास गर्ने कुरामा राजा राम शाहको विशेष भूमिका रहेको छ । राजा राम शाहले जग्गा धनीलाई तल्सीङ र कमाउनेलाई मोही नाम दिएका थिए । आज पनि त्यही शब्द प्रचलनमा छ । उनले अरूको बाँझो जग्गामा कुलो पानी चलाएर खेती गर्नेले पहिलो तीन वर्षसम्म जग्गा धनीलाई केही तिर्न नपर्ने र तीन वर्षपछि अँधिया दिनुपर्ने नियम बनाएका थिए । नेपालमा १९६४ मा भूमिसुधार कार्यक्रम लागू भए तापनि विभिन्न किसिमका तिर्ने तरिकाहरू सहित यो अँधिया प्रथा अद्यापि कायमै छ। कृषि गणना २०११ अनुसार ८४ प्रतिशतभन्दा बढी परिवारले आफ्नो साथै अरूको जग्गा कमाएको देखिन्छ । यिनीहरू कानुनी रूपमा मोही नभएर जग्गाधनीसँग छिमेकी भएका नाताले विभिन्न शर्तमा जग्गा कमाउनेहरू भएको अध्ययनले देखाउँछ । घरदेखि टाढा रहेका थोरै जग्गा भएका साना जग्गा धनीहरू र वास्तविक खेती गर्नेहरूलाई पुनर्विचार गरेर भूउपयोग नीतिको प्रभावकारी कार्यान्वयन गर्नु पर्ने देखिन्छ ।

Summary

The main purpose of this article is to document some historical facts and events of tenancy system with special focus on rice farming. For this, some earlier studies were reviewed along with the review of Agriculture Sample Surveys and Key-Informants Survey. Tenancy System was begun in Nepal from the ancient time -Kirat Regime- when nomadic man started cultivation. There were some arrangements on tenancy system and rent payment as guided by Manusmriti and Kautilya's economics. In Lichhavi regime, tenants had to pay *pindak*, which was a rent to be paid for the cultivation of royal families' land or religious properties. The word '*KUT*' was used for the first time in Nepal during the reign of Mandev. King Amsuvarma was influenced by Kautilya's economics under tenancy arrangement. In Medieval period, some initiation was taken by Jaysthiti Malla on tenancy improvement. King Ram Shah was the pioneer for developing the tenancy system. Under this, land owners were named as *Talsing* and tillers as a *Mohi*. *Mohi* had to pay rent for cultivating *Talsing's* land. Also, he made some provisions in favor of tenants. If fallow land was brought into cultivation, the tenant should not have to pay any rent to *Talsing* for three years, thereafter 50% (*Adhiya*) crop sharing was fixed. This *Adhiya* system still prevails even after the implementation of Land Reform Program in 1964 with varying mode of payments. According to the Agriculture Census 2011, more than 84% farm families were found cultivating their own land or in rented land. Most of the farmers who were cultivating others' land were not the legal tenants, but were the neighbors of landowners and cultivating land in different terms and conditions. Effective implementation of land use policy is required to grant due consideration to small and/or absentee land owners and real tenants.

Keywords: *Adhiya*, Land use policy, *Mohi,* Rice, Tenancy

Introduction

Tenancy System began in Nepal at the ancient time when nomadic man started cultivation. This cultivation is assumed to have started in Kirat Regime (Pandey 1985). In this regime, agricultural land was divided into three categories: i) land belonging to royal families ii) land for religious purposes and iii) land for common people (Pandey 1985). In this era, there was competition among people to accumulate land for cultivation since land was considered a symbol of power. As a result, two groups emerged - landlords and small land holders. These small holders and landless households started renting land for the cultivation with certain terms and conditions. These terms and conditions were guided by *Manusmriti* and *Kautily*'s economics. *Manusmriti* was a kind of state law to be followed by rulers and country people including tenants. In *Manusmriti*, tenants were made responsible for better land management, could be punished in case of land degradation and could be kicked out if there was unsatisfactory performance. These terms and conditions were in favor of landlords, not in the favor of tenants. *Kautilya*'s economics was also very conservative for tenants. In his economics, tenants had to pay three fourth of production to the landlords for the provision of land and seeds and tenant could get only one fourth of production for his labor. In case of cannel construction for the new irrigation, the terms were reversed. In other words, tenants had to pay only one fourth of the production for the use of land and tenants could get three fourth (Giri 2001).

History of tenancy system in Nepal

In *Lichhavi* regime, tenants had to pay *pindak*, which was rent for the cultivation of royal families' land and the land of religious institutions. The word *'KUT'* meant rented land during Mandev's regime. King Amsuvarma was influenced by *Kautilya*'s economics under tenancy arrangement. In the Mediaval period, some initiation was taken by Jaysthiti Malla on tenancy improvement. Land cadastral survey and provision of *Birta* land for selling rights and mortgage were major improvements. King Ram Shah was the pioneer of tenancy system. Under the system introduced by him, land owners were named as Talsing and tillers as Mohi. Mohi had to pay rent for cultivating Talsing's land. He also made provision in favor of tenants. If the fallow land was brought under cultivation tenants should not have to pay any rent to Talsing for three years; thereafter they had to pay 50% (*Adhiya*) of the harvested crop.

Similarly, Prithivi Narayan Shah had allocated land to civil servants as a *Jagir*. This *Jagir* land was cultivated by tenants and had to pay rent to civil servants. Prime Minister Bhimsen Thapa made it clear that no one could get additional benefits apart from the rent. In 1910 BS, *Muluki Ain* (civil code) was implemented, however, it was more in favor of land owners. After 1950, some efforts were made in favor of tenants through the formulation of acts and Commission Reports. However, these were not effectively implemented, this is because, owners themselves had been registered as the tenants, not as the actual tenants. In 2014 B.S. Voomi Sambandhi Ain (Land Related Act) was introduced focusing on rent. It was provisioned that tenants did not have to pay more than 50% of production to the land owner. This act was again revised in 1959 allowing transformation of tenancy from A to B.

Before the land reform in 1964, tenancy system was controlled by landlords, often absentees. These landlords include *Ranas* and their followers. There was no compromise to land lords' proposals. The landless households and/or those having no rice field or small rice area were bound to accept the terms what the landlords proposed/imposed. This was mainly due to the importance of rice having socio-cultural values as well as rice being a better option for livelihoods because of the limited opportunities in their areas. The situation no more prevails now. Rural youths are migrating to urban areas, or abroad instead of renting and working on rice field for cultivation.

There was some standard set for rent usually on production basis at 50% of all the production. Land was rented out mostly by absentee owners and even small land owners, who could not cultivate themselves due to the lack of working members in the family. Such rent was fixed either in amount, or in quantity or share crop basis. Under share crop, each seasonal production was divided on crop production basis. Even today, small holders of so called upper caste prefer other services over the agriculture. Such families grant their land temporarily on rent. This is a wide phenomenon continued both in the hills and Tarai for rice crop. However, these tenancy practices are varied even in rice farming from east to western Tarai and hills, depending upon the socio-economic environment.

Land reform program 1964

The land reform programs were introduced in Nepal in 1964 with the enforcement of the Land Act, 1964. The objectives of these reforms were: (i) a more equitable distribution of cultivable land; (ii) improvement in the living conditions of the actual tillers by providing them with technology and resources necessary to increase production; and (iii) to divert unproductive capital and human resources from land to other sectors of the economy.

According to Nepal Agriculture Sector Strategy Study, the most perceptible impact of land reforms has been on tenancy conditions. Almost 1.8 million tenants were identified and temporary identification slips were issued to them during the reforms. Certificates of tenancy were also awarded to more than 300,000 tenants. This was the first time that tenants were officially identified and security of tenancy was guaranteed to them. A substantial number of tenants, estimated at 40% of the total, were however, left out during the process.

The Government took various measures to improve the condition of tenants during the first few years of land reform. Firstly, total rents paid by tenants were confined to the main crop instead of total crops. Again in 1973, the government fixed rents payable by tenants in absolute amount in 12 districts of central and eastern tarai regions. These were: Chitwan, Bara, Parsa, Rautahat, Mahottari, Sarlahi, Dhanusha, Siraha, Saptari, Morang, Sunsari, and Jhapa. In three districts of Kathmandu Valley, rent was already fixed in absolute amount by law. The rents have been fixed by the Survey Department on the basis of fertility status and access to irrigation facility. These are: *Abal, Doyam, Seem, Char* in order as per the quality (in terms of productivity and irrigation facility) of land. As for rice cultivation, the rent was fixed NRs 827, NRs 661, NRs 468, and NRs 358 respectively for these four categories of land in Kathmandu Valley (ADB and HMG 1982).

These are some historical evidences on tenancy system in rice farming. The common practices now are crop sharing, land mortgage, fixed amount as a rent depending upon the demand and supply of rice fields.

Operating land by farm size

A comparison is made to identify the land holding status by holders and areas operated in percentage in past 30 years. **Table 1** shows the differences of holders and average size of holding over the period based on Agriculture Sample Surveys carried out in 1981/82 and 2011/12.

Table 1. Comparative information on land holding and size

Size of holdings	Household (%)		Land area (ha)		Average size (ha/HH)	
	1981/82	2011/12	1981/82	2011/12	1981/82	2011/12
Landless	0.37	3.02	0.00	0.12		0.03
<o.5 ha	50.12	51.87	6.58	19.20	0.15	0.24
0.5-1 ha	16.20	25.69	10.75	27.52	0.75	0.71
1-2 ha	17.28	14.33	19.91	29.69	1.29	1.37
2-5 ha	12.61	4.80	34	20.13	10.33	10.18
5-10 ha	2.74	0.28	15.78	2.74	6.47	6.44
>10 ha	0.68	0.03	13.09	0.60	21.68	14.45
Total HH	2193956	3831093	2463717	2525639	1.12	0.66

Table 1 shows that more than 50% land owners are small holders having less than 0.5 hectare of land. All the land owners are becoming smaller and smaller in terms of farm size over this period. This is mainly because of land fragmentation among the household members having no option of livelihoods in the rural areas. For instance, the total number of land owners was 2.2 million in 1981/82, whereas the number of land owners increased to 3.8 million in 2011/12 without significant increment in cultivated area. So, farm lands are becoming smaller and smaller in sizes. For example, in 1981/82, 13% land area was owned by large farmers having more than 10 hectares of land. In 30 years' duration, the percentage of land owned by such farmers was reduced to 0.6. Due to these reasons, the average size of holdings was reduced to 0.66 ha in 2011/12 from 1.12 ha in 1981/82 (DFAMS 1990, CBS 2013). This scenario clearly indicates challenges of land redistribution from landlords to actual tillers cum tenants, due to small number of large land owners. Since the number of so called landlords has been reduced drastically, there is little scope for the new tenants to emerge.

According to Nepal Agriculture Sector Strategy Study 1982, the land reform had, however, no tangible effect on the skewed distributions of land holdings. Regarding land ceilings, only 23 thousand hectares of land or less than one percent of the total cultivable land could be acquired for redistribution. This is because of the phase wise implementation of land reform program facilitated the land owners to manage their land as per the land ceiling without causing any loss to their existing landholdings. The outcome of such phase wise implementation had encouraged land owners to transfer their land to their close relatives while discouraging the actual tenants to register them as tenants. However, they are practicing interims of share crops on production basis or in other forms.

The status of tenancy system

According to agriculture sample surveys of 1981/82 and 2011/12, owner-tillers are major cultivators. The percentage of owner-tillers was 90.48 in 1981/82. This percentage decreased slightly to 84.62 in 2011/12. The reduction in percentage (nearly 6%) was shifted to owner cum tenants. The percentage of owner cum tenants was increased from 8.19% in 1981/82 to more than 14% in 2011/12. The percentage of officially recognized tenants was around one percent in 2011/12. This analysis indicates that more than 84% are owner cum tillers, more than 14% operate their own land as well as others in rent, and around one percent of the farmers are actual tenants (**Table 2**).

Table 2. Percentage distribution of holders and land by tenure type in 1981/82 and 2011/12

Tenure form	1981/82	2011/12	1981/82	2011/12
	Holders	Holders	Land	Land
Owner tiller	90.48	84.62	86.86	79.75
Owner tiller cum tenant	8.19	14.12	11.69	19.19
Tenant	1.34	1.26	1.45	1.06
Total	2185732	3831092	2463717	2525639

Forms of tenancy system

Table 3 summarizes the common practices prevailed in Nepal under one tenure and more than one tenure basis. Under one tenure system, tillers cultivate either owned land (owner-tiller) or rented in land only (absolutely tenant tiller), whereas under more than one tenure system, one holder operates both – owned land as well as rented land. On that basis, there are different types within the tenancy system in Nepal. These types are based mainly either on fixed amount, or in fixed quantity irrespective of production, or crop sharing basis. Among them, crop sharing practice is most common followed by fixed amount under one- tenure and land rented for mortgage under more than one-tenure system.

Table 3. The common practices prevailed in Nepal under one-tenure and more than one-tenure basis (%)

Tenancy form	2011/12			
	One Tenure Form		More than one Tenure Form	
	HH	Land	HH	Land
Rented for fixed Amoun	20	16	10	8
Rented for fixed quantity	8	12	9	11
Rented for share of	44	60	57	69
Rented in exchange for	4	1	1	1
Rented for mortgage	8	5	20	10
Other rental arrangements	15	5	3	1

Note: One-tenure means either owned and operated self or rented in others' land and more than one tenure means owner-tiller cum tenant.

As depicted in **Table 3**, 44% holders rented land from others under one-tenure system and occupy 60% area. In the same way, under more than one- tenure system, crop sharing is most common practice followed by rented for mortgage and fixed amount. The table shows that 57% holders share products on production basis. The quantity produced at the harvesting time is shared between land owner and tenant farmer. In most of the cases, this is 50% of the production.

Some case studies on land tenure system

a. Adhiya System in Rupandehi and Bardiya

Terms and conditions	Rupandehi (Practice)				Bardiya (Practice)				
	1	2	3	4	1	2	3	4	Case of absentee land owner-tiller
Cost sharing on seed and fertilizer	50:50%	50:50%	50:50%	50:50%	50:50%	50:50%	50:50%	This is called *kutia bataiya*. *Kutiya bataiya* is the fixed rent on quantity produced. This is fixed in quantity on *Kattha* basis due to small farm sizes. Usually 30 Kattha equals one hectare. There are two options. **Option One** 100 kg rice/*Kattha* in the main season and 60 kg. wheat in the winter to the land owner from the tenant. **Option Two** 150 kg rice/*Kattha*/year. No extra production produced in winter and summer season. 4) Terms and Conditions on contract System of rice area. Lump sum NRs 1800 to 2500/*Kattha*/year	50:50%
Production sharing	50:50%	50:50%	50:50%	50:50%	50:50%	50:50%	50:50%		50:50%
Sharing of cost of first ploughing		land owner	land owner	land owner	land owner	land owner	land owner		
Irrigation charge sharing			50:50%	50:50%					
All other costs	tenant	Tenant	tenant	tenant	tenant	tenant	Tenant		

A case of absentee –tiller getting fixed rent from the tenant, Sarlahi district

Name: Deepak Karki (47, absentee land owner cum tiller)

Permanent Address: Dungrekhola-7, Sarlahi district migrated from Aambote -9, Sindhuli district in 1973, currently living in Kathmandu valley on rent.

Land owned: One *bigha* ie 0.67 ha.

Contractual Arrangement: He receives NRs 20 thousand per annum as a fixed rent/contract. His elder brother has been cultivating his land since 1987. He is an unofficial tenant. He is cultivating sugarcane by replacing rice. This is because of the presence of sugar mills in surrounding areas. These mills have negotiated with farmers for the market guarantee. However, due to low price for sugarcane, he has again started cultivating rice. This is common phenomenon in this area. Most of the absentee land owners have given their land to neighbors for cultivation and receive money as income on fixed basis. Sugarcane was replacing rice field by more than 92% during the healthy period of sugar mills. Now, more than 60% sugarcane area has been reverted into its original rice crop due to untimely payment.

Conclusion

Tenancy system has prevailed in Nepal in rice farming from ancient period, rooted on *Manusmriti*, and *Kautilya*'s economics. Some corrective measures have taken place in favor of tenants and their securities and such attempts are still on. However, in the present context, the rural youths are migrating to urban areas or abroad instead of renting rice field for cultivation. Recent Agriculture Sample Survey, 2011/12 shows that majority of farm households is small in size. So, more than 84% holders are found to be owner cum tenants (mostly unofficial). In addition to their own land, they rented land from mostly absentee land owners with varying terms and conditions as shown in some case studies. In such circumstances, land use policy has to be formulated considering: small as well as absentee land holders and actual tenants. One percent of tenant do not possess any land for cultivation. In such circumstances, effective land use policy has to be formulated and implemented with due consideration to small as well as absentee land holders and actual tenants. In the present condition, the legal tenants have grown older and their successors have no more interests in continuing the cultivation. So there is a crises of agricultural labors for farming. In this context, some measures such as: making larger plots through the acquisition of lands from the absentee land holders with certain terms and conditions and encouraging production on commercial basis while integrating production, processing and marketing based on PPP approach or other measures seems to be the need of the hour. The recent 14th Plan of NPC advocates on scientific land reform programs. It could be practical to first understand the reality and take corrective measures.

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Challenges and Opportunities for Enhancing Rice Production in Nepal

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सारांश

नेपालको सन्दर्भमा धान एक महत्वपूर्ण खाद्यान्न बाली हो किन कि यसको देन कूल कृषि गार्हस्थ उत्पादन र क्यालोरी आपूर्तिमा महत्व पूर्ण रहेको छ । छिमेकी मुलुकहरूको तुलनामा यसको उत्पादकत्व न्यून रहेको र उत्पादकत्व वृद्धि पनि कम गतिमा भएको कारण नेपालका ५० प्रतिशतभन्दा बढी जिल्लाहरू खाद्य अभावबाट गुज्रिएका छन् । यो अध्ययनको मुख्य उद्देश्य नेपालमा धानको उत्पादकत्व वृद्धिका अवरोधहरूको पहिचान गर्नु र अवसरहरूको आंकलन गर्नु रहेको छ । विभिन्न समीक्षाहरूले देखाएका छन् कि धानको उत्पादकत्व वृद्धिका अवरोध र चुनौतीहरू जैविक, अजैविक, प्राविधिक, सामाजिक, आर्थिक, संस्थागत र पूर्वाधार क्षेत्रहरूसँग सम्बन्धित छन् । हालको उत्पादकत्व स्थिर रहने वा घट्ने अवस्था, जमिन क्षयीकरण र वातावरणीय प्रदूषण जस्ता पक्षहरूले गर्दा उत्पादकत्व वृद्धिको दिगोपनमा प्रश्न उठेको छ । साथै कृषकहरूले प्राप्त गरेको र अनुसन्धानबाट प्रमाणित उत्पादकत्व बीच धेरै ठूलो खाडल देखिन्छ । यति हुँदाहुँदै पनि जमिनको उत्पादकत्व र धानका जातहरूमा रहेको उत्पादकत्व क्षमता वृद्धि गरी उत्पादन बढाउने गुञ्जायस अझै छ । धानको बढ्दो आन्तरिक मागको आपूर्ति आयातबाट समेत हुने गरेको अवस्थामा धानको क्षेत्र विस्तारभन्दा उत्पादकत्व वृद्धि गरी आयात प्रतिस्थापन गर्न सकिन्छ । यसको लागि धानको अनुसन्धानमा लगानी वृद्धि गर्ने, बालीहरूको पानी आवश्यकता पुरा गर्ने सिँचाइ पुर्वाधारको विकास, सेवा प्रवाह र प्रसार प्रणालीको सुदृढीकरण, कृषकहरूका लागि सेवा सुविधामा विस्तार लगायतका कार्यहरू गर्नु जरूरी छ ।

Summary

Rice is an important food grains in terms of its contribution to Agricultural Domestic Product (AGDP) and calorie supply in Nepal. Its productivity is low compared to other neighboring countries and the growth and productivity is also slow resulting into food grain deficit in over 50% districts of Nepal. This paper aims to identify the constraints and assess the opportunities for enhancing production of rice in Nepal. Based on the reviews, it has been revealed that attempts to enhance rice productivity is fraught with several constraints and challenges related to: abiotic, biotic, technological, socio-economic, and institutional and infrastructures. Moreover, the recent phenomenon of the stagnant or even declining yields, land degradation and environmental pollution has raised concern regarding the long-term sustainability of increasing productivity. A large yield gap exists between what farmers are harvesting in their rice fields and what has been demonstrated by research. Despite this, there is still scope for the improvement, through increasing land productivity and raising its yield potential. The yield potential of the varieties developed also seems very high. The growing demand of rice is also met through imports in the recent years. This can be substituted by increasing mainly through growth in productivity rather than in harvested area. The increasing investment in rice research, developing irrigation infrastructures to support the water need of the crops, strengthening the service delivery and extension system, and provision of support to farmers, among others are needed to increase the production and productivity of rice in Nepal.

Keywords: Challenges, Food security, Imports, Investment, Productivity, Rice

Background

Rice is the most important cereal crop, in terms of both cultivated area and production, and livelihood of the people. It is the staple food crop which supplies about 40% of the total calorie intake for the people of Nepal. It occupies about 50% of the total area under food crops of 3.2 million hectares and its contribution to the total food supply is more than 50%. This crop alone contributes to about 40% of the total calorie intake. In Nepal, it was reported that about 70% of the agricultural holdings (with land) planted main paddy, fertilizer was used by 20% of the holdings and the chemical fertilizer was used in 41% of the total area under rice (CBS 2013).

The prevailing rice ecosystems are irrigated either fully or partially (63.6%), and rainfed (36.4%) of the total rice area (MoAD 2013). The Tarai region, considered the granary of the country, accounts for about three-fourth of the country's paddy output; the hills produce 23%, and the mountain about two percent. The production systems are still subsistence based and not yet market oriented. Until early 1980s rice used to be exported through rice exporting companies from the surplus Tarai region to the Indian markets due to easy transportation access while difficulty persisted in transporting grains to the food deficit hills within the country. Population growth and the increase in the demand for food, on the one hand, and dismal growth in farm productivity, on the other, have turned Nepal gradually from a food-exporting country to a food-importing country within a few decades. With this background, the objective of this paper is to identify the constraints and challenges and assess the opportunities for enhancing production and productivity of rice in Nepal.

Constraints and challenges

Increasing rice production and its productivity in Nepal has been facing several constraints and challenges that are related to: abiotic, biotic, technological, and socio-economic and infrastructures. Some of them are limited irrigation availability, limited technological choices, and depletion of soil fertility, low and inadequate supply of seeds, labor shortages, very limited marketing infrastructures and price volatility, high costs of production, institutional ineffectiveness, climatic change impacts, and fragmentation of land-holdings. These constraints and challenges are discussed below.

Biotic and abiotic stress

Rice productivity and sustainability are continually threatened by a series of abiotic and biotic stresses. Among the abiotic stresses, drought, submergence heat and flooding in southern part cause major losses in rice production. Similarly, biotic stresses such as bacterial leaf blight, blast, brown plant hoppers (BPH), stem borer are quite serious. These stresses account for more than 25% yield losses. These losses are a major concern and they pose a risk for yield stability and sustainability. Nepal had drought problems mainly in the years: 1964, 1967, 1973, 1974, 1977, 1979, 1980, 1983, 1992, 1994, 2001, 2002, 2005, 2006, and 2009 (MoPE 2002 and MoHA 2009). In recent years, Nepal has experienced frequent dry spells in various parts of the country, particularly during 2001, 2002, 2004, 2005, 2006, and 2009, 2010, 2011, 2013. Rainfed rice production environments are the hardest hit by the dry spells. The occurrence of early-stage drought is most common in Nepal. The prolonged dry spells occurring almost every year during the last two decades caused significant reduction in yield and production of rice.

Rainfed farming

The planting and production of the rice is very much dependent on timing and intensity of the monsoon rain, which is normally active during mid-June until mid-September. Despite its importance in national food security and the economy, currently, a majority of the farmers in Nepal produce their rice crop mainly under rainfed and risk-prone marginal conditions, in which drought is a major constraint to increasing production and improving rural livelihoods. Unlike most plants, rice needs assured water to produce good yields. To produce one kg of rice, an average of 2500 liters of water needs to be supplied (Tripathi et al 2012). The challenge here is to produce more rice with less water. The ground water resources in Tarai are also depleted further aggravating the situation of water scarcity for rice. In such conditions, rainfed farming seems the only alternative resulting in low productivity of rice.

Low level of pproductivity

In the past 30 years, the rice area and yield increased annually by 0.35 and 1.65%, respectively. The growth in yield contributed about 83% to total production and remaining 17% was from area growth. During the period of 1984-2013, the area growth has been the highest for the hills (3.28%) followed by mountains (2.67%) whereas yield growth was low (0.61% Mountain and 1.56% in Hills) during that period, meaning expansion in area planted has been observed as a major factor contributing to production in the hills and mountains. However, the growth in yield contributed significantly (around 98%) to the total production in Tarai. The growth in area was higher during 1984-1998 (0.60%) compared to the 1998-2013 (-0.38%) period. This was higher for the hills and mountains (in 1984-1998: 1.35% in Hills and 1.93% in Mountains and in 1998-2013: 0.55% in Hills and 1.96% in Mountains) compared with the Tarai (in 1984-1998: 0.32% and in 1998-2013: 0.84%,-calculated from various years' Statistical Information of Nepalese Agriculture). Although the area coverage by Modern Varieties (MVs) is in over 90% of the area, growth in yield has been very slow and marginal.

Soil and nutrient management

Soil degradation and quality deterioration limit crop yields in many intensively cultivated farms. Changes in organic matter and soil nutrient supplying capacity, nutrient imbalance and multi-nutrient deficiency, water logging, zinc and iron toxicity, soil salinity and alkalinity, and development of hard pans at shallow depths are some of the major indicators of deteriorating soil quality. Similarly, there is low efficiency in the use of nitrogenous fertilizer. Urea is the most preferred fertilizer by the farmers as a source of nitrogen (N) in rice fields. But its actual use by the rice plant is not more than 30% meaning that 70% of the applied nitrogen goes either into the air or into the water. The research in this area to avert this situation is lacking. In addition to chemical fertilizer, there are avenues to augment it through organic manure, biological nitrogen fixation, and the adoption of Integrated Plant Nutrition Systems (IPNS).

A lot of yield gaps can be attributed to knowledge gaps. Several factors affect yield increase and profitability in rice, and nutrient management is one. But nutrients can damage the environment too either in the case of inadequacy or oversaturation. Rice needs essential nutrients such as nitrogen, phosphorus, and potassium, which are typically not found adequately in the soil. Nepalese farmers' practice in fertilizer use with regard to timing and method of application could significantly reduce nutrient losses and improve nutrient uptake. Zinc deficiency is also a major problem in lowland rice culture with soil of neutral to alkaline pH.

Climate change

The major environmental problems that can seriously damage rice production include drought, flooding, and erratic rainfall. Rainfall appears to have a strong negative effect on yield if it occurs at nursery stage. Similarly, rice production also contributes to climate change by generating Green House Gas (GHG). Climate change is projected to affect rice production through changes in the concentration of carbon dioxide, and a rise in average temperature. In addition, it is expected that climate change will increase the frequency of extreme climatic events (ie storms, drought, monsoon, heavy rainfall), thus increasing the probability of flooding (Wassman et al 2004).

Increases in temperature above the current mean temperature for *ceteris paribus* conditions are expected to reduce rice yields by 7% for every 1^0C increase in temperature. Climate change increasing the concentration of carbon dioxide is expected to improve yields and water productivity. In this way, dry matter production and the number of panicles should increase as well as grain-filling percentage (Ziska et al 1997). Night time increases in temperature has shown negative impacts on rice yield. More specifically, for each 1^0C increase in night time temperature, a decline of 10% in grain yield has been recognized (Peng et al 2004). In terms of greenhouse gas emissions, rice is characterized by decreasing carbon dioxide and for having low emissions of nitrous oxide and high emissions of methane. Flooded rice fields have a tendency to sequester carbon. Rice monoculture systems accumulate about 45 tonnes of carbon per hectare; in rotational systems, the accumulation is usually lower. For nitrous oxide, emissions are relatively low and varying across the different rice environments. In irrigated rice fields, emissions are concentrated during the fallow period and after flooding. In rainfed fields, the aerobic accumulation of nitrate may foster remarkable emissions. Methane emissions are mostly influenced by the management of water and organic inputs. Flooding condition increases the potential for methane emissions.

Declining production resources

As a consequence of economic growth, current rice cultivation areas are likely to be lost to urban expansion, land conversion to other purposes and diversification into other agricultural products. In Nepal, the rice land is shrinking owing to industrialization, urbanization, crop diversification and other economic factors. Under these pressures, rice area declined from 1544604 hectares in 2001 to 1456000 hectares in 2011, which is 6% decline (CBS 2011). This all means that sufficient production to meet growing future demand will have to come from smaller and smaller areas, particularly if diversification is to be possible while keeping rice prices affordable to poor consumers. In turn, this adds urgency to the need to improve productivity. The growing urbanization will further reduce the agricultural labor and increase the labor wages which demands for more mechanization.

Investment in research

The past and present trends in research expenditure pattern in Nepal indicate that, historically, agricultural research has received a low priority, in spite of its major role in generating new technology to enhance and sustain productivity of rice growth in agriculture. The Research institution established for rice research currently has very limited resources and insufficient technical capacity to conduct and coordinate research activities and strengthen ties with national and international centers. The growth of research investment was erratic and inconsistent in rice, maize and wheat during last ten years. The overall research costs in all three commodities had declined in real term over the years. Of the last ten years, during the first three years, higher investment was found compared to latter years. This investment ratio changed in the following years. It showed that research investment varied according to donor's support in rice as the World Bank supported AREP had largely contributed in the research cost of rice during the initial three years period. On an average NRs 6077.6 thousand per annum had been invested for rice research whereas around 24% of this budget (NRs 1458.4 thousand) was allocated for varietal development.

Infrastructures and service delivery

In Nepal, the total number of farm household is about 3.8 millions. The ratio of JT/JTA to farm household is about 1:2300 in Nepal. Similarly, single agriculture service center is responsible to provide extension service to around 10000 farm household. With this scenario of the limited resource and extension personnel, rice farmers get very few extension services on different aspects of crop production and management. To depute specialized technicians at the field level are not in practice. The general agronomist or agriculturist takes care of extension related to rice production and post-harvest related matters. There is a challenge of developing and implementing effective and efficient service delivery system to the poor farmers.

Although the market centers (collection centers, wholesale markets etc) have been developed in different parts of the country, these are mostly used for perishable commodities such as vegetables, fruits and milk. The specialized markets for cereal grains including rice are lacking. Private sectors have developed their own storage facilities and market yards to buy and sale the rice as per their convenience. These facilities are not appropriate resulting into significant post-harvest losses.

The most important constraint is poor infrastructures as they revealed about the problems of poor road for transportation and non-availability of transporting facilities to move the rice produce from farmer's field in rural areas to the markets and home. Nepal's road density is the lowest in the region, with 0.6 kilometers of road per 1,000 people compared with 6.5 km in Bhutan, 4.7 km in Sri Lanka, 3.0 km in India, 1.9 km in Bangladesh, and 1.7 km in Pakistan (ADB 2009).

Fragmentation of holding difficult for mechanization

The total land holdings in Nepal has increased from 1654 thousand in 1971 to 2522 thousands in 2011. However, the average size of land holding has decreased from 1.13 ha in 1981 to 0.68 ha in 2011. There is a great challenge to meet the country's requirement of food from these small and scattered holdings. Land availability for agriculture is becoming limited due to competition for industrialization, urbanization and expansion of residential areas on rice field. Fragmentation has also put hindrances in adoption of agricultural mechanization and minimizing cost of production.

Markets and prices

Usual pattern of rice price in the country is that the prices are low during the harvesting season and higher at the later months when there is no paddy in the farmers' hand. Lack of marketing infrastructures, non-provision of Minimum Support Price (MSP), lack of storage facilities, price fluctuation due to open boarder with India are the major problems related to markets and price in rice.

Nepalese rice marketing is in the hand of private traders and its trade and prices are also influenced by the marketing agents and traders across the borders (India). Informal sources indicate that the agents across the border buy rice at low prices from Nepal during harvesting season and export to Nepal when the price increases at the later period. Due to the lack of regulated markets and storage facilities and unorganized marketing behavior of the producers in Nepal, the producers and consumers are at disadvantageous position (producer receiving low prices and the consumers paying high prices).

Varieties release and adoption

The National Agricultural Research Council of Nepal is developing modern varieties of rice considering the needs of diverse ecosystems and production environment in Nepal. This has resulted in coverage of MVs in around 90% of the total rice area. It is reported that around 52% of the total rice area is under old MVs (developed before 1990). Varieties released in India such as Sona Masuli (released in 1982) and Sarju-52 (released in 1979) occupy around half of the area under old MVs. Most of these varieties were released in the early 1970s and 1980s. Moreover, the farmers are still cultivating de-notified varieties although in a small area. The adoption of the varieties released over 40 years such as Masuli, and over 30 years such as Sabitri, Sarju-52 and Sona Masuli show that either other varieties were not disseminated in the recommended domains (or their seeds have not been made available to the farmers) or farmers' have special preferences for the attributes of these varieties. The share of the specified new MVs (released after 1990) in total area is around 35% (CDD 2015).

Profitability of rice production

The gross margin varies with per unit price factors (inputs) and the output (main products). There has been sharp increase in the wage rate and price of inputs (seeds and fertilizer) compared to the increase in yield and farm gate prices. During the last 13 years, the wage rate increased 339%, the price of seeds to 345%, price of fertilizer from 53 to 140%. During the same period the yield increase was only 46% and increase in farm gate price was 126%. The per unit net profit declined due to more increase in prices of factor inputs compared to the increase in yield level and output prices.

Opportunities of rice farming in Nepal

Of the 75 districts in Nepal, rice is grown in 73 districts except in Mustang and Manang of trans-Himalayan region. People of Nepal who do not eat rice as their main diet use to say that they eat *bhat* (table rice) which strictly implies to rice for eating rice is social prestige compared to other foods. In this way rice is not only a food but a culture as well. Hence, rice is culturally and socially associated to Nepalese society and role of rice is more important than ever from cradle to crave of Nepalese ethno-culture. Rice in Nepal is number one crop both in area and production. In 2013/14, share of agriculture for national Gross Domestic Product (GDP) was 32% of which the share of rice was 20% in Nepal. Therefore, rice holds very important position both in agriculture and economy of Nepal. The opportunities associated with rice production are discussed as follows.

Potential for increased production

The yield of rice and maize is the lowest in Nepal (3.31 t/ha) among the South Asian countries (Bangladesh-4.42 t/ha, Bhutan-3.68 t/ha, Pakistan-4.06 t/ha, Sri Lanka-3.85 t/ha) (FAOSTAT 2013). Comparing Nepal, Tarai (3.48 t/ha) with the Indian states (Punjab-3.74 t/ha) the yield level of Nepal is far below than the Punjab, an advanced state in terms of agricultural development. There is a potentiality for increasing yield in Nepal if proper assessment is made with regards to constraints and adopt the technologies developed elsewhere through adaptive trials.

Minimizing yield gaps

The promised yield of rice varieties comes to be 4.89 t/ha. The yield gap between the promised/potential yield and the actual yield at the farm level is 54% per unit of land. Geographically, the average potential yield and yield at farm level in Tarai, Hills and High hills are 4.23, 6.32, 5.40 and 3.29, 3.06, 2.09 t/ha respectively (NARC 2014, MoAD 2013). This demands an in depth analysis of underlying causes. This also indicates a prospect of increasing the food production through productivity increment.

Potentials for increased productivity

The increase in the production of rice is possible through improvements in productivity because of the closing land frontier. The differences in the yield of paddy occurs due to changes in the types of seeds and irrigations are provided as the yield levels gradually increase as we move up in the technology ladder from paddy production under the local seed without irrigation (1.86 t/ha) to the improved seed with irrigation (3.17 t/ha) (MoAD 2013). In Nepal about 92% of the area shown under paddy is covered by the improved varieties of rice. Therefore, paddy production could be increased further expanding the area under improved seeds. Similarly, under the rice-wheat cropping patterns, as we move up from local variety-unirigated to improved variety-irrigated farming, the grains yield go up from 1.86 t/ha to 3.72 t/ha (pooled average 3.17 mt).

Import substitution

As already mentioned, Nepal has been a net importer of food grains including rice. It is reported that Nepal imported NRs 26000 million (NRs 26 *Arab*) worth of rice last year. This includes coarse to fine rice and imported mainly from India. This is because the rice in Nepal is losing its competitive strength due to huge farm support provided in India and the higher yield level and existence of unregulated rice or commodity market in the Nepal-India border. Hence, with the development of institutions, infrastructures (markets and irrigation) support services (quality seed supply, extension etc), the yield could be increased. It is a well-established fact that the interaction of quality seed and availability of irrigation (jointly) could contribute to yield increase by 41%. With the increased income and urbanization, the demand for fine rice is increasing. Similarly, the people have substituted in consuming traditional food crops for rice in many parts of rural areas (much of remittance is spent on consumable items including fine grain table rice). Such changes taking place could signify the opportunity of rice production, although through improving our competitive strength.

Conclusion

Nepal's economic growth is dependent on the performance of the agricultural sector due to its contribution of about one-third to GDP. The contribution of rice to AGDP is still substantial in Nepal. Thus, accelerating the growth and the performance of agricultural sector should be the priority of the government. Recent observations of the stagnant or even declining yields, land degradation and environmental pollution have raised concern regarding the long-term sustainability of production and productivity. Despite this, there is still scope for the improvement, through increasing land productivity and raising its yield potential. The challenge is to grow more rice on less land using less water, less labor and fewer chemical inputs.

Rice is an important cereal in terms of consumption and calorie intake and contributing to national food security. There is a scope for import substitution and meet the need of high income consumers (increasing the production of fine and aromatic rice). At present, the yield level is lower compared with our neighbors. The yield potential of the varieties developed also seems very high. However, a large yield gap exists between what farmers are harvesting in their rice fields and what has been demonstrated by research. In order to meet the growing demand of food (rice), the additional production has to be increased through growth in yield rather than in harvested area. Increasing production through expanding rice area is not possible due to closing land frontier. The increasing investment in rice research for developing varieties suitable to diverse agro-ecosystem of the country and challenges posed by climate change, developing irrigation infrastructures to support the water need of the crops, strengthening the service delivery and extension system, support measures to farmers (prices and non-price measures, market and road infrastructures), and developing technologies for post-harvest related aspects are very much needed to increasing the production and productivity of rice in Nepal.

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Chapter IV

(अध्याय ४)

4. Miscellaneous
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Role of Media Communication in Disseminating Rice Technologies in Rural Areas

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सारांश

ग्रामीण क्षेत्रमा धान बालीका प्रविधिहरू प्रसार गर्नका लागि संचार माध्यमको महत्वपूर्ण योगदान रहेको छ । विभिन्न माध्यमहरूको के कस्तो योगदान रहेको छ भनी विभिन्न स्रोतहरूबाट अध्ययनमा प्रविधिहरू विस्तार गर्नका लागि प्रयोग हुने संचारका साधनहरूमा लिफलेट, समाचारपत्र, खबरपत्रिका, पम्फलेट, रेडियो तथा टेलिभिजन, पोष्टर आदि रहेका पाइएका छन् । साक्षरता दर कम भएको ग्रामीण क्षेत्रका लागि प्रविधिहरू विस्तार गर्न प्रकाशित माध्यमहरू भन्दा रेडियोको महत्वपूर्ण भूमिका रहेको छ । यसले एकै पटकमा धेरैजना कृषक समेट्छ भने कृषकहरूका लागि प्रयोग गर्न सहज पनि छ । प्रविधिको व्यवहारिक ज्ञान प्राप्त गर्ने हुँदा धानखेती गर्ने कृषकहरू अन्य स्रोतको तुलनामा सामूहिक क्रियाकलापहरू, तालिम, मिनीकिट वितरण तथा प्रदर्शनका कार्यक्रमहरू बढी रूचाउँछन् ।

Summary

Media communication has an important role in disseminating rice technologies in rural areas. A review is done to explore these roles in the context of Nepal. The source of information for this paper includes reports, journals, books etc. The communication media used for the transfer of technologies include farm magazine, leaflets, newsletters, newspapers, pamphlets, radio and television, posters etc. Radio was found to be the most effective tool for disseminating technologies in rural areas as this is affordable to them and it covers large number of recipients simultaneously. Similarly, printed materials were used in some areas but it is not convenient in the areas with low literacy rates. Rice growers preferred mini-kit distribution, group activities, demonstrations and training programs on improved rice technologies as compared to other sources because farmers can practically experience the performances of rice varieties with these sources.

