Government of Nepal
Ministry of Agricultural Development
Food Security, Agri Business Promotion and Environment Division

Environment and Climate Change Section

Singh Durbar, Kathmandu, Nepal

The Journal of AGRICULTURE AND ENVIRONMENT 2017

"I AM WITH NATURE"

"प्रकतिसँग हाम्रो सम्बन्ध रहिरहोस् अनन्त"

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(This issue is published on the occasion of World Environment /Population Day, 2017)

Vol: 18 ***June 2017***

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EDITORIAL

The world Environment Day (June 5), an auspicious occasion for all categories of people in only the green planet, the Earth, is celebrated to create awareness and to accomplish action for environment protection. The accelerated population growth in the planet has increased the needs for food, shelter, and security causing direct negative impact on the environment. Men itself and its activities related to injudicious use and exploitation of natural resources for fuel, fodder, shelter, power generation, and other development activities; are the major causes of such negative consequences.

"I am with Nature" is the theme declared by the United Nations Environment Program (UNEP) for the World Environment Day, 2017. The theme really draws the attention, attachment and affiliation with the nature because there is interrelationship between man and other living and non-living things in the nature. Due to the interference of human in the nature, some wild species of plants and animals were found endangered and some have disappeared. When some species disappeared then it may be very difficult to revive again. So, we should preserve our environment and their importance for conserving and maintaining ecosystem and balancing nature and sustainable livelihoods of the people. We should handover without degredation to our future generation. The motto should be incorporated in our consciousness for the sake of managing devastating consequences of environmental degradation.

The day is being celebrated through organization of several events and relevant environmental campaigns. The Food Security, Agri-Business Promotion and Environment Division (FSABPED) in the Ministry of Agricultural Development (MoAD) is publishing the new issue of Journal of the Agriculture and Environment (Vol. 18, 2017). The volume essentially includes technical and review articles on agriculture environment and population interrelationships. Climate change, organic agriculture and agriculture marketing linkages and other cross cutting issues have been the major coverage.

The editorial-in-chief acknowledges the invaluable contribution from authors, editors, reviewers, and the editorial management team. I hope that readers will find some useful information on environment friendly agriculture. The editorial board will highly be pleased to receive valuable suggestions and feedbacks to improve our upcoming issues. Thanks!

Editor-in-Chief

GUIDELINES TO AUTHORS: MANUSCRIPT PREPARATION AND SUBMISSION

Food Security and Environment Division (FSED) in the Ministry of Agricultural Development announces interested author(s) to submit relevant manuscripts for publication in forthcoming issue (Vol.18) of the ***Journal of Agriculture and Environment***. The author(s) should base the manuscript on issues of climate change/food security/agricultural biodiversity/gender and social inclusion ***(preferably in Nepalese or similar context)***.The author(s) should firmly follow the journal agreed guidelines and submit it electronically at fsed.moad@gmail.com or parashu.adhikari@gmail.com before end of Falgun 2073 (March 15, 2017).

Guidelines for the author(s):

The Journal of *Agriculture and Environment* is devoted to the cause of advancing understanding on the Environmental aspects of Agriculture through literature review, theoretical analysis, research and practical experiences. Besides research and review papers, the journal may arrange spaces for case study, methodological approach, book review, report on seminar and meeting, short communication and letter to the editor. Guidelines to authors on preparation and submission of manuscript follow.

1. The manuscript must be an original work written in English and not published elsewhere.
2. The title should be short and specific, but it should reflect the contents in the manuscript.
3. The abstract should be in italics 9-point font size, not exceeding 150 words, should concisely state major objective, methodology, findings and conclusion. It should not include diagram, footnote, equation or any parenthetical reference.
4. Key-words in alphabetical order should not exceed ten standard words.
5. Main text of the technical manuscripts should include introduction, objective, theoretical framework, methodology, results and discussions, conclusions and references.
6. The manuscript should not exceed 4500 words in total. It should be in MS-word with pages set on A4 size, the top and left margins at 3cm and the right and bottom margins at 2.5cm. The text format should be on Trebuchet MS font of, unless otherwise specified, 10-point size.
    a. The title of the manuscript set as HEADING 1 (paragraph style) should be all capitalized in bold 11-point font size.
    b. Name of the author(s) should follow the title in new paragraph in normal 9-point font size. Other details of every author's identification such as working organization, contact addresses including telephone, and e-mail should go in the foot notes. The foot notes should be in 8-point font size and marked in Arabic successively.
    c. The first level headings should be all capitalized and bold. The second level headings should be all capitalized and normal. The third level headings should be in sentence case, italicized and normal.

d. In tables, borders should be minimized, and text and numbers should be in 9-point font size.

e. Bibliographic entries in the reference should be in 9-point font size.

7. Number of footnotes should be minimized, and it should not come for citation.

8. Many/big tables and figures in the text should be avoided. Supplementary figures and tables may be placed in the annexure.

9. References should be given in alphabetical order by author's name, and the styles should differentiate the references such as books, journals, newspapers and other unpublished materials. The material not cited in the main text must not come under reference. Private communication, radio listening and TV watch should not appear in the citation as well as in the reference. Some examples of bibliographic entries follow.

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For a magazine article: Pandey, R.R. and Pradhanang, P.M., 1995. Potato wilt and its control measures (Nepali). In: Prabidhi Sangalo, vol. 9(3): 99-102. Lumle Agriculture Research Center, Pokhara. Nepal.

For a year book/report/periodical: UNESCO, 1986. Statistical yearbook.Paris : UNESCO Press.

National Pay Commission, 1992.A report on the pay structure for civil servants. Kathmandu: Aradhana Press.

For a newspaper : Sunuwar, D.K., 2008. Ecosan toilets bring multiple benefits. The Kathmandu Post, Vol. XVI (167), Aug 3, 2008:p.3(col.3).

For thesis/dissertation: Pokhrel, D. M., 2005. Citrus marketing system in the mountains of Nepal: a study based on market structure, conduct and performance analyses. PhD dissertation submitted to School of Environment, Resources and Development, Asian Institute of Technology, Thailand.

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11. The Editor-in-Chief and the Editorial Board are not responsible for any damage or loss of submitted manuscript and return of unaccepted manuscripts to the authors whatsoever.

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13. Previous issues of the journal are available at http://www.moad.gov.np.

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TABLEL CONTENT

ECONOMICS OF ORTHODOX TEA PRODUCTION: A CASE OF ILAM, NEPAL

A. Tiwari[1], K.B. Adhikari[2], S.M.Dhungana[3]

ABSTRACT

Research on economic analysis of conventional orthodox tea in Ilam district of Nepal was conducted by selecting Fikkal and Kanyam area of Suryodaya Municipality purposely. The average area under tea cultivation was 0.67 hectares per household in Fikkal area and 0.57 hectares per household in Kanyam area. The average productivity of green leaf in Fikkal area was found slightly higher than Kanyam area. The average cost of green leaf production per ropani in Fikkal area was found higher than Kanyam area. It was more in small category compared to large category in both study area. This signified the principle of economies of scale. Gross margin per hectares was positively correlated with increased farm size in both the study areas. Overall benefit-cost ratio was greater than one in both the study areas. The study revealed the scarcity of quality inputs and inadequate technical knowhow, quick perishability of green leaf, price instability, and unavailability of auction market, weak horizontal coordination and vertical coordination at the different stages of tea value chains were the major problems in the study area.

Keywords: Benefit-Cost ratio, Conventional, Economies of Scale, Gross margin.

INTRODUCTION

Agriculture sector in Nepal contributes about 30.13 percent share in the national Gross Domestic Product (GDP), whereas tea sector contributes about 0.0105 percent in the National Gross Domestic Product (NGDP) and 0.0347 percent in the Agricultural Gross Domestic Product (AGDP) (CBS, 2014). Agriculture has to be a key sector that has to be developed and commercialized to raise the living standard of rural people by providing employment opportunities (Adhikari, 2000).

Among the cash crops, Orthodox tea is a major cash-generating crop in the eastern hills (Jha, 2004). Orthodox tea is mainly destined for overseas market. About 96 percent is exported to America, Germany, Japan and the EU and remaining 4 percent is consumed in the country by the foreign tourists and wealthy families inside Nepal (Poudel, 2010).The new agriculture plan of Government of Nepal, Agriculture Development Strategy (ADS) has also given the due importance in commercialized farming and processing activities of high value cash crops like tea (MoAD, 2015).

OBJECTIVES

- To determine the economics of orthodox tea production.
- To determine the profitability of orthodox tea production.

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METHODOLOGY

A sample size of 70 tea growers, 35 each from Fikkal and Kanyam area were selected using simple random sampling method. This study was also conducted to analyse the different aspects of economics of production of green leaf based on the scale of production. This is why categorization of tea growers was done. This categorization was done based on the suggestion from NTCDB staff (Pokhrel, 2006).

Tea growing farmers, tea processing factories and local collectors were the major sources of primary data. Besides this, information was obtained through observation, focus group discussion (FGD) and key informant surveys. The primary and secondary information collected from the field surveys and different other methods were coded, tabulated and analysed by using Statistical Package for Social Science (SPSS) and Microsoft Excel.

The gross margin provides simple and quick method of analysing a farm business. For any enterprises gross margin is the difference between the gross return and the variable cost incurred. The variable cost must be specific to single enterprise and vary approximately in proportion to the size of the enterprise (Shankyan, 1983).

The gross margin of the tea growers in this study was calculated as:

Gross margin= Gross return- total variable cost

Gross return= Green leaf sold (kg) × per unit price of green leaf (NPR/kg).

Total variable cost= Summation of all variable cost items

Benefit-cost analysis was carried out by using following formula;

B/C ratio= Gross return/Total variable cost

RESULT AND DISCUSSION

The category wise distribution of area under tea cultivation and production in Fikkal and Kanyam area is presented in Table 1. The average land under tea cultivation per household in small category of Fikkal area (0.30 ha) was found lower than in Kanyam area (0.31 ha). However, in large category, opposite case was found. The average production of green leaf per household was found higher in Kanyam area (5390.86 kg) than Fikkal area (4410.00 kg).

Table 1: Average area/household, production and productivity by farm categories and study area

Farm Category	Fikkal			Kanyam		
	Area (ha)	Productn (kg)	Productivity (kg/ha)	Area (ha)	Production (kg)	Productivity (kg/ha)
Small	0.30	2502.17	8340.57	0.31	2221.25	7165.32
Large	1.21	8725	7210.74	1.20	10244.12	8536.77
Area average	0.76	4410.00	7775.66	0.76	6232.69	7851.05

Source: Field Survey, 2015

The average productivity was found increasing as the farm size increased from small to large in Kanyam area and in Fikkal area, it decreased slightly as the farm size increased from small to large.

Average productivity in Kanyam area was 7851.05 kg/ha and 7775.66 Kg/ha in Fikkal area (Table 1). The positive correlation between average productivity and farm categories was found in Kanyam area whereas it was found negative in Fikkal area. This may be due to the more amount of inputs and well managed tea plantation done in the increasing farm size in Kanyam area and in the Fikkal area, as the farm size became large the productivity decreased due to better management and more inputs used in the initial years of tea plantation by large farmers and in the later years improper management and less supply of labors by the large farm. Small farmers in the Fikkal area were found providing proper and constant management in all the year of tea plantation with efficient use of family labors and variable inputs.

Study showed that the average per hectare cost of green leaf production in Fikkal area (NPR 401.3735) was lower than Kanyam area (NPR 404.585). SNV (2010) reported that the cost of green leaf production was NPR 19.55 per Kg under the conventional cropping methods based on production yield of green leaf to be around 2.75 metric tons per year in a land of 0.5 ha. The cultivation cost was NPR 15 per Kg of green leaf while the manufacturing cost of orthodox tea was NPR 199 per kg of made tea (Thapa, 2005). The average cost of production in small farm was found higher compared to large farm category in both the study area (Table 2). This was due to more family labors used by small farmers and less amount of inputs used by large farmers.

Table 2: Average variable cost of green leaf production by farm categories and study area

Farm category	Fikkal		Kanyam	
	Cost(NPR/ha)	Cost(NPR/kg)	Cost(NPR/ha)	Cost(NPR/kg)
Small	464.2345	23.11	428.8965	23.67
Large	338.5125	18.16	380.2735	18.61
Area average	401.3735	21.41	404.585	20.92

Source: Field Survey, 2015

Average income from green leaf production was found higher in Fikkal area because of higher productivity. The higher income per kg of green leaf produced was due to higher price paid by processing factory in Fikkal area. Average income per hectare and per kg price among farm categories in the study areas is presented in Table 3.

Table 3: Average income from green leaf production by farm categories and study area (2015)

Farm category	Fikkal		Kanyam	
	Income (NPR/ha)	Price (NPR/kg)	Income (NPR/ha)	Price (NPR/kg)
Small	671.9595	31.69	540.4145	29.56
Large	649.7925	31.94	646.977	30.39
Area average	660.876	31.78	593.69575	30.01

Source: Field Survey, 2015

The per hectare gross margin and per kg gross margin of Fikkal area was found higher than Kanyam area. This was because of higher productivity in Fikkal area than Kanyam area.

Gross margin in large farm category was found higher than the small categories in both the study areas. This was because the total variable cost being lower in large farm category. This signifies the economies of scale. The gross margin analysis of different farm categories in both the study area is presented in Table 4. In case of Orthodox tea cultivation of 12 years age, annual average gross return and average net return from one hectare area was NPR 1,86,000 and NPR 1,11,000 respectively (DAARD, 2001).

Table 4: Gross margin analysis of green leaf production by study farm categories and study area

Study area	Farm category	Gross margin (NPR/ha)	Gross margin (NPR/kg)
Fikkal	**Small**	207.725	8.59
	Large	311.2795	13.78
	Area average	259.50225	10.37
Kanyam	**Small**	111.518	5.89
	Large	266.7035	11.78
	Area average	189.11075	9.09

Source: Field Survey, 2015

The benefit cost ratio of Fikkal area (1.74) was found higher than Kanyam area (1.70) which signified good profitability of green leaf production in that area. Pokhrel (2006) also reported B/C ratio greater than one in Fikkal and Jasbire area of Ilam district.

Table 5: Benefit cost analysis of green leaf production by farm categories and study areas

Study area	Farmer category	Average revenue (NPR)	Average variable cost (NPR)	B/C ratio
Fikkal	**Small**	79731.88	53885.00	1.48
	Large	257638.89	133259.17	1.93
	Area wise average	140728.57	81099.00	1.74
Kanyam	**Small**	66094.58	51068.75	1.29
	Large	244719.29	137110.53	1.78
	Area wise average	163062.29	97777.14	1.67
Overall average		151895.43	89438.07	1.70

Source: Field Survey, 2015

CONCLUSION

The research study was aimed at finding out the economics of production of the orthodox tea in Ilam, Nepal. The result of this research shows that Nepalese orthodox tea has the potential and competitive advantage of being an agricultural export product, which has already established its way to the international markets.

Orthodox tea production is one of the profitable enterprises. Contribution of green leaf orthodox tea production to household economy of the rural masses is significant. This enterprise creates self-employment to large rural masses in our country. The marginal sloppy hilly areas of eastern part of Nepal are suitable for growing high quality orthodox tea. The study indicated that the conventional orthodox tea production could emerge as a better tool to reduce poverty in eastern mid hills of Nepal and would recognize the country in the international arena by exporting orthodox tea with its brand name or logo.

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USE OF AGROBIODIVERSITY AND CROP MANAGEMENT PRACTICES FOR CLIMATE CHANGE ADAPTATION IN HIGH HILL AGRICULTURE OF NEPAL

Yuga N. Ghimire[1], Ram B. Rana, Shanti Ale, Indra Poudel and Bir B. Tamang

ABSTRACT

This paper highlights the effects of climate related hazards in crops and the existing adaptation pratices in the high hills of Nepal. First, interaction meeting held in Kathmandu decided to select three districts: Humla, Kaski and Solukhumbhu as the representative districts. Second, stakeholder interaction meetings held in respective districts selected three villages: Chhipra from Humla district, Lumle from Kaski district and Takashindu from Solukhumbhu district. Information was acquired using Focus Group Discussion with the use of diversity analysis tools viz. four-cell analysis, noting traits of local crop genetic resources, and matrix ranking of crop varieties. The study found that climate hazards were increasing in recent years affecting farming adversely. Existing adaptation practices included change of crops and cropping pattern and use of alternate crop management strategies. Tourism, low social value attached to traditional crops, inadequate research, and food subsidy and other forms of external support have been identified as the threat to agrobiodiversity conservation in high hills of Nepal. Promotion of agro-tourism, identifying crop varieties tolerant to extreme weather events and their promotion through technology development and value addition have been suggested to combat climate change effects in high hill agriculture in the country.

Key words: adaption strategies, climate hazards, crop richness, high hills

INTRODUCTION

With changing global climate, agriculture is always at risk. Nepalese high hills have been observed and predicted as areas of rapid climate change inviting high uncertainty in crop production (Bhatt, 2015). Climatic variability such as rising temperatures, irregular monsoon, and changes in intensity and pattern of rainfall have been observed in Nepal affecting agricultural sector significantly (Ghimire et al, 2010). Magnitude of such risks has shown an inclining trend over the past few years. Given low development of the country with subsistence based, rain-fed dominant farming system and complex topography, Nepal is highly vulnerable to climatic variability and managing agricultural risk associated with climate change is particularly important.

To manage this risk, different strategies have been adopted. They include change in crop varieties and livestock breeds, management, and insurance. Crop diversification has been found building climate change resilience in small holder farms in Zimbabwe (Makate et al, 2016). Fisher and Surminski (2012) reported importance of public and private sector to ensure that climate change adaptation measures are adapted to address vulnerability. In the context of developing country, informal approaches such as savings, household buffer stocks, and community savings were important (World Bank 2011). Hazzel etal, 1986 reported use of fixed rentals, crop sharing, and other forms of leasing in India.

How locally available crop species are reacting to extreme weather events and what are existing adaptation strategies in Nepal Himalaya have aroused interest of climate experts, agricultural scientists and the governments around the globe. With this background this paper highlights how rich are genetic base of agricultural crops in those areas, what is the trend of extreme weather events, and how local farmers are coping with change in climatic pattern. This paper is mainly based on the information collected for the site selection for the project Integrating Traditional Crop

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Genetic Diversity into Technology: Using a Biodiversity Portfolio Approach to Buffer against Unpredictable Environmental Change in the Nepal Himalayas (Ghimire et al, 2014).

OBJECTIVES

The objectives of the study were to assess the diversity of crops and crop varieties in the high hills of Nepal, mapping extent of change in weather events over time, analyse impacts of such events in crop farming, and assess the adaptation practices used by the farmers.

METHODOLOGY

Eight keystone crops namely cold tolerant rice, finer millet, foxtail millet, prosomillet, barley, *amaranthus*, buckwheat and beans were identified for the site selection study for the project Integrating Traditional Crop Genetic Diversity into Technology: Using a Biodiversity Portfolio Approach to Buffer against Unpredictable Environmental Change in the Nepal Himalayas. Three districts namely Humla, Kaski and Soukhumbhu were selected from midwestern, western and eastern development regions of Nepal respectively as representative districts for Nepal high mountain agro-ecology from national level stakeholder meeting organized in Kathmandu and with the help of desktop review on the availability of biodiversity of keystone crops identified. One village from each of these districts was selected from district level stakeholder workshop organized in respective districts. A set of village selection criteria was discussed in district level stakeholder meetings and finalized. Chhipra VDC from Humla, Takashindu VDC from Solukhumbhu and Lumle VDC from Kaski were selected for the project implementation. The criteria used to select these VDCs included availability of important keystone crops, high agro-biodiversity of keystone crops, climatic variability, accessibility for intervention, a virgin area (distributive impact and ease in implementation), demonstrative effect (location importance), public interest (prior public content and potential participation in the project) and availability of mixed ethnic setup (social inclusion component). Focus Group Discussion (FGD) with the use of diversity analysis tools viz. four-cell analysis, noting traits of local crop genetic resources, and matrix ranking of crop varieties were conducted. It was supplemented by climatic hazards matrix preparation and seasonal calendar. A transect walk and direct observation of sites were also done to validate the information collected so far.

RESULTS AND DISCUSSION

This section summarises location of study sites, their economy, major crops, cropping patterns and food sufficiency status. Also highlighted are adoption status of major crops, change in the nature of hazards over time affecting crops, and local adaptation strategies.

1. Description of study sites

Solukhumbhu district lies between 27° 20'N - 28° 06' N latitude and 86° 22' E – 87° 03' E longitude and has a diversity of sub-tropical, temperate, cool temperate and alpine climate. The district spreads from 1500 masl to 8848 masl. Similarly, Humla district lies between 29° 35' -30° 10' N latitude and 82° 23' E – 83° 41' E and has a diversity of temperate, cool temperate and alpine climate. The district spreads from 1524 masl to 7337 masl. Kaski district lies between 28 6' N – 28 36' N latitude and 83° 40' E – 84° 12' E longitude. Climate is similar to the climate of above districts. However, lower level elevation of 450 masl makes this district more intense in agriculture. The higher altitude level of the district is 7339 masl (Rimal and Rimal, 2006). The villages have diverse land uses ranging from snow clad high mountain areas to low lying river basin areas. Main land use types are forest, agricultural land and pasture. Among these uses, forest is dominant land use type in

Takashindu and Humla, whereas Lumle has more areas under cultivation than areas under forest. The pasture covered areas is very small ranging from 1-3 per cent total land available in the Village Development Committee. The VDCs are characterized by diverse caste structure. Chhetri, Brahman and Dalits are major castes in Chhipra and Lumle, whereas, Sherpa, Tamang and Dalits are major castes in Takashindu. Population densities were 30, 72 and 108 per square kilometre, repectively and this is low compared to other hill and terai VDCs spread in different clusters.

These VDCs have acute food shortage. Agricultural productions from these VDCs are barely enough to support their food needs for more than 20 per cent of the village population. Percentage of food sufficient households in the village counts less than 10 per cent. The food needs are met through importing from adjoining market centers. Potato, wheat, maize, barley and bean are four most important food security crops grown in Chhipra and Takashindu, and rice, wheat, maize and millet are most important for Lumle. Major livelihood strategies in the villages were agriculture and livestock keeping, Hotel/Business, office, labor and industry. Agriculture is the dominant sector in all these villages. In Takashindu, due to its location in the Khumjung Trek, hotel business is also spreading along the route.

2. Existing crops and major cropping patterns

Along with keystone crops, many vegetables are also grown including pumpkin, colocasia, tomato, gourd, garlic, onion, etc. Similarly, spices like coriander, turmeric, ginger, etc. Among fruits, apple, peach, and plum are common in Chhipra and Takashindu, whereas, orange, peach, plum and citrus are major fruits in Lumle. The village economy of Chhipra and Takashindu are also supported by the collection and sale of herbs including yarsagumba, paanchaule, attis, ghodamarchaa, etc. Regarding livestock, buffalo, cattle and sheep/goat are kept. Crops are grown in three major domains: lowland khet, upland khet and pakho. Cropping patterns in lowland khet are irrigated rice based patterns. Important second crops are wheat and barley. Chhipra and Takashindu have only a single crop of rice in rice land. Cropping pattern in Lumle is more intense with second crop of either wheat or barley. In upland khet, upland rice is grown which is followed either by barley, or wheat, or lentil, or pea, or soybeans, etc in either one-year or two-year pattern.

3. Adoption and social preference of crops varieties

Four Cell analyses show the condition of crops or variety in community level. Varieties for food security or for the market or with multiple use values tend to be cultivated in large areas by many households are kept in the first room. Second room includes landraces cultivated for sociocultural (traditions, religious rituals, food culture) purposes which are grown in small areas by many households. Third room has varieties with specific adaptations traits (such as cultivars adapted to swampy lands, poor soil fertility, drought, shade etc.) are grown in large areas by few households. Similarly, fourth rooms' keeps varieties with specific use or limited use as valued by particular families and are grown in small areas by a few households. Figermillet, rice, barley, maize and beans come in cell one indicating high level of adoption of these crops, whereas, horse gram, lentil, and vegetables and fruit crops come in Cell Four. The analysis of fingermillet variety reveals their adoption level by area and number of households growing. The pattern of adoption of fingermillet is not distinct among sites. Similarly, rice varieties *Dhoinala*, *Darmali*, *Reksali*, and *Kathe* have been grown by many households in large areas. *Chomorong*, *Kalo Dhatulao, Marsi, Gudura, Tauli, Sinjali*, etc. are grown by few households in small areas only. Bean varieties like *Jumli, Kalo, thulo seto, thulo pangre*, Kentuki wonder, Bhatte, offseason, Kathe, Maki, etc. are grown by many households in larger area. However, *Rato, Pahelo, Sano Kalo, Sano pangre, Ghiu simi* bean varieties are grown in small areas by few households.