Keywords: Communication, Media, Performance, Rice, Technology

Background

The success of agricultural development programs in developing countries largely depends on the nature and extent of use of communication media in manpower mobilization. The planners in developing countries realize that the development of agriculture could be hastened with the effective use of communication media (Purushothaman 2003). Information and communication are essential for effective transfer of technologies that are designed to boost agriculture production. For farmers to benefit from such technologies, they must first have access to these technologies and learn how to effectively utilize them in their farming systems and practices. This should be the function of agriculture extension agencies all over the world. These extension agencies make use of different approaches, means and media in transferring improved agricultural technologies to the end users (farmers). Communication media methods in agricultural information dissemination generally, are mass media and useful in reaching a wide audience in a short period of time. They are useful as sources of agricultural information to farmers and also constitute methods of notifying farmers of new developments and emergencies.

Food and Agricultural Organization (FAO 2001) reported that in developing countries, wide adoption of research results by majority of farmers remains quite limited. This therefore, calls for a system which allows adequate information flow from researchers to farmers and vice-versa. Hence, Agricultural extension agencies have a significant role in facilitating the flow of a variety of information to offer farmers the needed exposure to innovation for overall development. In order to disseminate agricultural technologies in Nepal, different programs based on agricultural technologies are broadcasted through television, radio, newspaper, posters, pamphlets, agriculture bimonthly booklets, etc.

Information needs of rice farmers

Information on marketing, agricultural credits/loan and new seeds varieties are the major information important for rice farmers (Ronald et al 2014). This implies that farmers lack access to market information for their crops. This is consonance with Meitei et al (2009), who pointed out that information on, quantities traded, market prices and other marketing-related matters rarely reaches farmers in developing countries. Also, most of the rice farmers complained about lack of currently, and timely information on weather conditions. This is probably because of the climate change which has resulted in unpredictable rainfall and variations in weather conditions. Hence farmers fail to plan the right time to plant their crops. This is supported by Stigter (2002) who pointed out that, access to relevant weather forecast information and its communication can greatly reduce the risk and uncertainty in rain fed agriculture.

Role of media communication

In Nepal, various communication media are being used to disseminate agricultural information to farmers in line with national policy on agriculture. The objective of communicating in agriculture is to disseminate technologies to the rural communities which help to change the knowledge, skills and attitude of the target communities (Manandhar 2007). The communication media include farm magazines, leaflets, newsletters, newspapers, pamphlets, radio and television, posters, etc. Among them, radio is the most widely used communication media for transformation of technologies in Nepal. Dissemination of technologies through radio programs is usually timely and capable of extending messages to the audience no matter where they may be as long as they have a receiver with adequate power supply. Role of different media in disseminating of rice technologies are given below.

Role of electronic media

Electronic media such as FM radio and radio have been popular in Nepal in the recent years. FM radio and radio are the most effective means for dissemination of rice technologies in Nepal (Tripathi 2011). Radio is considered as an effective tool to disseminate agricultural information among farmers and it is the most powerful mass media for broadcasting information quickly.

FM and Radio can reach large audience at the same time. In terms of cost, it is an extremely economical medium as compared to other extension media and methods involving individual and group contacts. Radio is considered as a credible source of information and is considered authentic, trustworthy and prestigious medium of communication. A credible source of information stimulates farmers to adopt the recommended package which is suitable to local farm conditions. The electronic media only provides information about the new technologies, but do not provide practical knowledge to farmers. Baloch et al (2006), reported that radio, although is a powerful medium of communication in the present era of information technology, this medium is less effective as it provides only information not the practical demonstration. However, Sapkota and Shrestha (2008) reported that radio, television and publications have been seen the most facilitating means of creating awareness of knowledge for technology transfer in Nepal. In recent years, dissemination of agricultural technologies and sometimes specific technologies of rice are broadcasted through television as the audiovisual effects can be more effective to farmers.

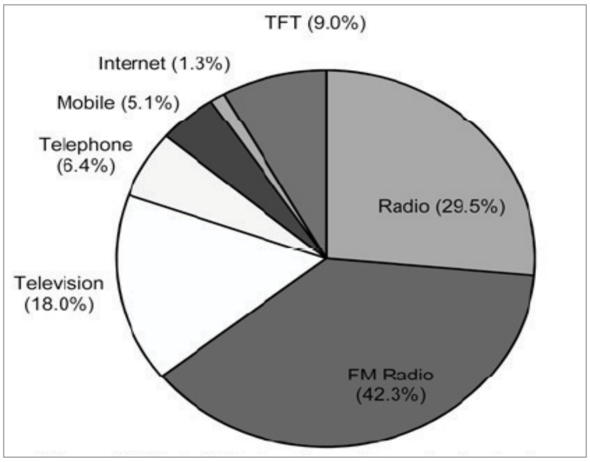

Figure 1. Effect of electronic media on rice technology dissemination

Source: Tripathi 2011.

Role of print media

Print media can combine words, pictures and diagrams to convey accurate and clear information. Their great advantage is that they can be looked at for as long as the viewer wishes, and can be referred to again and again. This makes them ideal as permanent reminders of extension messages. However, they are only useful in areas where a reasonable proportion of the population is literate. Print media used in extension include posters, leaflets, circular letters, newspapers and magazines.

In Nepal, limited print media in the form of booklet, posters, and pamphlets are produced and distributed to the limited number of farmers. Secondly, most of the farmers are not well educated and do not like to read the printed materials as they don't have enough time or the ability to read. Print media such as booklets followed by newspapers are less effective as compared to other sources of information for transferring rice technologies in Nepal (Tripathi 2011).

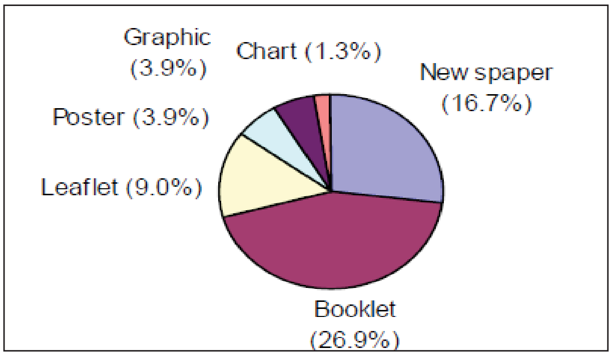

Figure 2. Effect of printed media on rice technology dissemination

Source: Tripathi 2011.

Role of other media

In Nepal, governmental as well as non-governmental organizations are disseminating rice technologies through farmer groups and cooperatives. Government of Nepal, through Ministry of Agricultural Development, is involved in disseminating technologies on seeds, varieties, disease and pest management, post-harvest technologies, etc. Similarly, many NGOs/INGOs are also transferring some specific technologies to farmers like System of Rice Intensification (SRI), Rice-duck farming, Rice-fish farming, etc. Rice growers indicate that mini-kit distribution, involvement of group farmers, demonstrations and trainings on improved rice technologies are their preferred sources of information about technologies as compared to other sources. Through their direct involvement, farmers practically experience the performances of rice varieties that they get in the form of mini-kits from different research organizations or agriculture extension offices. When agricultural technologies are provided to farmers' groups, members of such groups share their practical field experiences among themselves. In addition, they compete with each other for higher production. Regular training to farmers on improved agricultural practices updates their farming knowledge and capacitates their technical know-how. Kamruzzaman et al (2001) found that the farmers who have been exposed to farming system research sites and multiplication testing sites had less knowledge gap than other farmers. Similar findings were reported by Sapkota and Shrestha (2008), who mentioned that farmers' awareness, demonstration and verification in farmers' field along with the involvement of commercial farmers consisting of private sectors' involvement are the strengths of technology dissemination.

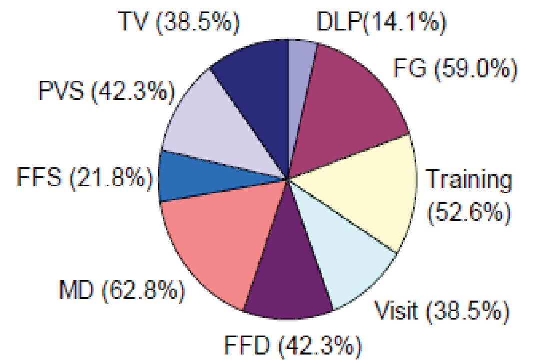

Figure 3: Effect of other than printed and electronic media

Figure 3. Effect of other than printed and electronic media

Source: Tripathi 2011.

Note: MD=mini-kit distribution, FFD=farmers' field days, FG=farmers' group, DLP=district level program, TV=television, PVS=participatory varietal selection, FFS=farmers' field school

Conclusion

The effectiveness of information or technology delivery depends on efficient application and effective combination of available audiovisual communication media. It is assumed that modern technologies are available at technology producing centers but not effectively transferred to the ultimate users. So, emphasis should be given to transfer modern agricultural techniques to farmers through the dissemination of agricultural information from various means. In order to gainfully exploit the potentials of the communication media system, the extension service agency should reach farmers regularly through the communication media to complement direct contact by extension agents. The government, on the other hand will have to direct attention to the use of communication media as the most effective means of reaching out the rural households in various development programs. With effective programming and information dissemination, the impact of communication media will be felt by the rural farmers. In this way, they realize that media is essential tool for getting the information they require for increasing their farm production and productivity.

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On-Farm Management of Rice Landraces Diversity through Community Seed Banks in Nepal: An Experience from LIBIRD

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South and South East Asian countries including Nepal are known as center of origin and diversity of rice landraces. Gupta et al (1996) had identified nearly 2,500 rice landraces diversity but now, it is estimated that most of them have already disappeared from their habitat due to various reasons including introduction of high yielding rice varieties by national research and extension system, and private seed companies. In order to know causes and consequences of loss of agricultural biodiversity and to understand the dynamism of on-farm management of agricultural biodiversity, a systematic research was initiated in late 1990s in Nepal in Bara, Kaski and Jumla districts (Sthapit et al 2005) through a Bioversity International coordinated global project called, Strengthening the Scientific Basis of In Situ Conservation of Agricultural Biodiversity. The project generated number of good practices of on farm management of agricultural diversity including community seed bank (Sthapit et al 2006).

Operated by farmers' organization, community seed bank is established to promote conservation and use of plant genetic resources for food and agriculture (PGRFA) and supply seeds and planting materials to meet the local need. This approach is now also being recognized as a mechanism to promote farmers' rights on seed and food sovereignty globally. In addition, the importance of community seed banks is also being realized in the face of climate change as it promotes crops and varieties that are adapted to local climatic condition. In general, community seed banks include conservation and seed production of various types of crops and varieties. This paper, however only describes the role of community seed banks in conservation and sustainable use of rice landraces diversity in Nepal in brief.

The first community seed bank supported by LI-BIRD in collaboration with Nepal Agricultural Research Council (NARC) and Bioversity International was established at Kachorwa village of Bara district in the Central Terai, Nepal in 2003 (Shrestha et al 2013). Learning from this case, LI-BIRD replicated community seed banks in Bardiya, Kailali and Kanchanpur districts in 2007 and 2008. Till 2015, LI-BIRD has facilitated establishment of 17 community seed banks in 14 districts and additional 4 community seed banks in Humla, Jumla, Lamjung and Dolakha are in process of establishment within 2016 (**Figure 1**).

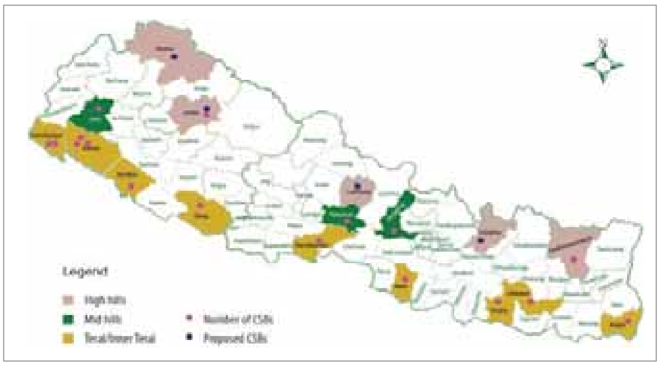

Figure 1. Map of Nepal showing community seed banks supported by LI-BIRD and its collaborating partners

Rice landraces conserved by community seed banks are regenerated regularly according to their habitat. Some community seed banks regenerate seeds in diversity block whereas some allocate responsibility among the members of community seed banks. For instance, community seed banks in Kachorwa, Bara, establish diversity block of 86 rice landraces every year. Depending on local demand, community seed banks also produce seeds of some local rice varieties in volume for selling and distribution such as *Ghiupuri* and *Jhinuwa* at Agyauli, Nawalparasi. Similarly, some community seed banks are also involved in participatory plant breeding and landraces enhancement with technical and financial support from LI-BIRD and its collaborating partners. For example, Community seed bank at Kachorwa, Bara, have developed a new rice variety named *Kachorwa* 4 using *Dhudhisaro* as a local parent. Community seed banks at Shivagunj, Jhapa and Rampur and Dang are involved in enhancing *Kalonuniya* and *Tilki* rice landraces respectively. Both of these landraces are in the process of final assessment for registration from the national system.

Table 1. Number of rice landraces conserved at community seed banks supported by LI-BIRD and its collaborating partners

SN	Location of CSB	Year of CSB establishment	Number of rice landraces conserved
1	Kachorwa, Bara	2003	86
2	Belawa, Bardiya	2007	NA
3	Gadariya, Kailali	2009	NA
4	Shankarpur, Kanchanpur	2007	12
5	Pathraiya, Kailali	2008	28
6	Masuriya, Kailali	2008	7
7	Beldandi, Kanchanpur	2008	5
8	Shivagun, Jhapa	2009	70
9	Tamaphok, Sakhuwasabha	2009	19
10	Agyauli, Nawalparasi	2009	15
11	Purkot, Tanahun	2009	18
12	Ghanteshwor, Doti	2009	7
13	Rampur, Dang	2009	28
14	Jogimara, Dhading	2009	14
15	Talium, Jumla	2011	2
16	Bhadaiya, Lahan, Siraha	2015	18
17	Katari, Udayapur	2015	NA
	Total		**329**

In total, 17 community seed banks supported by LI-BIRD have conserved 329 rice landraces (Table 1). Some of these rice landraces are cold tolerant, some are drought tolerant, some are suitable for water logging condition, and some are aromatic and fine grain. Most of the seed sample and passport data of these rice landraces have already been submitted to the National Genebank for safety duplication. There is tremendous potential of these rice landraces if properly assessed and promoted through breeding such as PPB and none breeding such as value addition and marketing for which, a strong and supportive policy environment, including more focused research is necessary.

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Parma System: A Traditional Labor Management System in Rice Farming

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Introduction

It is obvious that rice cultivation has remained labor intensive farm business of most of Nepalese farmer. Among diversified practices of technological adoption with typical labor management systems, *Parma* system, also called *Parima* or sometimes *Porima* in western hill and *Bola* in Newar (especially in Kathmandu valley) community, is one of the typical labor management system in rice.

Meaning of *parma* system

Parma is a system of labor exchange where member(s) of one family serve as a labor for other family and in return it receives equal number(s) of family labor for the same purpose from the family who gets served previously. It simply a reciprocal labor exchange between two families. In this system, value of labor in not counted in monetary term. Generally, it has been noticed that male labor is equivalent to male labor only in case of reciprocity of labor (Tamang et al 2014) and sometimes it has been found that one would get two female labor instead of one male labor (Pradhan 1983). One study carried out in Nepal (Ishii 1982) showed that exchange of labor in *Parma* system is different in Brahmin and Newar community. In Brahmin community, male and female labor were equally treated by people whereas, in Newar community one male is exchanged for two female labor. In this system labor exchange could takes place between two or more family members in a group or team basis.

J. Fortier had explained in his article (Fortier 1993) that existence of traditional labor management system like sharecropping, group labor, reciprocal labor are unique to the world. There is no evidence to provide the date when it actually started. Fortier indicated that this system has been practiced in Nepal before the eighteen century ie before the unification of Nepal.

Significance of *parma system* in rice farming

Due to biological reason, management function starting from seedbed preparation to the post-harvest activities of rice crop needs to be accomplished in time. Among those function, transplantation, weeding and harvesting activities of rice crop are more labor oriented and it is the peak time of labor demand. It was considered that *Parma* system was introduced to manage scarcity of labor at the peak time. A study done in different locations of Nepal also reveals that most of labor demand was fulfilled by *Parma* system (Pradhan 1983).

Female member of the family are more involved in *Parma* system than male for various operational activities of rice cultivation like transplanting, weeding and harvesting is done by female labor. Traditionally, labor work requiring high muscle power like ploughing, digging, bund making etc are done by male labor. Giving rice as a prioritized food security crop, wealthy family member was also found to be involved in *Parma* system and it contributed significantly to accomplish most of crop management activities by providing required number of laborer. This system has supported largely to those families that can't raise sufficient cash flow during cultivation period to paid hired labor. One study carried out in Jajarkot district of Nepal by Jana Fortier (Fortier 1993) showed that most of low caste families having land about 0.25 hectare were largely depend upon *Parma* or *Parima* system as they could pay cash to farm labor. However, this system was also adopted as powerful labor management option by high caste or greater land holding families.

Most of time, this labor management system was assured and trustworthy because you have already committed to supply labor as and when required on a reciprocal basis. When one breaks the understanding, s/he may not get assurance of labor supply in return at the peak period of crop establishment and management. So, no one can dare to breach the general understanding and rules of this system. In this system, labor could receive morning breakfast, lunch and day snacks from the immediate cultivator on the basis of equal or reciprocal treatment.

Besides its role in terms of labor management, this system has significant cultural and social value. One study carried out in Manamaiju Village Development Committee of Kathmandu Valley shows that this system has been deeply rooted in the Newar culture (Bhattrai 2006). Personal communication with many experts and elder person also used to explain that *Parma* system contributed significantly towards cultural harmony and social integration.

Present scenario of *parma* system

At present, it is rare to find the study done to reveal actual prevalence of *Parma* system. Study carried out in Manamaiju Village Development Committee of Nepal showed that 70% of local *Jyapu* community still following this system (Bhattrai 2006). Furthermore, this study revealed that this system was found more intact due to cultural reason. Despite of its economic, cultural and social benefit, number of people following this system of labor management has been decreasing. This is due to economic, socio-cultural, technical and ecological reasons.

Sharma (1987) explained that *Parma* system is the characteristics of under developed labor market and specialization of labor would cause to gradually cease this system. It is estimated that around 56% of household of Nepal receive remittance (ADS 2012). Out flux of male youth has led more farm land left uncultivated and most of female member of village have been started to opt less labor intensive farming (Tamang et al 2014). Furthermore, with the increase in income from selling muscle abroad, the practice of consumerism has been significantly increased. This economic factor could be one of the reason limiting its adoption. In addition, there is cultural and social cause also. As social and cultural factors the most important attribute to conserve this type of labor management system, but we are witnessing increasing trend of social and cultural disintegration in Nepalese communities. Additionally, fragmentation of land is one of the reasons. In the urban area, we often find that a plot of hectares of land turn into small parcels of land, and small pieces of land demand less labor and could be supplied enough by single family members. Similarly, another potential factor causing *Parma* system gradually to disappear is the farm mechanization.

Furthermore, a study conducted in Chitwan (Bhandari et al 1997) explained the probable reason why the *Parma* system is replaced by other system of labor management ie *Naike* system. It is because people's comfort to manage farm labor by simply contacting single leader locally called as *Naike,* who is to inform required number of labors.

Meaning of *naike* system

The meaning of *Naike* is leader and in *Naike* System he bridges the labor gap by assessing labor demand from crop cultivator and managing its supply. *Naike* collects seasonal demand of labor from the crop cultivators of the locations, contacts each and every laborer and mobilize those labors to the cultivators' field. Usually, *Naike* receives certain amount of commission from cultivators as incentive which is not deducted from the wage of laborers.

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A Memory Note on 'Khumal-4' Rice

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Khumal-4, developed in the mid 1980s, is the most popular Nepal bred rice variety in the mid hills of Nepal. However, the variety along with some other varieties having similar grain-type from the Tarai and inner Tarai has been named as 'Jeera Masino' by the rice traders for their convenience. These days, Jeera Masino is being marketed almost everywhere in the country. I have presented a memory note on the variety below. Khumal-4, a cross between a Nepali local variety Pokhareli Masino and IR-28, was released in 1987 for the Kathmandu valley and having similar climate in the mid hills ranging from 3000 to 4500 feet above the mean sea level. The variety has yield potential of 6.3 t/ha (nearly double of the national average yield of rice). The credit for breeding this variety goes to Mr Kedar Prasad Shrestha, a fine rice breeder of Nepal, worked at the Agriculture Botany Division (Khumaltar) of the Department of Agriculture (later the research wing was separated from the Department and called National Agricultural Research and Services Center and now called Nepal Agricultural Research Council). He got retired from his work long time ago. I as a plant pathologist working at Plant Pathology Division at Khumaltar got to involve in his team since 1983 and worked for this variety (along with other varieties, mainly Khumal-2 and Palung-2, released together with Khumal-4), especially on resistance to ‘blast’, the number one rice disease. We did evaluate this variety and others at farmers' fields for resistance to blast and other traits at many locations in the country before its release.When I said we, I referred to the team of that time which also included Mr Hari Bahadur KC, a senior and respectable person as an Agriculture Expert from USAID-Nepal, who worked at Khumaltar, Lalitpur for many years, and partly Mr Hem Singh Bhandari at the Agriculture Botany Division. Mr KC passed away a few years ago. I respect him very much for his friendly nature and unconditional support and contribution to the research and development of agriculture in Nepal. We collaborated with farmers' field trials conducted by the District Agriculture Development Offices (DADOs) of Parbat, Baglung and Myagdi, and conducted leaf blast and neck blast nurseries at different locations of the above-mentioned districts and Kaski in 1987 and 1988 main rice seasons. The blast nurseries were conducted by ourselves in collaboration with the DADOs and cooperator farmers. The trials and nurseries included primarily Khumal-4 and other promising varieties and lines. The purpose was to select the varieties under farmers' field conditions based on farmers' choice and promote them. Later, similar approach has become established internationally as participatory variety selection (PVS). We had no idea of the particular nomenclature and the process that time. We did travel to the sites three times per season (one for setting the blast nurseries, including planting, and two for observations on leaf and neck blast). There were no motorable roads in those districts, except in Kaski. So we had to walk from Naudanda in Syangja to travel to Parbat (one night stopover at Karkineta, a beautiful high hill site), Baglung and Myagdi and come back to the same point to catch a vehicle for Kathmandu or sometimes fly back to Kathmandu from Balewa in Baglung. Generally, it used to take 10 days per visit. The visits were supported by USAID-funded Agriculture Research and Production Project (ARPP). This was how Khumal-4 was promoted in the western mid hills. In one of the trips in September 1988, only Mr KC and I were travelling. We were on the way to Myagdi from Baglung. The porter was ahead of us. Mr KC, while walking, suddenly fell down from the road to the downwards of the hill. He was just rolling down and I was running after to catch him. But fortunately he got stopped at some point then only I could catch him and bring back to the road. He succumbed injuries on the head and backs with many blue patches. Then I realized that a camera and a tumbler I was carrying were not with me. I searched them around and found them lying at two different directions. It was the case that I threw them unconsciously before I ran after Mr KC. He received some antiseptic treatment (Dettol) at the site and later received some treatments at Beni bazar in Myagdi. He still managed to visit the fields next day. It was great. The beauty of our field work was that we did the work in collaboration with the respective District Agriculture Development Offices. That was the most memorable and lovely time working together. There was a great respect towards the people who come from research stations. I enjoyed that a lot. Now it is not the same. I have suspicion that it is possible to work together with such spirits these days as the so-called 'research' and 'extension' have been separated from each other. This has been very unfortunate for the country. With the time passed for so many years since 1987 Khumal-4 has spread throughout the mid hill regions from west to east. This variety has a great contribution in the agriculture sector. It has replaced blast susceptible but very popular rice varieties like Taichung-176 and Chainung-242 in the Kathmandu valley and adjoining areas to a great extent. Now Khumal-4 is no more blast resistant as it used to be before. There was one weakness of this variety from the beginning of its release. This variety is susceptible to foot rot/bakanae disease. However, we at Plant Pathology Division identified seed treatment technology (2-3 g Bavistin (carbendazim) per kg seed at least 3 days before seeding) for the management of the disease. The technology was demonstrated widely under farmer's field conditions in collaboration with NARC Research Stations and several District Agriculture Development Offices, which I believe is being widely used by seed companies and also by farmers. Also, Khumal-4 is susceptible to white tip nematode as I used to extract significant number of the nematode from the rice seeds. However, its effect has not been seen under field conditions.

In this memory note, I mainly took two names Mr Kedar Prasad Shrestha, who bred this variety, and late Mr Hari Bahadur KC, who played significant role in its development and dissemination process. Besides them, there must have been many others who have contributed to different aspects for the development and promotion of this variety directly and indirectly. I would like to dedicate this note to all of them.

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धान बाली भण्डारण पूर्व गरिने कृषि कर्म - दाइँ र उक्त समयमा गाइने दाइँ गीतबारे सक्षिप्त चर्चा

सत्यमोहन जोशी
इतिहास एवम् संस्कृतिविद्

नेपाली कृषकहरूको जीवनमा सबैभन्दा महत्वपूर्ण समय भनेको रोपाइँ नै हो । यही रोपाइँको समाप्तीपछि धान बाली भित्र्याउनु पूर्व खलामा दाइँ गर्ने बेलाको एक सुन्दर पक्ष यसरी देखा पर्दछ :

असार महिना धान रोप्ने
श्रावण महिना खेत गोड्ने ।
कार्तिक महिना धान काट्ने
मंसिर महिना दाइँ गर्ने ।।

विशेषतः पहाडतर्फ आषाढ श्रावणमा रोपेको धान कार्तिक मंसिरतिर काट्ने चलन छ । अनि काटेका धान परालसहित धानको कुनियोमा दशदेखि पन्ध्र दिन थुपार्ने र पछि गोरु लाएर गोरुबाटै सो धान माड्न लगाउने चलन छ । अनि यही धान माड्ने बेलामा धानको खलामा मियो गाड्ने चलन छ । मियो भनेको काठको एक लामो र ठूलो घोचो हो । यसको शोभा टुप्पामा बेरिराखेको धान सहितको परालका मुठ्ठाले दिइरहन्छ । परालको मुठ्ठामा बसि आउने कोइली र सिमलचरीले पनि शोभा दिइरहेको हुन्छ । मियोको फलपति या अन्नपति पृथ्वीमा एक परिधि खिचिएको हुन्छ जुन परिधिभित्र रासको चुट्ने धान छरिएको हुन्छ र मियोको माल दाम्लामा बाँधिएका गोरुहरूले अविराम गतिमा त्यस ठाँउको परिक्रमा गर्दछन् । गोरुहरूलाई **बरादो** भनि सम्बोधन गर्ने चलन छ र यी गोरुहरू ४ वटादेखि ८ वटासम्म पनि खला हेरी मियोको वरिपरिको परालसहितको धानको रासमा घुम्छन् अनि त्यसैबेला गोरुको पयरको चालले परालको बोटबाट धानको गेडा छुट्टिन्छन् या झर्दछन् । यसरी धान चुट्ने प्रथालाई **दाइँ** गर्ने भनिएको हो । दाइँ गर्ने खेतालाहरूलाई **दयैँरा दयैँर्नी** भनि नामाकरण गरिएको हुन्छ र यी नै दयैँरा दयैँर्नीहरूबाट पहाडमा धानखेती गर्ने कृषकहरूको नेपाली लोक गीतको पृष्ठभूमीमा चोखो लोकगीतका उद्गारहरू सृजना हुन्छन् र यतैबाट दाइँगीत झिक्ने चलन चलेको हो ।

दाइँ गर्न लागेको मियोको टुप्पामा उषाकालमा कोइली चरीले शुभ सन्देश लिएर आउँछ भन्ने पहाडी कृषकहरूको धारणा छ । अनि कोइलीकै पञ्चम स्वरमा दाइँ गर्ने गोरुको पयरको चालसँग दयैँरा दयैँर्नीहरूमा पनि भावोद्गारहरू संगीतमय भएर निस्कन्छन् :

मियोको टुप्पामा मेरा भाइ बरादो हो
बसिहाल्यो कोइली ।
आजका दयैँरालाई मेरा भाइ बरादो हो
घिउका च्वैली ।।
अ ह ह ....अ ह ह ह ....अ ह ह ह

दाइँ गीतमा सिमलचरीको पनि उत्तिकै उल्लेखनीय स्थान छ र यस चरीको नाम नउनिएको दाइँ गीत अपूरो र बेस्वादको जस्तो हुन्छ । सिमलचरी यति राम्री चरी हो कि यसको उपमा सिमलको भुवालाई नै लिन सकिन्छ । यसको मधुर गीत भने सुन्नेलाई मात्र रसपान गर्ने सौभाग्य प्राप्त हुन्छ । मियो गाडेको खलाको कटेरोमा बस्ने दयैँरा दयैँर्नीहरूको भने सिमल चरी पेवा जस्तै हुन्छ । यसैले यो सानो टुक्का दाइँ गीतमा मूल फुटे झै यसरी फुट्दछ :

आजका गोरुका मेरा भाइ बरादो हो
तिखा मोटा सिंग
आजका खला वरिपरि मेरा भाइ बरादो हो

सिमलचरी रिंग
अ ह ह ह ....अ ह ह ह ......अ ह ह ह ।।

दाइँ गीतमा उनिएको सिमलचरीको एक किंवदन्ती पनि छ । एकचोटी एउटी सिमलचरी मियोको टुप्पामा बस्न आउँदा खलाको धान यति बढ्यो कि पनेरामा पानी लिए झैं जति धान भरे पनि खलाका धान रित्तिएन । यसैले यो चरीलाई ज्यादै लक्षणकी लक्ष्मी मानिएको छ ।

दाइँ गीतमा बीचबीचमा करुवा झिक्ने चलन पनि छ। यही करुवाका धुनमा दयँरा दयँर्नीहरूले गोरुलाई आफ्नो चालमा हिंडाउछिन् जस्तो -

माडो भाइ माडो भाइ
चाँडो जाई जाई
मियाको गोरु फनफनी
घरकी बूढी गनगनी
दाइँ गर बरादो दाइँ गर ।।
अ ह ह ह ....अ ह ह ह ......अ ह ह ह ।।

करुवा भन्नाले बीचबीचमा गेडा नझिकी गीत लम्ब्याउनाको निम्ति साना साना रसिला र जोशिला टुक्का झिकी छोप्दै गैरहने धुवा हो । अनि बरादो हो भन्ने सम्बोधन शब्दचाहि दाइँ गीतमा साझा आलाप नै हुन्छ, जति सिपालु दयँरा दयँर्नी हुन्छन् आलाप खेल्ने उत्तिकै जोडदार मीठो गला उनीहरूमा हुने गर्दछ ।

दाइँ गीतमा वास्तविक सत्यताको एक साधन छ तथा चोखो नेपाली लोक गीतको एक साहित्यिक सृजना पनि छ । यसैले दाइँ गीतमा कृषकले गोरु जोत्न जानेको बेलादेखिको इतिहास, उसले बोल्न जानेको बेला देखिको भाषा साहित्य सत्यं- शिवं- सुन्दरम्का आदर्शमा मात्र होइन, बहुजन हिताय बहुजन सुखायको सिद्धान्तमा पनि सजीव तुल्य भैरहेको हामी देख्छौं । यसैले दाइँ गर्ने खलाका दयँरा दयँर्नीहरूले परम्परागत लोक सँस्कृतिको मूल आधार भएका पूजा आजा, थिति रीति चलनअनुसार खलामा भूमे देवतालाई र बृषवाहन महादेवलाई सर्वप्रथम पूजा गरी दाइँगीतको सृजना यसरी गर्दै जान्छ, साथ साथै निसहाय गोरुलाई सान्त्वना दिने सम्वोधन पनि, जस्तो -

धूप धुवार मेरा भाइ बरादो हो
भूमेले खाए ।
यो भार तिमीलाई मेरा भाइ बरादो हो
महादेवले लाए ।।
अ ह ह ह ....अ ह ह ह ....अ ह ह ह.........

अझ खलाका भूमे देवतालाई आराधना र आह्वान गरी गोरुलाई फकाउँदै फुलाउँदै भाषा साहित्यमा जोड दिदै जाने तरिका पनि दयँरा दयँर्नीले जानेका छन्, यसैले उनीहरू टुक्का जोड्छन् :

पुतली गाईको वाच्छो बरादो, माली गाईको नाती ।
हिड्न लाग्यो मेरो भाइ बरादो, धान पराल माथि ।।
हाम्रा बराजुका लामा लामा कान ।
ल्याऊ भूमे राजा खलाभरी धान ।।
हाम्रा बराजुले पाएन जोडी ।
खलाका भूमेराजा ल्याउ पहरा फोरी फेरी ।।

दाइँ गीतमा यस्तो एक भाव पनि उनिएको हुन्छ जसमा दाइँको मुख्य उद्देश्य र लक्ष्य लुकेको हुन्छ, यसैले यो गीतमा कृषकको जीवननै टाँसिएको हुन्छ। हुन पनि नेपाल जस्तो कृषकहरूले बसोबास भएको मुलुकमा अन्न उब्जाउकै प्राचूर्यतामा आर्थिक उन्नतिले जरा बसाल्छ, अझ झन् पहाडको कुना काप्चामा, जहाँ धानको खेती गर्नमा निकै कठिनाई, असुविधा पर्दछ, एक गेडा धानको पनि एक एक हिसाब हुन्छ । कृषकहरूले आफ्ना धानको खेतीमा शारीरिक परिश्रमको साथ अध्यात्मवादी भएर चोखो मनमा चोखो

भावना लिई सम्पूर्ण गुणहरू वटुल्न खोज्दछन्- यसैले यी कृषकहरू डोटी जिल्लामा हुने जस्तो पौष्टिक पदार्थपूर्ण भएको धान होस्, मधेशको खलामा जस्तै धान भर्न पाओस् भनी सन्तोषमा आशावादी टुक्का पनि जोड्दै जान्छन्। जस्तैः दाइँ गर्दा झरुवा धान ८० मुरी भए रासको धान बाह्रबीस अर्थात २४० मुरी होस्, चम्पा फूलको बासनाजस्तै धानका बसुमती बासना हिमालबाट लंकासम्म पनि सुगन्धित होस् इत्यादि। अनि यी भावनाका गीत हामीहरू यसरी पाउँछौ :

रिडदै जाऊ भाइ बरादो हो घुम्दै जाऊ
माल मधेशको भाइ बरादो हो डोटीको सह ल्याऊ ।।
सीमुरी झरुवा मेरा भाइ बरादो हो
बाह्रबीस रास ।
चम्पा फूल फूल्यो मेरा भाइ बरादो हो
लंका पुग्यो बास ।।
पारीका गोरु मेरा भाइ बरादो हो
बाटुलो जुरी ।
आजका रासमा मेरा भाइ बरादो हो
सय साठी मुरी ।।
कोरी बाटी चुल्ठी त मेरा भाइ बरादो हो
मुठी भरी केश ।
हिंडन लाग्यो मेरा भाइ बरादो हो
पुतलीको भेष ।।
पुच्छरले बढार मेरा भाइ बरादो हो
खुरले माड ।
कानले बताऊ मेरा भाइ बरादो हो
जुरीले बोक ।।

यस्तै रूपले दाइँको लोकगीतमा कृषिको साधन, कृषकको जीवनको छापा र भाषा साहित्य आदि सजीवता र सरसतामा गुल्जार भैरहेको हामी पाउँछौ। यस विषयमा खोजी गर्दै जाने हो भने हामी अझ अरू धेरै कुरा पाउँछौं, अनि यस्तै खोजी र प्रचारमा हामीले आफ्नो भन्ने कुरो देखाउने मात्र होइन, सुरक्षित गर्ने कुरो पनि आउँछ।

Rice Science and Technology in Nepal (MN Paudel, DR Bhandari, MP Khanal, BK Joshi, P Acharya and KH Ghimire, eds).
Crop Development Directorate (CDD), Hariharbhawan and Agronomy Society of Nepal (ASoN), Khumaltar.