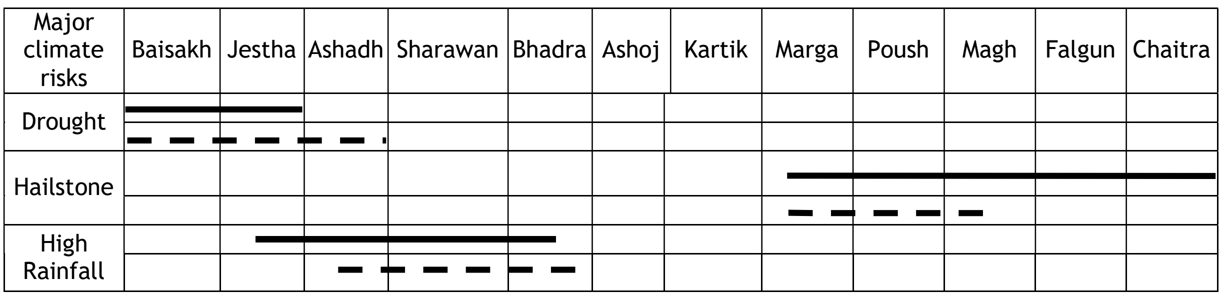
Matrix ranking shows that fingermillet varieties like *Riule*, *Tyanse*, and *aankhe* are most preferred fingermillet varieties in Chhipra, *paudure*, *mannsire*, and *seto* are preffered in Takashindu. Similarly, *Dalle, Archale*, and *Bhachuwa* are preferred in Lumle based on overall ranking and prioritization. In Takashindu high altitude areas, Paudure and Mansire, and Kalo are preferred in riverbasin areas of the VDC. Overall rating based on farmers' criteria, Channanth, *Kalo dhan* and *Kalo Mari* were top among other varieties in Chhipra. In Lumle, Kalo patle, *manamure*, and *Reksali* are better varieties. Upland rice varieties namely, Ratanpuro, Khachya, and Dhoi Nayala are ranked at the top in Chhipra. Lumle-2 and Chomorong are most important vaieties in Lumle. Takashindu farmers could not assignweights to the rice varieties. In Chhipra, bean varieties namely Jumli, Kato and Seto are most preferred. Thulo seto, thulo chirbire are best varieties in Takashindu; Kentuki wonder, four season and Ghandruke are best performers in Lumle.

4. Climate change effects in agriculture and adaptation strategies

Behaviour of major seasonal hazards has been assessed over time in each study village. Also, analysed were the existing adaptation strategies.

Climate change effects in agriculture and adaptation strategies in Chhipra

Table 1: Seasonal hazard calendar of Chhipra



Note: Solid line: Before B.S. 2000; Dotted line: present situation (B.S. 2014)

Drought, snowfall, low rainfall and frost/chilling are taken as the climate change parameters in the selected villages (table 2). Huge snowfall occurred in 2047 Jestha. One big drought was observed in 2054 and 2065, huge floods observed in 2060 and 2062. The effects of these manifestations are seen in principal crops, livestock animals and fruits. Buckwheat and legumes are reported to have smaller impacts of drought while, rice, millets, barley and domestic animals are most severely affected by these events. Snowfall effect is most severe in barley and wheat. However, chilling/frost does little harm than other hazards in the villages. Seasonal hazard calendar has been presented which shows the situation 15 years ago and present time compared in terms of agricultural practices and changes in occurrences of hazards.

Table 2: Hazard matrix: scale 0-3 (Small effect gets 0 or 1 while increasing effect gets more scale)

Crops	Drought	Snowfall	Low rainfall	Chilling/Frost
Rice	3	1	3	1
Potato	2	0	0	0
Buck wheat	1	0	0	1
Finger millet	3	2 (insect pest attack increases in low snow fall)	2	1

Proso millet	2	1	1	0
Foxtail millet	3	2	2	1
Amaranthus	2	1	2	0
Barley/ naked barley	3	3	2	1
Wheat	1	3	1	1
Soyabean, beans,horsegram	1/2/1	0/0/0	1/1/1	0/0/0
Livestock- cows, buffalo, goat, sheep	3	1 but grass production decreases	1	2
Apple, Peach, Khurpani	2	0	1	0

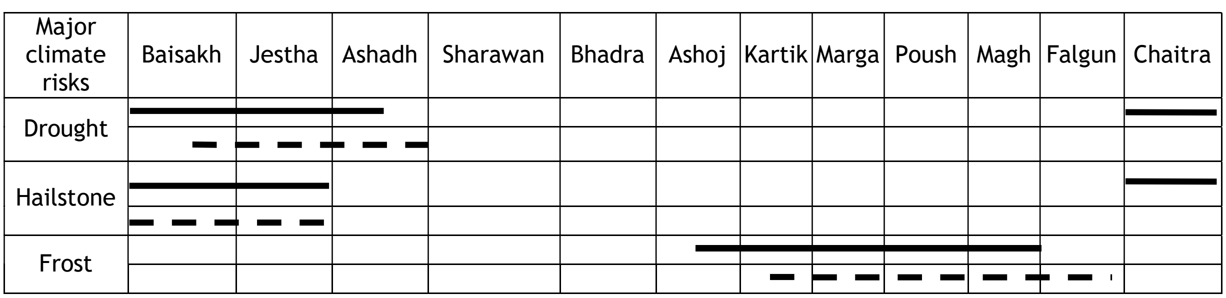
Adaptation strategies against drought for rice, millet and barley are presented in table 3. Farmers cannot transplant rice, fingermillet and foxtail millet, delay in rainfall in planting season. Drought in flowering stage causes sterility. If rain is further delayed, farmers even cancel transplanting. Barley and naked barley plant will be dried. Adaptation strategies include i) buckwheat, wheat and bean planted cancelling rice and fingermillet, and foxtail millet planting, ii) Manual irrigating from water sources and iii) if barley and naked barley crops dry up, farmers wait for next season planting.

Table 3: Adaptation practices

Crops	Effects	Adaptation Strategies
Rice	• Transplanting cancelled • Sterility	• Buck-wheat and beans planted in July • Harvest only straw and taking minimum production
Finger millet	• Transplanting cancelled	Buck-wheat and beans planted but few households plant FM by carrying water from resources
Foxtailmillet	• Transplanting cancelled	• Buck-wheat and beans planted
Naked barley/Barley	• Drying of plants	• Keep fallow until next season

Climate change effects in agriculture and adaptation practices in Takashindu

Table 4: Seasonal hazard calendar of Takashindu



Note: Solid line: Before B.S. 2000; Dotted line: present situation (B.S. 2014)

Heavy rainfall, frost, drought and snowfall are major climate hazards in Takashindu village too (table 5). Bean, potato, maize and wheat are severely affected by high intensity rainfall. Frost and snowfall damage crucifer vegetables. Barley, potato and crucifers also are moderately affected by drought. Seasonal hazard calendar has been presented which shows the situation in 15 years period and present time compared in terms of agricultural practices and changes in occurrences of hazards.

Table 5: Hazard matrix: scale 0-3 (Small effect gets 0 or 1 while increasing effect gets higher scale)

Crops	Drought	Snowfall	Low rainfall	Chilling/Frost
Bean	2	0	0	0
Barley/Naked Barley	0	0	1	0
Fingermillet	1	0	0	0
Buckwheat	0	0	0	0
Potato	2	0	1	0
Wheat	2	0	0	0
Maize	2	0	0	0
Cauli flower/Cabbage/board leaf mustard	0	2	1	3

Climate change effects in agriculture and farmers' adaptation practices in Takashindu have been presented in table 6. Heavy rainfall affects fertilization in bean and fingermillet and grain is not formed. With this hazard, wheat grains sprout in the field, maize plant lodge causing yield damages to these plants.

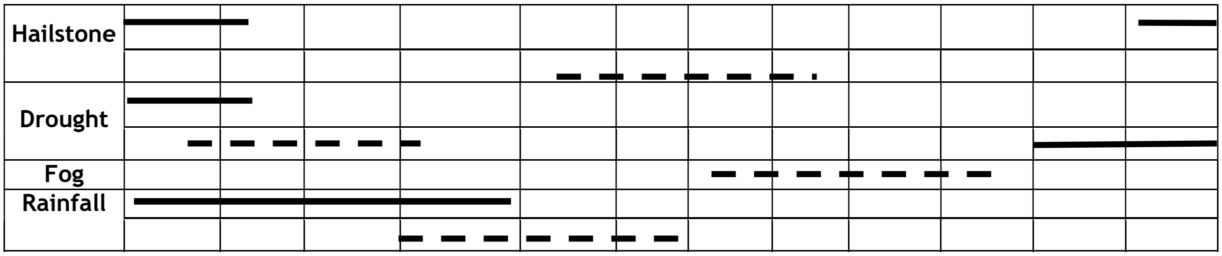
Table 6: Farmers' adaptation practices against heavy rainfall in Takashindu

Crops	Effects	Adaptation Practices
Bean	• Damage of flower • No grain setting	• No action taken
Fingermillet	• No grain setting	• No action taken
Potato	• Drying plants (blight disease)	• No action taken
Wheat	• Germination at the panicle	• No action taken
Maize	• Lodging • low yield	• No action taken

4.4 3 Climate change effects in agriculture and adaptation practices in Lumle

Table 7: Seasonal hazard calendar of Lumle

Major climate risks	Baisakh	Jestha	Ashadh	Sharawan	Bhadra	Ashoj	Kartik	Marga	Poush	Magh	Falgun	Chaitra
Snowfall												



Note: Solid line: Before B.S. 2000; Dotted line: present situation (B.S. 2014)

Major shift in climate and cropping behaviour in Lumle have been given in table 7. Drought, snowfall, low rainfall, high rainfall, hailstone, frost/chilling and fog are main the climate change manifestations in Lumle (table 8). Huge snowfall occurred in 2063, causing heavy loss of vegetables, mustard and wheat in the village. Hailstone of 2068 damaged rice crop at harvest time. Lightening of 2063 and 2067 Destroy of power houses destroyed houses, livestock, man and crops and other plants. Forest fire outbreak in 2066 took lives of many wild animals. Seasonal hazard calendar has been presented which shows the situation 15 years ago and present time compared in terms of agricultural practices and changes in occurrences of hazards.

Table 8: Hazard matrix: scale 0-3 (Small effect gets 0 or 1 while increasing effect gets more scale)

Crops	Low rainfall	More rainfall	Snowfall	High cold/ Frost	Hail stone	Drought	Fog
Rice	3	1	0	0	3	2	2
Maize	1	3	0	0	3	1	0
Wheat/Barley/NBarley	2	0	0	0	3	3	0
Potato	2	3	3	2	3	2	3
Amaranthus	0	0	0	0	3	0	0
Fingermillet	2	2	0	0	2	2	0
Soyabean	0	0	0	0	2	0	0
Beans	0	1	1	0	2	2	0
Vegetables	1	2	1	1	3	2	1
Livestock-Cows, buffalo	0	2	2	2	1	2	1
Goat, sheep	0	3	2	2	1	2	1
Chicken	0	0	0	0	0	0	0

Climate change effects in agriculture in Lumle have been presented in table 8. Mainly rice is affected by low rainfall, maize, potato, goat and sheep by heavy rainfall. Hailstone is devastating to all the crops plants. Wheat, barley are affected by drought. Fog is detrimental especially to potato crop which helps develop late blight the field. Farmers' adaptation practices against drought in Lumle has been given in table 9. Technology change and late planting are important practices farmers are adopting.

Table 9: Farmers' adaptation practices against drought in Lumle

Crops	Effects	Adaptation Strategies
Rice	• No timely transplantation	• Variety change • Late transplanting
Fingermillet	• No timely transplantation	• Variety change
Vegetables	• Low production	• Sprinkle and drip irrigation
Potato	• Insect and pest attack	• No action

THREATS AND BARRIERS TO AGRO-BIODIVERSITY CONSERVATION

Socioeconomic threats and barriers to agro-biodiversity conservation were found as follows:

- Finermillet, foxtailmillet, and prosomillet are minor crops for Nepal. These crops are not considered holy food in Nepalese society.
- Elitism in Nepal- 'Rice' is considered to be an elite food, even in places where it can't be grown, equally disparaging towards those who cannot eat them. Therefore, growing other crops, offers less incentive.
- Inadequate research in keystone crops except rice (NARC research highlights) has offered less incentive to growing these crops.
- Food subsidies and other forms of external support have created a state of dependency, stifling local initiative and reducing reliance on local resources (Roy et al, 2009).
- Less attraction to local crops due to development of tourism without linking it to use value of available diverse local foods in high hills where farming is less preferred.
- Push of market in favor of highly marketed crops has abandoned local crops and varieties.

CONCLUSION

High hill agriculture in Nepal is characterised by high agrobiodiversity. Incidences of Weather hazards have been found increasing with the change in global climate change posing threats to crop farming and local livelihoods. Farmers have developed adaptation strategies to cope with changing climate. Tourism, low social value attached to traditional crops, inadequate research, and food subsidy and other forms of external support have also been identified as the threat to agrobiodiversity conservation. Promotion of agro-tourism, identifying crop varieties tolerant to extreme weather events and their promotion through technology development and value addition have been suggested to combat climate change effects in high hill agriculture in the country.

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CONSERVATION AND MANAGEMENT PRACTICES OF TRADITIONAL CROP GENETIC DIVERSITY BY THE FARMERS: A CASE FROM KAILASH SACRED LANDSCAPE, NEPAL

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ABSTRACT

Crop genetic diversity has been an important source of subsistence livelihoods and nutrition in the remote Himalayan region for local communities. This study documents the crop diversity, their current status and farmer's knowledge and practices. Study was based on analysis of one local crop diversity fair, 18 key informant surveys, nine focus group discussions and 195 individual household surveys with set questionnaires. The community structure in the study area has female dominance (52%) with average family size of 7.1. The study documents 78 species of various crops which were used as food, vegetables, fruits, medicine, and spices. Highest varietal diversity was recorded in Maize (15), Paddy (12), wheat (11), and beans (10). However, a number of crop varieties are being lost and threatened over the time. Both anthropogenic and natural drivers of changes were reported as the major reason of such loss. Despite loss of crop varieties farmers have been maintaining a wide range of crop and varietal diversity in situ on farm by their own initiatives and experiences. Our study showed that self-saved seed contributed as the major source of planting material through which they are maintaining the crop diversity. However, a detailed study on the seed supply system is needed to support easy access to the farmers. More awareness raising program as well as empowerment of farming communities is essential for the continuation of conservation and management practices.

Key words: *Crop and varietal diversity, diversity fair, loss and threatened species, self-saved seed, Kailash Sacred Landscape*

INTRODUCTION

Agro-biodiversity has been recognized as an important factor in maintaining or enhancing agricultural sustainability and playing a significant role for the food security and livelihoods of a large number of local communities around the globe (Uprety 2000; Baldinelli 2014). Agriculture combined with agro-pastoralist communities is the basis of the livelihoods for over 80 percent of the rural population in the Hindu Kush Himalayan (HKH) region and has been recognized as a hotspot for

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crop diversity (Agnihotri and Palni, 2007). The traditional local cultivars, also known as landraces or farmer's varieties contribute significantly to sustainable food production, human nutrition and household income generation for the resource poor farmers in marginal agricultural areas and to overall climate resilience building (Baldineli, 2014; Katwal et al. 2015). Genetic diversity of traditional varieties of crops is the most economically valuable element of global agro-biodiversity and is of paramount importance for future world crop production (Rana et al. 2007; Galluzi et al. 2010). High genetic diversity of the local crops is a defense against pests, diseases and environmental changes and makes landraces more suitable than commercial varieties (Negri 2005). The HKH region has been identified as a repository for traditional knowledge widely used in natural resource use and conservation (Bist et al. 2007). However, due to socio-demographic changes such as out-migration of the younger generations to urban areas is resulting in loss of such knowledge. It is essential that such traditional knowledge and practices be conserved (Chaudhary et al. 2007; Rana et al. 2007; Chaudhary and Aryal 2009; Zomer and Oli 2011).

In the other hand, changes in agricultural land use system and climatic and non-climatic factors have caused a significant decrease in agricultural diversity (Aase et al. 2009; Chaudhary et al. 2011; Baldinelli, 2014). Furthermore, in recent years local varieties are being replaced by exotic varieties promoted by public schemes for higher production and specific robustness criteria for example pest resistant and drought resistant (Oli, 2003; Verma et.al 2010; Hyder et al. 2014) limit the option for farmers in having a balanced nutrition. On the otherhand, knowledge about climatic and non-climatic changes and their impact on food security and crop genetic resources management in the region have not been well documented (Aase et al. 2009; Singh et al. 2010; Chaudhary et al. 2011; Zoomer and Oli 2011;).

Indigenous and traditional agricultural communities act as the sole managers and custodians of local crop varieties and utilize their knowledge to maintain and manage diverse agricultural production system (Upadhyay & Subedi, 2003; Bisht et al. 2007). They have been accumulating knowledge about the agricultural practices through implementing wide range of indigenous and traditional practices based on generations of experience, informal experiments and intimate understanding of their environments (Abioye et al. 2011; Berkes et al. 2000; Usher 2000). These traditional knowledge and practices include numerous adaptations strategies at local context and also transmission of knowledge and practices to younger generations (Berkes et al 2000; Salick and Byg, 2007). However, the valuable knowledge gathered and practiced by farmers over generations is often neglected by researchers, although the information is quite essential for location specific recommendations and for developing sustainable farming systems (Abioye et al. 2011). Furthermore, lack of proper documentation of the traditional knowledge and practices, a number of crop varieties are eroding from the areas without proper knowledge of farmers about varieties and their cultivation (Sunwar et al. 2006; Regmi et al. 2009; Baral et al. 2012).

Having these contexts and background, this paper is trying to assess the richness and status of the local crop genetic resources and associated knowledge and practices of the local communities in Khar Village Development Committee (VDC) of Kailash Sacred Landscape, Nepal. We tried to document and analyze farmers' local knowledge and practices on managing crop diversity, not only in terms of 'what', 'who' and 'how', but also 'why', so that the blending of scientific and local knowledge is achieved for strengthening farmers' capacity and interest to continue growing traditional crop varieties for the long-term security of livelihoods of the local people as well as maintain high diversity on-farm so that climate resilience is inbuilt.

OBJECTIVE

This paper aims to document the status of crop diversity and traditional management practices adopted by the local people to manage the crop diversity on farm. The specific objectives were to:

- know the current status of local crop diversity and their changes over time;
- understand and document various anthropogenic and climatic drivers of change affecting the choice and management of crop genetic resources; and
- document local knowledge/practices and adoption strategies used by the local people for management of crop diversity on farm.

MATERIALS AND METHODS

STUDY AREA

The present investigation was particularly carried out in Khar VDC of Api Nampa Conservation Area (ANCA) (Figure 1). The elevation of the VDC ranges from 1,324 to 3,242 masl with subtropical climate at lower part and temperate in the upper reaches. The area is located at about 3 hour walk from Khalanga *Bazaar*, the district headquarter of Darchula district and also connected by rural road (14 km) with Khalanga *Bazaar*. The access of the vehicle is only possible during the winter and spring seasons (not in monsoon). With an area of 25.95 km^2, Khar VDC has 698 households with population of 4,272 (CBS 2012). Nearly half of the VDC area (51.1%) is covered by forest, other land use types are agriculture (44.3%), shrub land (4.1%), water bodies (0.31%), grassland (0.11%) and settlement area (0.07%) (ICIMOD, 2013).

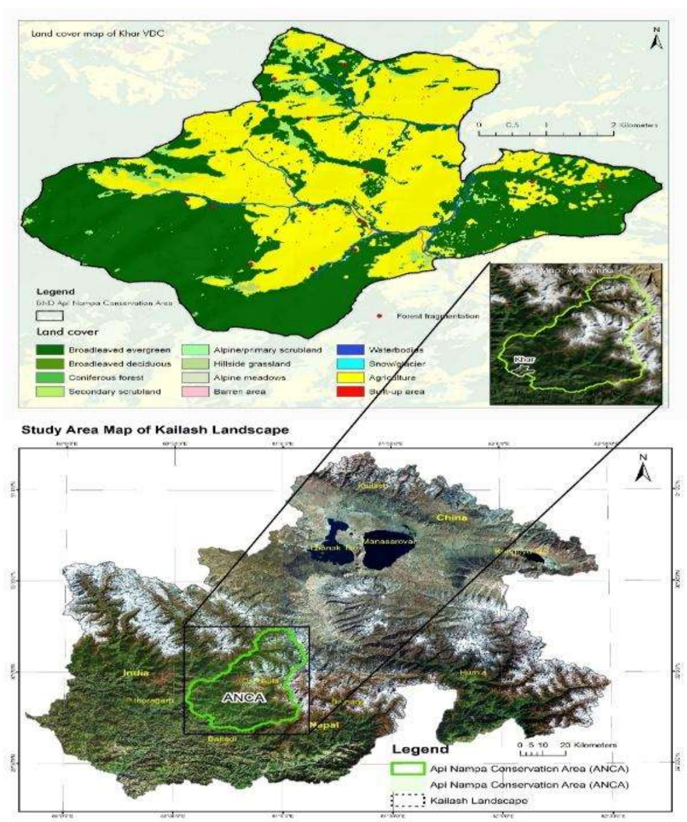

Figure 1: Study site (Land cover map of Khar VDC)

DATA COLLECTION

The research methodology involved both primary data collection and through literature review. For the primary data collection, sample size for household survey was determined using the following formula:

$$\text{Number of households to be audited} = \frac{Z^2_{1-X} * N * P(1-P)}{(e^2 * N) + (Z^2_{1-X} * P(1-P)}$$

Where,

N is the total number of households in the population (N=698)

Z is the level of confidence (assumed value for 90% level of confidence is 1.65);

P is the estimate of the indicator to be measured (assumed value 50% in the absence of any prior information)

e is the margin of error to be attained (assumed level of precision is set at 5%)

Under the above assumptions, a total of 195 households were selected for the detailed household survey. To have proper representation from each ward, the estimated sample size was proportionally distributed as per the number of households in nine wards of the VDC. Planned structured questionnaire for household survey was prepared and carried out in 195 households of Khar VDC. In addition, nine focus group discussions (one in each ward) were carried out and at least 18 key informants were interviewed. During the key informant's interviews, older people (more than 50 years of age) were consulted to gather traditional knowledge and practices about the local crop diversity. Farmer's recall method followed by Focus Group Discussions (FGD) was organized to see the changes of local crop diversity in last 10 years from their area. They were asked to identify the lost and threatened species along with the associated reasons. Besides, agricultural crop diversity fair was organized in Dallekh of Khar VDC in February 2016 in collaboration with District Agriculture Development Office (DADO) and Api-Nampa Conservation Area. During the fair local genetic materials were displayed, their indigenous/local knowledge were shared and documented and traditional food were also prepared from the local crops.

For data analysis, a questionnaire format was prepared in CS Pro 6.2 and then the survey data was entered into the program. Descriptive statistics like mean and frequency distribution were used to describe the household characteristics using Statistical Package for Social Sciences (SPSS, 2011) 16.0 Software.

RESULT AND DISCUSSION

SOCIO-ECONOMIC PROFILE

The farmers in the study site live under different socio-economic conditions in terms of education, family size, age group, occupation, and income source and food sufficiency level (see Table 1). The number of interviewed persons was 195 (94 male and 101 female).

The average household size of the study site is 7.1 which is higher than the district average of 5.41 and further the figure is higher than the national average i.e. 4.88 (CBS 2012). In general, the literacy rate is very low, only 39.3 percent can read and write their name and the rest 60.7 percent of the respondents were illiterate. This can be compared to the national literacy rate of 65.9% (CBS 2012).

Overall, agriculture was ranked as the most important occupation by majority of the respondents (84%). However, their self-grown food is only sufficient for 5 percent of the households. About 82 percent of the household could only live for 7-10 months on products from their own agricultural production and 13 percent of the household could live for less than 6 months from their own agricultural production. During the food deficit period households depend on multiple coping strategies such as wage labor, salaried employed, remittances, share cropping and collection of wild foods.

Table 1: Socio-economic features of the respondents.

Categories	No. of respondents (N=195)
Sex	
Male	94 (48%)
Female	101 (52%)
Age group	
15-25 years	37 (19%)
26-40 years	50 (26%)
41-55 years	74 (38%)
>56 years	34 (17%)
Average HH size	7.1
Education	
Illiterate	118 (60.7%)
Class 1-11	57 (29.1%)
Class 12-15	20 (10.2%)
Average income earned per HH	NRs 142,688
Food sufficiency level (months from self-grown food)	
Up to 6 months	25 (12.8%)
7-10 months	160 (82.1%)
>10 months	10 (5.1%)

Note: Proportions in different categories are presented within brackets.

CROP DIVERSITY IN THE STUDY SITE

Altogether 78 different species of various crops cultivated in the study site were documented through crop diversity fair organized in February 2016 in the study site. Traditionally, people grow wide range of crops for their livelihoods sustenance. The eight major crops grown by surveyed households are presented in Figure 2. Within the crops the highest diversity was recorded in Maize having 15 different varieties followed by paddy (12) and wheat (11) as indicated in Table 2. The name of the varieties mentioned in the table are given by the farmers based on their own descriptor during diversity fair where all these varieties were displayed. Some of the varieties displayed during the fair looked similar hence further detail analysis is needed to verify by establishing experimental plots using standard descriptors. Despite high varietal diversity, majority of the households grow only a few varieties on the farm.