धान बाली पात्रो (Rice Crop Calendar)

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तराई क्षेत्रका २० जिल्लाहरू

जिल्ला	ब्याड राख्ने महिना र हप्ता	रोपाई गर्ने महिना र हप्ता	काट्ने महिना र हप्ता
झापा	वर्षे धान: जेष्ठको पहिलो हप्तादेखि आषाढ पहिलो हप्ता	आषाढ पहिलो हप्ता देखी तेश्रो हप्ता	आश्विनको पहिलो हप्तादेखि मंसिरको पहिलो हप्ता
	चैते धान: माघको दोश्रो हप्ता/फाल्गुनको दोश्रो हप्ता	फाल्गुन/चैत	जेष्ठ र आषाढ
मोरङ्ग	वर्षे धान: जेष्ठको पहिलो हप्तादेखि आषाढ पहिलो हप्ता	आषाढ पहिलो हप्तादेखि श्रावणको तेश्रो हप्ता	आश्विनको पहिलो हप्तादेखि मंसिर पहिलो हप्ता
	हिँउदे बोरो धान: मंसिर पौष दोश्रो हप्ता	माघ	चैत र बैशाख
	चैते धान: माघको दोश्रो हप्तादेखि फाल्गुनको दोश्रो हप्ता	फाल्गुन र चैत	जेष्ठ र आषाढ
सुनसरी	वर्षे धानः जेष्ठ पहिलोदेखि तेश्रो हप्ता	आषाढ पहिलोदेखि तेश्रो हप्ता	मंसिर पहिलो हप्तादेखि तेश्रो हप्ता
	चैते धानः फाल्गुन दोश्रो हप्तादेखि तेश्रो हप्ता	चैत्र पहिलो हप्तादेखि दोश्रो हप्ता	जेष्ठ तेश्रो हप्तादेखि आषाढको दोश्रो हप्ता
सप्तरी	वर्षेः जेष्ठदेखि आषाढको पहिलो हप्ता	आषाढ/श्रावण महिना	भाद्रको अन्तिम हप्तादेखि मंसिरको दोश्रो हप्ता
	चैतेः माघको दोश्रो हप्तादेखि फाल्गुनको दोश्रो हप्ता	चैत्र महिना	जेष्ठदेखि आषाढ महिना
सिराहा	जेष्ठको पहिलो हप्तादेखि जेष्ठको अन्तिम हप्ता	आषाढको पहिलो हप्तादेखि श्रावणको पहिलो हप्ता	कार्तिकको अन्तिम हप्तादेखि पौषको दोस्रो हप्ता
धनुषा	जेष्ठ तेश्रो हप्तादेखि आषाढ महिनाको पहिलो हप्ता	आषाढको दोश्रो हप्तादेखि श्रावणको पहिलो हप्ता	मंसिरको दोश्रो हप्ता देखि मंसिरको चौथो हप्ता
महोत्तरी	जेष्ठदेखि आषाढ	आषाढदेखि श्रावण	कार्तिकदेखि मंसिर
	फाल्गुनदेखि चैत्र	चैतदेखि बैशाख	जेष्ठदेखि आषाढ
सर्लाही	जेष्ठदेखि आषाढ पहिलो हप्ता	आषाढदेखि श्रावण	कार्तिकदेखि मंसिर
रौतहट	जेष्ठ १५ गतेदेखि जेष्ठ मसान्त	आषाढ १५ गतेदेखि श्रावण मसान्त	कार्तिक १५ गतेदेखि मंसिर मसान्त
बारा	चैतेः फाल्गुण अन्तिम हप्तादेखि चैत दोश्रो हप्ता	चैत दोश्रो हप्तादेखि बैशाखको पहिलो हप्ता	आषाढको अन्तिम हप्तादेखि श्रावणको पहिलो हप्ता
	भदैया धानः बैशाखको दोश्रो हप्तादेखि बैशाखको अन्तिम हप्ता	जेष्ठको दोश्रो हप्तादेखि जेष्ठको अन्तिम हप्ता	भाद्रको दोश्रो हप्तादेखि भाद्रको अन्तिम हप्ता
	अगहनी धानः जेष्ठको तेश्रो हप्तादेखि आषाढको पहिलो हप्ता	आषाढको तेश्रो हप्तादेखि श्रावणको पहिलो हप्ता	कार्तिकको दोश्रो हप्तादेखि मंसिरको मसान्त
पर्सा	वर्षे धानः जेष्ठको दोश्रो हप्ता	आषाढको दोश्रो हप्ता	मंसिरको दोश्रो हप्ता
	चैते धानः फाल्गुनको तेश्रो हप्ता	चैत्रको दोश्रो/तेश्रो हप्ता	अषाढको दोश्रो हप्ता

जिल्ला	ब्याड राख्ने महिना र हप्ता	रोपाई गर्ने महिना र हप्ता	काट्ने महिना र हप्ता
चितवन	वर्षे धान सिंचित क्षेत्र (जिल्लाको पूर्वी क्षेत्र): जेष्ठको पहिलो हप्तादेखि अन्तिम हप्ता	जेष्ठको अन्तिम हप्तादेखि आषाढको अन्तिम हप्ता	कार्तिकको अन्तिम हप्तादेखि मंसिरको पहिलो हप्ता
	वर्षे धान असिंचित क्षेत्र (जिल्लाको पश्चिम क्षेत्र): जेष्ठको दोश्रो हप्तादेखि आषाढको पहिलो हप्ता	आषाढको दोश्रो हप्तादेखि श्रावणको पहिलो हप्ता	मंसिरको पहिलो हप्तादेखि अन्तिम हप्ता
	चैते धान सिंचित क्षेत्रः फाल्गुन अन्तिमदेखि चैत्र पहिलो हप्ता	चैत्र दोश्रो हप्तादेखि अन्तिम हप्ता	जेष्ठको अन्तिम हप्तादेखि आषाढको अन्तिम हप्ता
नवलपरासी	वर्षेः जेष्ठको महिनाको दोश्रो हप्ताबाट	आषाढ महिनाको पहिलो हप्ताबाट	कार्तिक महिनाको दोश्रो हप्ताबाट
रुपन्देही	वर्षे धानः जेष्ठ पहिलो हप्तादेखि आषाढ पहिले हप्ता	अन्तिम हप्तादेखि श्रावणको दोश्रो हप्ता	आश्विनको अन्तिम हप्तादेखि मसिरको पहिलो हप्ता
	चैते धानः फाल्गुणनको पहिलो हप्तादेखि चैतको पहिलो हप्ता	फाल्गुणको तेश्रो हप्तादेखि चैत्रको अन्तिम हप्ता	जेष्ठको अन्तिम हप्तादेखि आषाढको अन्तिम हप्ता
कपिलवस्तु	लवनी पटना,कपिलवस्तु न.पा., महाराजगंज, शिवराज बहादुरगंज क्षेत्रः आषाढ पहिलो हप्ता	आषाढ अन्तिम हप्तादेखि श्रावण तेश्रो हप्ता	कार्तिकदेखि सुरु भई मंसिर अन्तिम हप्ता
	भृकुटी र बुद्धवाटिका न.पा.,वाणगंगा (जीतपुर)क्षेत्रः जेष्ठ दोश्रो हप्ता	आषाढ पहिलो हप्तादेखि अन्तिम हप्ता	आश्विनदेखि सुरु भई कार्तिक अन्तिम हप्ता
दाङ	वर्षेः जेष्ठ १५ देखि आषाढ पहिलो हप्ता	आषाढ तेश्रो हप्ता	आश्विन २० देखि कार्तिकको २० गतेसम्म
	अगौटेः जेष्ठ २५ देखि आषाढ २५ सम्म	आषाढ तेश्रो हप्ता	आश्विन
बाँके	जेष्ठको दोश्रो हप्तादेखि आषाढको पहिलो हप्ता	आषाढ पहिलो हप्तादेखि श्रावणको तेश्रो हप्ता	कार्तिकको पहिलो हप्तादेखि मंसिरको तेश्रो हप्ता
बर्दिया	वर्षे धानः बैशाख अन्तिम हप्तादेखि आषाढ पहिलो हप्ता	जेष्ठ तेश्रो हप्तादेखि अषाढ अन्तिम हप्ता	भाद्र अन्तिम हप्तादेखि कार्तिक अन्तिम हप्ता
	चैते धानः फाल्गुन पहिलो हप्तादेखि फाल्गुन अन्तिम हप्ता	चैत पहिलो हप्तादेखि फाल्गुन अन्तिम हप्ता	अषाढ महिना भरि
कैलाली	अगौटेः जेष्ठ तेश्रो र चौथो हप्ता	अषाढ तेश्रो र चौथो हप्ता	आश्विन पहिलो र तेश्रो हप्ता
कन्चनपुर	सिंचितः जेष्ठ दोश्रो हप्ता	आषाढ पहिलो हप्ता	आश्विन अन्तिम हप्ता
	असिंचितः जेष्ठ अन्तिम हप्ता	आषाढ तेश्रो हप्ता	आश्विन तेश्रो हप्ता

मध्य पहाड क्षेत्रका ३९ जिल्लाहरू

जिल्ला	ब्याड राख्ने महिना र हप्ता	रोपाई गर्ने महिना र हप्ता	काट्ने महिना र हप्ता
पाँचथर	वर्षेः जेष्ठ पहिलो हप्ता	आषाढ दोश्रो हप्ता	कार्तिक, मंसिर दोश्रो हप्ता
	चैतेः फाल्गुन पहिलो हप्ता	चैत्र पहिलो हप्ता	आषाढ पहिलो हप्ता
ईलाम	बैशाख तेश्रो हप्तादेखि आषाढ पहिलो हप्ता	जेष्ठको तेश्रो हप्तादेखि श्रावणको दोश्रो हप्त	कार्तिक अन्तिम हप्तादेखि मंसिर महिना

जिल्ला	ब्याड राख्ने महिना र हप्ता	रोपाई गर्ने महिना र हप्ता	काट्ने महिना र हप्ता
	उच्च पहाड (वर्षे धान) :बैशाख १५ देखि जेष्ठ १५	जेष्ठ १५ देखि आषाढ १५ सम्म	कार्तिक र मंसिर
	बेसी तथा खोच (वर्षे धान): जेष्ठ १५ देखि आषाढ दोश्रो हप्ता	आषाढ १५ देखि श्रावण भरि	कार्तिक तेश्रो हप्तादेखि मंसिर भरि
	बेसी (चैते धान) :फाल्गुन पहिलो हप्तादेखि अन्तिम हप्ता	चैत्र महिना भरि	आषाढ १५ देखि श्रावणको दोश्रो हप्ता
तेह्रथुम	उच्च पहाडः चैत १५ देखि बैशाख १५ सम्म	जेष्ठ महिना भरि	कार्तिक महिनाभरि
	मध्य पहाडः बैशाख १५ देखि जेष्ठ १५ सम्म	जेष्ठ अन्तिम देखि आषाढ १५ सम्म	कार्तिक/मंसिर
	बेशी तथा खोंचः जेष्ठ १५ देखि आषाढ पहिलो हप्ता	आषाढ १५ देखि श्रावण १५ सम्म	कार्तिक/मंसिर
भोजपुर	वर्षेः बैशाखको पहिलो हप्तादेखि दोश्रो हप्ता	आषाढ पहिलो हप्तादेखि अन्तिम हप्ता	कार्तिक अन्तिम हप्तादेखि मंसिर दोश्रो हप्ता
	चैतेः फाल्गुन पहिलो हप्ता	चैत्र दोश्रो हप्ता	श्रावण दोश्रो हप्ता
ओखलढुंगा	आषाढ १० गतेसम्म	श्रावण पहिलो हप्ता	कार्तिक अन्तिम हप्ता
खोटाङ	लेकाली क्षेत्र (वर्षे धान): बैशाख दोश्रो हप्ता	जेष्ठ तेश्रो हप्ता	कार्तिक पहिलो हप्ता
	मध्य पहाडी क्षेत्र (वर्षे धान): बैशाख तेश्रो हप्ता	आषाढ पहिलो हप्ता	कार्तिक दोश्रो र तेश्रो हप्ता
	बेशी क्षेत्र (वर्षे धान): जेष्ठ पहिलो हप्ता	आषाढ तेश्रो हप्ता	मंसिर पहिलो र दोश्रो हप्ता
	बेशी क्षेत्र (चैते धान): फाल्गुन पहिलो हप्ता	चैत्र पहिलोदेखि दोश्रो हप्ता	श्रावण पहिलो हप्ता
उदयपुर	वर्षे धानः जेष्ठको दोश्रो हप्तादेखि तेश्रो हप्ता	आषाढको पहिलो हप्तादेखि श्रावणको तेश्रो हप्ता	कार्तिक दोश्रो हप्तादेखि मंसिरको तेश्रो हप्ता
	चैतेः फाल्गुनको दोश्रो हप्तादेखि तेश्रो हप्ता	चैत्रको पहिलो हप्तादेखि तेश्रो हप्ता	जेष्ठको तेश्रो हप्तादेखि आषाढको तेश्रो हप्ता
सिन्धुली	जेष्ठ महिना दोश्रो र तेश्रो हप्ता	आषाढ दोश्रो हप्तादेखि श्रावणको पहिलो हप्ता	कार्तिक महिना भरी
रामेछाप	वर्षे धान (लेक साईड): बैशाखको पहिलो हप्तादेखि दोश्रो हप्ता	जेष्ठको पहिलो हप्तादेखि दोश्रो हप्ता	मंसिरको पहिलो हप्ता
	वर्षे धान (टार, बेसी र फाँट क्षेत्र): जेष्ठको पहिलो हप्तादेखि अन्तिम हप्ता	आषाढको पहिलो हप्तादेखि अन्तिम हप्ता	कार्तिकको तेश्रो हप्तादेखि मंसिरको पहिलो हप्ता
	चैते धान (फर्पु गागलभदौर र तिलपुङ गाविसको केही क्षेत्र) : माघको तेश्रो हप्तादेखि फाल्गुणको पहिलो हप्ता	फाल्गुणको दोश्रो हप्तादेखि अन्तिम हप्तास	आषाढको दोश्रो हप्तादेखि अन्तिम हप्ता

जिल्ला	ब्याड राख्ने महिना र हप्ता	रोपाई गर्ने महिना र हप्ता	काट्ने महिना र हप्ता
काभ्रे पलान्चोक	खोपासी: बैशाख पहिलोदेखि दोश्रो हप्ता (१४०० मिटर उचाइ)	जेष्ठ दोश्रोदेखि तेश्रो हप्ता	आश्विनको पहिलोहप्ता
	पाँचखाल: जेष्ठ दोश्रो हप्तादेखि तेश्रो हप्ता(९०० मिटर उचाइ)	आषाढ तेश्रोदेखि अन्तिम हप्ता	कार्तिक दोश्रो हप्तादेखि तेश्रो हप्ता
	भकुण्डे: जेष्ठ पहिलो हप्ता	आषाढको पहिलोदेखि दोश्रो हप्ता	
	चैते: महादेवस्थान, जैसीथोक -फाल्गुनको पहिलो हप्ता	चैतको पहिलो हप्ता	आषाढ तेश्रोदेखि अन्तिम हप्ता
नुवाकोट	लेकाली भागमा: बैशाख अन्तिम हप्ता	जेष्ठ दोश्रो हप्ता	कार्तिक पहिलो हप्ता
	मध्य पहाडी भागमा: जेष्ठ दोश्रो हप्ता	आषाढ दोश्रो हप्ता	आश्विन चौथो हप्ता
	बेसी भागमा: जेष्ठ तेश्रो हप्ता	श्रावण पहिलो हप्ता	कार्तिक दोश्रो हप्ता
धादिङ	वर्षे: बैशाख तेश्रो हप्तादेखि आषाढको दोश्रो हप्ता	आषाढ दोश्रो हप्तादेखि श्रावण अन्तिम हप्ता	कार्तिक दोश्रो हप्तादेखि मंसिर दोश्रो हप्ता
	चैते: माघको दोश्रो हप्तादेखि फाल्गुन पहिलो हप्ता	चैत दोश्रो हप्तादेखि बैशाख पहिलो हप्ता	आषाढको दोश्रो हप्तादेखि श्रावणको पहिलो हप्ता
काठमाडौं	वर्षे: बैशाख अन्तिम हप्तादेखि जेष्ठ दोश्रो हप्ता	जेष्ठ तेश्रो हप्तादेखि आषाढ तेश्रो हप्ता	आश्विन दोश्रो हप्तादेखि कार्तिक तेश्रो हप्ता
	साँखु क्षेत्र (शंखरापुर न.पा.): चैतको तेश्रो हप्तादेखि बैशाखको पहिलो हप्ता	बैशाख दोश्रो हप्ताबाट जेष्ठको दोश्रो हप्ता	भाद्र तेश्रो हप्तादेखि आश्विनको दोश्रो हप्ता
भक्तपुर	जेष्ठको दोश्रो र तेश्रो हप्ता	आषाढको दोश्रो र तेश्रो हप्ता	कार्तिक दोश्रो र तेश्रो हप्ता
ललितपुर	वर्षे: जेष्ठ महिनाको पहिलो हप्ता	जेष्ठ अन्तिम हप्ता देखि अषाढ २० सम्म (पानी स्रोत अनुसार)	कार्तिक अन्तिम देखि मंसिर २० सम्म
	अगौटे: जेष्ठ देखि आषाढ ७ सम्म	आषाढ २० देखि श्रावण ७ सम्म	मंसिर २० देखि पौष मसान्त
मकवानपुर	तल्लो भेग (५०० मी उचाईसम्म): जेष्ठ दोश्रो हप्तादेखि आषाढ पहिलो हप्तासम्म	आषाढ दोश्रो हप्तादेखि श्रावण पहिलो हप्ता	कार्तिक दोश्रो हप्तादेखि मंसिर मसान्त
	५०० मी उचाईदेखि १२०० मी उचाईसम्म): जेष्ठ पहिलो र दोश्रो हप्ता	आषाढ पहिलो र दोश्रो हप्ता	आश्विन अन्तिम हप्तादेखि आषाढ कार्तिक मसान्त
	१२०० मी उचाई भन्दा माथी): चैत अन्तिम हप्तादेखि बैशाख दोश्रो हप्ता	जेष्ठ दोश्रो हप्तादेखि आषाढ पहिलो हप्ता	आश्विन दोश्रो हप्तादेखि कार्तिक अन्तिमसम्म
अर्घाखाँची	वर्षे धान (सिंचित क्षेत्र): जेष्ठको दोश्रो हप्तादेखि तेश्रो हप्ता	आषाढ पहिलो हप्तादेखि दोश्रो हप्ता	कार्तिकको पहिलो हप्तादेखि तेश्रो हप्ता
	वर्षे धान (असिंचित क्षेत्र): जेष्ठको चौथो हप्तादेखि आषाढको दोश्रो हप्ता	श्रावण महिना भरि	कार्तिकको अन्तिम हप्तादेखि मंसिर दोश्रो हप्ता
	चैते धान: फाल्गुन पहिलोदेखि दोश्रो हप्ता	चैत पहिलो हप्तादेखि दोश्रो हप्ता	आषाढ तेश्रो हप्तादेखि श्रावण पहिलो हप्ता

जिल्ला	ब्याड राख्ने महिना र हप्ता	रोपाई गर्ने महिना र हप्ता	काट्ने महिना र हप्ता
गुल्मी	उपल्लो पहाडः बैशाख पहिलो हप्तादेखि चौथो हप्ता	जेष्ठको तेश्रो हप्तादेखि आषाढको तेश्रो हप्ता	आश्विनकोअन्तिम हप्तादेखि कार्तिकको दोश्रो हप्ता
	मध्य पहाडः जेष्ठको तेश्रो हप्तादेखि आषाढको चौथो हप्ता	आषाढको दोश्रो हप्तादेखि चौथो हप्ता	कार्तिकको दोश्रो हप्तादेखि अन्तिम हप्ता
	तल्लो पहाडः जेष्ठको अन्तिम हप्तादेखि आषाढको दोश्रो हप्ता	सारको अन्तिम हप्तादेखि श्रावणको तेश्रो हप्ता	कार्तिकको दोश्रो हप्तादेखि मंसिर अन्तिम हप्ता
पाल्पा	जेष्ठ १५ देखि आषाढ १० सम्म	आषाढ पहिलो हप्तादेखि श्रावण दोश्रो हप्ता	कार्तिक पहिलो हप्तादेखि मंसिर पहिलो हप्ता
स्याङजा	टारीखेतहरूमाः जेष्ठको पहिलो हप्ता	अषाढ पहिलो हप्तादेखि अषाढभरी (बर्षा हुने र पानीको मूल फुटने आधारमा)	कार्तिक पहिलोदेखि दोश्रो हप्ता
	आधिखोला आसपास क्षेत्रः जेष्ठको दोश्रो हप्ता	आषाढ दोश्रो हप्तादेखि तेश्रो हप्ता	कार्तिक पहिलोदेखि दोश्रो हप्ता
	कालीगण्डकी कोरीडोर क्षेत्रः अषाढको पहिलो हप्ता	श्रावणको पहिलो दोश्रो हप्ता	कार्तिकको तेश्रो हप्तादेखि मंसिर पहिलो हप्ता
कास्की	जेठो बुढोः बैशाख २५ देखि जेष्ठ १५सम्म	जेष्ठ२५ देखि आषाढ २५ सम्म	कार्तिक १५ देखि मंसिर १, २ सम्म
	अगौटे धानः जेष्ठ १५ देखि २५ सम्म	आषाढ ७ देखि२० सम्म	आश्विन ७ देखि आश्विन १५सम्म
	मध्य सिजन (वर्षे) धानः जेष्ठ १५ देखि २५सम्म	आषाढ ७ देखि २० सम्म	आश्विन २५ देखि कार्तिक ७ सम्म
	चैते धानः माघ २५ देखि फाल्गुण ६ सम्म	फाल्गुण ३० देखि चैत्र ७ सम्म	आषाढ३० देखि श्रावण१५ सम्म
तनहुँ	जेष्ठ पहिलो हप्तादेखि आषाढ पहिलो हप्ता	आषाढदेखि श्रावणको दोश्रो हप्ता	आश्विन तेश्रो हप्तादेखि कार्तिक दोश्रो हप्ता
गोरखा	माथिल्लो क्षेत्रः बैशाखको अन्तिम हप्ता र जेष्ठको पहिलो हप्ता	जेष्ठ अन्तिम हप्ता र आषाढ पहिलो हप्ता	कार्तिक र मंसिर महिना
	तल्लो क्षेत्रः जेष्ठ र आषाढ महिना	आषाढ र श्रावण महिना	कार्तिक र मंसिर महिना
लम्जुङ	वर्षे धानः बैशाख अन्तिम हप्ताबाट आषाढ पहिलो हप्ता	जेष्ठ अन्तिम हप्ताबाट श्रावण अन्तिम हप्ता	आश्विन अन्तिम हप्ताबाट मंसिर पहिलो हप्ता
	चैते धानः माघ अन्तिम हप्ताबाट फाल्गुन पहिलो हप्ता	फाल्गुन अन्तिम हप्ताबाट चैत तेश्रो हप्ता	अषाढ पहिलो हप्ताबाट अषाढ अन्तिम हप्ता
म्याग्दी	१२००-१८०० मिटरसम्म :बैशाखको तेश्रो - अन्तिम हप्ता	जेष्ठ आषाढ पहिलो हप्ता	आश्विन- मंसिर अन्तिम हप्ता
	८००-१२०० मिटरसम्म :जेष्ठ पहिलो हप्ता- जेष्ठ अन्तिम हप्ता	जेष्ठ अन्तिम-श्रावण दोश्रो हप्ता)	आश्विन-मंसिर अन्तिम हप्ता
पर्वत	लेकमाः बैशाख अन्तिम हप्तादेखि जेष्ठ पहिलो हप्ता	आषाढ पहिलो हप्ता	कार्तिक दोश्रो हप्तादेखि
	बेसीमाः जेष्ठ दोश्रो हप्तादेखि जेष्ठ अन्तिम हप्ता	आषाढ दोश्रो हप्तादेखि पहिलो श्रावण हप्ता	कार्तिक अन्तिम हप्तादेखि मंसिर पहिलो हप्ता
वाग्लुङ	अगौटेः चैतको दोश्रो हप्तादेखि बैशाखको पहिलो हप्ता	बैशाखको अन्तिम हप्तादेखि जेष्ठको अन्तिम हप्ता	कार्तिक पहिलो हप्तादेखि मंसिर पहिलो हप्ता
	मध्यमः बैशाखको अन्तिम हप्तादेखि जेष्ठको अन्तिम हप्ता	आषाढको पहिलो हप्तादेखि श्रावणतेश्रो हप्ता	कार्तिक अन्तिम हप्तादेखि मंसिरको दोश्रो हप्ता
जाजरकोट	तल्लो बेल्ट ६०० देखि १२०० मि. : बैशाखको अन्तिम हप्तादेखि जेष्ठको दोश्रो हप्ता	जेष्ठको अन्तिम हप्तादेखि आषाढको तेश्रो हप्ता	आश्विनको अन्तिम हप्तादेखि कार्तिक अन्तिम हप्ता
	माथिल्लो बेल्ट १२०० मि. भन्दा माथि चैतको पहिलो हप्तादेखि बैशाखको पहिलो हप्ता	जेष्ठको तेश्रो हप्तादेखि आषाढको अन्तिम हप्ता	कार्तिक पहिलो हप्तादेखि मंसिर पहिलो हप्ता

जिल्ला	ब्याड राख्ने महिना र हप्ता	रोपाई गर्ने महिना र हप्ता	काट्ने महिना र हप्ता
कालिकोट	उच्च भेगः चैत्र १२ सम्म	बैशाखको अन्तिम हप्ता	कार्तिक पहिलो हप्ता
	मध्य भेग र बेसीः बैशाख१२ सम्म	जेष्ठको दोश्रो हप्ता	कार्तिक अन्तिम हप्ता
	बेसः जेष्ठपहिलो हप्ता	आषाढको दोश्रो हप्ता	मंसिर पहिलो हप्ता
दैलेख	लेकाली भागमाः बैशाखको पहिलो हप्तादेखि	आषाढको दोश्रो र तेश्रो हप्ता	कार्तिक पहिलो र दोश्रो हप्ता
	बेसी भागमाः जेष्ठको तेश्रो हप्ता	आषाढको तेश्रो हप्तादेखि अन्तिम हप्ता	आश्विन चौथो हप्तादेखि कार्तिक दोश्रो हप्ता
रोल्पा	बैशाखको पहिलो हप्ता	बैशाखको अन्तिमदेखि आषाढको अन्तिम हप्ता	आश्विनको दोश्रो हप्तादेखि मंसिर पहिलो हप्ता
रुकुम	वर्षे उच्च पहाडः चैत- बैशाख	जेठको १५ सम्म	कार्तिक
	वर्षे मध्य बेसीः बैशाख	जेठको १५ देखि आषाढ १५ सम्म	आश्विन-कार्तिक
	चैतेः फाल्गुण दोश्रो हप्तासम्म	चैत १५ सम्म	अषाढ
सल्यान	बैशाख दोश्रो हप्तादेखि जेष्ठ दोश्रो हप्ता	जेष्ठ दोश्रो हप्तादेखि आषाढ पहिलो हप्ता	कार्तिक पहिलो हप्तादेखि मंसिर पहिलो हप्ता
प्युठान	बैशाख महिनाको पहिलो र दोश्रो हप्ताभित्र ६०%	जेष्ठ महिनाको पहिलो हप्तादेखि जेष्ठ महिना भर	आश्विन पहिलो हप्तादेखि सुरु
	जेष्ठ महिनाको अन्तिम हप्तादेखि आषाढको दोश्रो हप्ता ४०%	आषाढ १५ देखि श्रावणको पहिलो हप्ता	आश्विन अन्तिम हप्तादेखि कार्तिकको पहिलो हप्ता
सुर्खेत	मध्य पहाडी क्षेत्रः जेष्ठ पहिलो र दोश्रो हप्ता	जेष्ठ चौथो देखि आषाढ पहिलो हप्ता	आश्विन दोश्रो हप्तादेखि कार्तिक चौथो हप्ता
	उपत्यका क्षेत्रः जेष्ठ तेश्रोदेखि आषाढ पहिलो हप्ता	आषाढ अन्तिमहप्तादेखि श्रावण दोश्रो र तेश्रो हप्ता	कार्तिक अन्तिम हप्ता
डड़ेल्धुरा	बैशाख पहिलो हप्तादेखि जेष्ठ दोश्रो हप्ता	जेष्ठ पहिलो हप्तादेखि आषाढ तेश्रो हप्ता	भाद्र चौथो हप्तादेखि कार्तिक दोश्रो हप्ता
डोटी	बैशाख पहिलो हप्तादेखि जेष्ठ चौथो हप्ता	जेष्ठ पहिलो हप्तादेखि श्रावण दोश्रो हप्ता	आश्विन पहिलो हप्तादेखि कार्तिक तेश्रो हप्ता
बैतडी	बैशाख पहिलो हप्तादेखि जेष्ठ तेश्रो हप्ता	जेष्ठ दोश्रो हप्तादेखि श्रावण तेश्रो हप्ता	भाद्र अन्तिम हप्तादेखि कार्तिक अन्तिम हप्ता

उच्च पहाडी क्षेत्रका १४ जिल्लाहरू

जिल्ला	ब्याड राख्ने महिना र हप्ता	रोपाई गर्ने महिना र हप्ता	काट्ने महिना र हप्ता
ताप्लेजुङ	उच्च भेगः बैशाख अन्तिम हप्तादेखि जेष्ठ पहिलो हप्ता	जेष्ठ अन्तिम हप्तादेखि आषाढ दोश्रो हप्ता	कार्तिक दोश्रो हप्तादेखि मंसिर पहिलो हप्ता सम्म
	मध्य र बेसीः जेष्ठ पहिलो हप्तादेखि अन्तिम हप्ता	आषाढ पहिलो हप्तादेखि श्रावण दोश्रो हप्ता	आश्विन अन्तिम हप्तादेखि मंसिर पहिलो हप्ता सम्म
संखुवासभा	लेकः बैशाखको तेश्रो हप्ता	जेष्ठको तेश्रो हप्ता	कार्तिकको दोश्रो हप्ता
	मध्य पहाडः जेष्ठको दोश्रो	आषाढ दोश्रो हप्ता	मंसिर पहिलो हप्ता
	बेसीः आषाढ पहिलो हप्ता	श्रावणको पहिलोरदोश्रो हप्ता	मंसिरको दोश्रो र तेश्रो हप्ता

सोलुखुम्बु	माथिल्लो भेग (१४०० मिटर भन्दा माथी) : बैशाखको अन्तिम हप्तादेखि जेष्ठ दोश्रो हप्ता	जेष्ठको अन्तिम हप्तादेखि आषाढको पहिलो हप्ता	मंसिर पहिलो हप्तादेखि दोश्रो हप्ता
	तल्लो भेग (१४०० मिटर भन्दा तल) : जेष्ठकोतेश्रो हप्तादेखि अन्तिम हप्ता	आषाढको दोश्रो हप्तादेखि तेश्रो हप्ता	कार्तिक अन्तिम हप्तादेखि मंसिरको दोश्रो हप्ता
दोलखा	माथिल्लो क्षेत्र : बैशाख पहिलो र दोश्रो हप्ता	जेष्ठ दोश्रो हप्तादेखि आषाढ १५ सम्म	कार्तिक तेश्रो हप्तादेखि मंसिर पहिलो हप्ता
	बेसी क्षेत्र : जेष्ठ पहिलो र दोश्रो हप्ता	आषाढ पहिलो हप्तादेखि श्रावण १५ सम्म	कार्तिकको दोश्रो हप्तादेखि मसान्त
सिन्धु	वर्षे : जेष्ठ अन्तिम हप्तादेखि आषाढको पहिलो हप्ता	आषाढ पहिलो हप्तादेखि श्रावणको पहिलो हप्ता	आश्विन अन्तिम हप्तादेखि मंसिर दोश्रो हप्ता
पाल्चोक	चैते : माघ अन्तिम हप्तादेखि फाल्गुनको पहिलो हप्ता	फाल्गुनको अन्तिम हप्तादेखि चैत पहिलो हप्ता	आषाढको दोश्रो हप्तादेखि श्रावणको पहिलो हप्ता
रसुवा	माथिल्लो क्षेत्र : बैशाख दोश्रो हप्तादेखि जेष्ठ दोश्रो हप्ता	जेष्ठ दोश्रो हप्तादेखि आषाढको जेष्ठ दोश्रो हप्ता	कार्तिक दोश्रो हप्तादेखि मंसिर दोश्रो हप्ता
	तल्लो क्षेत्र : बैशाख अन्तिम हप्तादेखि जेष्ठ दोश्रो हप्ता	आषाढको पहिलो हप्तादेखि श्रावणको अन्तिम सम्म	आश्विन अन्तिम हप्ताबाट मंसिरको पहिलो हप्ता
जुम्ला	चैत पहिलो हप्तादेखि तेश्रो हप्ता	जेष्ठ पहिलो हप्तादेखि आषाढ दोश्रो हप्ता	आश्विन अन्तिम हप्तादेखि कार्तिक दोश्रो हप्ता
हुम्ला	उच्च भेग : चैत्र पहिलो हप्ता	जेष्ठ अन्तिम हप्ता	कार्तिक पहिलो हप्ता
	मध्य भेग र बेसी : चैत्र	आषाढ पहिलो हप्ता	कार्तिक दोश्रो हप्ता
	बेसीः बैशाख पहिलो हप्ता	अषाढ दोश्रो हप्ता	कार्तिक दोश्रो हप्ता
डोल्पा	वर्षे धानः फाल्गुणदेखि बैसाख सम्म	चैतदेखि जेठसम्म	आश्विनदेखि मंशिरसम्म
मुगु	उच्च भेग : चैत्र १५ देखि बैशाख १५ गते सम्म		आश्विन अन्तिमदेखि कार्तिक पहिलो हप्ता
	चैते (पाखे धान): चैत पहिलो हप्ता	आषाढदेखि १५ गते सम्म आश्विन	आश्विन अन्तिमदेखि कार्तिक पहिलो हप्ता
अछाम	वर्षे मध्य बेसीः जेष्ठ दोश्रो हप्तादेखि आषाढको पहिलो हप्ता	आषाढ दोश्रो हप्तादेखि श्रावण तेश्रो हप्ता	आश्विन दोश्रो हप्तादेखि कार्तिक पहिलो हप्ता
	वर्षे बेसीः बैशाखको पहिलो हप्ता	जेष्ठको पहिलो हप्ता	भाद्र अन्तिम हप्तादेखि आश्विन पहिलो हप्ता
बझाङ	चैतदोश्रो हप्तादेखि बैशाख दोश्रो हप्ता	जेष्ठ तेश्रो हप्तादेखि श्रावण पहिलो हप्ता	आश्विन पहिलो हप्तादेखि कार्तिक तेश्रो हप्ता
बाजुरा	वर्षे : चैत महिनाको दोश्रो हप्ता उच्च पहाडी गा.वि.स.हरूमा	जेष्ठ दोश्रो हप्तादेखि श्रावण पहिलो हप्ता	आश्विन पहिलो हप्तादेखि कार्तिक दोश्रो हप्ता
	चैते : बैशाख दोश्रो हप्तादेखि जेष्ठ पहिलो हप्ता		
दार्चुला	उच्च भेग :चैत्र	जेष्ठ अन्तिम-आषाढ १५ सम्म	आश्विन
	मध्य भेग र बेसी : बैशाख	जेष्ठ अन्तिम-आषाढ १५ सम्म	आश्विन १५-कार्तिक पहिलो हप्ता
	बेसी : बैशाख-जेष्ठ	अषाढ अन्तिम-श्रावण पहिलो हप्ता	आश्विन १५-कार्तिक पहिलो हप्ता

स्रोत : जिल्ला कृषि विकास कार्यालय २०७३

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विगत २५/३० वर्ष यता नेपालको आर्थिक प्रवृत्तिमा मात्रात्मक परिवर्तन आएको भए पनि यो देश कृषि प्रधान देश हो । नेपालीले जीविकाको प्रमुख आधार कृषिलाई नै बनाई आएका छन् । फिरन्ते युगको समाप्तिसँगै सामूहिक रूपमा कृषि गर्ने र क्रमशः निजी सम्पत्तिको विकास हुँदै गएपछि व्यक्तिगत रूपमा खेती गर्ने प्रचलनको सुरुवात भएको पाइन्छ । नेपालमा उत्पादन हुने विभिन्न बालीमध्ये धान बाली पहिलो र महत्वपूर्ण मानिन्छ । खास गरेर पहाडको समथर पानी लाग्ने भूभाग तथा तराईको समथर भूभागमा विशेषतः धान खेती हुने गर्दछ । यस्तै मध्येको नेपालको मध्यभागमा अवस्थित रूपन्देही जिल्ला र त्यसको पनि मध्यभागमा पर्ने पुरानो नौकट्टी हालको तिलोत्तमा नगरपालिका क्षेत्र धान उत्पादनको हिसाबले देशकै महत्वपूर्ण क्षेत्रको रूपमा स्थापित भएको कुरा निर्विवाद छ ।

छत्तीस मौजाको इतिहास

जुनसुकै कृषि उत्पादनका लागि सिँचाइको ठूलो महत्व हुन्छ । अझै भन्ने हो भने धान उत्पादनका लागि सबैभन्दा बढी सिँचाइको आवश्यकता पर्दछ । यही आवश्यकतालाई मध्यनजर गरी लगभग पौने दुई सय वर्ष अगाडि तत्कालीन मक्रहर गा.वि.स.को कुमारी, कानपारा, सगरहवा र ठठेरियाका स्थानीय आदिवासी थारुहरूको सहभागिता तथा छेदा थारुको नेतृत्वमा जितराम थारु, बुझन र परमानन थारुहरूको पहलमा लगभग १५ कि.मी. उत्तरतर्फको तिनाउ खोलाबाट कुलो खनी बाँध बाँधी सिँचाइको कुलो निर्माण गरेको ऐतिहासिक दस्तावेज र बूढापाकाको भनाइबाट प्रमाणित हुन्छ । सुरुमा बस्तीको चाप कम र आदिवासी थारुहरू मात्र रहेकोमा क्रमशः बसाइसराइको प्रभाव तथा खेतीयोग्य जमिनको विस्तार (वनफडानी) हुँदै जाँदा क्रमशः गाउँहरू थप हुँदै जाने क्रम बढ्न थाल्यो जसका कारण सिँचाइ गर्ने मौजाहरू थप हुँदै गए र यिनको संख्या ३६ मौजा हुनपुग्यो । सोही समयका हाम्रा अगुवाहरूले यसको नामकरण छत्तीस मौजा कुलापानी भनेर गरे । बस्तीको विकाससँगै क्रमशः मौजाहरू थप हुँदै जाँदा ६२ मौजासम्म पुगेको यस प्रणालीमा हाल ५८ ओटा मौजा रहेका छन् ।

छत्तीस मौजा सामुदायिक सिँचाइ प्रणालीमा हालसम्म प्राप्त अभिलेख अनुसार निम्नानुसारको नेतृत्व परम्परा रहिआएको छ :

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१३. रुक्मागत पाण्डेय, सभापति, २०६०-२०६२
१४. बाबुराम अधिकारी, सभापति, २०६३-२०६५
१५. प्रेम बहादुर भण्डारी, सभापति, २०६६-२०६८
१६. यज्ञ गैरे, सभापति, २०६९- हालसम्म

पानीको स्रोत र छत्तीसले समेटेका क्षेत्र

यसको पानीको मुख्य स्रोत तिनाउ नदी हो, जुन चुरे पहाड रसाएर सुरु हुन्छ । यसको स्रोत अस्थायी प्रकृतिको छ । खास गरेर पाल्पा जिल्लाका विभिन्न खोल्साखोल्सीहरू मिसिँदै आउने माडी खोला, बल्डेङगडीबाट आउने कचल खोला मिसिई दोभान खोलाकोसँगमबाट बनेको तिनाउ नदी बुटवलको कन्याढुंगामा आइसकेपछि यस प्रणालीको बाँध सुरु हुन्छ । उक्त नदी नै हाम्रो पानीको स्रोत र जीवन जिउने आधार बनेको छ । यस सिँचाइ प्रणालीले सुरुमा बुटवल उपमहानगरपालिकाका ४ वटा वडा, तत्कालीन शंकरनगर, आनन्दवन, करहिया, मक्रहर, गंगोलिया तथा मधवलिया तथा अहिले तिलोत्तमा नगरपालिकाको अधिकांश भागमा सिँचाइ सुविधा पुऱ्याउँदै आएको छ ।

यसरी छत्तीस मौजातर्फ आउने पानीको व्यवस्थापन छत्तीसमौजा सामुदायिक सिँचाइ प्रणालीले गर्दछ । कूल ५८ मौजा रहेको यस प्रणालीमा एउटा मौजा बुटवल उपमहानगरपालिकामा पर्दछ भने बाँकी ५७ मौजाको कमान्ड एरिया तिलोत्तमा नगरपालिका रहेको छ । कन्याढुंगामा सुरु हुने बाँध सुरुमा कच्ची प्रकृतिको थियो । किसानहरूले विभिन्न सामुदायिक वनजंगलबाट झालाकिला, तिनगोडे सहित कुलाइ जाने र बाँध बाँधेर पानी ल्याउनु पर्ने तथा वर्षा याममा बाढीका कारण प्रत्येक पटकजसो अस्थायी बाँध बाढीले बगाउने र पुन बाँध बाँध्नुपर्ने बाध्यात्मक अवस्था रहेको थियो र अहिले पनि त्यस अवस्थामा केही सुधार भए पनि नहर पाटिने र पानी अर्कातर्फ सोहोरिने अवस्था यथावतै छ । पछिल्लो समय नेपाल सरकारको न्यून भए पनि सहयोगले केही सुधार भएको छ ।

बाँध, पानीको बाँडफाँड र नहर व्यवस्थापन

तिनाउ नदी बुटवलको कन्याढुंगामा आइसकेपछि यस प्रणालीको बाँध सुरु हुन्छ । कन्याढुंगाबाट केही तलको लगभग १.५ कि.मी.को दुरीमा हाम्रो अर्को इटियाभोड बाँध छ । त्यसलाई विगत १० वर्षदेखि सञ्चालन गर्न कठिन रहेको थियो । खास गरेर तिनाउ नदीको नदीजन्य पदार्थको अतिदोहनका कारण नदीको सतह गहिरिन गई बाँध पूर्ण रूपमा क्षतिग्रस्त भएको र किसान उपभोक्ताको बाहुबलले मात्र सञ्चालन गर्न नसकिरहेको अवस्थामा हाल नेपाल सरकार सिँचाइ विभागबाट IWRMP परियोजना अन्तर्गत यो सञ्चालनमा आएको छ । तिनाउ नदी खास गरेर हाम्रो मात्र नभई सिङ्गो रूपन्देहीको पानीको मुख्य स्रोत हो । रूपन्देहीका मुख्य सिँचाइ प्रणालीमध्ये सोह्र छत्तीस संयुक्त सिँचाइ प्रणाली, चार तपाहा सिँचाइ प्रणाली, मर्चवार लिफ्ट सिँचाइ प्रणाली यी सबैको प्रमुख स्रोत तिनाउ नदी नै हो ।