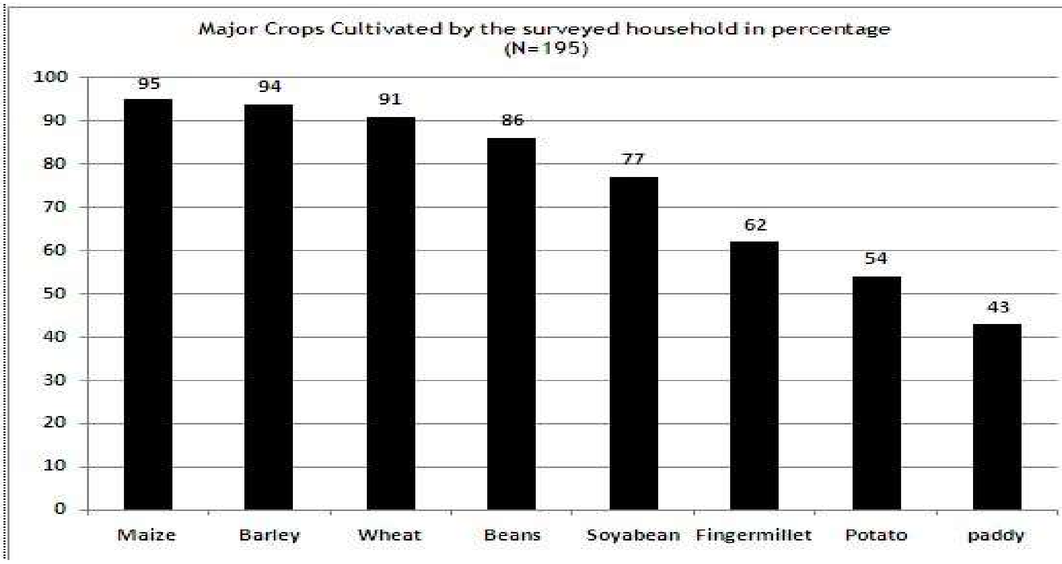

Figure 2: Major crops cultivated by majority of the household in Khar

STATUS OF CROPS AND CHANGES OVER TIME

Many of the participants in FGD recalled and reported that they used to cultivate large number of local crops species and varieties in their agriculture field in the past and are now not cultivated in the area. The reported lost and threatened species were mostly local crops and varieties of wild species. With this decline, crop varieties of various species are disappearing. A number of varieties of major crops grown in the area are disappearing (see Table 2). The cultivation of traditional crops such as finger millet, proso millet, fox tail millet, amaranths, rice bean and buckwheat has decreased in the last 10 years and it has become extremely difficult to even find the seeds of these crops. One of the older varieties of wheat (*Malaya* variety) is reported to be completely lost from the study area. Many old varieties of barley such as *jhuse jau*, *thaang jau* and *kalo jau* and maize such as *baktado*, *ragase* and *rato bilaas* are very difficult to find. The older varieties of beans such as black and white beans are also in the state of rapid decline. Two important reasons mentioned for such decline were low production potential and long crop duration which do not allow increasing cropping intensity. Similar reasons were mentioned in the study area carried out by Rana et al. (2007) and Rijal (2007). If this process continues, many such older varieties of crops will be lost forever without even being documented. This will not only reduces the local crop diversity but also increases farmer's vulnerability to climate related changes resulting on loss of traditional farming system (Bisht et al. 2007; Singh et al. 2010).

Table 2: Agricultural crop diversity of major crops grown locally (source: Diversity fair-2016)

Crop	Local name	Botanical name	Varieties	Remarks
Paddy	Dhan (12)	*Oryza sativa* L.	*Khasare, Sali, Chamade,Takmaro, Roti dhaan,Choti dhaan, Jaili dhaan,Jumli dhaan, Kirmuli dhaan,Jau dhaan, Mangali dhaan,Rato dhaan*	*Jau dhaan* and *Sali dhan* are almost eroded from Khar VDC only a couple of farmers maintain these varieties in small land area
Wheat	Gau (11)	*Triticum aestivum* L.	*Dautkhane, Bhote, Rato,Thulo, Jhuse, Geru,Moto, Haasa, Lide, Jumli Bhoto, Nangri Bhoto,*	*Jhuse, Haasa, Geru and Dautkhane* varieties have been eroding from the area
Maize	Ghoga (15)	*Zea mays* L.	*Bhabari, Rato, Murali,Temase, Pahelo, Seto,Bhate, Ragese, Airkoti,Male, Baktado, Ghar, Baure, Marudi, Bikasi*	*Baktado* variey is grown by only one farmer and *Rato, ragase* are also in the verge of disappearing from the area due to its low yield
Finger millet	Kodo (7)	*Eleusine coracana* Gaertn.	*Nang kate, Kalo, Rato,Temase, Tiuli, Mutke,Kodekauli*	All the varieties are disappearing due to its low yield and shifting towards new maize varieties introduced by DADO
Barley	Jau (5)	*Hordeum vulgare* L.	*Jhuse, Mankare, Kalo, Seto, Thang Jau*	*Jhuse, Kalo,* and *thang* are almost disappeared from the area
Beans	Sotta (10)	*Phaseolus vulgaris* L.	*Seto local, Kalo local, Rato Kirmire, Kaleji Kirmire, Asali rajma, Marma, Temase, Bote, Kalo, Batule, Ankhe Simi*	*Seto* and *Kalo* are two of the oldest varieties grown only few households (less than 10 households in Khar VDC)

FARMERS PERCEPTION ON LOSS OF CROP GENETIC RESOURCE

The multiple response on perceptions of respondents for both anthropogenic and natural drivers of changes on the loss and threatened varieties of the crops were recorded in the study area. The first important reason for loss of local crop diversity has been accelerated by the introduction of improved crops and varieties which is reported by 150 respondents out of 195 (Figure 3). About 94 percent of the respondent reported that easy availability of improved and hybrid varieties of crops is considered the leading cause of local crop diversity loss. It is followed by out and seasonal migration of the skilled human resources (110 respondents). Now, the trend changed as people migrate seasonally to India or abroad to work as wage laborers creating shortage of labor to work in agricultural fields which directly affects the crop diversity management. Other anthropogenic causes mentioned by the people are easy accessibility of road and market. Before roads were built people's livelihoods completely depended on self-grown food and mostly the traditional varieties of crops they grew in their fields. As the resources are easily available due to access to road and market people prefer buying rice from the market rather than depending on their production (Figure 3).

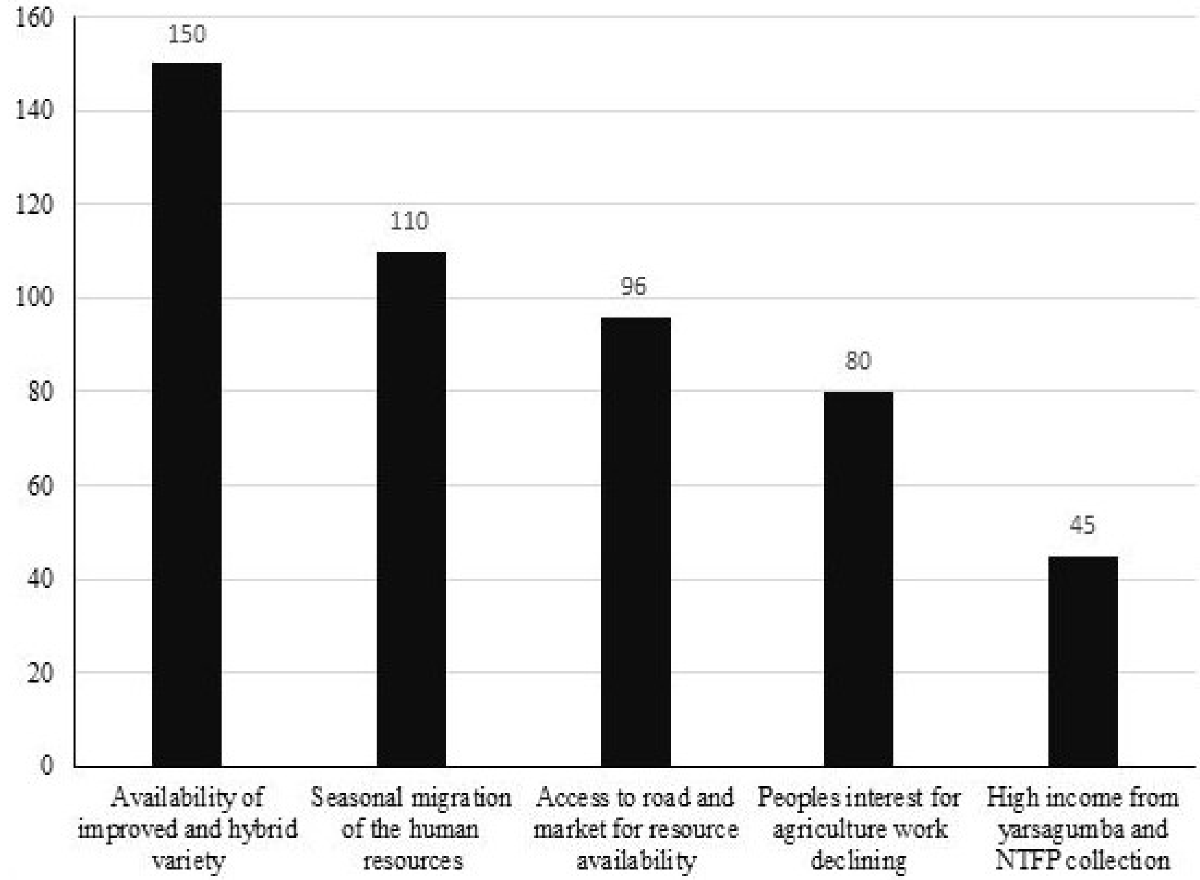

Figure 3: People's perception on anthropogenic reasons causing crop diversity management

We also conducted key informants interview with several elderly people and discuss the natural drivers of changes. A multiple and wide range of responses were recorded based on their own experiences and stories. Overwhelming (90%) of the respondent experiences that the climate is changing. Their experiences broadly range from erratic weather pattern, ecological variability, biological changes and their negative effects on local people's life. However, they are not quite sure whether these kinds of changes are because of climate only or linked to other associated reasons. We also tested several theories by asking the local people about their perceptions on changes that they are experiencing in their lifetime. To do this, at first we organized a FGD and asked them to share their various climate change related practical experiences. We listed them and prepared a major areas of changes that the local people who are experiencing in their locality and later included them in the household survey questionnaire where mixed response were recorded (see Table 3). We only presented responses on climate change related experiences which was mentioned by more than 50 percent respondents. In column 3, where respondents are not experienced the changes and in the last column the respondent didn't have any idea about such changes. Studies by Chaudhary and Aryal (2009) and Uprety and Ghale (2002) also supported our current study findings.

Table 3: People's experiences on natural drivers of change related happenings

Local people perception on various climate change related issues	Yes	No	No Idea
Experiencing long summer (more hotter days)	105	29	61
Less snowfall	130	20	45
Less rainfall during winter	110	40	45
Drying up the water sources	150	15	30
Longer duration of drought	160	10	25
Early flowering of rhododendron	120	25	50
Never seen weeds present in agriculture field	160	10	25
Insect pest attack on local varieties	110	30	55
New species adopted well	122	50	23

LOCAL MANAGEMENT PRACTICES AND ADAPTATION STRATEGIES

Seed management practice

The present study revealed that local seed sources are important for maintaining and managing crop diversity in their farm. A multiple responses on managing the seeds for next season have been recorded during the survey. Self-saved seed (reported by 98.5% HHs) are the first source of planting materials and has the highest contribution to all of the major farm components; cereals, pulses, vegetables, fruits, and spices and sharing between and among the neighbors contributed the second most important. Interestingly, their relatives play significant role in management of crop diversity by contributing third place as reported by 55 percent of the respondents (see Figure 4). Self-saved seeds are the primary source of seed management in other parts of Nepal where community people stored seeds for the next cultivation (Rijal et al. 1998; Poudel et al. 2015). But such a study is lacking focusing on local crop species particularly in far-western hilly districts and Kailash Sacred Landscape area. The proper management of traditional varieties depends on the continued functioning of informal seed exchange networks as it accounts for large proportion of seed exchange in various parts particularly in rural areas (Hodgkin et al. 2006).Therefore, local seed management through informal seed system needs to be strengthened to manage crop diversity in farmer's field.

In the other hand, many local crop varieties are lost and many more are threatened in the farmer's field. The present study reported that a number of crops like Marshe (locally called chuwa) (*Amaranthus* L.), finger millet (*Eleusine coracana* L.), proso millet (*Panicum miliaceum* L.*)*, and foxtail millet (*Setaria italica* (L.) Beauvois) are already in threatened condition in the study area. Therefore, such threatened crop species could be placed for ex-situ conservation where the formal institution could further improve the crop quality and resend them back to the community.

Furthermore, product diversification on these crops can enhance the conservation of these crop varieties on long run. Therefore, policy makers, researchers and other relevant organizations should initiate measures towards ex-situ conservation for threatened local crop varieties.