यीमध्ये सोह्र छत्तीस संयुक्त सिँचाइ प्रणाली सबैभन्दा ठूलो र महत्वपूर्ण सिँचाइ प्रणाली हो । यसमा दुई वटा सिँचाइ प्रणाली समाविष्ट छन् । एउटा छत्तीस मौजा सामुदायिक सिँचाइ प्रणाली र अर्को सोह्र मौजा सिँचाइ प्रणाली हुन् । यी प्रणालीले क्रमशः चार हजार हेक्टर र पच्चिस सय हेक्टर गरी जम्मा ६ हजार ५ सय हेक्टर जमिनलाई सिँचाइ सुविधा पुऱ्याउँदै आएका छन् । यसमा खास गरेर सोह्र छत्तीस संयुक्त सिँचाइ प्रणाली र चार तपाहा सिँचाइ प्रणाली बीच तिनाउको पानी बाँडफाँडको विषयमा भएको पुरानो सम्झौता अनुसार खोलाको जम्मा पानीलाई सय प्रतिशत मानी ६० प्रतिशत पानी सोह्र छत्तीस संयुक्त सिँचाइ प्रणालीलाई र ४० प्रतिशत पानी चार तपाहा सिँचाइ प्रणालीलाई हुने गरी बाँडफाँड गरिएको छ । खोलाको पश्चिमतर्फ सिँचाइ गर्ने चार तपाहा सिँचाइ प्रणाली र पूर्वतर्फ सिँचाइ गर्ने सोह्र छत्तीस संयुक्त सिँचाइ प्रणालीको रूपमा पहिचान गर्न सकिन्छ ।

सोह्र छत्तीस संयुक्त सिँचाइ प्रणालीका दुवै मुहान कन्या ढुंगा र इटियाभोडबाट गएको पानीलाई लगभग ३ कि.मी. दक्षिणनेर (न्यू होराइजन स्कुल) आइपुगेपछि पूर्वतर्फ छत्तीस मौजा र पश्चिमतर्फ सोह्र मौजाका लागि पानीको बाँडफाँड गरिएको छ । पानी विभाजन गरिएको यस ठाउँलाई ताराप्रसाद भोंड भनेर भनिन्छ । त्यहाँसम्म आइपुगेको नहरको सम्पूर्ण पानीलाई सय प्रतिशत वा सोह्र आना मानी साढे नौ आना छत्तीस र साढे छ आना सोह्र मौजामा जाने विशेष व्यवस्था मिलाइएको छ ।

पानी व्यवस्थापनका लागि मूल नहरका सबै साँचाहरू पक्की र व्यवस्थित गरिएको छ । पानी वितरण श्रमको अनुपातमा गरिएको छ । विगतमा हाम्रा अग्रजहरूले प्रति कुलारा २५ बिगाहलाई आधार मानी अघि बढेको सन्दर्भमा पछिल्लो समयमा मागको आधारमा

कुलाराको व्यवस्थापन गरिएको छ। हाल ५८ मौजाले १६५ कुलाराको श्रम गर्ने गर्दछन् र सोही सम्बन्धित मौजाको श्रमको आधारमा पानी वितरण गरिने गर्दछ। यस प्रणालीका सम्पूर्ण मौजाको कुलारा विवरण यस प्रकार रहेको छ :

क्षेत्र नं. १

क्र.सं.	**मौजाहरू**	**कुलारा संख्या**
१	डाँडाकुलो मौजा	१
२	माझगाउँ मौजा	२
३	आँपचौर मौजा	२
४	मैनकुलो मौजा	४
५	तुल्सीपुर मौजा	६
६	मंगलापुर मौजा	३
७	शङ्करपुर मौजा	३

क्षेत्र नं. २

क्र.सं.	**मौजाहरू**	**कुलारा संख्या**
१	पूर्वी शङ्कर नगर १ नं. मौजा	४
२	मणिग्राम १ नं. मौजा	६
३	सरदार नगर मौजा	३
४	नयाँ शङ्कर नगर मौजा	४
५	पशुपति टोल मौजा	३
६	कपिल मोहडा मौजा	४

क्षेत्र नं. ३

क्र.सं.	**मौजाहरू**	**कुलारा संख्या**
१	नयाँ चपरहट्टी मौजा	३
२	शान्ति नगर मौजा	३
३	शारदा मौजा	३
४	नव दुर्गा मौजा	३
५	देवनारायण मौजा	३
६	सातघरे मौजा	२
७	पाँडे टोल मौजा	४
८	प्रेमनगर मौजा	२

क्षेत्र नं. ४

क्र.सं.	**मौजाहरू**	**कुलारा संख्या**
१	२ नं. मौजा	५
२	३ नं. मौजा	१०
३	४ नं. मौजा	६
४	युवराज मौजा	३

क्षेत्र नं. ५		
क्र.सं.	**मौजाहरू**	**कुलारा संख्या**
१	चिनिया मौजा	२
२	पश्चिम जमुहानी मौजा	५
३	बर्गदवा मौजा	३
४	ज्योति नगर उत्तर मौजा	२
५	लाल बहादुर मौजा	१
६	सूर्यपुरा मौजा	३
७	ज्योति नगर दक्षिण मौजा	४
८	महुबारी मौजा	४
९	प्रगति मोहोडा	१

क्षेत्र नं. ६		
क्र.सं.	**मौजाहरू**	**कुलारा संख्या**
१	मन्द्राहनी मौजा	६
२	प्रदीप नगर मौजा	८
३	पेडेरहनी मौजा	२
४	मिर्गौलिया मौजा	१
५	कुमारी मौजा	३
६	मोहनाजोत मौजा	२
७	पूर्व जमुहानी मौजा	१

क्षेत्र नं. ७		
क्र.सं.	**मौजाहरू**	**कुलारा संख्या**
१	बुधबारे मौजा	३
२	मैनहवा मौजा	२
३	मकहर मौजा	२
४	विष्णुपुरा उत्तर मौजा	१
५	बेवँरी मौजा	२
६	विष्णुपुरा दक्षिण मौजा	१
७	ठठेरिया मौजा	२
८	बेवँरा मौजा	१
९	सखुई मौजा	२
१०	हरैया मौजा	२
११	सेमरा मौजा	१
१२	दर्शन टोल मौजा	१
१३	करैया मौजा	१
१४	राम नगरा मौजा	१
१४	ज्याहादा मौजा	१
१६	मुडियारी मौजा	१
१७	बिहुली मौजा	१
	जम्मा ५८ मौजा	**जम्मा १६५**

नहर सफाइ र मरमत संभार स्वयम् सिँचाइ प्रणालीले गर्ने भएकाले स्वाभाविक रूपमा किसान उपभोक्ता यसमा विशेष सक्रिय र जिम्मेवार रहेको देख्न सकिन्छ। नहर सफाई खास गरेर वर्षको एक पटक हुने गर्दछ जसका लागि प्रत्येक मौजालाई उनीहरूले पानीको उपभोग गर्ने आधारमा नाथ (नापो) दिने गरिन्छ र त्यसलाई निश्चित समयभित्र अनिवार्य रूपमा सक्नुपर्ने हुन्छ। साथै बाँधको मरम्मत तथा अन्य कार्य आवश्यकता अनुसार वर्षैभरि गर्ने गरिन्छ। यसका लागि साविक, डबल, त्रिबल, चौबल र झारा गरी यसको व्यवस्थापन गर्ने गरिन्छ। सो कार्य गर्दा अनुपस्थित कुलारालाई खारा (नगद जरिवाना) लिने गरिन्छ। यो काम मुख्य गरी मुहानमा गर्ने गरिन्छ। मुहानको मर्मत कार्य सोह्र मौजा र छत्तीस मौजाले पालैपालो अनुपातको आधारमा गर्ने गर्दछन्।

आर्थिक व्यवस्थापन

छत्तीस मौजा सामुदायिक सिँचाइ प्रणाली पूर्णतः जनताद्वारा सञ्चालित प्रणाली हो। यसको निर्माण र व्यवस्थापनमा राज्यको विगतमा कुनै लगानी थिएन र हाल पनि त्यस्तो नियमित सहयोग वा अनुदान रहेको छैन। हाल केही निर्माण कार्यमा सरकारले अनुदान दिने गरे पनि यसको सञ्चालन र व्यवस्थापनमा कुनै लगानी र सहयोग हुन सकेको छैन। यसले दक्षिण एसियाकै महत्पूर्ण सिँचाइ प्रणालीका रूपमा आफूलाई स्थापित गर्न सफल भएको छ। साथै यसको आर्थिक व्यवस्थापन स्वयम् प्रणालीले गर्दै आएको छ। खास गरेर यसको प्रमुख आर्थिक स्रोत भनेको खारा रकम, मौजाले कार्यालय व्यवस्थापनका लागि उपलब्ध गराउने रकम, विभिन्न अध्ययन भ्रमण टोलीले तिर्ने प्रवेश शुल्क र अन्य शुल्क रहेका छन्।

यिनै स्रोतका आधारमा यसलाई हालसम्म सञ्चालन गरिँदै आइएको छ। यसको आफ्नै दुई तले भवन तथा यसमा दुई जना कर्मचारी कार्यरत रहेका छन्। कुलाको सफाइ र मर्मत संभार तथा व्यवस्थापन गर्ने र पानी वितरण कार्यलाई व्यवस्थित गर्ने कार्यमा कर्मचारीहरू खटेका हुन्छन्।

संगठन, आमसभा, साधारण सभा र बैठक

यस प्रणालीको सुरुवाती अवस्थामा कुनै कार्यालय भवन र अन्य कुनै पनि व्यवस्थित व्यवस्थापन नभएकाले तोकिएको सार्वजनिक स्थलमा आम कुलारा उपभोक्तालाई आमन्त्रण गरेर यस संस्थाको समिति चुन्न प्रत्येक वर्ष आमसभा गर्ने कार्य गर्दथे भने हाल पछिल्लो चरणमा आएर संस्था दर्ता सहित विधानको निर्माण गरी व्यवस्थित तरिकाले संस्था चलेको छ। विधानतः यसमा १५ सदस्यीय कार्यसमिति गठन हुन्छ। प्रत्येक तीन वर्षमा नयाँ समितिको निर्वाचन हुन्छ जसमा प्रत्येक कुलाराको संख्यालाई आधार मानी १ कुलारा बराबर ४ जनाका दरले हुन आउने ६६० जना प्रतिनिधि सम्बन्धित मौजाले कार्यालयमा पठाउने गर्दछन् र सोही प्रतिनिधिले अध्यक्ष, वरिष्ठ उपाध्यक्ष, उपाध्यक्ष, सचिव र लेखासमितिको निर्वाचन गर्ने गर्दछ।

यस प्रणालीलाई ७ वटा क्षेत्रमा विभाजित गरिएकाले सम्बन्धित क्षेत्रबाट १/१ जनाका दरले ७ जना निर्वाचित भइसकेपछि बस्ने पहिलो बैठकले ४ जना सदस्य मनोनीत गर्ने र एक जना कोषाध्यक्ष चयन गर्ने काम समेत गरिसकेपछि समितिले पूर्णता पाउँछ। यस समितिले नियमित बैठक बस्ने, कुलाको रेखदेख र संरक्षण गर्ने, विभिन्न निकायसँग सम्बन्ध विस्तार गर्ने र नहरको व्यवस्थापनका निम्ति सम्पूर्ण काम गर्ने गर्दछ। आवश्यकताअनुसार बढीमा ९ सदस्यीय सल्लाहकार समितिको गठन गर्ने गर्दछ।

प्रत्येक मौजामा एकएक जना मुक्तियार रहने व्यवस्था छ। मुक्तियारलाई आवश्यक सहायक चाहिएका खण्डमा सहायक मुक्तियार या चौकिदार राख्ने चलन छ। हरेक मौजालाई छत्तीस मौजा सामुदायिक सिँचाइ प्रणालीसँग समन्वय गर्ने काम मौजा मुक्तियारले गरेका हुन्छन्। मौजाका उपभोक्ताबाट प्रत्येक वर्ष चयन र अनुमोदित भएर आउने मौजा मुक्तियारले मौजेनी कुलादेखि मुख्य नहरसम्मका सरसफाइमा कुलारा पठाउने व्यवस्था मिलाएका हुन्छन्। मौजाका अभिलेखहरू राख्ने, उपभोक्तालाई खटनपटन गर्ने, प्रणालीका निर्देशनहरू लागु गर्ने, साधारण सभाको सदस्यका रूपमा रही मौजाका समस्याहरूलाई प्रणालीमा पेस गर्ने, आफ्नो मौजामा प्रभावकारी रूपमा पानी बाँडफाँडको व्यवस्थापन गर्ने, सम्बन्धित मौजाका कुलारा प्रणालीको मूल नहरका सरसफाइ तथा मर्मतका काममा अनुपस्थित भएको अभिलेख राख्ने र सोको जानकारी प्रणालीबाट बुझी वार्षिक खारा तथा मौजालाई तोकिएको अन्य रकम सम्बन्धित कुलारा मार्फत लिई प्रणालीमा बुझाउने आदि काम गर्दछन्। आफ्नो मौजाका सम्पूर्ण जिम्मेवारी सम्हाल्ने मुक्तियारले मूल प्रणाली र मौजेनी उपभोक्ता समितिसँग समन्वय गर्ने पुलको काम गरेका हुन्छन्।

छत्तीस मौजा सामुदायिक सिँचाइ प्रणालीको प्रत्येक २ महिनाको १ पटक बैठक बस्छ। वर्षको २ पटक साधारणसभा हुने गर्दछ। कार्यसमिति, सल्लाहकार, लेखा समिति र संयुक्त सिँचाइ प्रणालीका प्रतिनिधि तथा ५८ मौजाका मौजा मुक्तियार यसका साधारण

सभा सदस्य हुने गर्दछन् । अर्कातर्फ प्रत्येक वर्ष आमसभाको रूपमा प्रति कुलारा ४ जनाका दरले प्रतिनिधि बोलाई आमसभा गर्ने गरिन्छ र सो नै यस संस्थाको सर्वोच्च निकाय भएकाले वार्षिक लेखा परीक्षण प्रतिवेदन, विभिन्न योजनाहरू तथा नीति निर्माण गर्ने काम सोही आमसभाले गर्ने गर्दछ र वर्षभरि भए गरेका कामको समीक्षा र अनुमोदन गर्ने काम समेत सोही आमसभाले गर्दै आइरहेको छ ।

उपसंहार

प्रणालीलाई व्यवस्थित रूपमा अगाडि बढाउने क्रममा यसलाई यहाँसम्म ल्याइपुऱ्याउनमा थुप्रै अग्रजहरूको त्याग, बलिदान र योगदानले काम गरेको छ । यसको आरम्भ नेतृत्व गर्ने छेदा थारुदेखि विभिन्न ज्ञात अज्ञात अगुवाहरू, पूर्व सभापतिका रूपमा रहनुभएका दिवंगत कुमारीकी रानी, वीरप्रताप सेन, गंगाबहादुर क्षेत्री, दुर्गाप्रसाद उपाध्याय, गुणाखर भट्टराई, भीमबहादुर कुँवर, खड्गबहादुर गुरुङ र यमलाल भण्डारीका साथै हालसम्म पनि सक्रियतापूर्वक लाग्नु हुने पूर्व सभापतिहरू प्रेमबहादुर भण्डारी, केशवराज न्यौपाने, बलराम खरेल, रुक्मागत पाण्डे, बाबुराम अधिकारी लगायतको महत्वपूर्ण योगदान रहेको छ ।

थुप्रै स्वदेशी तथा विदेशी अध्येताहरूले यसको अनुसन्धान र अध्ययन गरी थुप्रै दस्तावेजहरू तयार गरेका छन् । मानव श्रमको विशिष्ट अध्ययन केन्द्रका रूपमा यो संस्था परिचित रहेको छ । यी सबै कुराहरू हुँदाहुँदै पनि यो सिँचाइ प्रणाली थुप्रै समस्याहरूबाट ग्रसित भने छ । खास गरेर पानीको स्रोतको अभावका कारणले पानीको अप्राप्यता, परम्परागत कृषि प्रणालीका कारण लागत बढी हुँदा कृषकहरूको खेतीप्रतिको कम आकर्षण र निष्क्रियता, बढ्दो सहरीकरणका नाममा खेतीयोग्य जमिनलाई कंक्रिटको जंगलमा परिणत गर्ने अदूरदर्शिता, जमिनको खण्डीकरण जस्ता समस्या यसले भोग्दै आइरहेको छ ।

उपर्युक्त अभाव र विसंगतिले सिङ्गो कृषि अर्थतन्त्रमा प्रतिकूल असर पारेको सन्दर्भमा यसलाई राज्यले समयमै उचित सम्बोधन गर्नु जरुरी छ । पानीको वैकल्पिक व्यवस्था, आधुनिक कृषि प्रणालीका लागि कृषकहरूलाई सहयोग र प्रोत्साहन तथा खेतीयोग्य जमिनलाई सुरक्षित गर्ने कडा व्यवस्था गर्नु यस प्रणालीको टड्कारो आवश्यकता हो । यति गर्न सकेका खण्डमा यस क्षेत्रले पर्याप्त मात्रामा धान लगायत गहुँ, मकै, दलहन, तेलहन जस्ता बाली उत्पादन गरी राष्ट्रिय अर्थतन्त्रलाई महत्त्वपूर्ण सहयोग पुऱ्याउने कुरामा ढुक्क हुने अवस्था रहने थियो ।

Rice Science and Technology in Nepal (MN Paudel, DR Bhandari, MP Khanal, BK Joshi, P Acharya and KH Ghimire, eds).
Crop Development Directorate (CDD), Hariharbhawan and Agronomy Society of Nepal (ASoN), Khumaltar.

धान बालीका सम्बन्धमा केही कुरा

हीराकाजी मानन्धर

(साभार : गोरखापत्र दैनिक, वर्ष ८८, अंक २७०, २२ माघ २०४५)

धान नेपालको प्रमुख खाद्यान्नबाली भएको तथ्य सर्वविदितै छ। यसको खेती तराई, भित्री तराई, उपत्यका, बेशी, पहाड र उच्च पहाडमा समेत व्याप्त छ। साथै जुम्ला जिल्लाको झण्डै ३,०५० मीटर उचाईसम्मको क्षेत्रमा समेत धान खेती सफलतापूर्वक गरिदै आएको छ र यो उचाई (३,०५० मी.) लाई विश्वमा धान खेती गरिने सबभन्दा अग्लो उचाई मानिएको छ। आर्थिक वर्ष २०४४/०४५ को आँकडाअनुसार नेपालमा जम्मा १४,२३,२९० हेक्टर जग्गामा भएको खेतीबाट २९,८१,३४० मे. टन धान उत्पादन भएको थियो।

धान खेतीलाई सिंहावलोकन गर्दा धान रोप्दैमा र धान फल्दैमा धान खेती सफल भएको मान्न सकिन्न। शब्दमा 'धान' एक भएतापनि यसको चाहना र यसमा हुनुपर्ने गुणहरू धेरै छन्। तीमध्ये धानको उत्पादनले सर्वोपरि महत्व राख्दछ। समयको मागअनुसार थोरै जग्गामा धेरै फल्ने धानको छनौट, विकास तथा खेती नै पहिलो आवश्यकता हो। वर्तमान अवस्थामा धान बालीको उत्पादनलाई हेर्दा विभिन्न ठाउँका स्थानीय जातका धानले प्रति रोपनी सरदर डेढ-दुई मुरी दिने गरेको छ भने उन्नत जातका धानले प्रतिरोपनी ६-८ मुरीसम्म दिने गरेको प्रमाणित तथ्यहरू छन्। जस्तै तराईको निम्ति सिफारिस भएका मकवानपुर-१, परवानीपुर-१, खजुरा-१, घैया-२, वर्षे-२, चैते-२, चैते-४, आई.आर.-८, आई.आर.-२०, आई.आर.-२४, सि.एच.-४५, विन्देश्वरी, चन्दिना, लक्ष्मी, मलिका, दुर्गा, जानकी, सावित्री र मंसुली जातहरूको सरदर उत्पादन क्षमता ४ मुरी प्रतिरोपनी (४ मे. टन प्रति हेक्टर) छ भने पहाडी क्षेत्रको निम्ति सिफारिस भएका ताइचुङ्ग-१७६, चाइनुङ्ग-२४२, ताइनान-१, चाइनान-२, खुमल-२, खुमल-३, खुमल-४, पालुङ-२, हिमाली र कन्चन जातहरूको औषत उत्पादन क्षमता ६ मुरी प्रति रोपनी (६ मे.टन प्रति हेक्टर) छ। यसरी हालसम्म सिफारिस भएका उन्नत जातहरूको सरदर उत्पादन क्षमता ५.० मुरी प्रतिरोपनी (९० मन प्रति बिगाहा अर्थात ५.० मे. टन प्रति हेक्टर) भएको पाइन्छ भने हाम्रो धान बालीको राष्ट्रिय उत्पादकत्व २.०९ मे. टन प्रति हेक्टर मात्र छ। यसबाट यदि धान खेती हुने अधिकांश क्षेत्रलाई उन्नत जातले ढाक्न सकियो भने उत्पादनलाई धेरै बढाउन सकिने कुरा प्रष्ट हुन्छ। यिनै परिप्रेक्ष्यमा केही रमाइला अनुभवहरू यहाँ प्रासंगिक हुनेछ। जतिसुकै राम्रो उत्पादन दिने उन्नत जात भएतापनि कोही कोही किसानहरू 'छुक'को निम्ति भनेर आफ्नो परापूर्वकालदेखि लगाउँदै आएको धान एउटा गऱ्हा वा खेतको एक छेउमा लगाउन छाड्दैनन् भने कोही त यस्ता किसान पनि पाइन्छन् जो उन्नत जात लगाउनै मान्दैनन्। किनकि उन्नत धान लगायो भने 'सह' हुँदैन रे, जसलाई समय नपुग्दै पाक्ने अनिकाले धान भन्छन्।

मुखको स्वादअनुसार मसिनो र बासना आउने चामलको भात नै मीठो हुने कुरामा विवाद छैन। तथापि सबैले मसिनो र बासना आउने चामलमात्र रुचाउँदैनन्। जस्तै, धनी परिवारमा आफूलाई खान मसिनो र बासना आउने नै रुचाउँछन् भने निम्न आय भएका परिवार र साधारण कृषक परिवारले मोटो र बासना नआउने चामलको भात नै रुचाउँछन्। यसरी मोटो र बासना नआउने चामल रुचाउनु मुखको कुनै विशेष स्वाद नभई वाध्यता हो। यस्तो वाध्यताको पछाडि किनेर खानु पर्नेलाई महँगो पर्ने एउटा कारण हो भने बेचेर खानु पर्नेलाई बढी मूल्य पाउने अर्को कारण हो। त्यस्तै अर्को कारण छ, मसिनो र बासना आउने चामलको भात मीठो र बढी रुचिकर भई प्रतिछाक खानाकै हिसाबले पनि बढी लाग्ने हुन्छ। उदाहरणार्थ, खुमल-४ भन्ने जातले पूर्वी मध्य पहाडदेखि लिएर सुदूर पश्चिमको बैतडीसम्म राम्रो नतिजा देखाउँदै आइरहेको पृष्ठभूमिमा कतैकतै कुनैकुनै किसानहरूले मसिनो र मीठो भएको कारणले गर्दा मन पराएनन्। मीठो र नमीठोको साथसाथै अर्को रमाइलो तर वास्तविक पक्ष छ, आडिलो। साधारणतया उन्नत जातको धानको चामलको भात चाँडो पच्छ र छिटो भोक लाग्छ भन्ने गरेको पाइन्छ भने त्यसको दाँजोमा केही स्थानीय जातको चामलको भात आडिलो हुन्छ भन्ने छ। यस्तो अवस्थामा उन्नत धानको उत्पादन बढी भएर मात्र के गर्नु र खर्च पनि त बढी हुन्छ भन्ने किसानको गुनासो केही हदसम्म सामयिक हुन आउँछ।

धान खेतीमा अर्को महत्वपूर्ण पक्ष छ, चाँडो पाक्ने, ठिक्क समयमा पाक्ने वा ढिला पाक्ने। कसैलाई चाँडो पाक्ने जात चाहिन्छ भने कतिपयलाई फाँटमा अरूसरह पाक्ने जातको धान नै चाहिन्छ। खासगरी तीन बाली लिने किसानहरूलाई चाँडो पाक्ने जातको धानले विशेष महत्व राख्दछ। काठमाडौं उपत्यका तथा अन्य कुनै पनि क्षेत्रका हिउँदे तरकारी खेती गर्ने किसानहरू छिटो पाक्ने जातको धानलाई बढी रुचाउँछन्। यसैकारणले गर्दा खुमल-३ (के-३९) भन्ने जात काठमाडौं उपत्यका, काभ्रेपलान्चोक, नुवाकोट, कास्की र अन्य कतिपय क्षेत्रहरूमा चाँडो फैलियो। तर त्यस्ता कैयन क्षेत्रहरू छन् जहाँ छिटो पाक्ने धान मान्य हुन सक्तैन। किनकि फाँटमा अन्य धान बालीभन्दा चाँडो पाक्यो भने भएभरका मुसा, चरा, कीरा आदिले सखाप गर्ने गर्दछ भने कहीँकहीँ खेतबाट नै चोरीसमेत हुने गर्दछ।

यसको अलावा अरूको भन्दा चाँडै धान भित्रियो भने पैंचो दिनुपर्ने अर्को बाध्यता। यतिमात्र नभएर किसानहरूको अर्को गुनासो छ, चाँडो पाक्यो भने वर्षातको समय पर्ने हुँदा परालालाई सम्हाल्नैको समस्या।

धान खेतीको क्रममा त्यस्ता कतिपय समस्याहरू आइपर्छन् जुन हेर्दा सामान्य लागेतापनि त्यसको असर कम हुँदैन। जस्तै बेर्ना। साधारणतया हाम्रो अवस्थामा एक महिनासम्म बेर्नालाई रोपिने गर्दछ तर त्यस्ता कतिपय जात छन् जसलाई एक महिना पुऱ्याउनै नहुने। जस्तै खुमल-३। यदि यसको बेर्नाको उमेर २५ दिन नाघ्यो भने रोपेको १ महिना नपुग्दै पसाएर उत्पादनमा ठूलो ऱ्हास आउँछ। त्यस्तै कतिपय जातहरू पाक्ने बेलामा एकै पटक नपाक्ने अर्थात एउटै बालामा आधा चाँडो पाक्ने आधा ढिलो पाक्ने पनि छन्। फेरि त्यस्ता पनि जात छन् जुन काट्न ढिलो भयो र चाहिँदो चिस्यान पायो भने बालामै उम्रने गर्छन्। जस्तै सि.एच.-४५। त्यस्तै अर्को मुख्य चासोको विषय छ, धान कत्तिको झर्छ। कतिपय धानका जातहरू हल्का धक्काबाट नै झर्छन्। जसले गर्दा काट्नुभन्दा अघि, काट्दा र काटेर खलमा लैजाँदाको बीचमा झरेर नै धेरै नोक्सानी हुने गर्दछ। अर्कोतिर यसको ठीक विपरीत चुट्दा पनि नझर्ने हुन्छ। यसरी बढी झर्ने र झार्नै गाऱ्हो दुवै किसिमका धानहरू किसानलाई अमान्य हुन्छ। तर झार्न गाऱ्हो धानको एउटा फाइदा के छ भने, असिनाको प्रकोप हुने क्षेत्रमा यो धान राम्रो हुन्छ। साथै यस्तो धानको बोट अग्लो भई या अन्य कारणले ढलेतापनि नोक्सानी कम हुन्छ।

यी त भए मानिसको आवश्यकता र अभिरुचिअनुरूप धान बालीमा हुनुपर्ने विविध गुणहरू। अब धान बालीको निम्ति आवश्यक पर्ने केही प्राकृतिक पक्षहरूतर्फ लागौं। कुनै पनि जातको धान कुनै पनि क्षेत्रमा सप्रिन र फल्नको निम्ति त्यस क्षेत्रको हावापानी, घाम, माटो आदि अनुकूल हुनु नितान्त आवश्यक छ। सामान्यतया तराई क्षेत्रमा हुने जात पहाडमा हुँदैन भने पहाडमा हुने जात उच्च पहाडमा हुँदैन। यस्तो हुनुको मुख्य कारण तापक्रम हो। फूल फुल्ने र धान पाक्ने समयमा तापक्रम नपुगेमा फूल नै लाग्दैन भने अर्कोतिर फूल लागे पनि पाक्दै पाक्दैन। उदाहरणार्थ क्षेत्रको उचाईअनुसार खुमल-३ र खुमल-४ जातहरू ३००० देखि ५००० फिटसम्मको उँचाईमा लगाउन सकिन्छ। त्यस्तै तराईको निम्ति सिफारिस भएका जातहरू सामान्यतया ३००० फिट र सोभन्दा मुनीको क्षेत्रमा मात्र राम्रो हुने गर्दछ। तापक्रम जस्तै अर्को पक्ष छ, दिनको लम्बाई। कतिपय जातहरू लिनको लम्बाइमा आधारित हुन्छन्। जस्तै मंसुली, पोखरेली मसिनो जातका धानहरू दिन छोटो हुन थालेपछि मात्र पसाउन थाल्छन्।

धान बालीको निम्ति अर्को संवेदनशील पक्ष छ, पानी। धान खेती पानी लाग्ने खेतमा मात्र गर्ने नभई कम पानी पर्ने क्षेत्र र पाखो बारीमा पनि गरिन्छ। तर खेतमा हुने धानको जातले पाखो बारीमा राम्रो गर्दैन भने पाखो बारीमा हुने धान खेतमा नहुन सक्छ। अतः यी अवस्थाहरूमा छुट्टाछुट्टै धानका जातहरूको आवश्यकता पर्दछ। जस्तै घैया धान खेती अर्थात पाखो बारीकै निम्ति भनेर विन्देश्वरी र घैया-२ नामबाट दुई जातहरू सिफारिस भएका छन्। खेत वा पाखो बारीको साथसाथै अर्को पक्ष छ, माटोको मलिलोपना - धेरै मलिलो, मध्यम मलिलो र कम मलिलो। सामान्यतया मलिलो माटो चाहिने जात कम मलिलो माटोमा सप्रिन सक्तैन भने कम मलिलो माटोमा हुने जातले धेरै मलिलो माटो खप्न सक्तैन। अधिराज्यमा त्यस्ता धेरै क्षेत्रहरू छन् जहाँ अधिकतम उत्पादनको निमित्त अत्यधिक रासायनिक मलको प्रयोग गरिन्छ भने त्यस्ता क्षेत्रहरू पनि कम छैनन् जहाँ रासायनिक मलको मुखसम्म पनि देख्न पाएका छैनन्। यस्तो अवस्थामा बढी मलिलो जग्गा खप्नसक्ने जातको साथसाथै कम मलिलो जग्गामा समेत हुने छुट्टाछुट्टै जातहरूको आवश्यकता पर्दछन्।

मानिसको आवश्यकता तथा अभिरुचिअनुरूप हुनुपर्ने गुणहरू धानाबालीमा विद्यमान हुँदैमा र धान बालीको निम्ति उपयुक्त हावापानी हुँदैमा मात्र धान बाली सफल हुन सक्तैन। किनकि धान बालीमा ७० भन्दा बढी किसिमका रोगहरू लाग्दछन् भने त्यस्तै ७० भन्दा बढी विभिन्न जातका किराहरूले आक्रमण गर्दछन्। तीमध्ये नेपालमा मात्र धान बालीमा विभिन्न २५ भन्दा बढी रोगहरू लाग्ने गरेको पाइन्छ भने झण्डै १५ भन्दा बढी विभिन्न किराहरू धान बालीविरुद्ध सक्रिय पाइएका छन्। रोगहरूमा ब्लाष्ट (मरुवा), ब्याक्टेरियल ब्लाइट (ढडुवा), ब्राउन लिफ स्पट (खैरो थोप्ले), सीथ ब्लाइट, सीथ रट् आदि प्रमुख छन् भने किराहरूमा गवारो, फड्के, पतेरो, ढुङ्गे, पात खन्ने, पात बेरुवा, मिलिबग आदि मुख्य छन्। यिनै रोग र किराहरू खासगरी रोगको कारणबाट कतिपय उत्कृष्ट जातहरू खेतीको निम्ति सम्भव नहुने गरेका छन् भने कतिपय प्रमुख समस्याका रूपमा विद्यमान छन्। अतः रोग तथा किरा नलाग्ने जातको छनौट, विकास तथा खेतीले महत्वपूर्ण भूमिका निर्वाह गर्दछ। तर एउटै जातको धानमा सबै किसिमका रोग तथा किरा नलाग्ने गुण विद्यमान हुन कदापि सम्भव छैन, तथापि कुनै पनि उन्नत जातको धान सिफारिस गर्दा जुन क्षेत्रको निम्ति सिफारिस गरिने हो त्यस क्षेत्रको प्रमुख रोग तथा किरालाई विशेष ध्यान दिइन्छ। यसै क्रममा विभिन्न प्रमुख रोग तथा किराहरू नलाग्ने, कम लाग्ने वा सहन सक्ने जातहरूको सिफारिस भएका छन्। रोग किरा नलाग्ने जातसँग सम्बद्ध अर्को पक्ष छ, यदि कुनै धानको जात कुनै रोग वा किरा नलाग्ने छ भनेतापनि सो गुण सदाको लागि कायम रहन सक्तैन। अर्थात केही वर्षपछि सो गुण हराउन सक्छ। त्यस्तै अर्को पक्ष छ, कुनै निश्चित रोग वा किरा कुनै निश्चित धानको जातमा कुनै एक निश्चित क्षेत्रमा लगाग्ने सिद्ध छ भने सोही रोग वा किरा सोही जातमा अन्य क्षेत्रमा पनि लाग्दैन भन्न सकिन्न। किनकि जीवाणुहरू र किराहरूको उपजाति एक क्षेत्रबाट अर्को क्षेत्रमा फरक हुनसक्छ। तसर्थ सफल धान खेतीको निम्ति समयानुकूल क्षेत्र अनुसारको प्रमुख रोग तथा किरा नलाग्ने वा कम लाग्ने वा सहन सक्ने जातहरूको छनौट तथा विकास गर्दै जानुपर्ने हुन आउँछ।

नेपालका विभिन्न भौगोलिक क्षेत्र तथा जिल्लाहरूमा पाइने धानका जैविक विविधता तथा खेती प्रविधि

पूर्वी पहाडी जिल्लाहरूमा प्रचलनमा रहेका धान बालीका स्थानीय जातहरू

सरोजकान्त अधिकारी
वरिष्ठ कृषि प्रसार अधिकृत

पूर्वी पहाडका भोजपुर, संखुबासभा, खोटाङ र धनकुटामा पाइने स्थानीय जातहरूको लामो पराल हुने, खाँदा मीठो स्वाद र भात फरफराउँदो हुने, कम मलखादमा समेत राम्रो उत्पादन दिने र रोग एवम् किराको प्रकोप कम मात्रमा देखिने आदि गुणहरू भएकाले स्थानीय जातका धाननै बढी मात्रामा खेती गरेको पाईन्छ । स्थानीय जेष्ठ कृषक अगुवाहरू एवम् अनुभवी कृषि प्राविधिकहरूका अनुसार पूर्वी पहाडका स्थानीय जातहरूमा अट्टे (चामल पर्ने,भात मसिनो हुने र खादा आडिलो हुने), बेलगुट्टी (भात ज्यादै मसिनो र राम्रो, पराल लामो), मनसारा (रातो धान, पराल छोटो, कम मलखादमा र थोरै सिँचाइमा समेत राम्रो उत्पादन दिने), स्थानीय बासमती (लामो चामल र बासनादार भात हुने) आदि स्थानीय धानका जातहरू लोकप्रिय रहेका छन् । त्यसै गरी अन्य पुराना स्थानीय जातहरूमा हलपुडो, चिराखे, कालो झिनुवा, चुल्ठे, थापाचिनी, कालो मार्सि, लौरे, च्युरे (च्युराको लागि राम्रो), आनापासी (ज्यादै मीठो भात हुने) अनदी, सेथारो, याकुले, भोटाङे, कार्तिके न्याउली, भगेरी (छिटो पाक्ने), मालिधान, जमदार मसिनो, ताकमारु (लेकमा हुने मसिनो धान), फूलपाटा, मनिपुरे (डल्ले धान) तथा कनजिरा आदि मुख्य रहेका छन् । अन्य पुराना जातहरूमा फापरे (कालो खस्रो),भोटे मार्सी समेत रहेका छन् । यी जातहरूका धान खेत गर्न कृषकहरूले धुले तथा हिले ब्याड राख्ने गरेको पाइन्छ । बाहुल्यताका हिसाबले हिले ब्याड नै बढी प्रचलनमा देखिन्छ । धुले ब्याडमा चिस्यान कायम गर्न तथा पछि कुहिए पछि मल हुन्छ भनेर तितेपाती, असुरो जस्ता बनस्पती काटेर मसिनो पारी छापो (Mulching) समेत गरेको पाइन्छ । बीउ चाँडै उर्मानका लागि बीउलाई ढड्याएर उमारेर राख्ने गरेको समेत पाईन्छ । परम्परागत रूपमा धानको राम्रो बाली लिन कृषकहरूले राम्रा–राम्रा धानका बाला छनोट गरी बल्याएर राख्ने गरेको पाइन्छ । बीउ आफ्नै खेतबाट बल्याएर राख्ने र चिनजान, आफन्तहरूबाट समेत राम्रा जातका बीउहरू ल्याएर कृषकहरूले बिगतका वर्षहरूमा पूर्वी पहाडका जिल्लाहरूमा प्रयोग गर्ने गरेको पाइन्छ । पूर्वी पहाडी जिल्लाहरूमा धानसँग सम्बन्धित विभिन्न परम्परागत प्रचलनहरू पनि चलिआएका पाइन्छन् । जस्तै मंसिर महिनामा (तिहार पछि) मौरी भुनु भुनाएको जस्तो आवाज दिउँसोको समयमा महसुस भएपछि धान काट्न सुरु गर्नु भन्ने सल्लाह बिजुबा (राई जातिका धामी) बाट भएपछि सहकाल (राम्रो समय) आयो भनी धान काट्न सुरु गर्ने चलन भोजपुरमा रहेको थियो । त्यसैगरी पानी मूल भएको कुलो लाग्ने खेतमा भोजपुरमा कृषकहरूले मंसिर महिनामा धान काटेदेखि जेठ असारसम्म धान नरोपेसम्मका लागि खेतमा पानी जमाएर राख्ने चलन रहेको छ । जसबाट हिलो कुहिने, धान खेतमा झार कम आउने भन्ने कृषकहरू माझ रहेको छ । माटोमा प्रागांरिक पदार्थको कुहिने क्रममा पानी जमाएर राख्नाले प्रांगारिक पदार्थको कुहिने क्रम (क्षति हुने क्रम) कम हुन गई प्रांगारिक पदार्थको संचय माटोमा बढ्न जाने र माटो मलिलो हुने चाहि वैज्ञानिक आधार मान्न सकिन्छ । दाइँ गर्दा धानको रास (थुप्रो) मा भुमे पूजा गर्ने, फूल चडाउने, धूप बाल्ने, पूर्व फर्केर पाथीले ३ पटक भरी रासको सिरमा चढाउने गर्दा सह बढ्छ भन्ने प्रचलनमा रहेको छ । धान भकारीमा राखिसकेपछि धामि लगाएर छुनिमाङ, चसुमाङ पूजा गरेपछि मात्र धान झिक्ने चलन राई जातिमा रहेको पाईन्छ । यो कार्य प्राय पुस-माघ महिनामा गरिन्छ । नयाँ धान काट्न सुरु गर्दा दिन हेरेर तिथि, मिति जुराएर मुठी लिने चलन छ । त्यसै गरी नयाँ धानको चामल खान सुरु गर्दा दिन हेरेर न्वागी खाने चलन समेत रहेको पाईन्छ । धानको दाइँ गरीसके पछि धान सफा गरेर ठूलो रासमा (थुप्रोमा राख्ने) त्यसको वरीपरी नाङलोको घेरा लगाउने, धुप बाल्ने र खरानीको घेरा समेत राखी रासको टुप्पोमा हँसिया, खुकुरी जस्ता हतियार घुसार्ने र रासमा खरानीबाट त्रिसुल जस्ता आकृति समेत लेख्ने गरेको पाईन्छ । त्यसै गरी फूलले पुजा समेत गरी पूर्व फर्केर पाथीले थैलोमा भरी भण्डारणमा राख्ने गरेको पाइन्छ । त्यसै गरी यसको अलाबा भण्डारणको लागि भकारीमा राखिसकेपछि देवी देवताको प्रतिकको रूपमा ढुङ्गाको शीला तथा शालिग्राम समेत भकारी भित्र राख्दा सह कायम भई अन्न फारु हुने जनविश्वास समेत परम्परागत रूपमा रहेको पाइन्छ ।