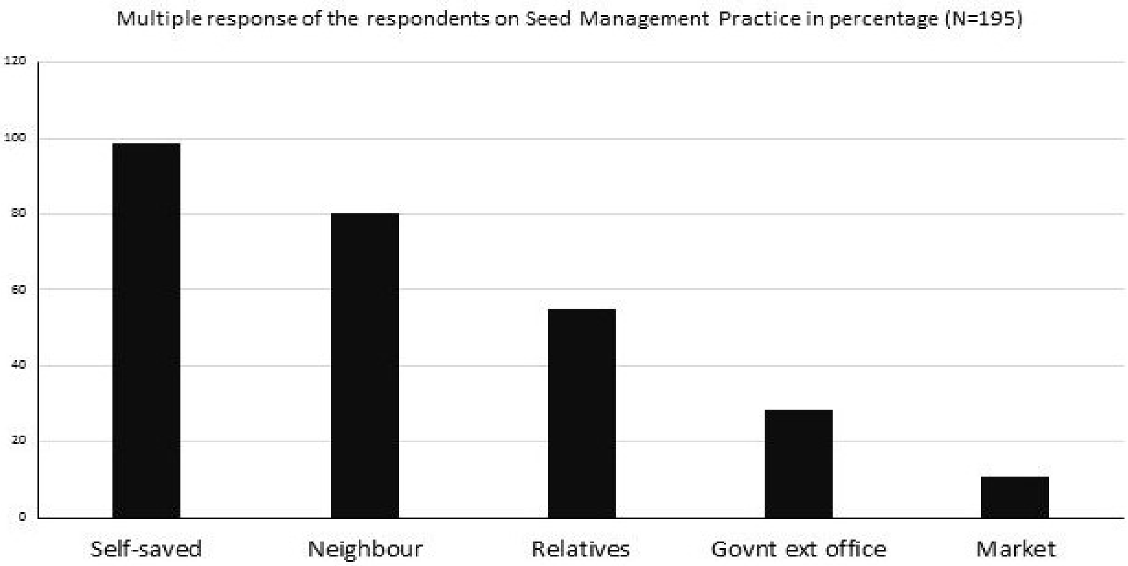

Figure 4: People's response on seed management practice

Women's role on seed selection and management

Once we knew majority of the households keep their own grown seed for the next cultivation, we asked the respondents who manages the seeds most in their household. About 82 percent of the respondents mentioned that the management of local crop diversity is one of the key responsibilities of women because they are good in seed selection, seed storage and seed supply/exchange. Since women are the ones who do the actual seed selection, they select according to their preference and household needs. In this regard we asked women to exchange their views and information regarding seed management practice. They have the information on how seed is selected and stored, and what varieties and seed qualities others have in the village. In this way, they serve as the manager because they know who has what seeds and their quality and are the member of informal seed network at village. Farmer's seed networks play an essential role to help ensure access to varieties at risk and enable and incentivize on-farm conservation of crops diversity. They create the linkage between farmers and provide channels for mutual assistance (Sperling and Mcguire 2010). Research shows that the communities with weak social networks tend to be more vulnerable to adverse conditions because of constrained access to locally adapted seeds compared to those communities with strong social seed networks (Poudel et al. 2005). So, this seed networks needs to be studied well and their importance in conservation of local crop diversity should be valued. Informal/social seed systems almost entirely provide the supply of seeds of traditional varieties (Poudel et al. 2015).

Farmer's initiatives and local adaptation strategies to manage crop diversity

Our current study indicates that farmers have initiated various local level adaptation practices to minimize the impacts of both climatic and non-climatic changes. The findings suggest that about 87 percent of the surveyed households reported that they practice intercropping i.e. planting two or more crops together such as growing maize and beans together. Interestingly, about 75 percent of the respondents mentioned that they carefully do the right crop and seed selection to avoid adverse conditions (Table 4). For instance, local people in Khar cultivate *Dautkhane* (local wheat variety having drought resistant) when they thought this year dry period likely to be longer. Other on farm adaptation practices (see Table 4) are changes in planting time and location, soil management, diversifying livelihoods options like depends more on off-farm work. Adopting off-farm works such as mat making, wage labor helped to earn additional income for the family to cope with such changes.

Similar study carried out by Ajani et al. (2013); Unruh (2004); Bellon (2008) also shows that diversification of crop varieties is one of the potential adaptation options to reduce vulnerability to climatic and non-climatic variability and changes. It is also common to other parts of Nepal where farmers increase the crop diversity to reduce such adverse effects (Poudel et al. 2015; Rana et al. 2007). Policy incentives to cultivate the new modern variety sometimes forced farmers to grow only a single variety which is also contributing in reducing crop diversity on farmer's field (Di Falco and Perrings 2005). In these contexts, it is better to encourage farmers to use more local crop varieties to grow diverse crops in their farm rather than providing incentives and reward to those farmers who grow only one or two crops in commercial scale.

Looking at the various strategies and practices that the farmers are practicing indicates that farmers in the study sites are very cautious about the changes and are constantly looking for the ways to adapt such changes. However, the study also documented that they have limited access of information and materials of the crop varieties grown widely. Furthermore, the scientific information about the weather and climate forecasting are rarely available. Therefore, there is a need of balanced approach where farmer's local knowledge and practices as well as scientific knowledge and practices blend together for the best output.

Table 4: Local level initiatives adopted by farmers to minimize the impacts of changes (anthropogenic and climatic)

Local level initiatives adopted to minimize impacts of anthropogenic and climate changes	Yes	No
Planted different crops together	86.8*	13.2
Changes in cropping systems	34.1	65.9
Changed planting locations of crops	67.6*	32.4
Changed planting time	50	50
Kept more livestock, instead of depending on crops	60.4*	39.6
Planted trees	52.2*	47.8
Done more water harvesting	6.6	93.4
Done more off-farm work, instead of farming	73.6*	26.4
Soil management	69.8*	30.2

Note: * represents the percentage above 50.

CONCLUSION

The present study focuses on the local crop diversity and its management by the farmers in Kailash Sacred Landscape area of far-western Nepal. The crop diversity in farmer's field is high with higher varietal diversity in major crops like maize, paddy, wheat, finger millet and barley. These diversity could be considered as potential units for maintaining species as well as varietal diversity and conserving the important plant genetic resources for food, nutritional as well as cultural security. However, a number of varieties as well as the species are being lost and threatened due to anthropogenic and climate drivers of change. Despite genetic erosion happening, local people are initiating a number of adaptation strategies and practices to minimize the loss. Self-conserved seed contributed as the major source of planting material followed by exchange of seeds and information with neighbors.

Awareness raising among and between the farmers are necessary. Local level crop diversity fair and other cultural fair enhance farmers' understanding about the status as well as the importance of their own varieties maintained by them. It also provides information about the seed source within the community. So, such events should be organized in the accessible areas where farmers can participate and benefit from cross-exchange.

Strengthening the local seed supply system of the local crop varieties is very important for the on-farm management of crop diversity in the village. It is also important to constantly monitor the changes of the crop varietal diversity. This is important particularly to those threatened crop species with its associated reasons. Informal as well as the formal network should be established between community people and ex-situ conservation. The species that are threatened could be placed in a national gene bank under the National Agriculture Research Council.

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COMPETITION AMONG WILD RICE, LANDRACE, IMPROVED CULTIVAR AND F_1 HYBRID RICE

Bal Krishna Joshi[1], Sanjaya Gyawali[2], Surya Narayan Sah[1] and Rewati Raman Chaudhary[1]

ABSTRACT

Four genotypes, namely Oryza rufipogon, F_1 of IR68888A/Chaite-6, Chaite-6 and Ratodhan were grown in crop and competition environment at Rampur, Nepal to study the effect of genotypes mixture on the characters. Univariate, multivariate and correlation methods of analysis were applied. Seven characters namely panicle length, panicle number, grain yield, harvest index, internode length and leaf width showed significantly different response in crop and competition environment. The performance of cultivar was poor in competition environment than hybrid and wild rice. Hybrid and wild rice showed longer panicle length in competition environment. Significant reduction in panicle number was found in cultivars. The pattern of tiller number over the growth period showed that the competition started after 50 days of seeding. Grain yield of cultivars was significantly reduced in competition environment. Considering the most important characters, hybrid was best competitor and local landrace (Ratodhan) was poorest competitor. Significant variations in culm characters were not found between two environments but leaf characters varied significantly. Highest increment in plant height was found in F_1 grown in competition than crop environment. Relationship between characters was affected by growing environment. Among 162 pairs of characters r-value of six and 36 pairs were highly significant different from zero in crop and competition environment respectively. Multivariate analysis indicates that growing environment does not suppress the genetic characters. Competition among the tested genotypes exists even in the recommended spacing. Competition should be studied in detail planting at different spacing.

Keywords: Crop environment, competition environment, mixture, grain yield, rice

INTRODUCTION

Rice is the principle crop in Nepal where different kinds of landraces as well as wild species are found. Nepalese farmers have been practicing the mixture of different landraces. In the survival capacity of the genotypes, many factor e.g. types of neighbors, resources availability, abiotic and biotic stresses play important roles. Growing environment is also equally important in the expression of characters in genotypes. Since genotypes are generally evaluated under several environmental conditions, the differential competing abilities of genotypes under different environments inflate the genotype · environment interaction (Frey, 1983). Sakai (1955) concluded from a study of paired mixtures of six rice varieties that variation in plant characters due to competition effects must be considered in the estimation of heritabilities. In a soybean mixture of

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three cultivars, Muraw and Weber (1957) showed that within five years of propagation, Bavender special, an unadapted profusely branching type constituted 70% of the mixture, where as Adams a well adapted cultivar had been eliminated. Jennings and de Jesus (1968) studied the survival of five rice cultivars in a mixture and found that TN1, Ch242 and M6, non-tillering and short cultivars were practically eliminated from the mixture in a year of propagation. Whereas BJ and MTV, tall leafy cultivars dominated yield. Abilities of these fine cultivars in pure stands were exactly inversed to their capabilities to survive in mixtures. Competition among homozygous genotypes indicates that adapted varieties are highly competitive against unadapted types (Allard, 1960). For mixtures the relationship between competitive ability and yield in pure stands has been showed to be negative (Sunsen, 1949; Sakai and Gotah, 1955; Schutz and Brim, 1967). Harlen and Martini (1938) suggest that agronomically poor types are also poor competitors. Most study on competition has been done on inter-varietal mixture to know the survival capacity. Here diverse genotypes were taken to study on the survival capacity of species mixture, and the competitiveness of different genetic make-up individual.

MATERIALS AND METHODS

A field study was conducted at the Institute of Agriculture and Animal Science (IAAS), Nepal (224 m above sea level, 84°29'E and 27°23'N) in two types of environment, crop and competition environment (Fasoula and Fasoula, 1997). Four different genotypes (wild rice: *Oryza rufipogon*, local cultivar: Ratodhan, improved cultivar: Chaite-6, and F_1 hybrid: IR68888A/Chaite-6) were grown in crop environment of having the plot size 1.2 m · 1.2 m and 20 cm · 15 cm spacing. Four types of genotypes mixture (wild rice + IR68888A/Chaite-6, wild rice + Chaire-6, wild rice + ratodhan and Chaite-6 + IR68888A/Chaite-6) were grown in the same spacing of crop environment in competition environment. In mixture plot, two genotypes were planted in alternate rows. F_1 seeds were produced using the CMS line IR68888A and cultivar Chaite-6 as procedure described by Joshi (1999). Being felt difficulty to get seed of wild rice, about 300 tillers of plant were collected from Maidi Tal, Kaski, Nepal, and these tillers had been directly transplanted in the field. Random selection was made for others genotypes. Ratodhan were collected from the Germplasm Center of IAAS, Chaite-6 from National Rice Research Program (NRRP), Hardinath and IR68888A from IRRI, Philippines.

Nursery of all experimental material except wild rice had been developed in greenhouse at tray. Only compost was used as manure in nursery beds. Pre-germinated seeds were planted as randomized plan that was done using MSTAT-C. Eighteen days old seedlings were transplanted one seedling per hill in the field, which was fertilized @ 100:60:60 kg $N:P_2O_5:K_2O$ ha^{-1}. Field was laid out in RCBD with two replications. Standard agronomical practices were followed. Data on following observations (Table 1) were recorded from the central two rows of each plot as described in IRTP (1980).

Table 1: Evaluated characteristics in rice genotypes

SN	Code for character	Parameter measured
1.	DTF	Days to 50% flowering

2.	DTM	Days to maturity
3.	PlHt	Plant height, cm
4.	PanNo	Panicle number per 2 rows
5.	SpkNo	Spikelet number per panicle
6.	Fert	Fertility, %
7.	GrY	Grain yield per 2 rows, g
8.	1000-gr	1000-grain weight, g
9.	StrY	Straw yield per 2 rows, g
10.	HI	Harvest index, %
11.	CulL	Culm length, cm
12.	CulD	Culm diameter, cm
13.	NdsNo	Nodes number per plant
14.	IstIntL	First internode length, cm
15.	LstIntL	Last internode length, cm
16.	PanL	Panicle length, cm
17.	LfShL	Leaf sheath length, cm
18.	LfBlL	Leaf blade length, cm
19.	LfW	Leaf width, cm

STATISTICAL ANALYSIS

Genotypes grown in crop and competition environment were used as different entry to compare the performance among genotypes in two environments. Analysis of variance and mean separation using DMRT were done to test the effect of environment on yield and other characters. Contrasts for crop vs. competition environment were also calculated for each character. Correlations among 18 characters were estimated. Major concern to estimate correlation was to know the effect of environment in association of different characters. Grouping was done using the Euclidean distance methods of clustering to know the environment effects considering multiple characters. Percentage contribution of four rice genotypes in grain and straw yield was estimated for both environments. Tillering and plant height development pattern over the growth period were studied. MINITAB 12, MSTATC and MS-Excel were used to analyze the data.

RESULTS AND DISCUSSION

Means and contrast information of four different genotypes grown in two environments for 22 characters are given in Table 2. All the mean squares except for days to maturity were highly significant different. But contrast information indicates that only seven characters namely panicle length, panicle number, grain yield, harvest index, internode length and leaf width showed significantly different response in crop and competition environment. Generally the performances of commercial cultivars were poor in competition environment than hybrid and wild rice.

Table 2: Mean and contrast information of four different genotypes grown in crop and competition environment

a. Agronomical characters

Entry	DTF	DTM	PlHt	SpkNo	PanL	PanNo	Fert	GrY	1000-grwt	StrY	HI
Crop environment											
F_1	76de	114	75.50f	112bc	21.90bcd	107bc	7.715c	19.00e	18.55cde	305.0c	5.130b
Chaite-6	85b	114	84.50ef	97bc	21.30cd	114bc	82.21ab	165.0ab	20.10bc	208.0cde	30.31a
Ratodhan	81c	111	120.0cde	110bc	21.30cd	100cd	93.38ab	194.5a	21.20ab	175.5de	33.76a
OR	95a	129	170.5ab	72bc	18.30e	183a	96.43a	54.08de	16.66e	607.0a	7.390b
Competition environment											
OR + F_1											
OR	95a	129	195.5a	78bc	20.30cde	165a	94.53ab	50.70de	16.66e	541.0ab	7.865b
F_1	75de	114	102.5def	127b	24.30ab	67e	3.305c	12.00e	17.52de	271.5cd	3.815b
OR + Chaite-6											
OR	95a	129	140.0bcd	48c	21.20cd	135b	94.79ab	25.52de	16.67e	523.5ab	4.595b
Chaite-6	82bc	114	81.00ef	89bc	19.50de	73de	80.82b	69.00d	20.00bc	92.00e	29.60a
Chaite-6 + F											
Chaite-6	81bc	114	85.00ef	97bc	20.90cde	87cde	81.91ab	124.5bc	22.30a	153.0de	29.51a
F_1	74e	114	115.0def	226a	26.00a	111bc	10.95c	32.50de	19.10bcd	448.5b	5.810b
OR + Ratodhan											
OR	95a	129	157.0bc	65bc	22.00bcd	167a	93.26ab	42.40de	16.66e	533.5ab	6.780b
Ratodhan	78cd	111	112.5def	109bc	22.50bc	69e	83.77ab	116.0c	21.00ab	127.5e	31.63a
P value	0.00	>.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

CV, %	1.81	0.00	13.69	26.60	5.39	10.67	8.96	26.56	4.90	15.65	14.77
Contrast, Crop vs. competition environment											
SS			638.0	261.3	10.26	1430	21.66	12840	0.806	808.5	93.88
P value			0.15	>0.05	0.02	0.01	>0.05	0.00	>0.05	>0.05	0.00

Means followed by the same letter/s are not significantly different at 0.05 level using DMRT. F_1 = IR68888A/Chaite-6, OR = Oryza rufipogon, SS = Sum of square, CV = Coefficient of variation.

b. Culm and leaf characters

Entry	CulL	CulD	NdsNo	IstIntL	LstIntL	AvIntL	LfShL	LfBlL	FLL	Bl/Sh	LfW
Crop environment											
F_1	53.60f	1.270bc	3b	2.67d	24.17d	13.41d	28.70b	54.60de	83.30cde	1.90cd	0.86bcd
Chaite-6	63.20ef	1.350abc	4b	2.66d	32.67c	17.67c	29.00b	56.10cd	85.10cde	1.93cd	0.76cd
Ratodhan	98.70cde	1.640a	4b	4.66c	31.67c	18.17c	28.20b	62.90bc	91.10bc	2.23a	0.78cd
OR	152.2ab	1.290bc	8a	5.50bc	48.50b	27.00b	28.88b	56.75cd	85.63cd	1.96bcd	0.72d
Competition environment											
OR + F_1											
OR	175.2a	1.280bc	8a	7.83a	53.50ab	30.67a	28.60b	52.50de	81.10de	1.83d	0.75cd
F_1	78.20ef	1.400ab	4b	1.67d	35.00c	18.33c	32.80a	65.10b	97.90b	1.99bcd	0.80bcd
OR + Chaite-6											
OR	118.8bcd	1.320abc	7a	6.83ab	54.50a	30.67a	26.90b	48.70e	75.60e	1.81d	0.76cd
Chaite-6	61.50ef	1.040c	4b	1.50d	30.50c	16.00c	26.40b	52.95de	79.35de	2.00bcd	0.80bcd
Chaite-6 + F_1											
Chaite-6	64.10ef	1.260bc	4b	1.33d	35.17c	18.25c	27.00b	54.40de	81.40cde	2.01bcd	0.90abc
F_1	89.00def	1.380abc	4b	1.66d	32.33c	17.00c	35.10a	72.20a	107.3a	2.05abc	0.95ab
OR + Ratodhan											
OR	135.0bc	1.230bc	7a	7.83a	50.00ab	28.92ab	28.00b	50.90de	78.90de	1.82d	0.81bcd
Ratodhan	90.00def	1.470ab	4b	1.83d	30.83c	16.33c	26.80b	57.40cd	84.20cde	2.14ab	1.01a
P value	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
CV, %	17.0	10.72	19.2	19.43	6.33	4.91	5.06	5.15	4.72	4.20	7.62
Contrast, Crop vs. competition environment											
SS	486.9	0.043	2.08	0.02	190.72	46.6	0.35	3.57	1.69	0.014	0.023
P value	0.21	0.17	0.17	>0.05	0.00	0.00	>0.05	>0.05	>0.05	0.18	0.03

Means followed by the same letter/s are not significantly different at 0.05 level using DMRT. F1 = IR68888A/Chaite-6, OR = Oryza rufipogon, SS = Sum of square, CV = Coefficient of variation.

F_1 hybrid had longest panicle length grown in mixture with Chaite-6. Hybrid and wild rice showed longer panicle length in competition environment but panicle length of cultivars was decreased in competition environment. Wild rice had highest number of panicle in mixture of Ratodhan followed by in combination with hybrid. Tillering capacity of wild rice was found highest. Rooting from each node in wild rice helped to increase the number of tillers. In crop environment wild rice had highest panicle number across the environment, it indicated that wild rice did not get any benefit grown in other genotypes for that characters. Significant reduction in panicle number was found in cultivars. More tillering of F_1 and wild rice in mixture (Figure 1) indicated that these are more competitive than cultivated cultivars for resource utilization. The pattern of tiller number over the growth period showed that the competition started after 50 days of seeding. All genotypes yielded less in competition than crop environment. Low grain yield was observed in hybrid and wild rice in both environments because of low spikelet fertility rate. Ratodhan yielded highest grain in crop environment and Chaite-6 in competition environment. Improved cultivar was found high yielder than local landraces. But grain yield of cultivars was significantly reduced in competition environment. Considering the grain and straw yield hybrid was best competitor (Figure 2) and local landrace (Ratodhan) was poorest competitor. There are different reports on the grain yield of crop in mixture. Soybean varietal blends, according to Probst (1943) were not superior in yield to the best variety. In soybean trials Hinson and Hanson (1962) found no yield superiority for blends over the best variety but within the mixtures certain varieties yielded more at the expense of others. For corn, Stringfield (1927) found no difference in yield, moisture content at harvest, percentage of root lodging, or percentage of broken stalks in mixtures compared with pure stand of similar or dissimilar hybrids.

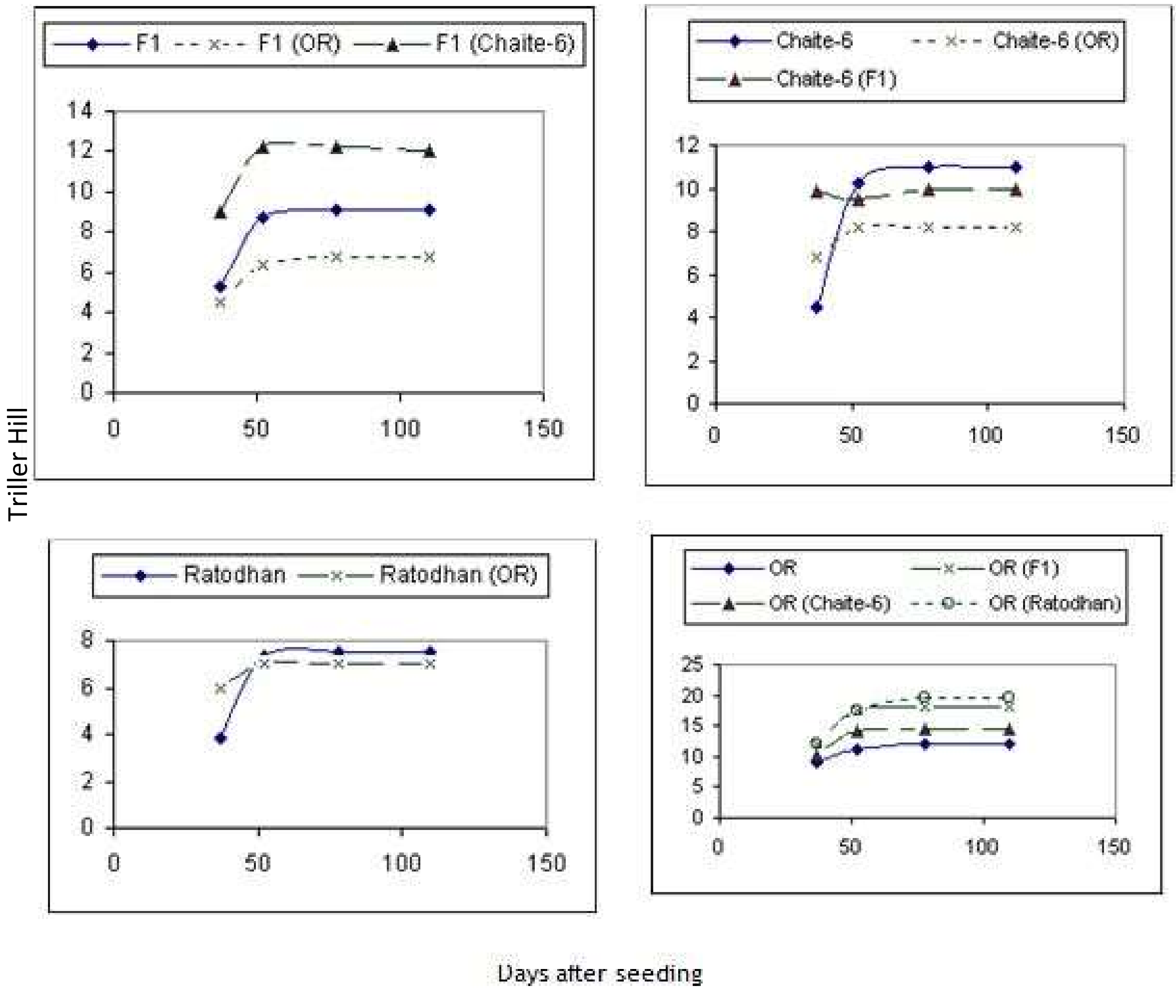


Figure 1: Triller number per hill counted in different dates of seeding of rice genotypes grown in crop and competition environments. Mixture genotypes are indicated in parenthesis. OR = 0. rufipogon, F1 = IR68888A/Chaite - 6.