मध्य तराई क्षेत्रमा प्रचलित धानका स्थानीय जातहरू तथा तिनको जातीय विशेषता

हरि यादव
प्राविधिक सहायक

तराईको जिल्लाहरूमध्ये विशेषगरी सप्तरी, सिराहा, धनुषा, महोत्तरी जिल्लाहरूमा विगतमा धानका पुराना तथा स्थानीय जातहरू लगाइने गरिएको भएता पनि हालैका वर्षहरूमा कतिपय स्थानीय तथा पुराना धानका जातहरू हराउँदै गइरहेका छन् । यस क्षेत्रमा लगाइने स्थानीय तथा पुराना जातहरूको बारेमा देहाय अनुसार उल्लेख गरिएको छ ।

अगहनी

- करीया कामर, तुलसीफुल : अग्लो बोट, बाला कालो रंगको (करीया कामर)/बाला सेतो रंगको (तुलसीफुल), मसिनो, पातलो दाना हुन्छ । चामल हल्का लाम्चो मसिनो, पातलो र बासनादार हुन्छ । चामलको रंग सेतो, चामलको भात बासनादार, धान कुटाउदा १० क्वीन्टल अन्य जातको धानमा १ क्वीन्टल करीया कामर धान/तुलसीफुल मिसाएर कुटाइ खाने चलन
- लल्का बासमती : अग्लो बोट, बाला रातो रंगको, मसिनो, पातलो दाना, चामल हल्का लाम्चो मसिनो, पातलो र बासनादार
- उजरा बासमती : धानको अग्लो बोट, बाला सेतो रंगको, लाम्चो र पातलो दाना, चामल सेतो, लाम्चो, पातलो र बासनादार
- मनसरी : अग्लो बोट, बाला सेतो रंगको, लाम्चो र पातलो दाना, चामल सेतो, लाम्चो, पातलो र बासनादार
- कलमकाठी, कलमखोर : अग्लो बोट, बाला सेतो रंगको, लाम्चो, पातलो दाना, चामल सेतो, लाम्चो, पातलो, स्वादिलो
- जसवा : अग्लो बोट, बाला सेतो रंगको, लाम्चो, पातलो दाना, चामल सेतो, लाम्चो, पातलो र स्वादिलो
- छबिस नम्बर : अग्लो बोट, बाला सेतो रंगको, लाम्चो, मध्यम दाना, चामल सेतो, मध्यम, भात खानमा ठीक
- धुसरी : अग्लो बोट, बाला सेतो रंगको, मोट्टो दाना, चामल सेतो, मोटो, भात खानमा त्यति मीठो नहुने
- धुमाखेरहा : अग्लो बोट, बाला सेतो रंगको, मोटो दाना, दानाको टुप्पोमा काँडा जस्तो हुने, चामल सेतो, मोटो, कम स्वादिलो

अगौटे भदैया / चैत

- भदरी : धानको होचो बोट, गाँज बढी आउने, सेतो रंगको, पातलो लाम्चो साइजको दाना, चामल सेतो, पातलो लाम्चो साइजको, भात खानमा स्वादिलो हुन्छ,
- रंगवा आउस, उजरा आउस : प्राय बासमतिको गुण मिल्छ तर बासनादार नहुने, मध्यम र अग्लो बोट, गाँज बढी आउने, बाला रातो रंगको, पातलो र मध्यम साइजको दाना, चामल सेतो, पातलो र मध्यम, स्वादिलो र बासना नहुने,
- गमहरी : धानको होचो बोट, गाँज बढी आउने, बाला गुवोभित्रै (घोघा) फूल फुल्ने, फल्ने, बढ्ने र पाक्ने गर्छ, कालो रंगको, मध्यम साईजको दाना, चामल सेतो, मध्यम, भात खानमा स्वादिलो,
- जिरी : धानको मध्यम र अग्लो बोट, गाँज बढी आउने, बाला सेतो रंगको, मध्यम र मोटो साइजको दाना, चामल सेतो, मध्यम र मोटो खालको, स्वादिलो नहुने

धौलागिरी क्षेत्रमा लोकप्रिय स्थानीय तथा उन्नत धानका जातहरू

बासुदेव रेग्मी
वरिष्ठ बाली विकास अधिकृत

धान धवलागिरी अञ्चलमा पर्ने वाग्लुङ, म्याग्दी र पर्वत जिल्लाको प्रमुख खाद्यान्न बाली हो । यस क्षेत्रका अधिकांश कृषकको जीविकोपार्जनको मुख्य स्रोतमध्ये एक हो । यस क्षेत्रमा धान बालीको आफ्नै सामाजिक र आर्थिक महत्व रहेको छ । क्षेत्रफलको हिसाबमा वाग्लुङ, म्याग्दी र पर्वत जिल्लामा क्रमश ६०१२, ३८९५ र ९६१२ हेक्टरमा धान खेती गरिन्छ भने वार्षिक रूपमा उत्पादन १९२६८, १३८३८ र २५०४२ मे.टन रहेको छ (जि.कृ.वि.का पर्वत, वागलुङ र म्याग्दी २०१५) । धान खेती गरिने जम्मा क्षेत्रफल मध्ये ९ प्रतिशत सिंचित तथा ९१ प्रतिशत आंशिक सिँचाइ सुविधा उपलब्ध भएको पाखोबारी र १० प्रतिशत क्षेत्रफल चैते धानले ओगटेको छ । यस क्षेत्रमा खेती गरिने जातहरू प्राय *Oryza Sativa* उप-प्रजाति *indica* छन् । धान खेती यस क्षेत्रको समुद्र सतहबाट ५२० मिटर (पर्वत जिल्लाको शालिग्राम गा.वि.स) देखि २२०० मिटर (म्याग्दी जिल्लाको सिखा र मुडी) उचाईसम्ममा गरिन्छ । यस क्षेत्रको बेंसीमा खुमल सेरिज तथा माथिल्लो पहाडी क्षेत्रमा माछापुच्छ्रे र छोमरोङ जातका धानहरूको खेती गरिन्छ । कालीगण्डकी, सेतिखोला र मोदीखोला का केही भूभागमा वर्णशंकर धानको खेती पनि गरिने गरिएको पाइएको छ । अन्य जिल्लाको तुलनामा पर्वत जिल्लामा बढी मात्रामा स्थानीय जातको खेती गरिन्छ । एक्ले नामको स्थानीय जातले सम्मभवत: त्यस क्षेत्रमा क्षेत्रफल र उत्पादनको हिसाबले पहिलो स्थान ओगटेको छ । एक्ले जातको अग्लो हुने विशेषताले गर्दा गाईवस्तुको परालको लागि उपयुक्त मानिन्छ । साथै कम बासना आउने, ढिलो पाक्ने (१५० दिन), एकमात्र बिरुवा लगाइने, नढल्ने गुण, कम मलिलो जग्गामा राम्रो उत्पादन दिने, मध्यम गाँजहाल्ने क्षमता, पकाउँदा नरम हुने गुण, र विशेष गरी केटाकेटी र बृद्धाले मन पराउने गुण भएकोले यसको क्षेत्रफल बढ्ने क्रममा छ । यसको औसत उत्पादन ४ मुरी प्रति रोपनी छ । धौलागिरी क्षेत्रमा खेती गरिने स्थानीय र उन्नत प्रजातिहरूको बारेमा तल जानकारी गराईएको छ ।

फोटो १. धान (एक्ले जात) कुश्मा नगरपालीका १३, पर्वत

पर्वत

स्थानीय जातहरू

एक्ले, बिरमफूल, पहेंले (सानोपहेंले, ठूलोपहेंले असीना सहने), गुडुरा (कोदे गुडुरा, भैंसे गुडुरा, लहरे गुडुरा, सेतो गुडुरा (स्वादिलो), ठूलो गुडुरा(अगौटे), बलेवालीगुडुरा, आरचौर गुडुरा, जेठोबुढो, गौरीया (बासनादार), कालनाथ्रे, जर्नेली, रामनी (कालो र फुस्रो), अनदी (सेतो र रातो, औषधीय गुण), पोखरेली, रामसाली, रातजाडो, मनसरा (रातो), राते (रातो र भद्दा), कृष्णभोग (कालो र बासनादार), झिनुवा (कालो सेतो र बासनादार), आगा (असिंचित कालो), गोलकोटे, मार्सी, सिदली, जरपानी, सेतोमनसरा, बाङ्गे, पाखे जर्नेली, थापाचिनी (असिंचित), मानामुरी, दूधराज, कनजीरा, बतिसरा, आनझुत्ते, कौडे, रेसाली, गुर्जु, मल्लाजी, गोला, तकमारे (अगौटे), भकुण्डे (होचो), राउसे (उच्च पहाड) सिलाङ्गे (उच्च उचाई), तैरिङगे (रातो), फलामे (उच्च उचाई), काठे (उच्च उचाई), रविजाडो ।

उन्नत जातहरू

वर्णशंकर, खुमल ४, खुमल ८, खुमल १०, लोकतन्त्र, रामधान, मकवानपुर, लुम्ले, बासमती, माछापुच्छ्रे ३, छोमरोङ, बिरमफूल ३, सावा मंसुली ।

बाग्लुङ

स्थानीय जातहरूमा गौरीया, गुडुरा, जर्नेली, बिरमफूल, जेठोबुढो, आगा, गलकोटे, एक्ले, राते, धम्पुसे, खजुरा, जदन, नेपाली र ***उन्नत जातहरूमा*** खुमल ७, सावित्री, लुम्ले २, राधा ७, राधा ९, हर्दीनाथ १, सी.एच ४५, खुमल ४

म्याग्दी

स्थानीय जातहरूमा गौरीया, गुडुरा, मार्सी, घरखोले, भट्टे, रमानी, जुनजाडो, दूधपाते, आगा, तकमारे र ***उन्नत जातहरूमा*** माछापुच्छ्रे, छोमरोङ, खुमल ४, लुम्ले २ आदि ।

सुदूर पश्चिमको मध्य पहाडी क्षेत्रमा खेती प्रणालीको अभिन्न पक्षः घैया धान

पशुपति पोखरेल
वरिष्ठ योजना अधिकृत

धान खेती भन्ने बित्तिकै हामी तराईका फाँटहरू र मध्ये पहाडका नदी आसपासका सिंचित बेसी र टारहरूमा असार साउनमा हिलाम्मे अवस्थामा रोप्ने बाली सम्झन्छौं । धान बाली लगाउने खेत सधैंभरि कुलो लाग्ने हुन्छ भन्ने हाम्रो विश्वास छ । तर त्यो भन्दा पृथक् नेपालको सुदूर पश्चिमका डोटी, डडेल्धुरा, बैतडी, बझाङ्ग, अछाम र बाजुरा जिल्लाहरूमा पाखाबारीमा बिना पानी धान खेती गरिन्छ भन्दा कतिलाई विश्वास नलाग्न पनि सक्छ । तर, यथार्थमा सुदूर पश्चिमका पहाडी क्षेत्रका पाखोबारीमा सदिऔंदेखि घैया नामक धान खेती गरिन्छ । यस घैया धानलाई तराई तथा सिंचित क्षेत्रमा बाली अवधिभरि नै कुलोबाट पानी लगाई रोपिने धानको जस्तो पानीको आवश्यकता पर्दैन, न त यसलाई छुट्टै नर्सरी ब्याड नै राख्नु पर्छ । यस क्षेत्रमा घैया धान खेती प्रणालीको अभिन्न अंग एवम् पाखोबारी मात्र हुने घरधुरीहरूको खाद्यान्नको प्रमुख स्रोतको रूपमा स्थापित छ । वर्षौंदेखि खेती गरिदै आएपनि यस धानको बारेमा अध्ययन अनुसन्धान भएको आधिकारिक जानकारी भने पाइएको छैन, यद्यपि यसको उत्पादकत्वमा पहिले र अहिलेमा उल्लेख्य अन्तर नभएको कृषकहरूको अनुभव रही आएको छ ।

चैत बैशाखमा जब पहिलो झर पानी सुरु हुन्छ तब सुरु हुन्छ घैया धानको खेती । बैशाखको सुरुमानै कृषकहरूले पाखोबारीमा प्रति रोपनी १०/१५ भारी गोठेमल थुपार्ने गर्छन् । साधारणतया यो गोठेमल बैशाखको घाममा त्यसै सुकेर खेर जान्छ । जब पहिलो झर पानी पर्छ तब माटो केही कमलो भई खनजोत गर्न सहज हुन्छ । पहिलो जोताइको क्रममा गोठेमल माटोमा मिलाइन्छ तत् पश्चात् दोश्रो पटक पानी परेपछि प्रति रोपनी ४–५ माना (प्रति हेक्टर ४०–५० केजी) घैयाको बीउ छरिन्छ । धानको साथमा प्रति रोपनी २ माना मकै पनि छर्ने गरिन्छ । सँगसँगै दोस्रो जोताई पनि गरिन्छ । मकैको अलवा बारीको चारैतर्फ छेउभागमा एक लाइन तील र त्यसको भित्रपट्टी भटमास पनि लगाउने गरिन्छ ।



फोटो १. करिब २ महिनाको घैया धानको अवस्था मकै र घैया धानको मिश्रितबाली घैया धानको वरीपरी लगाईएको तील बाली

घैया धानका विभिन्न स्थानीय जातहरू छन् । कृषकहरूका अनुसार श्याम जिरो, अन्जना, लमडी, झिमुवा, सुनौलो र गुर्धौलो प्रमुख जातहरू हुन् । भातको स्वाद, चामलको रंग, पातको आकार, डाँठ र दाना आदिको अवलोकनबाट विभिन्न जातहरू छुट्ट्याउन सकिने स्थानीयहरूको अनुभव रहेको छ । कृषकहरूको भनाइमा झिमुवा सबैभन्दा लोकप्रिय जात हो । लमडीको खुमलचारको जस्तो र अन्जनाको चन्दनाथ जस्तो जातीय गुण रहेको स्थानीय कृषि प्राविधिकहरू बताउँछन् । घैयालाई ३ पटक गोड्ने गरिन्छ । पहिलो पटक करिब ६ इन्च जति उचाइमा, दोश्रो पटक २४ इन्च जतिमा र तेस्रो पटक धान पसाउने बेलामा । घैयाको बोट सरदर १०० से.मि. सम्म अग्लो हुन्छ । एउटा बोटबाट ४ देखि ७ वटासम्म सराहरू आउने गरेको पाईन्छ । गोडमेल गर्दा घरायसी कामदारहरूले हातको प्रयोगबाट गोडमेल गर्ने गरिन्छ । घैयामा रासायनिक मलको प्रयोग नगण्य रूपमा गरिन्छ । कसैकसैले सिंचित खेतमा प्रयोग गरी बचेको युरीया मल पहिलो गोडाई पश्चात् प्रयोग गर्छन् ।

घैयामा केही रोग किराले समेत सताउने गर्दछ । स्थानीय कृषकका अनुसार घैयामा रातो मान, खैरो मान र पहेंलो मान भन्ने समस्या देखा पर्दछ । रातो र पहेंलो मान भन्नाले ब्लाष्टरोगको क्रमशः प्रारम्भिक र विकसित अवस्था हो । खैरो मान भनेको जिङ्क तत्वको कमीबाट देखिने लक्षण हो । केही वर्षयता डोटीमा जिङ्क तत्वको प्रयोगबाट खैरो मानको समस्या कम भएको स्थानीय कृषकहरू बताउँछन् । त्यसैगरी पात र गुवो खाने गबारोले किराको प्रकोप पनि रहको छ घैया धानमा । यसका लागि कुनै उपचार प्रचलनमा छैन सुदूर पश्चिममा । बैशाखमा लगाएको घैया असोजमा पाक्छ र पानी ढिलो परी लगाएको घैया पाक्न कात्तिक सम्म पनि लाग्ने गर्दछ । एक रोपनीमा ८० देखि १२० केजी (१.६ देखि २.४ मे टन प्रति हेक्टर) सम्म घैया फल्छ । बाली अवधिभर जति पानी बढी पर्यो सोही अनुसार उत्पादन पनि राम्रो हुने स्थानीय कृषकहरूको अनुभव छ । उप उत्पादनको रूपमा प्रति रोपनी १५ के.जी. (०.३ मे टन प्रति हेक्टर) जति मकै उत्पादन हुछ । बाक्लो भएको मकैलाई घाँसको रूपमा प्रयोग गरिन्छ । उत्पादन भएको घैया धान कृषकहरूले घरायसी उपभोगका लागि प्रयोग गर्ने र कसैलाई बढी भएमा स्थानीय अन्य कृषकहरूलाई बिक्री गर्ने, अन्य अन्नबालीसँग साट्ने गरेको तर व्यापारीहरूलाई बिक्री गर्ने चलन साधरणतया पाइदैन । घैयाधानको चामल केही मोटो देखिएता पनि स्वादमा भने रसिलो तथा आडिलो भएको स्थानीयबासीहरू बताउँछन् । उत्पादन गर्न खासै मेहनत गर्नु नपर्ने तथा सिँचाइ पनि गर्नु नपर्ने भएकोले यसको खेती गर्न सजिलो भएतापनि कृषकहरू भने सिंचित क्षेत्रमा लगाइने मुख्य धान बाली नै धेरै फल्ने र राम्रो हुने स्थानीयको ठम्याई छ ।

फोटो २. घैया धान सुनौलो

ईलाम जिल्लामा पाइने धानका स्थानीय जातहरू तथा खेती प्रविधि

प्रकाश कुमार डाँगी
वरिष्ठ कृषि प्रसार अधिकृत

समुद्र सतहबाट ३०० मीटरदेखि ३६३७ मीटरको उचाइमा रहेको ईलाम जिल्लामा प्रायः सबै किसिमको हावापानी पाइन्छ । त्यसैले अन्य बालीका साथसाथै यहाँ धान खेती पनि राम्रो हुन्छ । परापूर्वकालदेखि नै यहाँ धान खेती गरिदै आएको पाइन्छ । यस जिल्लाका देउमाई नगरपालिका, गजुरमुखी, इभाङ्ग, लुम्दे, चुलाचुली दानाबारी, चिसापानी, लक्ष्मीपुर, शान्तिपुर, महमाई, सोयाक, सिद्धिथुम्का, ईलाम नगरपालिका, बरबोटे, सोयाङ्ग, नाम्सालिङ्ग, गोदक, साङ्गरुम्बा, गोर्खे, जिर्मले, ईरौंटार, सुम्बेक, सुलुबुङ्ग, प्याङ्ग, माईमझुवा, शान्तिडाँडा, एकतप्पा, फुयतप्पा, आम्चोक आदि गा.वि.स.हरूमा धान खेती राम्रो हुन्छ । ईलामका स्थानीय धानका जातहरूमा फौडेल, चिराँखे, वर्षे जमरा, चरी नङ्गे, भँगेरी, कृष्ण भोग, चिराखे पुरानो, राम तुलसी (गौरे), ओइराँगे, फाटसे, अट्टे (चिराखे पनि भन्ने चलन छ), बेलगुठी, नानीया, वयरनी, रातो वयरनी, चुल्ठे, कालो नानीया, दूधे, लड्वा, चम्पासरी, हलुवा, घैया, दमौली, रुदुवा, टिम्बुर, मार्सी, आदि पर्दछन् । यी मध्ये भँगेरी, चिराखे, मार्सी लेकतिर (१५००–१८०० मीटर) लगाइन्छ भने बाँकी अन्य बेंसितिर (३००–१२०० मीटर) लगाउने गरिन्छ । स्थानीय जातका धान बाहेक अन्य उन्नत जातका धानहरू पनि लगाउने गरिन्छ । ती धानका जातहरूमा खुमल-४, हर्दिनाथ, राधा-१२, मन्सुली, लोकतन्त्र आदि पर्दछन् । धान रोपाइँ गर्ने समय र चलनको हिसाबले लेकतिर जेठको दोस्रो हप्तादेखि असारको पहिलो हप्तासम्म र बेसीतिर असारको दोस्रो हप्तादेखि भदौको दोस्रो हप्तासम्म रोपाइँ गर्ने गरिन्छ । धान रोपाइँमा कतै कतै खसिया (खाँडु पनि भन्ने गरिन्छ) गर्ने भन्ने चलन पनि छ । जसअनुसार १५–२० दिनको बेर्नालाई अर्को ब्याडमा सारिन्छ र फेरि १५–२० दिनपछि वा पानी परेपछि रोपाइँ गरिन्छ । यसले गर्दा धानको बाला भरिलो भएर आउने, भुस कम आउने तथा बढी फल्ने यहाँका कृषकहरूको अनुभव छ । प्रायः धेरै खेती हुनेले समय मिलाउन र बढी फलाउन यो चलन अपनाएको पाइन्छ । यसरी पहिलो ब्याडबाट दोस्रो ब्याडमा सार्दा एक दुई वटा गावो अलिक बाक्लो गरी रोपिन्छ । त्यसपछि दोस्रो ब्याडबाट खेतमा रोपाइँ गर्दा एक दुई वटा गावो रोप्ने गरिन्छ । विशेष गरी सोयाङ्ग र सोयाक गा.वि.स. तिर यो चलन अपनाउने गरिन्छ । आर्थिक वर्ष २०७२/७३ को तथ्याङ्कलाई हेर्ने हो भने ईलाम जिल्लामा धान लगाइएको क्षेत्रफल करिब १५९१५ हेक्टर र उत्पादन ४६४११ मेट्रिक टन रहेको छ ।




फोटो १. ईलाम जिल्लामा पाइने स्थानीय धानका जातहरू

रसुवा जिल्लाको उच्च हिमाली क्षेत्रमा लोकप्रिय बोराङ्गधान र पतलाधान

रमेश हुमागाँई
वरिष्ठ बाली विकास अधिकृत

बोराङ्गधानः यो जातको धान रसुवा जिल्लाको उच्च हिमाली क्षेत्र (१७५०–१८०० मी.) उचाइमा परम्परा देखिनै खेती गरिँदै आएको छ । बैशाख–जेठ महिनामा ब्याड राखिने असार महिनामा रोपिने यो धान मंसिर महिनामा भित्र्याइन्छ । यस जातको औसत उत्पादकत्व १.५ मे.ट/हे रहेको छ । यो जातको धान खेत र पाखो बारीमा लगाइन्छ । हिमाली क्षेत्रमा सिमिसँग मिसाएर खोले बनाई खाने प्रचलन छ । यसले हिमाली क्षेत्रको खाद्य सुरक्षामा महत्वपूर्ण स्थान राख्दछ ।

फोटो १. बोराङ्गधान (रसुवा जिल्लाको माथिल्लो क्षेत्र)

पतलाधान : यो जातको धान पनि बोराङ्ग जस्तै रसुवा जिल्लाको उच्च हिमाली क्षेत्र (१७५०–१८०० मी.) उचाइमा परम्परादेखि नै खेती गरिदै आएको छ । बैशाख–जेठ महिनामा ब्याड राखिने असार महिनामा रोपिने यो धान बोराङ्ग धानभन्दा १ महिना छिटो पाक्दछ । यस जातको औसत उत्पादकत्व १.५ मे.ट/हे रहेको छ । यो जातको धानखेतमा मात्र लगाइन्छ । हिमाली क्षेत्रमा सिमिसँग मिसाएर खोले बनाई खाने प्रचलन छ । यसले पनि हिमाली क्षेत्रको खाद्य सुरक्षामा महत्वपूर्ण स्थान राख्दछ ।

फोटो २. पतलाधान (रसुवा जिल्लाको माथिल्लो क्षेत्र)

सिन्धुपाल्चोक जिल्लामा शताब्दी वर्ष अगाडि प्रचलनमा रहेका स्थानीय जातहरू तथा तिनको जातीय गुणहरू

हिक्मत कुमार श्रेष्ठ
वरिष्ठ कृषि प्रसार अधिकृत

आजभन्दा करिब १०० वर्ष अगाडि पनि धानको खेती गरिने यस सिन्धुपाल्चोक जिल्लामा त्यस ताका लगाइने गरेका देहायका स्थानीय जातहरूको बारेमा यस लेखमा जानकारी गराउने प्रयास गरिएको छ ।

मन्सरा

यो जातको धान नरम र मसिनो चामल हुने मसिनो धान हो । यो धान १ पाथी धानको बीउ वा २ वटी रोपारले रोपेको ठाँउमा २०/२५ पाथीसम्म फल्दथ्यो, चामल सरी बस्ने र राम्रो मूल्यमा बिक्री हुने भएकोले यो धान प्राय सबै भेगमा रोप्ने गरिन्थ्यो । यो धान आजभन्दा करिब १०० वर्ष अगाडि यस धानबाट तयार पारिएको चामल साँखुसम्म बोकेर लगेर १ पाथी चामलको १६ आना (६४ पैसा) सम्म बिक्री गरिन्थ्यो । केही वर्षपछि यस धानबाट तयारी चामल १ पाथी को १ रूपियाँ देखि १ रूपियाँ पचास पैसासम्म बिक्री वितरण गरियो । यो धानको भात अत्यन्तै नरम र खान स्वादिलो भएकोले दरबारिया मानिसहरूले बढी प्रयोग गर्दथे ।

शोभरा

यो मसिनो धान हो । यसको दाना मसिनो र सुन्दर पहेंलो लाम्चिलो आकारको हुन्छ । यो धान २ वटी रोपार १ पाथी धानको बीउ रोपेको ठाँउमा २० देखि २५ पाथी फल्दथ्यो । चामल सरी बस्ने मसिनो धान भएको हुँदा बिक्री गरी घर खर्च चलाउने प्रयोजनको लागि यो धान रोप्न कृषकहरूले रुचि राख्दथे । सरी चामल बस्ने र राम्रो मूल्य आउने यस धानको विशेषता हो । तयारी चामल हालको साँखु पुऱ्याएर १ पाथी चामल ६० देखि ६५ पैसामा बिक्री गर्न सकिन्थ्यो । यो धानको चामल अलि महँगो तिर्नु पर्ने हुँदा सम्पन्न व्यक्तिहरूले मात्र प्रयोग गर्दथे ।

रातो मन्सरा

यो धान डल्ला दाना केही मोटा र सुन्दर पहेंला दाना भएको मोटा धान हो । यसको चामल पनि सरी बस्ने र खान गुलियो र केही कडा भात हुने हुदा गाँउ घरमा पर्वहरूमा खाने गरिन्छ । यसको अरू मसिनो चामलको तुलनामा सस्तोमा बिक्री हुन्छ । यसको चामल १ पाथीको १० देखि १२ आना ४० देखि ४८ पैसा सम्म बिक्री गरिन्थ्यो । सुख्खा टारमा पनि राम्रो उत्पादन हुने हुँदा यो धान पनि राम्रो प्रचलनमा थियो ।

आँगा

यो धान कालो डल्लो दाना भएको मोटो धान हो । यो धानलाई कालो धानको नामले पनि चिन्न सकिन्थ्यो । यो धान ढिकीमा कुटी सकेपछि सुन्दर सेता डल्ला खालका चामल देखिन्थे । यस धानको विशेषता अर्को यस धानलाई औषधी धान पनि भनिन्थ्यो । यसको चामल राम्रोसँग पिधेर भाँचिएको मर्केको ठाँउमा लगाई नेपाली कागज राम्रोसँग टाँसी दिदा उक्त भाँचिएको वा मर्किएको ठाँउमा निको नभएसम्म नउप्किने र राम्रोसँग समातेर सो ठाँउ निको हुने गर्दथ्यो । सुख्खा टारिखेतमा उत्पादन हुने भएकोले अरू धानको तुलनामा केही कम फल्दथ्यो । यस धानको चामल मसिना डल्ला दाना भएका हुने हुँदा यसको मूल्य पनि सस्तोमा बिक्री हुन्थ्यो । यस धानको चामल जिउ दुखेको बेला खोले पकाएर खादा जिउ दुखेको बिषेक हुने हुँदा औषधी चामल भनेर बजारमा बिक्री हुन्थ्यो । त्यसको मूल्य १ पाथी चामलको १० देखि १२ आनामा बिक्री हुन्थ्यो । यो चामल देव कार्यमा बिक्री गरिन्थ्यो ।

नाम्लाडे मार्सि

यो धान उच्च पहाडी भेग हेलम्बु क्षेत्रमा लाग्ने धान हो । यो धान असारको सुरुमा रोप्दा त्यस क्षेत्रमा कार्तिक अन्तिम या मंसिर सुरु हप्ता पाक्ने लामो अवधिको धान हो । यो धानको पराल अग्लो र अन्तिम सम्म झपक्क पात रहने र बाला निस्किसक्दा समेत

पातले बाला छोपिने यस धानको जातीय गुण हो । यो धान झार्न सजिलो मोटा दाना भएर पनि खान अत्यन्त नरम र स्वादिलो गुलियो मोटो भात हुने धान हो । यो धान १ पाथी बीउ रोपेको ठाँउमा २० देखि २५ पाथीसम्म फलेको पाइन्छ । लेकाली भेगमा अन्यन्त कम खेत र धानको उत्पादन कम हुने हुँदा स्थानीय स्तरमा नै चामल बिक्री गर्ने वा वस्तुसँग साटासाट गर्ने प्रचलन रहेको पाइन्थ्यो । धान मोटा दाना भएको भएमा पनि यस धानको चामलबाट बनेको भात खाँदा अलि गुलियो स्वादको मीठो र नरम थियो ।

काठे शोभरा

यो काठे शोभरा धान पनि हिमाली या माथिल्लो भेगमा लगाइने जात हो । यो धानको डल्लो दाना हुने र चामल डल्लो मोटा भएता पनि अत्यन्त स्वादिलो र मोठो भात हुन्थ्यो । यो धान माथिल्लो भेगमा लगाइने हुँदा असारको सुरुमा रोपेर कार्तिक अन्तिममा काट्न तयार हुन्थ्यो । यसरी लामो अवधी लिएर उत्पादन हुने भएर होला यसको भात अत्यन्त मीठो स्वादको थियो । यसको उत्पादन १ पाथी बीउ रोपेको ठाँउमा १८ देखि २० पाथी धान फल्दथ्यो । यसको पराल लामो र पात झ्याप्प परेको थियो । माथिल्लो भेगमा धानको उत्पादन हुने हुँदा चामल अन्यत्र लगेर बिक्री गर्ने चलन थिएन, स्थानीय गाउँमा नै वस्तु साटासाटमा नै चामल एक अर्कामा जाने गर्दथ्यो ।

यस जिल्लामा धेरै वर्ष पहिले लगाइने धानका अन्य स्थानीय जातहरूमा नागबेली र कृष्णबेली डल्ला छोटा दाना भएको मोटा धान हुन् । यी दुवै धानहरू २००० साल तिर प्रचलनमा आएका जातहरू हुन् । झुप्पेमार्सी र झिन्वा मसिनो चामल हुने धान हुन्, यी दुवै धान मसिनो नरम र स्वादिलो भात हुने हुँदा ठूला बडाले प्रयोग गर्ने गर्दथे । उल्लेखित जातहरू माथिका जातभन्दा ३० वर्ष पछाडि निस्किएका जातहरू हुन् । यस समयमा १ पाथी चामलको मूल्य १ रूपैयाँ ५० पैसादेखि २ रूपैयाँसम्म पर्दथ्यो । केही वर्ष अघिसम्म मार्सी, डल्ले मसिनो, तौली, अनदी, थापाचिनी, अछामी मार्सी, पाखा मसिनो, छोमरोङ घैया धानहरू खेती गरेको पाइन्छ । आजभोलि सिन्धुपाल्चोक जिल्लामा खुमल–४, खुमल–६, खुमल–८, खुमल–११, हिमाली, कन्चन, पोखरेली मसिनो, मकवानपुर–१, राधा–४, मालिका, र केही हाईब्रिड (US312, DY 28/69) जातहरू लगाउने गरेको पाइन्छ ।

(प्रस्तुत लेख यस जिल्लाका अग्रजहरू कृषकहरू कलाधर दुलाल (जन्म १९८२), राम बहादुर रस्तेल (जन्म १९८४), डोम प्रसाद दुलाल (जन्म १९९२) र बाबुकाजी रायमाझी (जन्म १९८०) ज्यूहरूसँगको व्यक्तिगत कुराकानीको आधारमा लेखिएको हो) ।

गुल्मी जिल्लामा पाइने धानका स्थानीय जातहरूको जातीय विशेषता

चेत नारायण पाण्डे
वरिष्ठ बाली विकास अधिकृत

गुल्मीमा पाइने स्थानीय धानका जातहरूको विशेषता

नाम तथा विशेषताहरू	हंशराज	जर्नेली	वासमती मसिनो	अनदी	खर्से	धल्वाई
इतिहास	पुरातन	पुरातन	पुरातन	पुरातन	पुरातन	पुरातन
अन्नको आकार	लामो	लामो	गोलो	गोलो	गोलो	गोलो
अन्नको रंग	सेतो	सेतो	सेतो	सेतो	सेतो	सेतो
बासना आउने गुण	हल्का	हल्का	तीव्र	नआउने	नआउने	नआउने
टाँसिने वा नटाँसिने गुण	मध्यम	मध्यम	नटाँसिने	टाँसिने	नटाँसिने	नटाँसिने
मिलिङ प्रतिशत (मात्रा)	४०	४०	५०	४५	४५	४५
पाक्ने गुणस्तर	नरम उत्कृष्ट	नरम उत्कृष्ट	मध्यम	नरम	तंग	तंग
विशेष व्यावसायिक उपयोगिता	अतिथि खाना	अतिथि खाना	बासना आउने अतिथि खाना	औषधि, खट्टे र हलुवाको लागि राम्रो	कम उत्पादन हुने	लामो अवधिको लागि
प्रति के.जी. चामलको मूल्य रू.	७५	७५	१२०	७५	६०	६०
उत्पादन क्षमता	मध्यम	मध्यम	मध्यम	मध्यम	उच्च	उच्च

गुल्मीमा लगाईने स्थानीय जातको विशेषताहरू

वासमती मसिनो

- भान्सामा पकाउँदा अत्यधिक वासना आउने तथा पराल समेत बसाउने,
- पकाउने गुणस्तर कठिन भएता पनि घिउ थपेपछि उत्कृष्ट स्वाद कायम हुन,
- घरमा उपयोग गर्दा गैर बासनादार चामलमा मिसाई पकाउँदा बासना थप्ने गुण भएको,
- उच्च मूल्य र उच्च बजार माग ।

अनदी

साधारण उखान (सबैमा राजा,अनदीको खाजा) अर्थ अरू भन्दा अनदी एक नम्बर । यसबाट खट्टे, हलुवा र खिर जस्ता लोकप्रिय खाद्य पदार्थ तयार गरिन्छ । यसको पिठोबाट तयार गरेको रोटीमा अतिरिक्त स्वाद र गुणस्तर हुन्छ । यसबाट तयार हुने टाँसिने तरल पदार्थले टूटेको हड्डीको उपचारमा प्रयोग गरिन्छ साथै मांसपेशी बलियो र मांसपेशीको दुखाई कम गर्न प्रयोग गरिन्छ ।

फोटो १. अनदी धान

हंशराज

यो जात विषेश गरी अतिथि, बच्चा, बिरामी र बुढो मान्छेलाई खानलाई दिइन्छ साथै पराललाई चकटी बनाउन प्रयोग गरिन्छ ।

कपिलवस्तु जिल्लाका धानका पुराना स्थानीय जातहरू तथा खेती प्रविधि

अरविन्दमणि त्रिपाठी
बाली विकास अधिकृत

धान कपिलवस्तु जिल्लाको प्रमुख खाद्यान्न बाली हो र यसले कूल खेती गरिएको भूभागको तीन चौथाई भाग ओगटेको छ। कपिलवस्तु जिल्लामा सन् १९७५ अघिको धान खेतीको अवस्थालाई यहाँ स्पष्ट पार्न खोजिएको छ। त्यसताका जग्गाको तयारी गर्न गोरुको प्रयोग गरिन्थ्यो र भण्डारण गरेको बीउ प्रयोग गरी छरुवा धान र नर्सरी ब्याडमा तयार गरेको ४०–५० दिनको बेर्ना रोप्ने गरिन्थ्यो। खेती गरीने मुख्य जातहरूमा अनजी, अनादी, बासमती, बगरी, चैनाफोरे, दिदिया, धनिया धान, गन्जोगंज, कारंगी, कालानमक, कनकजिरा, कलाकन्डा, फूलबिरन्च, पदनी, जसो, लोहती, मकरकद्दु, गौरीसफेद, गौरीयाला, मनसरा, तुलसीराम, रामभोग, सरया, साकेत, सथा, लटरा, हंशराज आदि हुन्। सिँचाइको स्रोत आकासे पानीको भर भएता पनि केही स्थानमा किसानले व्यवस्थित कुलोको प्रयोग गर्थे। झारपात व्यवस्थापन सामान्यतया हातले तानेर नष्ट तथा पानीको व्यवस्थापन गरेर गरिन्थ्यो। पात बेरुवा किराको नियन्त्रण गर्न केही स्थानमा बयरको काँडाको प्रयोग गरिन्थ्यो भने अन्य स्थानमा ढुसी जन्य रोग नियन्त्रणको लागि गाईको दूधको प्रयोग गरिन्थ्यो। धानको कटाई बेर्ना रोपेको १०५–११० दिनमा गरिन्थ्यो र धानको कटानी गर्न स्थानीय औजारहरूको प्रयोग गरिन्थ्यो। काटेको धानलाई केही दिन सुक्न दिई खलोमा काठ र ढुंगामा पिटाई गरी चुट्ने तथा हावाको सहयोगमा बत्ताउने अभ्यास गरिन्थ्यो। बत्ताएको धानलाई भकारी तथा गोदाममा भण्डारण गर्ने चलन थियो। सो समयमा धानको उत्पादकत्व सिँचाइको उपलब्धताको आधारमा सरदर १ देखि २ मे.टन प्रति हेक्टर थियो।

रोल्पा जिल्लामा प्रचलनमा रहेका धानका जातहरू तथा खेती प्रविधि

किशोर प्रसाद पन्त
वरिष्ठ कृषि प्रसार अधिकृत

आदिबासी जनजाति खास गरेर मगर समुदायको बाहुल्य रहेको यस जिल्लामा धानलाई सांस्कृतिक धरोहरको रूपमा लिने गरेको पाइन्छ। धान र चामल कुनै शुभ कार्य जस्तै टीका, अन्नप्राशन, विवाह आदिमा प्रयोग हुन्छ भने धान पनि लावा, सिदा र मृत्यु परन्त कार्यमा प्रयोग गरिन्छ। उत्पादनको हिसाबले धानको उत्पादन कम भए पनि अधिकांश रोल्पालीको रोजाइको खाना भात हो। प्रायः भोजनमा एक छाक आटो (मकै) र एक छाक भात (चामल) खाने चलन रहेको छ। भातको अलवा चामलको रोटी, चिउरा र पेय प्रदार्थको रूपमा पनि प्रयोग गरेको पाइन्छ। यस जिल्लामा परम्परागत रूपमा खेती गरीएको जुन स्वादिलो जातहरू तर उत्पादन कम फल्ने जातहरू जस्तैः गोपाल, जरन मार्सि, अनदी, सिमटारो, रोकचालि, चाइनाफोर (जुम्ली) भटे बिजम स्थानीय जातहरू पनि क्रमशः विस्थापित भै उन्नत धेरै फल्ने जातहरू खुमल-४, राधा-४, राधा-७, र केही स्थानमा हाइब्रिड जातहरूको पनि प्रयोग गरेको पाइन्छ। यस जिल्लामा पाखो जमिनमा पाखे धान (घैया), खेतमा चैते धान र वर्षे धान लगाउने चलन छ। पाखे धान घैया बैशाखमा छर्ने, यसलाई दुई पटक गोड्ने र एक पटक बाला लागि सकेपछि सोर्ने चलन छ भने प्रायः भाद्र असोज भित्र बाली भित्र्याइन्छ। पाखे बालीका रूपमा प्रयोग गरिने जातहरूमा घैया-१, घैया-२, बिन्देश्वरी छन् र उत्पादनका हिसाबले कम उत्पादन भए पनि स्वादका हिसाबले उत्तम रहेको कृषकको धारणा छ। केही क्षेत्रमा मकैसँग मिश्रित रूपमा घैया खेती गर्ने चलन पनि रही आएको छ। खेत बारीमा चैते र वर्षे बालीको रूपमा धान खेती गरे पनि वर्षमा एक बाली मात्र धान खेती गरिन्छ। चैते धानको बीउ फाल्गुनमा राखेर बैशाखमा रोप्ने भाद्र महिनामा बाली भित्राउने चलन छ भने वर्षे धानको लागि बैशाख महिनामा धानको ब्याड तयार गरी स्थान अनुसार जेष्ठ सम्म ब्याड राख्ने र जेष्ठ देखि श्रावणसम्ममा धानको बेर्ना सार्ने चलन छ। खेती गर्ने तरिकालाई हेर्ने हो भने यहाँ अत्यन्त बूढो (४५ दिनको) बीउ रोप्ने, गाज धेरै (४-६) र बाक्लो रोप्ने चलन रहेको छ। यहाँ खेती गरिने स्थानीय जातहरूमा मार्सि, जरन, अनदी, सिमटारो, चाइनाफोर जातहरू रहेका छन् भने उन्नत जातहरूमा खुमल-४, राधा-४, राधा-७, बिन्देश्वरी, हिमाली, घैया छन्। खेतबारीमा रासायनिक मलको प्रयोग अत्यन्त कम र स्थानीय स्रोतहरू जस्तै स्याउला र कम्पोष्ट मलको प्रयोग अत्याधिक गरेको पाइन्छ। गोडमेलको कुरा गर्दा प्रायः एक पटक मात्र गोडमेल गर्ने र अशोज भित्र धान भित्र्याई सक्ने परम्परा रहेको छ। यस जिल्ला रोल्पामा धान उत्पादन हुने क्षेत्रहरूमा बुढागाउँ, जुँगार, बडाचौर, बागमारा, मिभिङ, अरेस, गुम्चाल नुवागाउँ, खुग्रि, घोडागाउँ, गजुल र जंकोट आदि स्थानहरू प्रमुख रहेका छन्।

कैलाली जिल्लाका धानका पुराना तथा लोकप्रिय स्थानीय जातहरू तथा खेती प्रविधि

सुदिप खतिवडा
बाली विकास अधिकृत

सुदूर पश्चिमाञ्चल विकासक्षेत्र अन्तर्गत सेती अञ्चलमा रहेको कैलाली जिल्लामा कूल ७१,२५० हेक्टरमा धान खेती गरिन्छ जुन नेपालमा लगाइने धान बालीको कूल क्षेत्रफलको ५% हो। कैलाली जिल्लामा विगतका करिब १५–२० वर्ष अगाडि सौउठ्यारी (रातो धान, ताईचिन जस्तै किसिमको तर चामल रातो देखिने, चामल कडा हुने र नपच्ने हुदाँ आडिलो, भोक नलाग्ने, पेटमा टिकाउ हुने, सुख्खा र पानी जम्ने दुवै जमिनमा राम्रो हुने), गगुवा (पानी जम्ने ठाउँमा हुने, अग्लो हुने, पानी धेरै भयो भने झन् अग्लो हुने) तिल्की (बस्ना आउने धान, नरम र मसिनो चामल, आफै नै घरमा खानलाई लगाउने), अन्जना (बोटको उचाई कम, धान गरुङ्गो हुने, धेरै पानीको नचाहिने, धेरै फल्ने, धान बिक्रि गर्ने किसानले लगाउन रुचाउने), आइरेड (चाडै पाक्ने, छोटो उचाई, हालको सर्जु-५२) जस्ता धानहरू प्रचलनमा रहेको यस जिल्लाका अग्रजहरू बताउँछन्। यस जिल्लामा धान खेती गर्ने सिलसिलामा ब्याड तयारी गर्दा बीउ नादा (माटोको भाडा) वा तामाको ताउलो वा बाल्टी/बाटामा २ दिन सम्म भिजाउने र पानीमा माथि उत्रेका बीउलाई प्रयोग नगरेको दृष्टान्त पाइएको छ। ब्याड तयारी गर्न जङ्गलबाट बेसर्माको पात काटेर ल्याई, टुक्रा बनाएर खुट्टाले कुल्चेर माटोमा मिसाउने, केराको पात वा अन्य बिरुवाको पात पनि केही किसानहरूले माटोमा राख्ने गरेको पाइएको छ। धुले र हिले ब्याड दुवै किसिमका धानका ब्याडहरू राख्ने अभ्यास भएको पाइएको छ। ३० देखि ३५ दिनको बेर्ना लगाउने गरको पाईयो भने केही किसानले छरुवा धान प्रविधि समेत अनुसरण गरेको पाइएको छ भने रासायनिक मलको प्रयोग नगर्ने र घरमा गाईवस्तुको गोबरमल उपलब्ध भए सम्म प्रयोग गर्ने गरिएको अनुभवी र अग्रज कृषकहरूले बताउँछन्। धान खेती गर्दा गान्धी किरा र फटेङ्गराको प्रकोप देखिने गरेको र कृषकहरूले आषाढमा गुरुवा (धामी) बाट गांधी हाप्ने (फुक्ने) चलन रहेको र फुकी सकेपछि सबैले गाईको दूध र धानको दूध (नरक धान पिसेर बनाउने) मिसाएर छर्ने प्रचलन पनि रहेको पनि कृषकहरूले बताउँछन्। धान पाकीसके पछि धान काट्ने पुला बाध्ने र खेतमा नै सुकाउने र हातले नै सुकेका पुला (मुठा) हरू चुटेर पराल र धान छुट्याउने गरिएको साथै बीउको गुणस्तर वृद्धि गर्न बीउको लागि पोटिला दानाहरू छुट्याएर अलग्गै माटोको धन्सारमा राखिने समेत गरिएको अग्रज र अनुभवी कृषकहरूले वताउँछन्।

आफ्ना बुबा बाजेले १६ कठ्ठामा १८ क्यून्टल फलाएका देखेका थारू समुदायका एक किसानले आफूले ३३ क्वीन्टल सम्म गत वर्ष फलाएको कथा उत्साहका साथ सुनाउनु हुन्छ।

बर्दियाको राजापुर क्षेत्रमा लोकप्रिय धान : मकवानपुर–१

जय बहादुर महत्रा
बाली विकास अधिकृत

बर्दिया जिल्लाभित्र पर्ने राजापुर क्षेत्र कृषि कार्यको लागि निकै उर्वर क्षेत्र मानिन्छ । यस क्षेत्रको कूल १,४५,०० हेक्टर क्षेत्रफलमध्ये करिब १३००० हेक्टर क्षेत्रफलमा धान खेती गरिन्छ । प्रशस्त धान उत्पादन हुने यस राजापुर क्षेत्रमा ८० प्रतिशतभन्दा बढी क्षेत्रफलमा मकवानपुर–१ उन्नत जातको एकाधिकार रहेको पाइएको छ । वि.सं. २०५७ सालभन्दा पहिले यस क्षेत्रमा लगाइने गरिएको मकरकदु भन्ने धानको स्थानीय जातलाई विस्थापित गरी रोगकिरा सहन सक्ने (विशेष गरी ढुङग्रे किरा सहन सक्ने क्षमता भएको) जातको रूपमा मकवानपुर–१ धान भित्रिएको स्थानीय अगुवा वताउँछन् । तत् पश्चात् बढी उत्पादन दिने (प्रति कट्ठा २ क्वीन्टल) यस धानको माग अत्याधिक बढ्न गएकाले सरकारी क्षेत्रबाट समेत यस धानको विस्तार र प्रवर्द्धनमा विभिन्न प्रयासहरू भएका थिए । यस क्षेत्रमा मकवानपुर–१ धानलाई कृषकहरूले रुचाउनुमा बजार मूल्य राम्रो हुने (मंसिर महिनामा (रू. २०५० र श्रावणको महिनामा रू. ३००० प्रति क्वीन्टल), भुजा तथा चिउरा बनाउनमा प्रयोग हुने (यसको दाना गोलो ठूलो र पुष्ट भएको हुनाले भुजा र चिउरामा प्रयोग हुने, बनेको भुजा फुलेको र भुजाको गुणस्तर समेत राम्रो, चिउरा नभाचिने, राम्रोसँग फैलावट भै चिउरा प्रतिशत पनि बढी आउने), सामान्य रासायनिक मल राखेकै भरमा राजापुर क्षेत्रमा मकवानपुर-१ जातको धानको उत्पादकत्व ४ मे.टन. प्रति हेक्टरभन्दा पनि बढी हुने, चामलको प्रशोधित प्रतिशत (Milling percent) अधिक (७० देखि ७२ प्रतिशत), खल्ला खेतमा उपयुक्त (आलु, तोरी लगाउने खेतको अलावा अन्य पानी जम्ने खेतहरूमा समेत उपयुक्त), गुणस्तरीय पराल, दाइँ गर्दा पराल नटुक्रने, पराल पनि राम्रो पर्ने र गाईवस्तुले रुचाउने, अन्य धानहरूभन्दा कम ढल्ने, बूढो बेर्ना रोपे ता पनि राम्रो उत्पादन दिने, छिट्टै वर्षा रोकिए पनि उत्पादन दिने आदि रहेका छन् । साथै थारु समुदायको बाहुल्यता भएको यस राजापुर क्षेत्रमा वर्षातको समयमा खेतमा काम गर्दा अडिलो हुने भएकाले मकवानपुर–१ कै चामलको भात खाने चलन रही आएको, साथै नास्ताको रूपमा माँड खाने चलन रहेको, माँड पनि मकवानपुर–१ कै रुचाइने गरिएकाले यो धान निकै लोकप्रिय रहँदै आएको छ । यी विभिन्न विशेषताका वावजुद ढिलो पाक्ने (१५० दिन), खैरा रोग (जिङ्कको कमी) देखा पर्ने, गवारो सहन नसक्ने, मोटो चामल आदि अवगुणहरू यस राजापुर क्षेत्रमा मकवानपुर–१ जातको धानका सिमितताहरू रहेका छन् ।

थारु जातिको चाड माघीमा नभै नहुने चिचर खानाबारे जानकारी

कृष्णलाल चौधरी
खैरहनी न.पा. १०, चितवन

पकाउने विधि

- नेपालीहरूको खाना चाम्रे/लटे पकाउने अनदी चामललाई २-३ घण्टा जति पानीमा भिजाउने र मःम पकाएको जस्तो गरी तल पानी राखेर कसौंडी आकारको माटोको ठूलो भाँडो (पैन) वा घैटो जसको पिंधमा ४-५ इन्च गोलो गोलो प्वाल हुन्छन्, त्यसको माथि पातलो कपडामा छिचरी (भिजाएको चामल) राख्ने जसमा जाली हुन्छ (खडाई वा वाँसको)
- पानी निथ्रेको भिजाएको चामल सो भाँडोको मुखभन्दा केही तल सम्म राख्ने,
- माथिबाट माटोकै ढकनीले छोप्ने जसलाई झोपता भनिन्छ, आगो बेस्सरी लगाउने,
- ढकनीको वरिपरिबाट हावा बाहिर नजाओस भनेर कपडा भिजाएर जोर्नीहरूमा लगाउने
- बेला बेलामा पाकेको हेर्ने, भात पाकेर फरर भए जस्तै फरर पर्यो भने चिचर पाक्यो भन्ने जान्नु पर्दछ,
- यसरी पाकेको चिचर डालो (बाँसको) वा प्लाष्टिक वाल्टीमा राख्ने र तात्तातै खानाको रूपमा पनि प्रयोग गर्न वा पछि खाजाको रूपमा पनि खान सकिन्छ अथवा यो खानालाई केरा वा भोर्लाको पातमा डल्लो पारेर परालले बाँधी बिहान भएपछि भुसको आगोमा (घौरा) पातमा बेरेको डल्लो करिब १ घण्टासम्म घुसाई तताउने र तातेपछि छेउछाउमा बसेर सबैले बाँडीचुँडी खाने प्रचलन छ ।

यो खाना खास गरी थारु जातिको माघी पर्वमा खाने प्रचलन छ । यो चामलको स्थानीय मूल्य प्रति के.जी. रू. ११० देखि १३० सम्म पर्दछ । यो खाना विशेष गरी थारु जातिमा पुषमा पकाएर माघमा (माघे सक्रान्तिका दिन) खाने चलन बढी मात्रामा प्रचलित छ । हाल आएर थारु समुदायका अलवा अन्य जातिका व्यक्तिहरूमा पनि ५-७ वर्षदेखि चिचर खाने प्रचलन विद्यमान रहेको पाइन्छ । यो खाना थारु जातिमा ठुलो चाडको रूपमा आफन्तहरूसँगै बसेर घुंगी, घ्यू, माछा, मासुका साथ खुसियाली, रमझमका साथ रमाएर खाने, चाड मान्ने चलन पछिल्लो समयमा अत्याधिक बढेको पाईन्छ । यो खाना स्वास्थ र पौष्टिकका हिसाबले पनि उत्तिकै राम्रो मानिन्छ, किन कि चिचर, अनदी चामल बाहेक केही थप वस्तु प्रयोग नगरी स्टीमवाफ गरिएको शुद्ध शाकाहारी खाना हो ।

फोटो १. चिचर

Rice Science and Technology in Nepal (MN Paudel, DR Bhandari, MP Khanal, BK Joshi, P Acharya and KH Ghimire, eds).
Crop Development Directorate (CDD), Hariharbhawan and Agronomy Society of Nepal (ASoN), Khumaltar.

धान बालीसँग सम्बन्धित केही लोकोक्तिहरू

सत्यमोहन जोशी
इतिहास एवम् संस्कृतिविद्

कृषि प्रधान देश नेपालमा विविध मातृभाषा तथा सांस्कृतिक विविधता भएका जाति जनजातिहरू बासिन्दाहरू अनेकता र विविधताका राष्ट्रिय एकतामा आवद्ध भएर वसेका छन् । प्रत्येक जाति जनजातिको लोक संस्कृतिमा आ आफ्नो जातीय विशेषता बोकेका मौलिक परम्परामा जीवन्त भैरहेको लोकोक्तिहरू हुने गर्दछन् । नेपाली कृषकहरूको जीवनमा लोकोक्ति (उखान, गाँउखाने, लोकगीत, कथा आदि) को प्रचालन प्राचीन समयदेखिनै हुँदै आएको देखिन्छ । नेपाली कृषकहरू नेपाली माटोमा अन्नबाली उब्जाउनमा ज्यादै परिश्रमी र मेहनती छ भन्ने कुरो उनीहरूले धान बालीसँग सम्बन्धित भन्ने गरेको उखान, गाउँ खाने कथा आदि लोकोक्तिहरूबाटै प्रस्ट हुन्छ । यहाँ यसका केही उदाहरणहरू प्रस्तुत गर्ने प्रयास गरिएको छ :

धान बालीसँग सम्बन्धित केही उखानहरू :-

- धान पाके निहुरन्छ, कोदो पाके ठाडो हुन्छ
- धान खाने मुसो, चोट पाउने भ्यागुतो
- धान छ भने नाइटोमा भएपनि कुटेर खान पाइएला
- मुठी छरेर मुरी फलाउने
- रोटी चिल्ला मीठा कुरो खस्रो मीठा
- शोक न सुर्ता, भोक न भकारी
- साउनमा आँखा फुटेको गोरुले वाह्रै महिना हरियो देख्छ
- बेला न कुबेला असारे गाउने ?
- बोकाले दाइँ गर्ने भए गोरु किन चाहियो ?
- माम पनि नाईं, काम पनि नाईं
- मानो खाई मुरी उब्जाउने
- माग्नेलाई फलेको चामल
- माग्नेलाई तातो भात
- मुखमा माड नलाग्ने भयो
- जस्तो काम, उस्तै माम
- जुठो लोटयाउदा झैँ लुटुमुटु भयो
- जुठो खानु मिठोको लोभले
- जाउलो पेटमा नपर्ने भयो
- जागर न सांगर खानेबेलामा आँ गर
- पराल खुट्टे फुर्ति नदेखा ।
- फाँटको टौवा दुनियाको रजाई ।
- बिना मियोको दाइँ ।
- तिम्रा मुखमा दूध र भात ।
- चामल पिन्दा घुन पिसिन्छ ।
- कुराले च्युरा भिज्दैन ।
- के निऊ पाऊँ कनिका बुकाऊँ ।
- काम न धाम, पेट भरि माम ।
- कनिका छाराई गर्दैमा के हुन्छ ?
- खुर्सानी बिना भतेर अड्कदैन ।
- धोक्रोभरी धान छ, त्यसै मेरो मान छ ।

धान तथा चामलसँग सम्बन्धित केही गाँउ खाने प्रश्नहरू

१. थालमा भात, बिटमा दाल- के हो ?

२. उर्लुकू चरी बुर्लुक्क, पुच्छर छैन ड्याचै- के हो ?

३. एक सिंगे गोरुले दाइँ गर्छ - के हो ?

४. वरिपरि दाल, माझमा भात - के हो ?

५. सुनलाई काट्दा निस्क्यो चाँदी
चाँदी पकाई मुखभित्र खाँदी - के हो ?

६. सुन साङली रूप आङली
पिंधैबाट पानी माङली - के हो ?

७. सेतो किराको मीठो फल - के हो ?

८. हरियो गाड्छन् सुन फलाउँछन्
सुन फ्याँकेर चाँदी तुल्याँउछन् - के हो ?

९. हरियो चरीले पुच्छरले पानी पिउँछे - के हो ?

१०. राम्रो अन्न फलाउन तीव्र आशा बोकेरै
दश पाउ हिडेका छन् जमिनमा खन्दै - के हो ?

११. भुँडे गोरुको एउटै सिंग- के हो ?

१२. बसी बसी घ्याम्पे दाइले खान्छ अलि छिटो
राख्ने पेट छैन उसको ओकल्छ पिठो - के हो ?

१३. बाल्यकालमा हरियो, बूढो हुँदा पहेंलो - के हो ?

१४. बाहिर हेरे सुन जस्तो भित्र हेरे चाँदी
सुनभन्दा महँगो छ किन होला चाँदी - के हो ?

१५. पानी भित्र रमाउँछिन् तिनी जलपरी होइन
सुनगेडी फलाउँछिन् तर रुख तिनको छैन - के हो ?

१६. पानीमा वस्ने, शंख फुक्ने - के हो ?

१७. पिंढीमा कुरे चेप्टे दाइले खान्छन् छिटो छिटो
पेट छैन अटाउने उकेल्दछन् पिठो- के हो ?

१८. पुच्छर तिर थिच्यो भने टाउको तिर उठ्छ
खानु पिउनु केही छैन धान पाए कुट्छ - के हो ?

१९. पुच्छर थिच्दा जुरुक्क उठ्छ
थिच्न छोडे चुच्चाले टेक्छ - के हो ?

२०. पुड्के राइको खुट्टामा सियो, टाउकामा टुपी
जोडीसगै चलाए भुइँ भत्काउँछ, मुनि मुनि घुसी - के हो ?

२१. फल झर्‍यो भुइँतिर, रुख छैन वरिपरि - के हो ?

२२. फले बस्छ कतै कतै नफले बस्छ जताततै - के हो ?

२३. फलामको झिटिमिटी, काठको जोर
अगि लाग्या राम लक्ष्मण, पछि लाग्या चोर - के हो ?

२४. पहिले दिन्छन् मलाई, खान भए भरको जम्मै
त्यसपछि ओकलेर रुवाउँछन् टम्मै - के हो ?

२५. पहिले भने खुवाउँछन् भए जति मलाई
पछि फेरि पालैपालो रित्याएर जान्छन् - के हो ?

२६. पहिले मलाई भिजाउँछन्, त्यसपछि कुट्छन्
कुटेपछि मस्तसँग आफ्नो भोक मेट्छन् - के हो ?

२७. पानीमाथि हिंडे पनि माछो भनिदैन अन्न मात्र खान्छ
त्यसले, मानिस पनि होइन - के हो ?

२८. पालेको माछो जमिन मुनि दगुर्छ - के हो ?

२९. खाली हुँदा ठाडो हुन्छ भरिएमा लड्छ, त्यसपछि
नउठाए जमिनमै सड्छ - के हो ?

३०. खुट्टा हुन्छ दशवटा, छ वटा कान दुई खुट्टाले धकेल्ने,
आठ खुट्टाले तान - के हो ?

३१. खेतको चरी ट्वार्र ट्वार्र गर्छिन, पानी नपाए ठहरै
मर्छिन - के हो ?

३२. गाली हो कि बोली हो स्यार्र स्यार्र गर्छ, टाउका
त्यसको देखिदैन, खुट्टा देखा पर्छ - के हो ?

३३. घट्टमा बस्छ घटेरो होइन
भुँ भुँ गर्छ भँवरो होइन
जनै लाउँछ बाहुन होइन - के हो ?

३४. घण्टौं हिंडछ तर जहाँको त्यही - के हो ?

३५. लचक लचक तान
दशवटा खुट्टा चारवटा कान - के हो ?

गाउँ खाने प्रश्नका उत्तरहरू

१. खेतमा धान, आलीमा मास, २. ढिकीमा धान कुटेका, ३. जाँतो, ४. मास र धानको वोट, ५. भात, ६. धान, ७. भात, ८. चामल, ९. धानको बीउ, १०. गोरु जोतेको, ११. चामल पिन्ने जाँतो, १२. चामल पिन्ने जाँतो, १३. धानको बोट, १४. धान र चामल, १५. धान रोपेको, १६. भ्यागुतो, १७. चामल पिन्ने जाँतो, १८. ढिकी, १९. ढिकी, २०. हलीले जोतेको, २१. असिना, २२. धान, चामल, २३. हलो जोतेको, २४. धानको भकारी, २५. धानको भकारी, २६. चिउरा, २७. पानी घट्ट, २८. हलोको फाली, २९. धानको बोट, ३०. गोरु जोतेको, ३१. भ्यागुतो, ३२.पानी वर्षेको, ३३. घट्टको चरी, ३४. चामल पिन्ने जाँतो, ३५. गोरु जोतेको ।

त्यस्तै खेतमा काम गर्ने कृषकहरू आफ्ना कृषक जीवनलाई रसिलो र उज्यालो पार्नका लागि लोकगीतहरू पनि भाक हालेर गाँउछन् जस्तै -

नेपालको तौलीको धान सबैले काट्यो
यो पातलो आँसीले ।
पैला गोर्खा सकिन आयो छलाङ रेखिन्
मायाको फाँसीले ॥
भातै र खाने चरेसै थाल बाँडाले कमाएको
बाह्र गोरु दाउरा हजुरज्यूको दर्शन पाउँदा
म क्यारी रमाएको ।
राशाली धानको, हजुरै ज्यानको
धरती धसी धसी रामखोलैमा बसी
सीसा काटी गोली हजुरको बोली
गर्दै रहुँला सम्झना

हलो र गोरु जोखमी भयो ।
सोमबार डाम्नाले ॥
धान खायो भङगेरी चरीले ।
बोल माया प्रेमको रसले ॥
ऐया बाबै घैया पाक्यो ।
चिउरा कुटी देउन ॥
क्वैली चरी सिमल चरी ।
धान परालमाथि ॥
ह ह माले हह हह तारे हह

नेपालमा धान रोपाइँ सम्बन्धी असारे गीतहरू

थारु भाषामा असारे रोपाइँ गीत (दाङ देउखुरी)

पुरुबसे उमरल कारी बदरीया......रे
पश्छिउ घुंगुरा....आ...रे
बर्षिअ जाउ बुंदएक पनियां
बुईबुं तिल्की धान..........२
बाहु बहल पुरबिया आ......रे
पुरुवा मोर बैरी
पिहावक झलरी छत्तरीया

उपर झापनदोल २
अगलाह् हरोहीया मोर दिउरा ...रे
पछला हरोहीया मोर जेठवा
मझला हरोहीया मोर पिहवा
रुघुर रुघ जोतल.........२

हरे..अ गगना मगना उपर बदुरी .....रे
सरग मेर्राआ...वे
उत्तर दखिन मेघ गरजे
पिहा मोर....परदेश........२
हरे....बरसो बरसो मोर दइया ..रे
आजुरे दइया बरसोसरग मेर्राआ...वे
उत्तर दखिन मेघ गरजे
पिहा मोर....परदेश........२
हरे....बरसो बरसो मोर दइया ..रे
आजुरे दइया बरसो

बर्षी जाऊ बुंदएक पनियां...रे
बुईबु झिनवा धान अ.......२
हरे..घामकी घमासल अइनु रे मै
बनके पियासल
बुंदएक पनियां मै पैतु जे
हृदाजुराइत.........२

थारु भाषामा असारे रोपाइँ सजना गीत

तड्पता बिजली छैलामे गोरी अइलो रे
तहरे अंगनामे भैलो रे ठाडे
तुहरे कारण छैला ठाढी मै भिजतु
खोली देउ बजरा केवारे
तोहरे कारण छैला ....
पिहा मोर....परदेश........२
हरे....बरसो बरसो मोर दइया ..रे
आजुरे दइया बरसो

भितजी भितजी छैला रे गोरी मै अईलुं रे
तुहारे दुवारे भैलु मे ठाडे
तुहरे कारन छैला ठाढी मै भिजतु
तोहरे कारण छैला ....
पिहा मोर....परदेश........२
हरे....बरसो बरसो मोर दइया ..रे
आजुरे दइया बरसो

कितुहुं छैलारे मरि हरि गैलो
अरे कि बाघ सिकार खेललो रे
अब कि उठल काली नागिनिया की मास भाँच लगेरे
नही मै ते गोरी मरी हरि गैलु रे,
नहि बाँधी खैलो रे, अब नहि उठल रे काली नागिनिया
न मास भाँचल गिधिनियाँ ।

कि वहरी सुतल की बाबा मोर, हरि जागो निद सुतै रे
चौठे रात ओ गोरी, बाबा मोर जागो निद मोरे,
मै कैसे खोलु बजारा केवरिया ।
न मास भाँचल गिधिनियाँ ।

ओतरा वचन जब सुनला बाबा मोर, खोल्दे रे पुत बजरा केवरीया
राजा ओ हाकिम सुनही, पकरी झिकईही गनदेवो लाख रूपैया
उलफी जुलफी कि उठला छैला रे, कि खोली देलो बजरा केवरीया
सिरही नेवारे गोरी जवतक पैठे रे सजिया पर दुनु पाउ ।
एक रात खेलल गोरी हुई रात जो खेललुँ, अतेल रात खेललुँ रे

मैथिली भाषामा असारे रोपाइँ गीत (धनुषा)

बैशाख हे सखी, उठे धुन्धकाले (कालो बादल)
धाम से भिजल शरिर हे । बैशाख हे सखी, ...
चन्दन धसी धसी अंग लपेटे (शरिरमा दल्ने)
शितल भए शरिर हे। बैशाख हे सखी, ...
जेठ हे सखी, हेट (सुरु) भेल बर्षा
चाहु दिस (चारेतिर) गर्जत मेघ हे । जेठ हे सखी, ...
ठनका जे ठनके रामा, बिजुली जे चमके,
चमके ला धनि के शरिर हे । जेठ हे सखी, ...।

यहि पिरती कारण रामा, सेतु बधवाबल,
सिया खोजन श्रीराम हे । जेठ हे सखी, ...
असार हे सखी, रिमीझिमी बर्षा
भिजी गेल सब रंग चिर हे । असार हे सखी, ...
साउन हे सखी, शब्द सोहावन
झिंगूर शोर मचावे हे । साउन हे सखी, ...
भादव हे सखी, रैना भियावन, दोसर अंधेरीया के रात हे । बर्षा जे बर्षै रामा, बिजुली जे चमकै । तेही देखी जियरा डेरायल है । भादव हे सखी , ...
आश्विन हे सखी, आस लगेली, आस नई पुरा भेल हमार हे । आसो जे पुगलै रामा कुबरी शौतीनिया, जिन कन्ट रखल लोभाई हे । आश्विन हे सखी, ...

कार्तिक हे सखी, कन्त पुरान दिन, सब सखी गंगा असलान हे ।
सब सखी पेन है रामा, पात पितम्बर, हम बेन्धनी पेन्ही पुराना हे ।
कार्तिक हे सखी, ...
अगहन हे सखी, अग्र सुहावन, चाहु दिस उब्जत धान हे ।
चकवा चकेवा रामा सेल करत है । तेही देखी जियरा हुलास हे ।
अगहन हे सखी, ...

नेवारी भाषामा असारे रोपाइँ गीत-सिनाज्या (ललितपुर)

असार या ध्याच ले हला जोना
तनागु थउँ तिनी याद वल,
ख्वा जक सोया मुसुमुसु न्हिगु
थउँ तिनी लुमना वल हाय ।
अकसे चोङ्गु तिरीमिरी नगु
ल्याःखंना ल्याःख्या मफु,
वाघद्वा वना नाप नाप चोनागु
थउँ तिनी याद वल हाय थउँ तिनी
याद वल हाय ।

नु ज्याना छपी चा ज्यामी वल
ल्यासी चा व बजी नल पेमना,
केले मिखा कना बागः मिखा सोया
म्ह झितुझिखु वल हाय ।

बगया खुशी सिथे वा पिःगु लः
छती हे मवल,
गथे याना लःहेगु वा छक तेमाल
गथे याना वा पिगु हाय ।

धन्य धन्य धन्य वासुकी
नाग राजा वा गाएका बिमाल,
प्वचा दु सा लः मदु लः दु सा
प्वचा मदु गथे याना वा पिगु हाय ।
धन्य धन्य धन्य वासुकी नाग
राजा वा गाएका बिमाल

प्वचा बुढा जुल बुँ फुकं गनावन
वा वेका बिमाल हाय ।
असार या ध्याच ले हला जोना
बनागु थउँ तिनी याद वल,
ख्वा जक सोया मुसुमुसु न्हिगु
थउँ तिनी लुमना वल हाय ।

जुम्ला जिल्लामा गाइने असारे रोपाइँ गीत

लाछु ज्यूलो राम्रो धान पारिलो धामले
दै रोपउली म गोडुला धान फलुन मायाले
रोप रोप रोपन्यारी हौ असाड गोडौली
एकचोटी लायाकोमाया फेरीकाँ छोडौली
ताँ तल धाँस काटने को हो धानका डाँठ भाचौली

चैत बीउ राख्याको हाम्मो जेठ खेत रोपाइँ छ
तिम्मा घरका सबै आया आज खेत चोपाई छ
कात्तिक घान खाने चरी जेठ जौकि नल्खा
दिन दिन राइली सुवा वास्न लागिन अल्का
घटट् लाग्यो घटघट्याउन पानी लाग्यो पेल्न
लागिगो कात्तीकको मैना धान लाग्या ढल्न

यो तुम्मो भरियो जोवन कस्कालाई साँचौली
घाँस काटदै छु धान भाच्दैन लाहुऱ्या गाईकन
यो मेरो भरियो जोवन साई तिम्रा भाईकन
उभो जाने खुम्मेनीका मार्सि धानका कुम्ला
चिसो पानि, मिठा चामल कठै हाम्मा जुम्ला

पश्चिमाञ्चल क्षेत्रमा गाइने असारे रोपाइँ गीत (स्याङ्जा)

बसन्त ऋतु पार .. गरेर वर्षात आइगयो
किशान जति मिलेर अब खेत रोप्ने बेला भो ।
सिराने हलि गैरारे बाउसे बीयाडे भाफ घरे
खेताली सबै मिलेरसँगै खाउँला खीर भरे ।
खेताली खेतमा बाउसे आलीमा हली दाई मोइलाउने
कमलो हिलो बनाई गह्रा सबैले सम्याउने ।
छुपु र छुपु छिप्छिपे हीलो छी मलाई घिनलग्यो
पातली नानीलाई फरिया किन्दा छ बीस रीन लाग्ये ।

माघको जाडो अनदी चाम्रे खाएर कटाम्ला
पहेलेधानको सगला चामल नेपालमा पठाम्ला ।
लौ घरका बाबा खाजा ली आए आजको मेलामा
बैसालु खेतालीहरू रमे गोधुली बेलामा ।
घरकी आमा अचार बाँडिन हलीलाई बढी भो
बाउसेले देखे अनि भन्थाले हाम्रो त इज्जत गो ।
बाबाले बाँडे ठेकीको दही बाउसेलाई बढी गो
खेताली भन्न थाले नी यहाँ यो त अतिनै भो ।

जावो एक सारी किन्दिदा किन यत्रो यो फिराद
कुटौला धान पारौला चामल तिर्दिउला रिन साद ।
हली बाउसे र खेताली मिली गरौ है धान खेती
धान गोडी काटी पाके पछि त लाईन्छ पिरती ।
तिजमा खाउला तौलीका चिउरा दशैमा गुडुरा
हिलोमा धेरै नमात बाउसे हिल्याम्मे हौ दौरा ।
दशैमा बास्ना गाउंभरी आउने यो काली भनुवा
तिहारको रोटी जर्नेली धान पहेलेको पुवा ।

असारे हिलोको चिसो काट्न फुरौला नि आए
हली खेताला बाउसे सबै राम्ररी र माए ।
हिलोमा धान रोप्दाको दिन मन खुसी भै गयो
खेताली बाउसेको पिरती मनै मारै गयो।
मेलो सारौ है छीटोमा छीटो नरोकी एकै छिन
मानो खाई मुरी उव्जाउने हुन यी हाम्रा दिन ।
स्याङ्जा डाँडा पानी र बतास माया कता छ.......

धानसँग सम्बन्धित केही कविता

किसानको रहर

महाकवि लक्ष्मीप्रसाद देवकोटा

सानो छ खेत, सानो छ बारी, सानै छ जहान
नगरी काम, पुग्दैन खान, साँझ र बिहान ॥

बिहानपख झुल्किन्छ घाम देउराली पाखामा
असारे गीत घन्किन्छ अनि सुरिलो भाकामा ॥

काँधको शोभा हलो र जुवा हातमा कोदाली
जीवन धान्न गर्नु नै पर्ने उकाली ओराली ॥

छुपु र छुपु हिलोमा धान रोपेर छोडौंला
बनाई कुलो लगाई पानी आएर गोडौंला ॥

भनेर सानी पटुकी रातो बाँधेर झरेकी
धमिलो खोला बाढीले होला कसरी तरेकी !

गालामा साना पसिना दाना मोतीझैं खुलेकी
घाम र पानी भोक र तिर्खा कसरी भुलेकी ।

सुसेली हाली बयेली खेल्छ बतास रातमा
जूनले पोख्छ शीतका थोपा धानका पातमा ॥

सुनौला बाला झुलेर होला भुईँलाई छोएको
फलेको हाँगो कहिले छ र ननुही रहेको ?

हिमाल हाँस्छ मिलाई सेता दाँतका लहर
किसान बनी जहान पाल्ने यो मेरो रहर ॥

स्रोत : कक्षा ५ को महेन्द्रमाला

आकर्षित महिमाधानको

शिबराज पौडेल,
जीता सप्तधारा लम्जुङ्ग, हाल बागडोल ललितपुर
सम्पादक : कृषि विकास मन्त्रालयबाट सेवा निवृत्त ८२ वर्षीय पूर्व राष्ट्रसेवकको कलमबाट

गरिंदा नै बिवेचना बेदले औंल्याएकै ।
"धान्यमसि धिनु हि देवा....." मन्त्र पूजन यज्ञकै ॥
आरम्भमा नै गरिने सदायन कलस राखिन ।
पर्ने धानकैमाथि नै पसारेर हातले छोइन ॥
गर्ने नै गरिंदा पूजा यज्ञकै सामाग्री जुटाइन ।
भै अभावनै जौं गरेको प्रयोग धान ठहोराइन ॥
धानमाथि नै कलश राखी छोइएरै गरिने नै आवहान ।
जुटाइए सामाग्री गरिने पूजन यज्ञकै पनि हवन ॥

औल्याउने यज्ञ लाई नै "अध्वर" सार्थक होओइन ।
प्रयोग "अज" गरिदा चढाइने बलि नै ठहोराइन ॥
हिंसा नियालिंदा नै सामाग्री "अर्जे यष्टव्यं अध्वर" ।
नहुने नै सार्थक प्रमाणिक हिंसा नै होओइन र ?
औचित्य तथ्य आधारित सही सही सम्मत शास्त्रकै ?
जुटाईनै पर्ने आवश्यकीय सान्दर्भिक प्रामाणिकै?

नहुने नै बिजन योग्य चाँहि नै छरी उमारीनै नउम्रने ।
तात्विक यथार्थ नै "अज" सात्विकै उपयुक्त औल्याउने ?

"जा" बाहेक नै अन्य पबित्र अन्नप्रासन ।
सर्ब प्रथम नै बालकलाई खुवाइने गरिने नै हवन ॥
गर्ने गरिएको खेती "नवान्न" "न्वागी" प्राचीन ।
धानकै नै भै परम्परा नकुटिए कै नटुक्रिइकन ॥
चढाइने "अक्षता" योग्य लगाई पानी रोपिएकै ।
हो अर्घिने पितृलाई पिसेर नै गराइएकै ॥
"जौ" को नै चूर्ण पिठो-पिण्ड उपयुक्त तीर्थ श्राद्ध कै ।
गर्ने गरिने नै मात्र होओइन हुने बैकल्पिक ॥

अन्न नै नकि श्राद्द गरिदा घरमानै अपनाइन ।
पर्ने नै हो हुने नै भै यत्र-तत्र दुर्लभ भै ठहरोइन ॥
प्रयोग नगरिने गरेकै गाईकै दूधमा पकाएकै ।

चामल खिरकै उपयुक्त होला ठहराएकै ॥
अन्नश्री औंल्याउने गरिंदा पूजा यज्ञकै ।
अतिरिक्त नै पितृ कार्य हुँदा सिधा चामलकै ॥
दिइने र गरिने "पूर्ण पात्र" नै आखिर ।
व्रतबन्धमा नै दिइने लिइने नै भिक्षा थापिएर ।
झोली परिक्रमा गरिदै गरिंदा पूजा तिहारकै ।
हुने नै भरि नै गराइएर स्थापना गरिने लक्ष्मीकै ॥
प्रतिक भैली आउँदा मागी नै दिईने ।
भिक्षा उपहार नै योग्य पद किन्चित ठहराइने ॥
अन्न चामलकै कार्तिककै उपयुक्त नै
धानकै नै उल्लेखनीय उत्कृष्ठ नै ?
गर्ने गरिने नै मात्र होओइन हुने वैकल्पिक ?
गहा कै अभावमा पनि शाली धान नै गरिनु प्रयोग ॥

गराइने नै नैबेध्य "अयुपम" "माल्पुवा" प्रमाणिक ।
अन्यथा चढाईने बली देवीलाई नै बाहेक ॥
विप्रलाई गराएकै "सप्तशती-चण्डी" कै उल्लेख ।
"विप्र वर्ण मनोरिता" प्रासंगिक पौराणिक ॥
आख्यान कै गरिंदा विबेचना उपयुक्त ठहराइने ।
योग्य आवश्यकीय पूजा सामाग्री बिहित अविहित चढाइने ॥
अर्पिननै ग्राह्य प्रविधि पानी पटाइए कै आवश्यक ।
धान नलगाइएकै पाखो बालीकै होओस उही उही माफिक ॥

योग्य नहुने ओंल्याएकै पर्ने नै देख्न लागि परि गराएकै ।
गरा पानी पटाई रोपिने खेतमा नै बहु आयमिकै ॥
हुने नै खेती अधिकतर औंल्याएकै "यज्ञ-अध्वर" ।
हिंसा रहित नै हुनु पर्ने गर्ने गराइएकै ठहरोइन र ?
सात वर्ष अघिकै धान ठहराइने नै "अज" ।
अन्यथा देवीलाई चढाइने नै बलि गरिएकै निषेध द्विज् ॥
विप्र नै सही सान्दर्भिक यज्ञ हिंसा रहित नै ।
शास्त्र सम्मत आधारित प्रमाणिक उपयुक्त नै ॥

पुर्खाकै दूरदर्शिता आत्म निर्भर प्रेरक ।
स्वावलम्बी नै सही व्यवहारिक आयामनै ठीक ॥
लगाइने तह बसालिने गरिने गरेकै छर्दाकै नै ।
सानै नहुने अनन्यथा चाणक्यले औल्याएकै नै ॥
महिमा धानको हकमा "अहंमान्य" धान्य नै भै लोकलाई नै ।
कहलाइएका धान नकि सर्वोपयोगी दुर्लभ नै ॥
नहुने नै उब्जाइन सरल लागिनै परि परि गराइएकै ।
कृषककै लागि सुबिधा उपलब्ध पत्रहरूनै आधुनिकै ॥

मियो ठड्याएरै खलोमै बटुलेर बाँधी गोरु धपाइने ।
हक....हक.... हिंड चाडै माड दाइँ भनी घुमाइने ॥
ताकिएरै लडी द्याराले उधिनेरै छिरोली पराल ।
टक टकयाएरै धान माडिएकै एकोहोऱ्याई पराल ॥
नियाली पन्छ्याएरै लुंडो बेरी कसी भारी चांगै लगाइन ।
बाँधेर खातकै बोकी छिरोली टौवा चुल्याइन ॥
गराएकै पर्ने नै देख्ला धनाढ्य कहलाइन ।
नपर्ने पालिएरै गोरु हल हलोले नै जोतिन ॥

अधिकतर व्यवहारोपयोगी धाननै गरिदा कार्य ॥
मर्नुनै पर्दानी पनि पर्नेभो आवश्यकै अनिवार्य ठहोरोइन र ?
चाहिनै गर्ने गरिन होओइन दुर्लभै ठहराइने ।
असम्भव नै सम्भव सार्थकै श्रम गराइने ॥
नहोस् वरपर नै स्रोत पानीकै कुलो नहर ।
खनिएर पटाइने पानी मिटाइननै पनि रहर ?
गरिएर धान खेती मात्रनै नकि विविध ।
वर्षे हिउँदेनै बाली लगाएर आमदा ॥

सकिने नै सम्भब सुलभ हुनेनै वर्षाकै पानी ।
मात्रा नै नकि नभै प्रयोग गैरहने खेर नै पनि ॥
उसै धाए तुर्तुरेकै निकास यिनको होला यी डमफाए नै ।
खनेर पोखरी गाहिरै होओइन हुने यथेष्ट नै ॥
यत्र तत्र नै डम्फिने नै खोलिदा तल नपर्ने नै ।
जेनेरेटर लगाइन बेगले बग्ने खुल् खुल् नै ?
उकालो तिरका हकमा लगाएर जेनेरेटर नै ।
पटाइने नै गरे पानी लह लहिने बेमौसमी नै ॥

बाली हुने होओइनत मनाइने चहाड पाईयोइन ?
धाई धाई पुगी परै अक्षता किनी नै परोइन ॥
महँगै तरकारिकै मूल्य नै पनि चुकाइन ।
गरेकै उपभोग अर्काले देख्दा नै चुक चुकाइन ॥
वर्षामा वर्षाकै पानी एक हजार नै हुनेछ ।
यत्र तत्र नै डमफिने बाली धान
मात्र नै नकि विविध नै पाईने छ ॥
वर्षे हिउँदे नै पनि हुनेनै हरियाली हरा भरा ।
होओइनौ कसै रिगाईने हैसियत कै बबुरा बिचरा ?

खाना नै पनि नेपालीको ठहराइने अधिकतर ।
सबेर साँझ कै मात्र नभै खाजा नै भुटेर ॥
"खट्टे" बाहेक नै कुटी च्युरा गराइने मनाईदा ।
"चहाड" मै पकाइने "लट्टे" व्रतबन्ध विवाह हुँदा ॥

सेलरोटी कसार विविध जुट्दा समूह नै भतेर ।
अकेलैले नसकिने उतारिन दुइटैले कसिएर ॥
समाइए लानपर्ने गरालो नै घुसाइएर ।
उचालेर नै ताउलाहरू बोकिएर पानी रोचाभरि ॥

गरेरै जोहो राखिन हुने हुनुनै होसियारी ।
गर्ने गरिने नै खेती लागि परेरै धानकैभरी ॥
उत्पादननै हुने बढी नियाल्दा तथ्यांक रास्ट्र कै ।
प्रयोग गर्ने गरिनु अन्न नै पर्ने धानकै ॥
संस्कार संस्कृति उत्कृस्ट ठहराइने आर्यकै होनी ।
रितिरिवाज धानमानै ठहराइने नेपालीकै होनी ॥

धान बाली सम्बन्धी बाल कविता

नन्दनी दास
विद्यालयः आई. बि. ए. गौर, रौटहत

यो किसान जसले बनाउँछन् आफ्नो पहिचान,
दिएर अरूलाई चावल, धान
पाल्छन सबैलाई भएर महान ।

गर्छन् परिश्रम दिनभरी खेतमा
लिएर माटो आफ्नो हातमा
हेर्छन् सपना रातभरी खेतको
कस्तो होला उब्जनी धानको ॥

पसिना पोख्छ माटोमा जस्को
गर्छन परिश्रम दिनरात त्यस्को
किसानको सपना हुन्छन् साकार
जब उब्जिन्छ अन्नका प्रकार ॥।

जब हेर्छन् अन्नका वृष्टि
देखेर हुन्छन् धेरै खुसी
दिएर अन्नका प्रकार सबैलाई,
गर्छन् सबै जगतलाई खुसी ॥

स्रोतः राजदेवी दैनिक, गौर २०७३

Mapping of Rice Cultivars (Varieties and Landraces) in Nepal

Summarized from: CDD. 2015. *Rice varietal mapping in Nepal: Implication for development and adoption*. Crop Development Directorate (CDD), Department of Agriculture, Hariharbhawan.

सारांश

धानले राष्ट्रिय अर्थतन्त्र र खाद्य सुरक्षामा पुऱ्याउने भूमिकालाई मध्य नजर राख्दै नेपाल सरकारले धानको उन्नत जातको विकास र गुणस्तरीय बीउको आपूर्तिलाई प्राथमिकतामा राखेको छ । तर पनि नेपालमा उन्मोचन तथा सिफारिस भएका धानका जातहरूको आधाको संख्यामा मात्र कृषकहरूले उपयोग तथा प्रयोग गरेको पाइन्छ । यस सन्दर्भमा धानको जातीय नक्सांकन मार्फत नेपालका विभिन्न भौगोलिक परिवेशमा धानका जातहरूको अनुसरण अवस्थाको चित्रण गर्ने प्रयास गरिएको छ । यस पुस्तकमा धानका खुल्ला सेचित, हाइब्रिड तथा स्थानीय र परम्परादेखि प्रचलनमा रहेका ७३ जिल्लाहरूका धानका जातहरूको क्षेत्रफलका साथै धानका जातहरूको कृषकमाझ अनुसरणको अवस्था तथा धानको उत्पादन र उत्पादकत्व वृद्धिका लागि व्यवहारिक सिफारिसहरू विस्तृत रूपमा प्रस्तुत गरिएको छ । सन् २०१५ मा तयार गरिएको यस पुस्तक तयार गर्न बाली विकास निर्देशनालयले जिल्ला कृषि विकास कार्यालयहरू मार्फत एक सर्वेक्षण गरेको थियो । सर्वेक्षणबाट प्राप्त तथ्याङ्क तथा विवरणहरूलाई अन्य प्रकाशनहरूको सहयोग एवम् सम्बन्धित व्यक्तिहरूसँगको टेलिफोन बार्ताबाट अनुमोदन तथा आवश्यक परिमार्जन गरिएको थियो । यहाँ धानको जातीय नक्सांकन पुस्तकमा समावेश भएका विभिन्न विषयवस्तुहरूलाई सारांशको रूपमा प्रस्तुत गर्ने प्रयास गरिएको छ ।

Summary

Considering the important role of rice in the economy and food security, Government of Nepal (GoN) has prioritized the development and deployment of new crop varieties and quality seeds. Only about half of the varieties released by GoN are being adopted by farmers and many unregistered and denotified varieties are still being widely cultivated by farmers. CDD took an initiative to document the adoption status of rice varieties by farmers in different ecological regions of Nepal through Rice Varietal Mapping. The book "Rice Varietal Mapping" assesses the area under various open pollinated, hybrids and traditional varieties across all seventy three districts of Nepal. This study imparts insights on reasons for adoption and non-adoption of different released rice varieties and provides practical recommendations to increase the production and productivity of rice in Nepal. In order to gather required information on rice, Crop Development Directorate (CDD) administered a survey among District Agriculture Development Offices (DADOs) in 2015. The data received from DADOs were compiled and analyzed. District level data and information was triangulated and verified in CDD by reviewing secondary sources and telephone interviews with the district colleagues. An attempt has been made to summarize Rice Varietal Mapping in Nepal: Implication for Development and Adoption.

Rice area in major agro-ecological zones

Rice is grown in three distinct major agro-ecological zones, which are Tarai (60-900 masl), Mid hill (900-1,500 masl) and Mountain/High hill (1,500 - 3,050 masl). The Tarai and Inner Tarai consist of major portion (69.7%) followed by the Mid-hill (25.8%) and the mountain (4.4%) of total rice area in Nepal. Based on water regime, prevailing rice ecosystems are irrigated either fully or partially (63.6%), and rainfed (36.4%) of the total rice area (MoAD 2013). Some part of Tarai plains also consist of deep-water rice, which is negligible. The rainfed lowland has diversified rice environments.

Table 1. Rice area and production by ecological region

SN	Agro-ecology	Area (ha)	Percentage share
1	Mountain	68,052	4.4
2	Mid Hill	395,493	25.8
3	Tarai	1,067,949	69.7
	Total	**1,531,494**	**100.0**

Source: Data from District Agriculture Development Offices 2014.

Trend in area, production and yield

In the last 39 years, the rice area and yield grew annually by only 0.59 and 1.75% respectively. The growth in yield contributed about 72% to total production and remaining 28% was from area growth. The area growth has been the highest for the mountain (3.10%) followed by the mid hill (1.96 %) and Tarai (0.12%) whereas yield growth was low during that period. In the mid hill and mountain, expansion in rice area was major factor contributing to production. However, the growth in yield contributed significantly (around 94%) to the total production in Tarai. This is true for Tarai where green revolution technologies are widely disseminated aided by support services, research and extension systems from government of Nepal (GoN). Furthermore, several donor funded projects were concentrated in the region. The growth in area was higher during 1974-1990 compared to 1991-2012 period. This shows that the scope of increasing paddy outputs by increasing area is very limited.

Table 2. Annual compound growth (%) in area, production and yield of rice in Nepal

Year	Mountain	Mid hill	Tarai	Nepal
1974-1990				
Area	3.83	4.54	0.15	1.07
Production	2.94	3.46	1.93	2.28
Yield	-0.89	-1.08	1.78	1.21
1991-2012				
Area	3.05	0.72	0.07	0.34
Production	3.63	2.54	1.84	2.04
Yield	0.58	1.82	1.77	1.70
1974-2012				
Area	3.10	1.96	0.12	0.59
Production	3.16	2.63	1.91	2.10
Yield	0.06	0.67	1.79	1.51

Comparing the yield of rice crop in the region

The yield of rice is the lowest in Nepal (3.3 t/ha) among the South Asian countries. Comparing Nepal Tarai with the Indian states, the yield level of Nepal is far below than the Punjab (3.7 t/ha), an advanced state in terms of agricultural development, while higher than the lagging state like Bihar (2.1 t/ha) and Uttar Pradesh (2.3t/ha).

Minimizing the gap between potential and actual Yield

As of 2014, NARC has developed 73 varieties and NSB has registered 17 varieties of rice mostly developed by India based multinational seed companies. In case of rice it is one plus variety release per year. The number is very small considering the fact that over 2,500 landraces were grown in Nepal before the green revolution period and also a small village of Nepal harbors 10-70 rice varieties. Some of the varieties being considered as improved had been released some 35 years ago. The genetic quality of such stocks may be questionable. The formal seed sources and the seed production programs of the government are able to meet 6-8% of the seed requirement in case of major cereal crops. The potential and actual yield for some of the major rice varieties is presented in table below. Table shows the number of varieties developed for different ecological regions, their potential and farm level yield calculated based on the information of NARC (2014).

Table 3. Yield gap between potential and actual yield of rice varieties

SN	Region	No. of varieties	Potential yield (t/ha)	Farm level yield (t/ha)	Differences between potential and actual yield	
					t/ha	%
1	Tarai/ Inner Tarai	24	4.23	3.29	0.94	29

SN	Region	No. of varieties	Potential yield (t/ha)	Farm level yield (t/ha)	Differences between potential and actual yield	
					t/ha	%
2	Mid Hill	10	6.32	3.06	3.26	107
3	High hill	3	5.40	2.09	3.31	158
	Overall	37	4.89	3.17	1.72	54

Source: Calculated based on NARC 2014 and MoAD 2013.

The potential yield of rice varieties comes to be 4.89 t/ha. The yield gap between the potential yield and the actual yield at the farm level is 54% per unit of land. This demands an in depth analysis of underlying causes. This also indicates a prospect of increasing the food production through productivity increment through genetic and agronomic means. Most of the rice varieties developed by NARC have high yield potential but large gap exists between research station and farmers'field. In order to strengthen synergism among disciplines, the National Rice Research Program (NRRP) has started strategic research for accelerating rice breeding program by conducting conventional breeding in combination with molecular tools, resource conservation technologies, integrated disease and pest management system, integrated plant nutrient management system, post harvest technology and value addition, socioeconomic and policy research, participatory technology assessment and transfer, and human resource development (NRRP 2009). The commodity research programs throughout the country under NARC are preparing to boost up crop production by developing site-specific, advanced, and affordable agronomic technologies.

Potentials for rice productivity growth

Considerable increase in the production of rice is possible through improvements in productivity rather than by area expansion. Yield levels gradually increase as we move up in the technology ladder from rice production under the local seed without irrigation to the improved seed with irrigation. 92% of the area is under improved varieties of rice. However, seed replacement is significantly low among the improved seed growers. Therefore, the rice production might be increased by further expanding the area under improved seeds and by increasing seed replacement rate. This talks about the performance of Nepalese improved rice varieties vis-à-vis others, and the agricultural research systems' capacity to supply more rice varieties. Meanwhile, area under irrigated and un-irrigated is 63 and 37% respectively. The effects of technology to changes in the yield of rice and wheat are similar. Under the rice-wheat cropping patterns, as we move up from local variety-un-irrigated to improved variety-irrigated farming, the grains yields go up from 1.86 to 3.72 t/ha (pooled average 3.17 t/ha).

Table 4. Yield of rice by seed and water technology 2012

SN	Farming conditions	Cropped area (%)	Yield (t/ha)
1	Local seed, un-irrigated	5.35	1.86
2	Improved seed, un-irrigated	31.03	2.35
3	Local seed, irrigated	2.21	2.54
4	Improved seed, irrigated	61.41	3.72
	Pooled	100	3.17
A	Improved seeds	92.44	3.26
B	Local seeds	7.56	2.06
	Pooled	100.0	3.17

Source: MoAD 2013.

Development of stress tolerant rice varieties

Drought and submergence are two most important abiotic stresses causing significant yield losses across the country especially in the rain-fed rice environments. In Nepal, 30% and 15% of total rice cultivated areas are prone to drought and submergence respectively (Gumma et al 2011). Considering this reality, rice breeding focusing on attaining a high grain yield under drought and submergence has been initiated in Nepal since 2007 with active collaboration of IRRI, Los Banos, Philippines. NRRP has developed and released seven varieties of drought tolerant and two varieties of submergence tolerance. The varieties: Sukha-1, Sukha-2, Sukha-3, Sukha-4, Sukha- 5, Sukha- 6, Swarna Sub-1, and SambaMansuli Sub-1 were released in Nepal with the support of Stress Tolorent Rice for Africa and South Asia (STRASA) Project. These are verities are getting popular in rainfed ecosystems of Nepal.

Consumption of rice

The estimates of elasticity of household consumption demand functions for rice shows that people have very strong preference for rice. The demand for fine rice will increase by 0.9% with every percent increase in the income, whereas the demand for maize would decline with rise in income. On the other hand, the demand for rice with respect to its prices is highly negative. Thus, the rise in the prices of rice may increase the welfare of the farmers depending on how competitive the markets are. But the non-farm communities such as those living in urban areas or doing non-farm occupations will suffer greatly thanks to the food prices. Furthermore, rice eating culture is in increasing in hills and mountains where food security is a burning issue.

Table 5. Elasticity of income and prices in the household demand for foods 2003

Food item	**Elasticity coefficients with respect to.**		**Coefficient of determination (R^2)**	**F-ratio**
	log per capita income	**log average price**		
Fine rice	0.922	-4.003	0.355	120.6
Coarse rice	-0.541	NA	0.355	103.6
Beaten rice	0.283	-2.116	0.289	73.3
Maize	NA	-9.937	0.475	118.8
Maize flour	-0.294	-4.271	0.459	133.9
Wheat flour	NA	3.102	0.246	68.2
Millet	-0.240	-5.318	0.399	113.8
Black gram (Mas)	0.485	-7.841	0.259	63.0
Lentil Musuro	NA	NA	0.297	88.0
Red gram (Rahar)	0.315	-12.022	0.299	73.4
Horse gram (Chana)	0.508	-22.408	0.203	63.4
Potato	0.259	NA	0.120	29.1

Note: NA refers to not applicable at 5% level of significance in the stepwise regression process. The regressions equations had 3,911 degrees of freedoms. Source: Data based on NLSS 2003/04, Thapa 2008.

Farmers' supply response

The cropping intensity has increased while the number of animals for providing manures has decreased. So the supply of plant nutrients largely rest on the import of chemical fertilizers. The Government procured fertilizer used to be solely distributed by the Agriculture Inputs Corporation (AIC) till November 1997. The policy used to provide the price and transport subsidies in fertilizer sales to promote fertilizer use. The general policy was to maintain fertilizer prices about 15 to 20% higher than India to prevent informal re-exports. During November 1997 to November 1999, the government gradually phased out the price subsidies. In late 1999, the government enacted a Fertilizer Regulations for fair trade of fertilizers and completely liberalized the fertilizer trade. Thus, the government gradually encouraged private sector in the deal of chemical fertilizer, whose share rose to around 85% of total supply in 2005/2006. The monitoring system was weak, which led to the import of low quality fertilizer to the detriment of productivity and soil fertility. The share of private sector has gradually declined and remained negligible in the recent years. The government has reintroduced the fertilizer subsidy and the level of subsidy differs with the type of fertilizer. It is estimated that around 40% of income from the fertilizer sale is used for rice cultivation. The removal of subsidy of fertilizer has negative impact on the supply of rice. A study has shown that the elasticity of rice supply/ production with respect to the fertilizer prices negative, that is, (-) 0.40. This is to say if the fertilizer prices were to rise by one percent, the production of rice would decline by 0.4%. The fertilizer subsidies in neighboring countries have further weakened the position of the Nepalese farmers (Thapa and Pokhrel 2003).

Table 6. Elasticity of supply of rice and demand for rice and competing crops

SN	Main crops and competing crops for area	Elasticity of rice production/supply with respect to	
		Own-price elasticity	Fertilizer/ feed price elasticity
1	Rice	1.01	-0.40
2	Sugarcane	0.60	-0.46

A study by the ADB team estimated an econometric production function for rice yields. The production function for rice yield with respect to fertilizers was a cubic equation with constant term as 2.6 t/ha, first slope coefficient 11.23 kg rice/kgfertilizer (NPK) and third term as -0.04 kgrice/kg NPK (where NPK is nitrogen, phosphorous and fertilizer). This study assumed that farmers would use some 145 kg of NPK per hectare to get maximum yield of rice even without fertilizer uses. But if we consider the marginal value productivity of fertilizer uses, farmers can hardly apply 69-73 kg of fertilizer per hectare if the unit price of fertilizers is around NRs 15/kg. The farmers are presently using nearly this quantity of fertilizers through formal and informal sources. Hence unless the condition of trade improves with farmers in terms of the output/input prices, they may not supply any more output.

Table 7. Rice yield production function

Variables	Coefficients (kg/ha)	t-Static	Average?
Intercept	2,654.2	102	
NPK	11.23	5.3	33
$(NPK)^2$	-0.038	-2.7	2,705
Irrigation	652.2	8.0	0.67
Variety	-507.6	-6.2	0.65
Mountain	-1,086.0	-10.0	
Hill	-181.2	-2.0	
Adjusted R^2	0.33		
Average response to nutrients	85		
Elasticity of yield response to nutrients	0.11		
Observations	719		

Source: Selected Indicators from ANZDEC 2002.

Production seasons and varietal coverage

The total rice area reported by the DADOs for the present study is higher compared to the area estimated by MoAD. This has been adjusted with the area for the year 2011/12 reported by MoAD (15,31,493 ha). Out of the total rice area in Nepal (1,531,494 ha), 70% is in the Tarai, 26% in the mid hill and 4% in the mountains. About 92% of rice area falls under main (*Barkhe*) season while 7% is under spring (*Chaite*) season. Hiundedhan (Boro rice) and *Bhadaiya* rice is also practiced in few districts of Tarai occupying less than 1% of the total area. Likewise, improved OPVs occupy about 82.4% followed by local (10.2%) and hybrids (7.4%).

Table 8. Rice production area under different varieties and growing season

SN	Variety	Main season	Spring season	Boroand *bhadaiya* rice	Total	Percentage
1	Improved	1152314	101265	8096	1261675	82.4
2	Hybrid	112295	1469	126	113890	7.4
3	Local	146319	9579	32	155929	10.2
	Total	1410928	112313	8253	1531494	
	Percentage	92.1	7.3	0.5	100	100

Area under improved OPVs, hybrids and local varieties

A total of 270 rice varieties including improved, hybrids and local are grown in different ecological zone and development regions of Nepal. Out of these varieties 157, 59 and 54 are local, improved and hybrids, respectively. On an average, the improved OPVs occupy nearly 82% of the total rice area. This consists about 60.1%, 71.4% and 87.9% in the mountains, hills and Tarai respectively. Similarly, 7.4% of total rice area in Nepal is covered with the hybrid rice varieties. Those hybrids include both registered and illegally imported seeds from India and China. The share of local varieties is the highest in the mountain (39.5%) followed by hills (23.8%) and Tarai (3.3%). Among the development regions, the share of the local varieties is the lowest in the central (4.9 %) and the highest in the eastern region (18.2%).

Table 9. Percentage of rice area covered with improved, hybrids and local varieties (Total area: 1,531,494 ha)

SN	Development region	Mountain			Mid hill			Tarai			Total		
		Improved	Hybrid	Local	Improved	Hybrid	Local	Improved	Hybrid	Local	Improved	Hybrid	Local
1	Eastern	47	0	53	49.2	0.3	50.5	93.2	0.8	5.9	81.1	0.7	18.2
2	Central	71	0.9	28.1	82.6	10.6	6.9	94.6	2.3	3.1	91	4	4.9
3	Western				75.2	5.2	19.7	65.5	33.5	1	69.4	22.1	8.5
4	Mid-western	56.4	0	43.6	81.3	6.4	12.3	81.4	17.1	1.5	80.1	13.4	6.5
5	Far-western	74.7	0.7	24.6	80.1	0	19.9	97.6	1.1	1.4	91.8	0.8	7.4
Nepal		**60.1**	**0.4**	**39.5**	**71.4**	**4.8**	**23.8**	**87.9**	**8.9**	**3.3**	**82.4**	**7.4**	**10.2**

Distribution of modern varieties (MVs)

As of December 2014, eighty rice varieties are released (62) and registered (18) in Nepal. Among these varieties, 63 are OPVs and 17 are hybrids. All of the hybrids are developed in India and China. GoNhas denotified11 varieties released during 70s and 80s. Out of those varieties, a total of 55 varieties are cultivated in Nepal, out of which 46 are developed in Nepal and rests are of Indian and Chinese origin. In some cases, the name for the same variety might have differed by locations. Among the Indian varieties, SonaMasuli was released in 1982 from Andhra Pradesh which matures in 145 days with a yield potential of 5 t/ha and Ranjit, a variety prominent in submergence-prone environments in Assam and West Bengal maturing in 155-160 days was released in 1992. Similarly, Samba Mahsuri (Sawa Masuli) which matures in 140-145 days, was released from Andhra Pradesh in 1986 and notified by Central Variety Release Committee in 1988. The Sarju-52 was released in 1979 from Uttar Pradesh of India. The exact source of origin of Kanchhi Masuli in India and its release status are not known. Kanchhi Masuli has been grown in eastern Nepal since the early 1990s and it is popular among farmers due to its wide adaptation, good yield, and medium grain quality. Likewise, Rambilas a popular variety is believed to be the sister line of Radha-11 (Pandey et al 2012).

Eastern development region (EDR)

The distribution of the varieties by ecological regions and their area share is presented in table below. In total, 27 registered and 7 non registered varieties are reported to be cultivated in this region. In some cases, the name(s) of the varieties have not beenspecified and have been classified as "others".

In the eastern mountain, the Khumal-4 is very popular occupying around 25.04% of the area under MVs, followed by Chhomrong local (11.49%) and Mansuli (9.30%). In the hills, the top three popular varieties are Khumal-4 (19.78%) followed by Mansuli (17.18%) and Radha-12 (7.33%) while in the Tarai Sona Mansuli leads the highest coverage (23.03%) followed by Radha-12 (15.21%) and Kanchhi Mansuli (13.95%).

Table 10. Area under normal improved rice varieties in eastern development region

Mountain			Mid hill			Tarai		
Variety	**Area**	**% area**	**Variety**	**Area**	**% area**	**Variety**	**Area**	**% area**
Khumal-4	2753	25.04	khumal- 4	9329	19.78	Sona mansuli ##	63868	23.03
Chhomrong	1263	11.49	Mansuli	8102	17.18	Radha- 12	42196	15.21
Mansuli	1022	9.30	Radha- 12	3458	7.33	Kanchhi mansuli	38682	13.95
Sabitri	943	8.58	Makawanpur- 1	3444	7.30	Ranjit ##	28936	10.43
Radha-12	825	7.51	Kanchhi mansuli	3160	6.70	Mansuli	27458	9.90
Hardinath-1	820	7.46	Tarahara-1	3146	6.67	Lalka basmati	16849	6.07
Mithila	736	6.70	Khumal- 8	2784	5.90	Swarna sab- 1	15624	5.63
Loktantra	736	6.70	Khumal- 10	2756	5.84	Hardinath- 1	10008	3.61
Makawanpur-1	695	6.32	Ranjit	2145	4.55	BB- 11##	6350	2.29
Kanchhi mansuli ##	244	2.22	Hardinath -1	2134	4.52	Tarahara- 1	5011	1.81
Others	955	8.69	Sabitri	1824	3.87	Rampur mansuli	4658	1.68
			Radha- 4	947	2.01	RP- 1017##	4439	1.60
			Rambilash##	752	1.59	Sabitri	4164	1.50
			Sukhkha- 2	597	1.27	Anamol mansuli	1975	0.71
			Loktantra	590	1.25	Barse- 3004	1938	0.70
			Swarna sab -1	535	1.13	Sukkha-3	1119	0.40
			Khumal- 2	444	0.94	Barse- 2014	1097	0.40
			Taichung- 176	281	0.60	Sawa mansuli	1035	0.37
			Chomromg	262	0.55	Mithila	742	0.27
			Radha- 17	200	0.42	Makawanpur- 1	451	0.16
			Ghaiya- 2	123	0.26	Others	432	0.16
			Radha- 7	102	0.22	Sukkha-2	199	0.07
			Others	56	0.12	Sukkha-1	150	0.05
Total	**10992**	**100.00**		**47171**	**100.00**		**277381**	**100.00**

Indian/non-registered varieties

Central development region (CDR)

In the CDR, 32 registered and 4 non registered varieties are reported to be cultivated. Among them, Makwanpur-1(29.18%), Khumal-4 (29.05%) and Khumal-10 (15.78%) are popular varieties in the mountains occupying about three-fourths of the total area. Similarly, dominant varieties such as Makwanpur-1(24.81%), Sabitri (21.67%) and Khumal-4 (18.98%) share nearly 65% of the area in the hills. On theother hand, Sona Masuli occupies about 48.82% of the total area in the Tarai followed by Sabitri (10%) and Hardinath-1 (8.94%).

Table 11. Area under normal rice varieties in central development region

Mountain			Mid Hill			Tarai		
Variety	**Area**	**% area**	**Variety**	**Area**	**% area**	**Variety**	**Area**	**% area**
Makawanpur-1	2524	29.18	Makawanpur-1	15456	24.81	Sona mansuli ##	122241	48.82
Khumal-4	2513	29.05	Sabitri	13503	21.67	Sabitri	25029	10.00
khumal-10	1365	15.78	Khumal-4	11822	18.98	Hardinath- 1	22379	8.94
Chinung-242	390	4.51	Khumal-11	4249	6.82	Swarna sab- 1	18052	7.21

Mountain			Mid hill			Tarai		
Variety	**Area**	**% area**	**Variety**	**Area**	**% area**	**Variety**	**Area**	**% area**
Khumal-8	388	4.48	Chinung-242	2922	4.69	Rambilash##	13876	5.54
Khumal-11	313	3.62	Radha-4	1952	3.13	Radha 4	10626	4.24
Himali	218	2.52	Taichung-176	1744	2.80	Ram dhan	7536	3.01
Radha-6	175	2.02	Khumal-10	1736	2.79	Mansuli	6813	2.72
Radha-4	172	1.99	Ghaiya-2	1723	2.77	Sarju- 52##	4760	1.90
Mansuli	165	1.91	Hardinath-1	1671	2.68	Sabha sab- 1	3762	1.50
Mansuli	141	1.63	Radha -7	1035	1.66	Sambha mansuli sab-1	2760	1.10
Ghaiya-2	69	0.80	Khumal-8	870	1.40	Sukkha-2	2511	1.00
Kanchan	66	0.76	Ram Dhan	592	0.95	Others	2083	0.83
Others	151	1.75	Loktantra	443	0.71	Sukkha-1	1873	0.75
			Rambilah##	399	0.64	Mithila	1529	0.61
			Chhomrong	273	0.44	Radha- 11	1041	0.42
			Sunaulo sugandha	264	0.42	Sukkha-3	901	0.36
			Ranpurmansuli	253	0.41	Makawanpur- 1	880	0.35
			Himali	224	0.36	Sunaulo sugandha	759	0.30
			Parwanipur-1	91	0.15	Ghaiya- 1	521	0.21
			Mansuli	86	0.14	Kanchimansuli##	338	0.13
			Mallika	46	0.07	Loktantra	119	0.05
			Sukkha-3	40	0.06			0.00
			Sukkha-2	31	0.05			0.00
			Swarna sab-1	23	0.04			0.00
			Sukkha-1	20	0.03			0.00
			Others	832	1.34			0.00
Total	**8649**	**100.00**		**62298**	**100.00**		**250390**	**100.00**

Indian/non-registered varieties

Western development region (WDR)

Rice is not cultivated in the mountains of WDR. In other ecological regions, it is reported that 27 registered and 4 non registered rice varieties are cultivated. Among them, Sabitri (20.07%), Khumal-4 (16.41%) and Ram dhan (13.94%) are popular occupying nearly 50% of the rice area in the hills. In case of the Tarai, Radha-4 (26.55%), SawaMansuli (19.11%) and Sabitri (11.04%) occupy nearly 57% of the total area.

Table 12. Area under different normal rice varieties in western development region

Mid hill			Tarai		
Variety	**Area, ha**	**% area**	**Variety**	**Area, ha**	**% area**
Sabitri	17735	20.07	Radha- 4	31737	26.55
khumal-4	14495	16.41	Sawa mansuli##	22842	19.11
Ram dhan	12319	13.94	Sabitri	13203	11.04
Makawanpur-1	7155	8.10	Sambha mansli sab- 1	12283	10.27
Khumal-10	3867	4.38	Ram Dhan	8762	7.33
Sudhariyako Jethobudo	3593	4.07	Sarju- 52##	8665	7.25
Mansuli	3426	3.88	Mansuli	7920	6.63
Radha-7	2692	3.05	Sona mansuli##	6230	5.21
Rampur mansuli	2691	3.05	Swarna sab-1	3085	2.58

Mid hill			Tarai		
Variety	Area, ha	% area	Variety	Area, ha	% area
Radha-4	2467	2.79	Hardinath-1	1796	1.50
Sunaulo sugandha	2162	2.45	Radha-12	450	0.38
Hardinath-1	2045	2.31	Radha-7	270	0.23
Loktantra	2030	2.30	Sukha-1	40	0.03
Khumal-8	1539	1.74	Sukha-3	32	0.03
Machhapuchre-3	1033	1.17	Others	2230	1.87
Chhomrong	1019	1.15			
Lumle-2	999	1.13			
Khumal-2	872	0.99			
Radha-11	772	0.87			
Khumal-11	737	0.83			
Radha-12	543	0.61			
Sukha-3	369	0.42			
Sukha-1	350	0.40			
Sawa mansuli ##	337	0.38			
Malesiya##	149	0.17			
Sukha-2	49	0.06			
Others	2904	3.29			
	88349	100.00		119545	100.00

*Indian/non-registered varieties

Mid-western development region (MWDR)

In the MDR, 30 registered and 2 non registered rice varieties are reported to be cultivated. In the mid-western mountain, seven varieties have been reported, out of which Chandannath-3(45.66%), Chandannath-1(20.34%) and Khumal- 10 (13.54%) are popular and share nearly 80% of the area under MVs. The varieties Bindeshowri (19.48%), Radha-4 (16.22%) and Khumal-4 are the top three varieties in the hills occupying 49% of the total area. Unlike Tarai of other development regions, the varieties released from Nepal are popular in MWDR. Among them, Radha-4 is the most popular variety (39.07%) followed by Bindeshwori (15.40%) and Sabitri 14.19%).

Table 13. Area under normal rice varieties in mid-western development region

Mountain			Mid hill			Tarai		
Variety	Area	% area	Varieties	Area	% area	Variety	Area	% area
Chandan nath-3	2216	45.66	Bindeswari	7624	19.48	Radha-4	38190	39.07
Chandan nath -1	987	20.34	Radha-4	6351	16.22	Bindeswari	15053	15.40
Khummal-10	657	13.54	Khumal-4	5283	13.50	Sabitri	13870	14.19
Chhomrong	487	10.03	Radha-7	4815	12.30	Makawanpur-1	7500	7.67
Machhapuchhre-3	228	4.70	Sabitri	2889	7.38	Sarju-52##	5451	5.58
Taichung-176	163	3.36	Himali	1562	3.99	Ram dhan	4042	4.14
Lumle-2	115	2.37	Ram dhan	1348	3.44	Janaki	2894	2.96
			Khumal-11	1026	2.62	Mansuli	2617	2.68
			Radha-12	905	2.31	Sukhkha-3	1463	1.50
			Loktantra	899	2.30	Sukhkha-2	1392	1.42
			Khumal-8	862	2.20	Hardinath-1	1314	1.34

Mountain			Mid hill			Tarai		
Variety	Area	% area	Varieties	Area	% area	Variety	Area	% area
			Khumal-10	841	2.15	Sambha mansuli sab- 1	1273	1.30
			Mansuli	781	2.00	Sawa mansuli ##	1257	1.29
			Makawanpur-1	564	1.44	Sukhkha-1	1209	1.24
			Ghaiya-2	535	1.37	Others	215	0.22
			Sukkha-3	460	1.17			
			Sukkha-1	420	1.07			
			Sukkha-2	410	1.05			
			Khumal-9	405	1.03			
			Mithila	281	0.72			
			Tarahara-1	279	0.71			
			Hardinath-1	196	0.50			
			Sawa mansuli##	63	0.16			
			Others	347	0.89			
Total	**4853**	**100**		**39147**	**100**		**97741**	**100**

Indiannon-registered varieties

Far-western development region (FWDR)

In the FWDR, 22 registered and 2 non registered rice varieties have been reported. In the mountain, three varieties namely Radha-4 (32.34%), Khumal-4 (22.73%) and Hardinath-1(13.02%) share 68% of the total area. Radha-4 (40.78%), Khumal-4 (26.13%) and Hardinath-1(16.42%) occupy 83% of the total area in the hills. On the other hand, Saryu-52, an Indian variety is popular in Tarai occupying 46.79% of the total area followed by Radha-4 (21.14%) and Sabitri (11.73%).

Table 14. Area under normal improved rice varieties in far-western development region

Mountain			Mid hill			Tarai		
Variety	Area	% area	Varieties	Area	% area	Variety	Area	% area
Radha-4	3404	32.34	Radha- 4	10955	40.78	Sarju-52##	50722	46.79
Khumal-4	2393	22.73	Khumal- 4	7030	26.17	Radha- 4	22919	21.14
Hardinath-1	1371	13.02	Hardinath-1	4411	16.42	Sabitri	12719	11.73
Chhomrong	1054	10.01	Khumal -11	1692	6.30	Hardinath- 1	10632	9.81
Himali	1045	9.93	Khumal -10	1207	4.49	Ram dhan	2759	2.54
Chandannath-1	623	5.92	Loktantra	792	2.95	Loktantra	2237	2.06
Chandannath-3	505	4.80	Sawa mansuli##	409	1.52	Sawa mansuli##	1714	1.58
Sukhkha-1	122	1.16	Sukhkha- 3	279	1.04	Makawanpur- 1	1390	1.28
Khumal-11	5	0.05	Others	85	0.32	Mansuli	645	0.59
Khumal-13	5	0.05				Mithila	534	0.49
						Swarna sab- 1	534	0.49
						Sukhkha- 1	434	0.40
						Sukhkha- 3	434	0.40
						Janak	402	0.37
						Radhakrishna	334	0.31
Total	**10527**	**100.00**		**26860**	**100.00**		**108409**	**100.00**

Indian/non-registered varieties

Area under old and new improved varieties

The National Agricultural Research Council (NARC) of Nepal is developing modern varieties of rice considering the needs of diverse ecosystems and production environments in Nepal. This has resulted in coverage of improved varieties in around 90% of the total rice area which were developed and released from 1966 to 2014. There are few varieties released during 70s and mid 80s which are still being widely adopted in Nepal. Around 52% of the total rice areas are under old improved varieties. Indian, non-registered two varieties such as Sona Masuli (released in 1982) and Sarju- 52 (released in 1979) occupies around 23% of the area under old varieties. Moreover, farmers are still cultivating banned varieties although in a small area. The adoption of the varieties released over 40 years such as Masuli, and over 30 years such as Sabitri, Sarju-52 and Sona Masuli show that efforts to deploy new improved varieties are not sufficient, new improved varieties are incompetent with old varieties for specific traits. Besides, for some old varieties farmers have special preferences for their traits such as wider adaptability, low fertility tolerance etc. The share of the specified new MVs in total area is around 48.91%.

Table 15. Area under old and new improved of normal rice varieties 2012

SN	Area under old improved varieties (%)			SN	Area under new improved varieties (%)		
	Variety	**Area (ha)**	**%**		**Variety**	**Area (ha)**	**%**
1	Sona mansuli ##	192340	16.69	1	Radha-4	129720	11.26
2	Sabitri	105879	9.19	2	Hardinath-1	58777	5.10
3	Sarju-52##	69598	6.04	3	Radha-12	48378	4.20
4	Mansuli	59176	5.14	4	Swarna sab-1	37853	3.28
5	Khumal-4	55619	4.83	5	Ram Dhan	37358	3.24
6	Makawanpur-1	40058	3.48	6	Ranjit ##	31081	2.70
7	Sawa mansuli##	27656	2.40	7	Lalka basmati	16849	1.46
8	Bindeswari	22677	1.97	8	Sambhamansuli sab-1	16316	1.42
9	Chinung-242	3312	0.29	9	Khumal-10	12429	1.08
10	Janaki	3296	0.29	10	Radha-7	9164	0.80
11	Himali	3049	0.26	11	Tarahara-1	8436	0.73
12	Ghaiya-2	2450	0.21	12	Loktantra	7846	0.68
13	Taichung-176	2187	0.19	13	Khumal-11	7785	0.68
14	Khumal-2	1316	0.11	14	Rampur mansuli	7603	0.66
15	Parwanipur-1	91	0.01	15	Khumal-8	6680	0.58
			0.00	16	Sukhkha-2	5190	0.45
			0.00	17	Sukkha-3	5097	0.44
			0.00	18	Sukkha-1	4619	0.40
			0.00	19	Chhomrong	4357	0.38
			0.00	20	Mithila	3822	0.33
			0.00	21	Sudhariyako jethobudo	3593	0.31
			0.00	22	Sunaulo sugandha	3185	0.28
			0.00	23	Chandan nath-3	2721	0.24
			0.00	24	Barse-3004	1938	0.17
			0.00	25	Radha-11	1813	0.16
			0.00	26	Chandan nath-1	1611	0.14
			0.00	27	Machhapuchre-3	1261	0.11
			0.00	28	Barse-2014	1097	0.10

SN	Area under old improved varieties (%)			SN	Area under new improved varieties (%)		
	Variety	Area (ha)	%		Variety	Area (ha)	%
			0.00	29	Ghaiya-1	521	0.05
			0.00	30	Khumal-9	405	0.04
			0.00	31	Radhakrishna	334	0.03
			0.00	32	Khumal- 13	5	0.00
Total		**588705**	**51.09**			**477844**	**41.47**
Others						**85765**	**7.44**
Grand total						**1152313.77**	**100.00**

Indian non-registered rice varieties **denotified varieties

Varietal area share in spring (*Chaite*) Season

The coverage of MVs for spring or Chaite rice is the highest in the Tarai (76.0%) followed by the hills (18.18%) and the mountains (5.82%). Thirteen specific named varieties were reported to be cultivated, among them, the Hardinath-1 occupies around 56.05% of the total area followed by Chaite-2 (14.55%) and Chaite-4 (6.33%). Few non-registered varieties are also reported.

Table 16. Area share of major varieties during spring (*Chaite*) season

SN	Variety	Area, ha	Area share (%)
1	Hardinath-1	62957	56.05
2	Chaite-2	16345	14.55
3	Chaite-4	7110	6.33
4	CH-45	6153	5.48
5	Kanchan	2786	2.48
6	Radha-11	1084	0.97
7	Kanchhi mansuli ##	1058	0.94
8	Chaite-6	790	0.70
9	PR-101 ##	731	0.65
10	Khumal-11	382	0.34
11	Chaite-1	288	0.26
12	Sabitri	217	0.19
13	Hardinath-2	208	0.19
14	Others/local	12204	10.87
Total:		**112313**	**100.00**

##Indian/non-registered variety

Area share byhybrids

The share of hybrid varieties in the total cultivated area of rice is 7.4% in Nepal. Western Tarai has the highest share of area (55.04%) followed by mid-western Tarai (18.10%) and the central hills (8.09%). As a whole, Tarai accounts for 83% followed by mid hill (16.79%) and mountain (0.22%). The hybrid varieties are cultivated in 39 districts of which 3 are mountain districts, 19 mid hill districts and 17 Tarai districts

Area share by fine and aromatic rice

A total of 48 fine and aromatic rice varieties are found to be grown in Nepal. They include both improved as well as local land races. The area under fine and aromatic rice varieties is 258855 ha, which constitutes 16.90% of total area under rice cultivation in Nepal. Of the 258855 ha, under fine and aromatic rice, the mountains, hills and Tarai share 5.92%, 44.20% and 49.88% respectively. Similarly, area under fine and aromatic rice in eastern, central, western, mid-western and farwestern development regions are 40.39%, 18.35%, 28.37%, 6.38% and 6.51%, respectively. The calculation is based on the quality attributes of the improved and local varieties as identified and reported by the respective DADOs and in discussions with the concerned technicians.

Table17. Area and percentage share of fine and aromatic rice (%)

Development region	Ecological Regions						Region total	
	Mountain		Mid hill		Tarai			
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
EDR	4141	1.60	24867	9.61	75533	29.18	104541	40.39
CDR	7913	3.06	18644	7.20	20946	8.09	47503.3	18.35
WDR	0	0.00	51215	19.79	22225	8.59	73440	28.37
MWDR	755	0.29	9395	3.63	6360	2.46	16510.5	6.38
FWDR	2504	0.97	10298	3.98	4058	1.57	16859.7	6.51
Total	**15313**	**5.92**	**114420**	**44.20**	**129122**	**49.88**	**258855**	**100.00**

Out of total area under rice, 16.90% is occupied by fine and aromatic rice in Nepal.

Area share by local varieties or landraces

Landraces have evolved under continuous natural and selection practices in farmers' fields, and are the progenitors of modern crop varieties used by farmers around the world (Harlan 1972). They are an important source of novel alleles for crop improvement. In poorer countries and in areas that are environmentally heterogeneous and isolated from markets, many farmers still rely directly on the genetic diversity they sow for food and fodder as well as the next season's seed. More heterogeneous than the modern semi-dwarf varieties, landraces are often adapted to specific local human needs and environmental niches (Simmonds 1979). The concern is that the replacement of landraces by MVs implies a loss of (potentially valuable) genetic variation. For this reason, their conservation in genebanks (ex-situ) has been practiced. At the same time, interest in in-situ conservation through on-farm management in farmers' fields has also gained considerable attention. Landraces names are based on phenotype. As a result, the nomenclature is imperfect, different names can be given to genetically closely related populations, while the same name can be given to genetically very distinct ones. However, farmers have recognized, controlled and acted upon these descriptors for many years. There has been a decline in the number of landraces under cultivation in Nepal. Changes in the production environment, the farmers' preference for consumption and market integration have acted to increase the area sown for MVs at the expense of both area and diversity of landraces. However, the cultivation of the landraces is shaped in part by the production environment, and by the cultural and religious significance (Joshi and Bauer 2006).

The average area share of landraces is slightly over 10% in Nepal. By season, this accounts 10.3% during *Barkhe* and 8.8% during *Chaite* season. The popular varieties grown are *Belguthi, Ate, Dudhe Marshi, Mansara, Sepilo*, and *Kalkuda* in the eastern mountains and *Belguthi, Ate* and *Chirakhe* in the eastern hills. On the other hand, *Basmati, Chanamchur, Sathiya, Chirakhe, Kariyakamod, Jaswa, Belguti* and *Kalo Nuniya* are the landraces cultivated in the eastern Tarai. The top five varieties in terms of area coverage *are Pokhreli Masino, Anadi, Marshi, Anpjhutte*, and *Ghiya* (*Kalo/Rato/Seto*), in the central mountains. *Pokhreli Masino, Basmati, Manbhog, Mansara*, and *Bhotagi* are the dominant landraces in the central hills while *Basmati, Kariyakamod* and *Kalanamak* are cultivated in the central Tarai. In case of western hills, the landraces diversity is quite high (in terms of numbers). The landraces cultivated are *Jethobudho, Jarneli, Jhinuwa, Ekle, Gudura, Panhlele Dhan, Anadi, Gauriya, Gurdi, Anpjhutte, Mansara*etc while *Kalanamak, Makarkaddu, Latera, Pidani*, and *Saratha* are cultivated in the western Tarai. The varieties popular in the mid-western mountains are: *Palte dhan, Bhattalo, Basmati, Jumli Marshi/Kali Marshi, Junge, Chinamari* and *Ghaiya.* The landraces cultivated in the mid-western hills are: *Jugari, Dada Mansuli, Basmati, Marshi, Jodan (Kalo/Seto/Pahelo), Pokhreli Masino, ParanPyuli* and *PyuthaniSeto*etc while *Shyamjira, Gauriya, Sindur, Anadi, Kalanamak, Kanakjira, Tilki, Makarkaddu* and *Sugabodh* are popular in the mid-western Tarai. In term of landraces diversity, it is quite high in the far-western hills (22varieties). The popular cultivated landraces in the far-western hills are: *Thapachini, Jorayal Basmati Shyamjira, Marshi, Jaulo, Ratodhan* and *Dudhe*. On the other hand, *Anjana, Tilki, Jhinwa, Anadi* and *Raimanuwa* are the major landraces cultivated in the far-western Tarai. However, other several landraces being grown by farmers in remote and in small portions of land are not covered by this study. The eastern mountains and *Belguthi, Ate* and *Chirakhe* in the eastern hills. On the other hand, *Basmati, Chanamchur, Sathiya, Chirakhe, Kariyakamod, Jaswa, Belguti* and *Kalo Nuniya* are the landraces cultivated in the eastern Tarai. The top five varieties in terms of area coverage are *Pokhreli Masino, Anadi, Marshi, Anpjhutte*, and *Ghiya (Kalo/Rato/Seto),* in the central mountains. *Pokhreli Masino, Basmati, Manbhog, Mansara,* and *Bhotagi* are the dominant landraces in the central hills while *Basmati, Kariyakamod* and *Kalanamak* are cultivated in the central Tarai. In case of western hills, the landraces diversity is quite high (in terms of numbers). The landraces cultivated are *Jethobudho, Jarneli, Jhinuwa, Ekle, Gudura, Panhlele Dhan, Anadi, Gauriya, Gurdi, Anpjhutte, Mansara,*etc while *Kalanamak, Makarkaddu, Latera, Pidani,* and *Saratha* are cultivated in the western Tarai.

Dominant improved rice varieties

Region wise distribution of varieties has shown that Khumal-4 is the most dominant variety in the Mountain (25.04%) and Mid Hill (19.78%), and Sona Masuli (23.03%) in the Tarai regions of Eastern Development Region. Likewise, Makwanpur-1 ranks first in the Mountain (29.18%) and Mid Hill (24.81%) of the Central Development Region. In the Tarai region Sona Mansuli (48.82%) is the most popular variety. In the Hills of western development region, Sabitri is the first (20.07%) and in the Tarai Radha-4 is dominant (26.55%) variety. Two mountain districts namely Manag and Mustang of the WDR do not produce rice. In case of Midwestern Development Region, Chandannath-3 (45.66%), Bindeswari (19.48%) and Radha-4 (39.07%) are the most accepted varieties in the Mountain, Hill and Tarai, respectively. The variety, Radha-4 is widely grown in Mountain (32.34%) and hills (40.78%) of the Far-western Development Region. However, in the Tarai regions of the FWDR Sarju-52 is grown in the largest areas (46.79%). The overall scenario of dominant rice varieties in EDR, CDR, WDR, MWDR and FWDR are found to be: Sona Mansuli (19.03%), Sona Mansuli (38.04%), Radha-4 (16.45%), Radha- 4 (31.42%) and Sarju-52 (34.79%), respectively.

Table 18. Dominant improved rice variety and its percentage in different agro-ecological zone and development region 2012

SN	Region	Agro-ecological zones						Region (Over all)	
		Mountain		Mid Hill		Tarai			
		Varietiy	Area (ha) (%)	Variety	Area (ha) (%)	Variety	Area (ha) (%)	Variety	Area (ha) (%)
1	EDR	Khumal-4	2753 (25.04)	Khumal-4	9329 (19.78)	Sona mansuli ##	63868 (23.03)	Sona mansuli ##	63868 (19.03)
2	CDR	Makawanpur -1	2524 (29.18)	Makawanpur -1	15456 (24.81)	Sona mansuli ##	122241 (48.82)	Sona mansuli ##	122241 (38.04)
3	WDR			Sabitri	17735 (20.07)	Radha-4	31737 (26.55)	Radha -4	34204 (16.45)
4	MWDR	Chandan nath-3	2216 (45.66)	Bindeswari	7624 (19.48)	Radha-4	38190 (39.07)	Radha-4	44541 (31.42)
5	FWDR	Radha-4	3404 (32.34)	Radha-4	10955 (40.78)	Sarju-52##	50722 (46.79)	Sarju-52##	50722 (34.79)

non registered / Indian varieties

Ranking of dominant rice varieties at the national level

Among 15 most popular rice varieties, their adoption differs from east to west of Nepal. Since deployment and adoption of hybrids are new in Nepal, all top varieties are of open pollinated type. Among these varieties, 10 are released through national system and remaining 5 (marked by double asterisks) entered into the country from the nearby cities of India. The modern 15 rice varieties occupied about 67.47% of the total rice cultivated area. The coverage from 5 non registered varieties (SonaMansuli, Sarju-52, KanchhiMansuli, Ranjit and Sawa mansuli) are found to be 23.78%.

Table19. List of the fifteen widely adopted (improve, hybrid and local) rice varieties in Nepal

SN	Variety	Area (ha)	% share
1	Sona mansuli**	192340	12.56
2	Hardinath-1	129313	8.44
3	Radha-4	121294	7.92
4	Sabitri	106096	6.93
5	Sarju-52**	69598	4.54
6	Mansuli	59176	3.86
7	Khumal-4	55619	3.63
8	Radha-12	47928	3.13
9	Kanchhi mansuli**	43481	2.84
10	Makawanpur-1	40058	2.62
1	Swarna sab-1	37853	2.47
12	Ram dhan	37358	2.44
13	Gorakhnath-509	34442	2.25
14	Ranjit**	31081	2.03
15	Sawa mansuli**	27656	1.81
Total		**103329**	**67.47**
Others		**498202**	**32.53**
Grand Total		**1531494**	**100.00**

Trans-domain varietal movement

Crop varieties are released and recommended for the particular geographical domain by the National Seed Board (NSB). However, seeds of different varieties are also grown in the non- recommended areas through informal channel and are being scaled up from farmers to farmers extensions. Due to huge demand of seeds for non-recommended sites, suppliers supply seeds informally to those areas for cultivation. In most of the cases, the performance of the variety is found to be better. There are many examples of varieties grown in non-recommended areas. Such as Makwanpur-1 is recommended for the Tarai region but this is popularly grown in hills and mountains of central development region. Likewise, Sabitri variety is recommended for Tarai and Inner Tarai but this is also widely grown in western hills. The variety Radha-4 is recommended for mid-western and far-western Tarai but is dominantly grown in western Tarai and hills of far-western region.

Costs and returns of rice seed production

The unit price of seed is higher than normal grain as it requires more inputs and greater care in its production. It is estimated that rice seed production required about 30% additional costs in comparison with the grain production. The average rice grain price was NRs 20 per kg while price of certified seed was NRs 42 per kg in 2011/12. Among the cost factors, cost incurred with the labor accounts for more than 73% of total cost in rice seed production. A study conducted by PACT in 2012 showed that there is a high profit margin in the rice seed in comparison with the grain production.

Table 20. Share of different items on total cost of rice seed production

Cost item	Cost, Rs/kg	% share
Seed	0.56	5.76
Labor	7.11	73.15
Fertilizer	1.32	13.58
Pesticide	0.06	0.62
Others	0.67	6.89
Total	**9.71**	**100**

Source: PACT 2012.

Pricing of breeder and foundation seed produced by NARC is done by a committee of officials from NARC, MoAD and private sector entrepreneurs. Cost of production of the specific crop and variety, involvement of technical manpower and physical facilities are considered while determining the prices. Prices of foundation seed are higher than certified seed and prices of breeder seed are higher than prices of foundation seed. The private sector seed producers have their own pricing system, which is normally guided by ongoing market prices of food grains. The average per kg price of Breeder seed was NRs 70 and Foundation seed was NRs 42 in 2011. Cooperatives and seed companies normally provide 20% premiums for certified/improved seed over on-going market prices of food grain of the same crop and variety while buying from their members and contract farmers with some variations specific to location and prior agreement.

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Chapter V

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5. Photo Gallery Related to Rice Science and Culture in Nepal

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Rice landraces and related species in Nepal

Rato Marshi

Kalo Anadi

Baaspate Dhan

Gamadi rice

Seto marshi

Khumal - 11

Source: BK Joshi, NARC

Gurdi Dhan

Manunge Sali

Jarneli Dhan

Masino Dhan

Pakhe Sali Dhan

Anadi

Source: BK Joshi, NARC


Jumli Marshi


Amaghauj


Kalo Dhan


Junge Dhan


Jungali Dhan


Rice storage in CSB

Source: BK Joshi, NARC

Basmati Dhan

Rato Anadi

Sali dhan

Anadi

Diversity in rice panicles

Leersia sp.

Source: BK Joshi, NARC

Lekali Dhan - 3

Weedy rice

Chandannath-1

Deep water rice

Pakhe Dhan

Jharuwa Dhan

Source: BK Joshi, NARC

Growth stages of rice

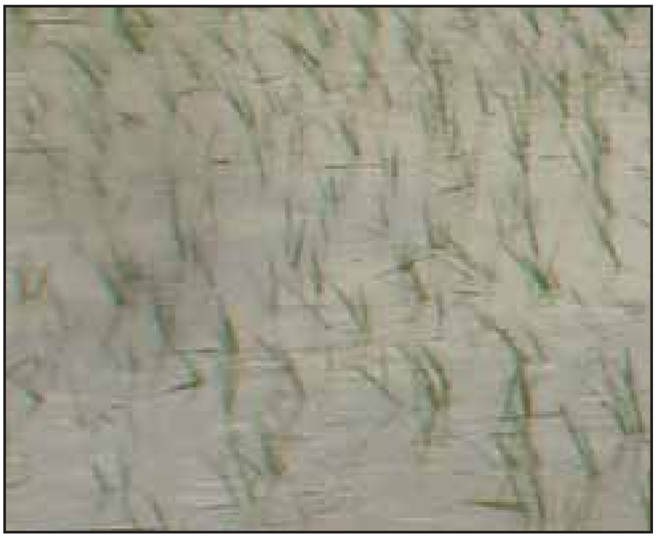
Source : www.google.com.np

Source : www.google.com.np

Source : MN Timilsina, DoA

Source : R Upreti, DoA

Seedling stage



Tranplanted rice seedlings (Source: AM Tripathi, DoA)

Rice plant after few DAT (Source: www.google.com.np)

Transplanting stage

Early tillering

Late tillering stage (Source: R Upreti, DoA)

Tillering Stage

Source : R Upreti, DoA

Source : www.google.com.np

Panicle Initiation Stage

Source: G Acharya, DoA

Source: KN Chapagain, DoA

Flowering and milking stage


Source: KN Chapagain, DoA


Source : Bal K Joshi, NARC


Source : D Pokharel, DoA


Source : MN Paudel, NARC


Source : Bal K Joshi, NARC

Maturity stage

Rice production and marketing activities in Nepal

Source : MN Timilsina, DoA

Source : www.google.com.np

Source : www.google.com.np

Source : Devraj Bhusal, DoA

Source : MN Timilsina, DoA

Nursery establishment

Green manure (Sesbania rostrata) for rice fields (Source: DR Bhandari, DoA)

Preparation of rice field (Source: MN Timilsina, DoA)

Preparation of rice field in Kathmandu valley (Source: DR Bhandari, DoA)

Land preparation by plough and tractor (Source: www.google.com.np)

Power tiller use in land preparation (Source: FB of Krishna Sharma)

Field levelling (Source: www.google.com.np)

Land preparation

Seedling uprooting for transplanting
(Source: www.farmingandfoodnepal.blogspot.com)

Rice transplanting in Kathmandu Valley (Source: DR Bhandari, DoA)

Rice transplanting in Tarai (Source: AM Tripahti, DoA)

Seedlings assembled in transplanter (Source: MN Timilsina, DoA)

Without fuel operating transplanter
(Source: FB of Krishna Sharma)

Machine transplanting (Source: www.google.com.np)

Transplanting

Weeding using weeder (Source: MN Timilsina, DoA)

Weeding by weeder in SRI field
(Source: FB of SRI Network of Nepal

Weeding in rice field (Source: FB of Her Farm Nepal)

Manual weeding (Source: FB of Global Press Journal)

Weeding

Source: Parasuram Rawat, DoA

Source: Benu Prasai, DoA

Crop protection

Serrated sickles for harvesting
(Source: www.farmingandfoodnepal.blogspot.com)

Harvesting in Tarai (Source: AM Tripathi, DoA)

Harvesting in Hills (Source: KN Chapagain, DoA)

Harvestor for harvesting rice (Source: FB of Krishna Sharma)

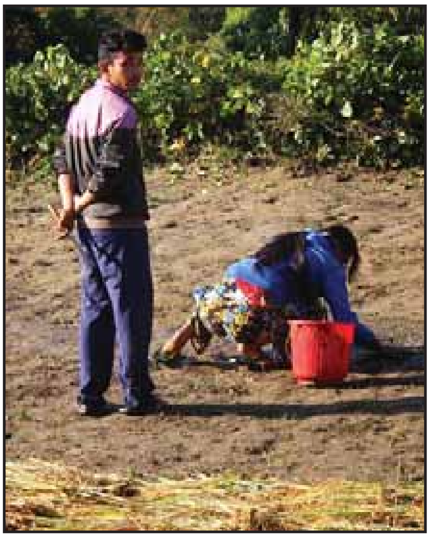
Harvesting by reaper (Source: G Acharaya, DoA)

Harvesting by combine (Source: BR Sapkota, DoA)

Harvesting

Rice left on field after harvestin
(Source: www.farmingandfoodnepal.blogspot.com)

Rice sheaves are hand bound (Source: KN Chapagain, DoA)



Carrying of harvested rice and making floor for keeping rice sheaves
(Source: www.farmingandfoodnepal.blogspot.com)

Rice being carried to threshing floor
(Source: www.developmatalidealism.com)

Rice sheaves carried to a central place where stack is built (Source: www.farmingandfoodnepal.blogspot.com)

Collection of rice sheaves for threshing

Mannual threshing
(Source: www.farmingandfoodnepal.blogspot.com)

Threshing of paddy grown in Small areas
(Source: CN Adhikari, DoA)

Threshing using bullock (Source: Bal K Joshi, NARC)

Threshing against the wooden plank (Source: nicksimages)

Use of thresher for threshing (Source: BR Sapkota, DoA)

Threshing using combine (Source : MN Timilsina, DoA)

Threshing

Source: www.google.com.np

Source: AM Tripathi, DoA

Source: www.farmingandfoodnepal.blogspot.com

Source: AM Tripathi, DoA

Source: JB Mahatra, DoA

Straw managment practices

Manual winnowing and separation of grain from other materials (Source: www.farmingandfoodnepal.blogspot.com)

Winnowing by fan (Source: AM Tripathi, DoA)

Drying (Source: DR Bhandari, DoA)

Drying of rice (Source: DR Bhandari, DoA)

Drying of rice (Source: www.alamy.com)

Winnowing and Drying

Source: JB Mahatra, DoA

Source: AM Tripathi, DoA

Source: P Acharya, DoA

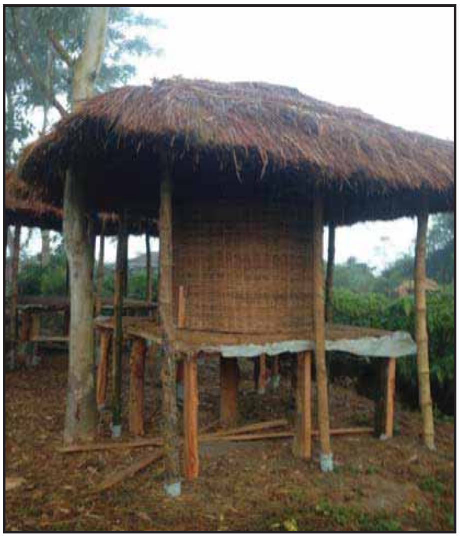
Packaging of rice


Preparation of storage structure for rice
(Source: www.farmingandfoodnepal.blogspot.com)


Bhakari for storage (Source: Dr. HB KC, DoA)



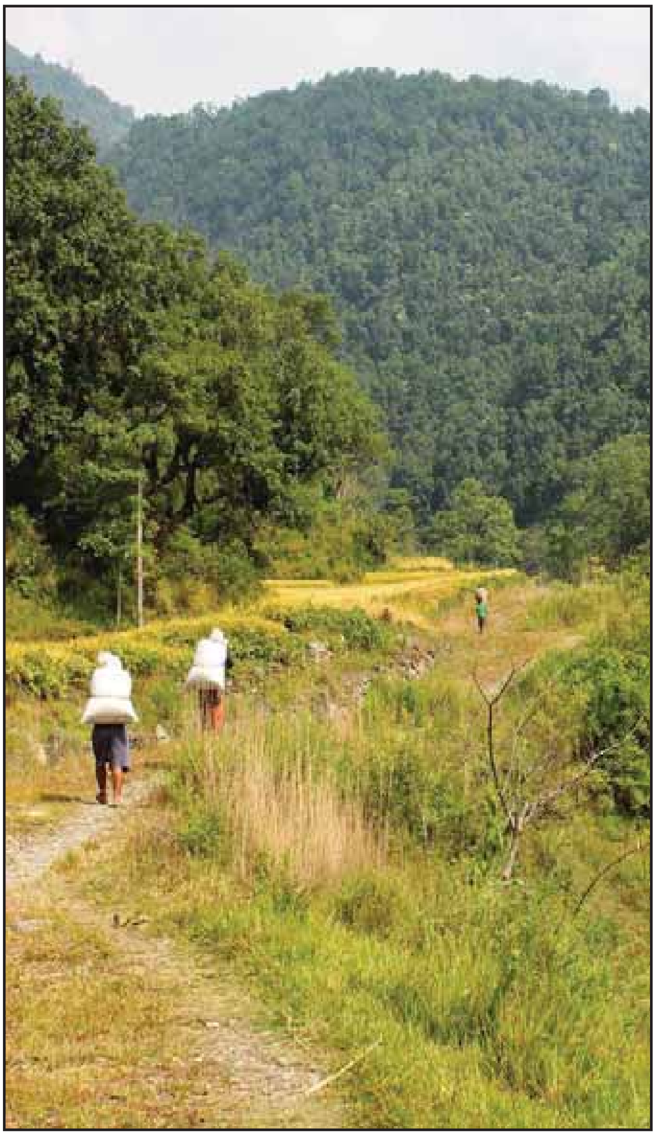
Storage Structures (Source: HB KC, DoA)


Storage Structure
(Source: DR Bhandari, DoA)


Source: AM Tripathi, DoA


Wooden storage structure for rice (Source: Dr. HB KC, DoA)

Storage



Rice carrying to home (Source: www.farmingandfoodnepal.blogspot.com)

Rice transporation by different means (Source: JB Mahatra, DoA)

Transportation of rice to destination

Source : B Gyawali, DoA

Weighing and sale of rice in Tarai

Government publications for promotion of rice in Nepal

gk|fn ;/sf/af6 ljleGg ;dodf wfg;F ;DalGwt /xL k|sfzg ePsf l;Ssf tyf xhfs l6s6

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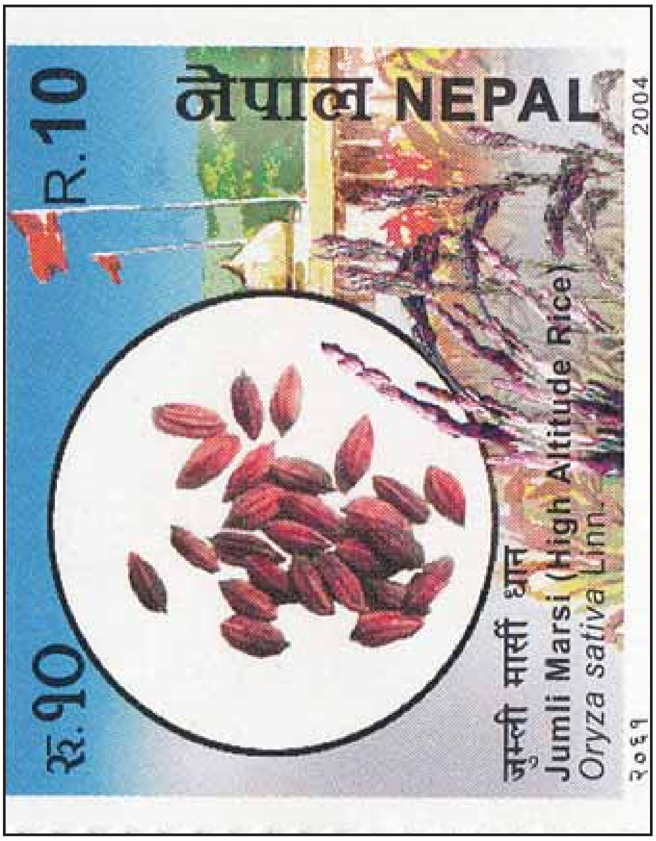

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Rice related cultural and religious activities

National Rice Day celebration (Source: P Devkota, DoA)

National Rice Day celebration (Source: BD Regmi, DoA)

National Rice Day celebration (Source: BR Sapkota, DoA)

National Rice Day celebration (Source: M Kadaria, DoA)

National Rice Day celebration (Source: D Khanal, IAAS)

Dahi Chiura to be consumed in National Rice Day (Source: www.google.com.np)

Celebration of National Rice Day


Latte eaten in festivals (Source: Bal K Joshi, NARC)


Naahi - Naya chamal (Source: Bal K Joshi, NARC)


Preparation for storage (Source: B Regmi, DoA)


Model of rice grain in temple (Source: Bal K Joshi, NARC)


Cow stamped with rice flour paste duirng Tihar (chamal ko dhaap) (Source: BK Joshi, NARC)

Source: B Gyawali, DoA

Collection of rice in Dhana Dhanyanchal Mahayagya (Manigram, Rupandehi)

Miscellaneous

Dhiki

Janto (Source: DR Bhandari, DoA)

Kalimati fossilized with fish (used as manure for rice cultivation) during the period when Kathmandu Valley was a lake (Source: Satya Mohan Joshi)

Kuri – farmers select panicles from rice field and store like this called kuri, bundle of selected rice panicle inside. (Source: BK Joshi, NARC)

Rice plantlet from anther culture (Source: BK Joshi, NARC)

Sadar Dhan Godaam, Kathmandu

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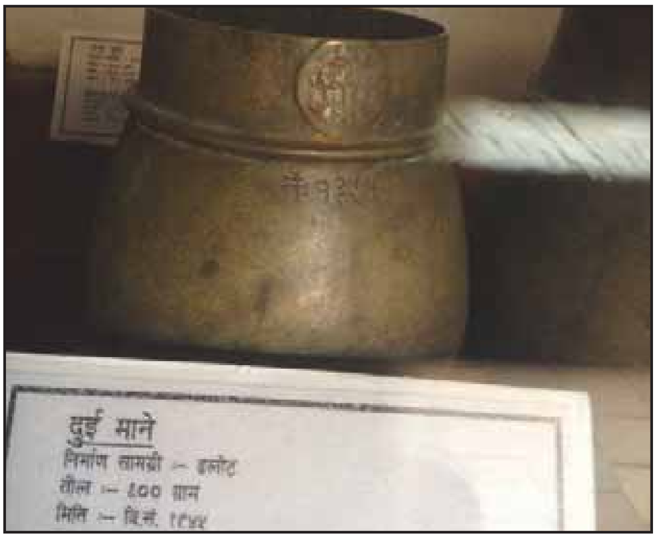

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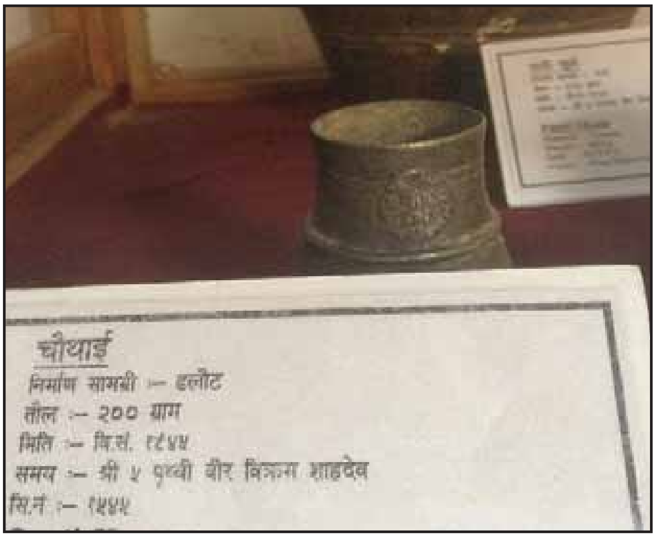

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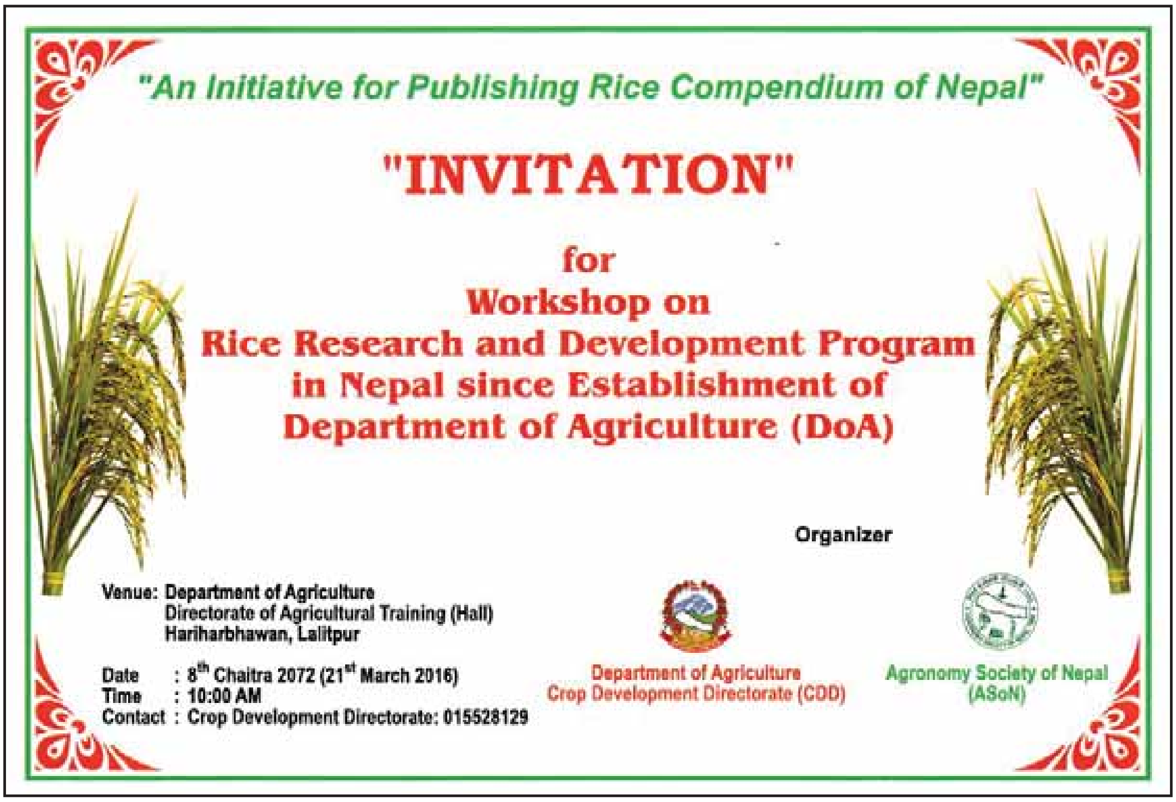
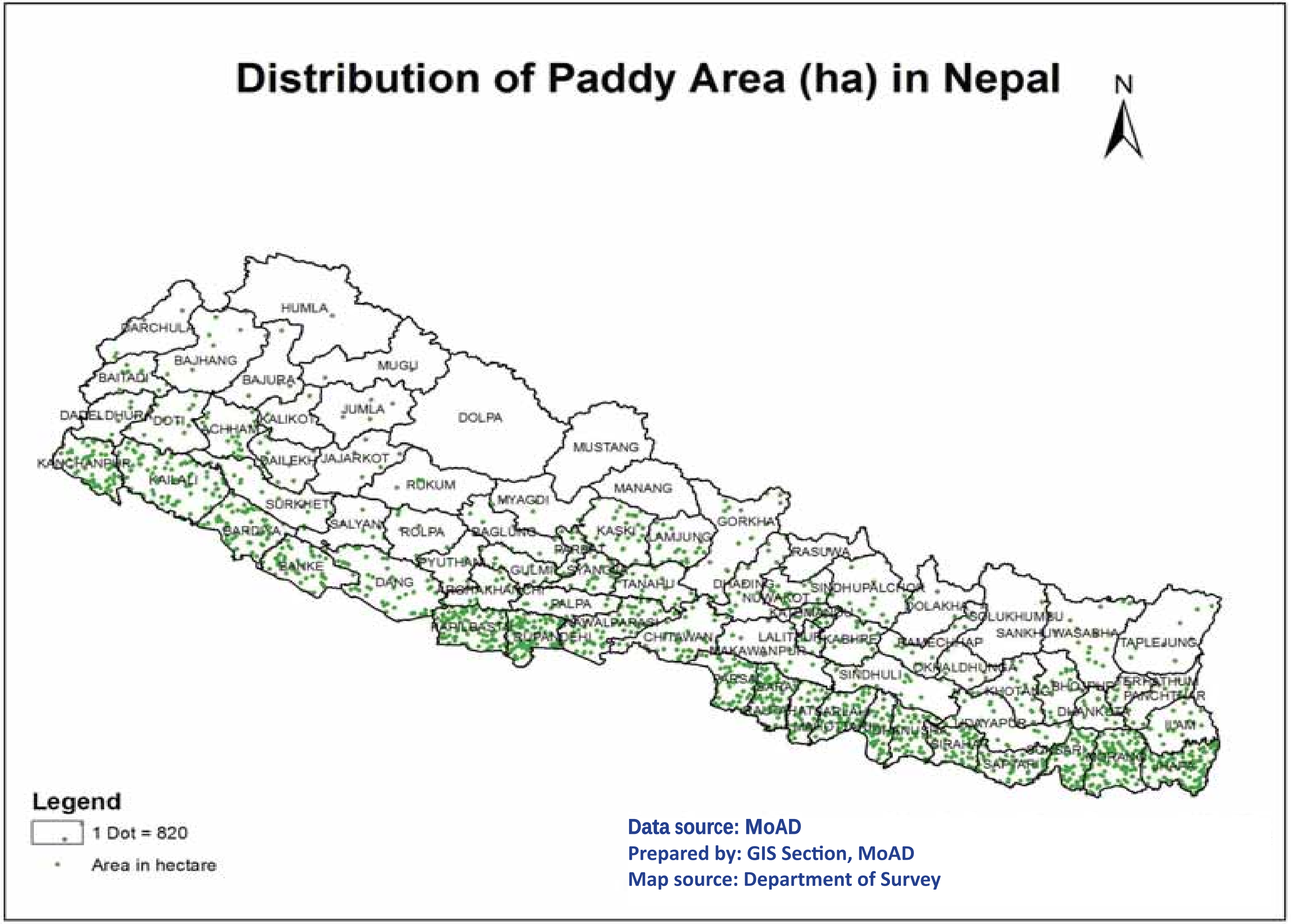


Initiatives for publication of Rice Science and Technology in Nepal


Distribution of Paddy Area (ha) in Nepal
N
HUMLA
DARCHULA
BAJHANG
MUGU
BAJURA
BAITADI
JUMLA
DOLPA
DADELDHURA
DOTI
ACHHAM
KALIKOT
MUSTANG
KANCHANPUR
KAILALI
DAILEKH
JAJARKOT
ROKUM
SURKHET
MYAGDI
MANANG
SALYAN
ROLPA
BAGLUNG
KASKI
LAMJUNG
GORKHA
BARDIYA
PARBAT
RASUWA
BANKE
PYUTHAN
GULMI
SYANGJA
DANG
TANAHU
DHADING
SINDHUPALCHOK
NUWAKOT
PALPA
DOLAKHA
SOLUKHUMBU
SANKHUWASABHA
TAPLEJUNG
CHITWAN
MAKAWANPUR
SINDHULI
OKHALDHUNGA
KHOTANG
PANCHTHAR
DHANKUTA
ILAM
UDAYAPUR
SIRAHA
SAPTARI
Legend
1 Dot = 820
Area in hectare
Data source: MoAD
Prepared by: GIS Section, MoAD
Map source: Department of Survey

Keywords Index

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Authors Index

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Experience : During his 35 years of career in agriculture R&D, served for NARC, DoA in several capacities of chief of different DADOs, SQCC and CDD, and at present Director General of the DoA under MoAD. As a dynamic leader, his contribution in agriculture helped declare Jumla the first "Organic District 2007" in Nepal, founder of the DISSPRO 1998 and National Seed Vision (2013- 2025) approved by GoN and now under implementation. The concept of publishing this document in this form is envisioned by him. He has served high office of the Managing Director/Chairman of National Seed Company Limited, Nepal. He was awarded the Environment Conservation Prize 2010 and decorated with *"Suprabal Jana sewa Shree Padak"* from the Honorable President of Nepal in 2013. He is author of three technical books on agronomy and organic agriculture as well as has published several technical articles in agriculture R&D in national dailies and weeklies in Nepal.

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