Significant increment in length of internodes was found in hybrid grown in competition compared to crop environment. Significant variations in culm characters were not found between two environments but leaf characters varied significantly. The flag leaf width and flag leaf length did not show much variation except for wild rice across the environments. The nodes per panicle were double in wild rice as compared to other genotypes and wild rice has highest internode length for both crop and competition environment. Neighbor effect was not only in grain but other agronomical as well as morphological character were also affected. Little variation was found in hybrid and wild rice for plant height (Figure 3). Highest increment in plant height was found in F_1 grown in competition than crop environment. Plant was varied after 50 days of seeding which support the statement of competition start at latter stage of development. Plant height and tillering ability were two obvious traits of importance to survival of rice in mixtures. What is most obvious from the study of survival of cultivars in mixtures is the lack of a positive relationship between yield and ability to survive. Jennings and Aquino (1968) determined that, even though competition between tall and short rice plant did not begin until 50-60 days after germination tall plants had vigorous vegetation, a decided competitive advantages for light interception.

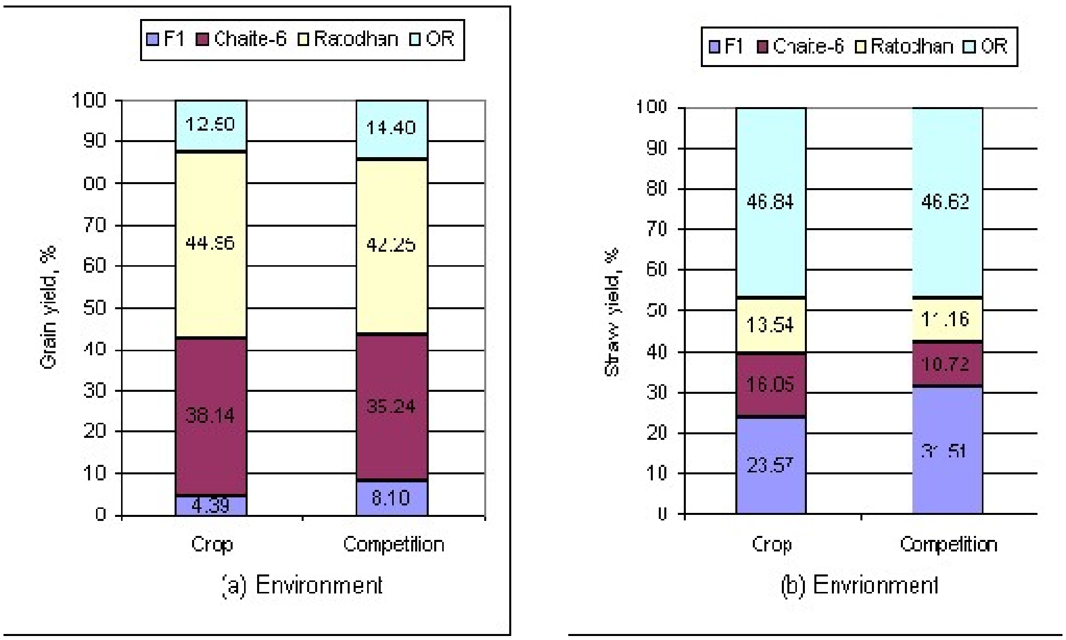


Figure 2.Percentage contribution of four rice genotypes in grain (a) and straw (b) yield grown in two environments. OR= *O. rufipogon*, F_1=IR68888A/Chaite-6.

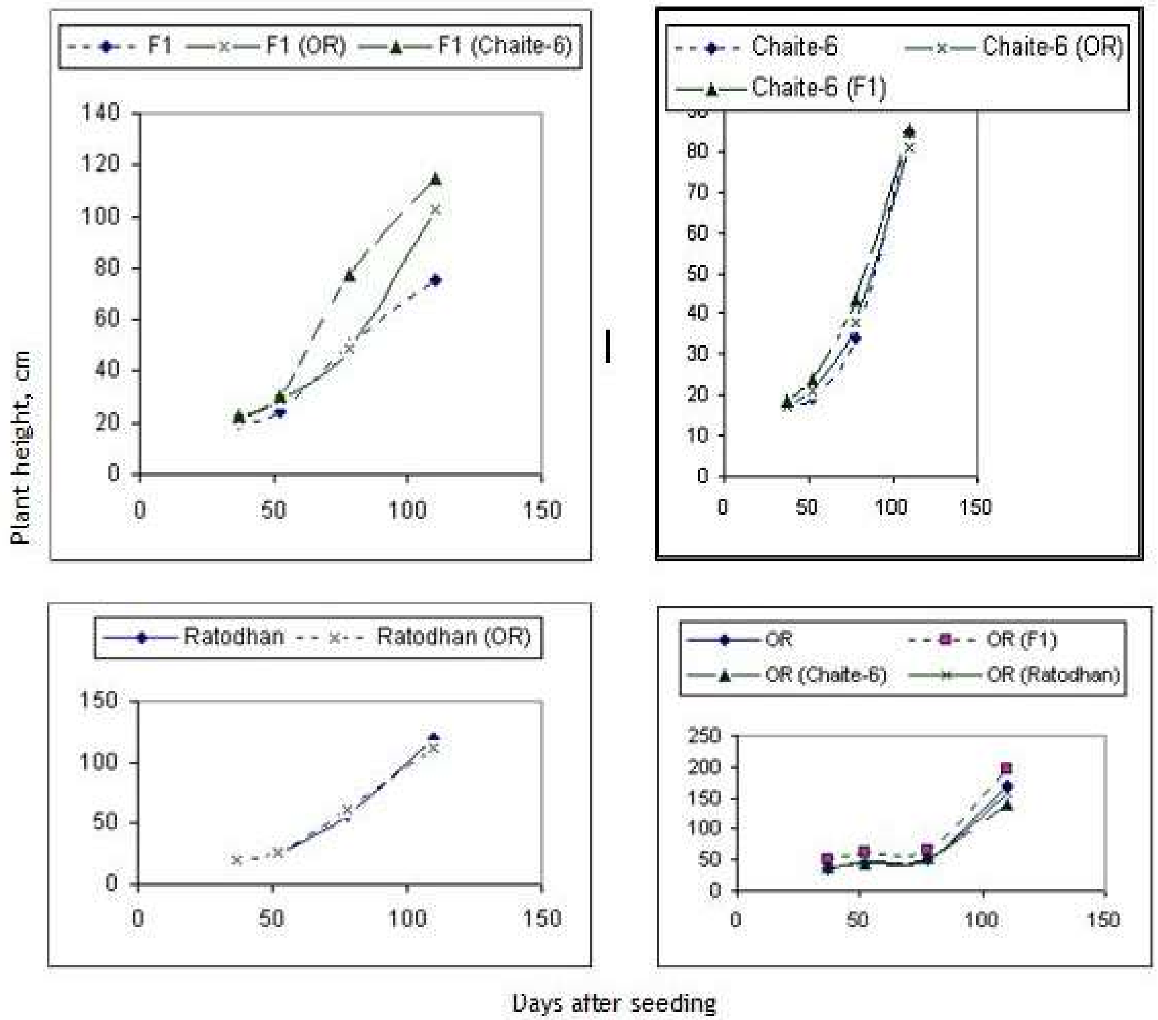
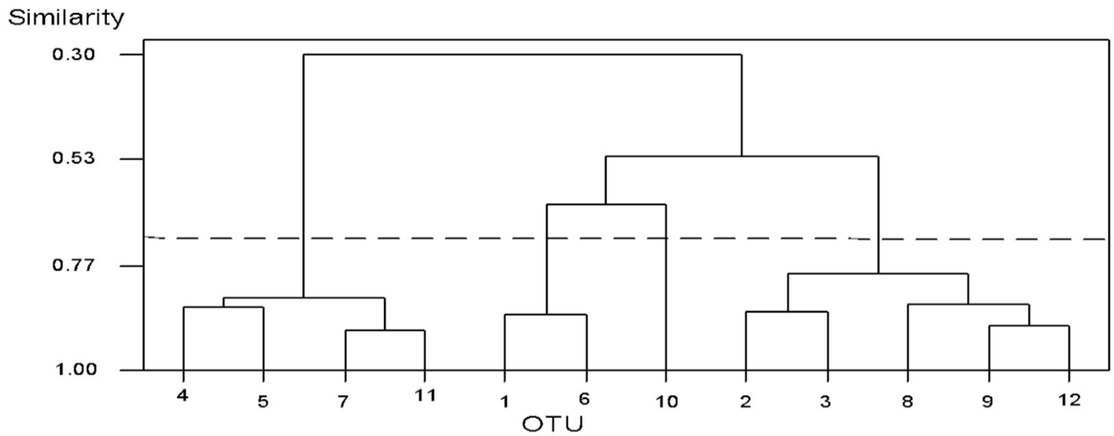


Figure 3: Trend of plant height of rice genotypes grown in crop and competition environments

Mixtures of genotypes are indicated in parenthesis. OR= *O. rufipogon*. F_1= IR68888A/Chaite-6.

Correlation matrix of 18 characters measured in crop and competition environment are given in Table 3. Relationship between characters was affected by growing environment. Among 162 pairs of characters r-value of six and 36 pairs were highly significant different from zero in crop and competition environment respectively. The negative association was found in 14 pairs of characters in crop environment and 22 pairs in competition. Similarly, 23 pairs showed positive association in crop environment and 12 pairs in competition environment. In both environments 69 pairs were not significant different from zero but non-significant pairs were 115 in crop and 75 in competition environment. Spikelet number was negative to grain yield in competition. This might be due to the high spikelet sterility. Thousand grains weight was negative association with fertility in competition, which may be due to the size of grain. The r-value for yield and yield components was similar for both environments. More variation in r-value was found in leaf and culm characters among the environment. Multivariate analysis indicated that growing environment did not suppress the genetic characters (Figure 4). Distinct three groups were obtained by cluster analysis using 21 variables. The group was based on the genetic make up i.e. wild rice, hybrid and cultivated cultivars.

Figure 4. Dendrogram obtained by cluster analysis using 21 variables measured in four different rice genotypes. 1=F_1, 2= Chaite-6, 3= Ratodhan, 4= WR, 5= WR (F_1), 6= F_1(WR), 7= WR (Chaite-6), 8= Chaite-6 (WR), 9= Chaite-6 (F_1), 10= F_1 (Chaite-6), 11= WR (Ratodhan), 12= Ratodhan (WR).



In mixture the tallness of the plant is the important characters to give better performances (Pendleton and Seif, 1962). Here wild rice had highest plant height but due to lodging problems it did not perform well. Due to erectness and long culm of F_1 hybrid, its performance was good in mixture. Result indicated that for mixture planting best combination should be considered otherwise competitiveness would result in poor benefit. During the selection pressure considering the correlation, it is equally important to consider the growing environment. Wildness and perenniality of the wild rice make them more competitors. Generally F_1 rice hybrid showed the heterosis for yield and other characters. This might be due to the more competitiveness for resources available. Competition among the tested genotypes existed even in the recommended spacing. Competition should be studied in detail planting at different spacing.

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Table 3: Correlation matrix of 18 characters measured in crop (first row) and competition (second row) environment

	DTF	DTM	PlHt	PanNo	SpkNo	Fert	GrY	1000-grwt	StrY	HI	CulL	CulD	NdsNo	IstIntL	LstIntL	PanL	LfShL	LfBlL
DTM	0.87** 0.94**																	
PlHt	0.82* 0.71**	0.78* 0.80**																
PanNo	0.89** 0.79**	0.96** 0.90**	0.74* 0.82**															
SpkNo	-0.77* -0.73**	-0.73* -0.55*	-0.68 -0.24	-0.63 -0.23														
Fert	0.71* 0.74**	0.32 0.52*	0.66 0.35	0.39 0.43	-0.38 -0.73**													
GrY	-0.04 -0.20	-0.51 -0.42	-0.08 -0.30	-0.39 -0.32	0.29 -0.04	0.64 0.46												
1000-grwt	-0.57 -0.57*	-0.87** -0.75**	-0.49 -0.67*	-0.79* -0.63*	0.63 0.24	0.15 -0.02	0.81* 0.68**											
StrY	0.75* 0.62**	0.97** 0.82**	0.72* 0.80**	0.92** 0.88**	-0.68 -0.06	0.13 0.08	-0.65 -0.58*	-0.94** -0.75**										
HI	-0.14 -0.32	-0.59 -0.60*	-0.19 -0.54*	-0.48 -0.57*	0.35 -0.08	0.56 0.37	0.99** 0.88**	0.88** 0.79**	-0.74* -0.83**									
CulL	0.83* 0.73**	0.79* 0.81**	1.00** 0.99**	0.75* 0.82**	-0.69 -0.27	0.66 0.40	-0.09 -0.27	-0.51 -0.66**	0.72* 0.78**	-0.20 -0.51*								
CulD	-0.16 -0.25	-0.43 -0.15	-0.01 0.12	-0.29 -0.04	0.44 0.46	0.36 -0.29	0.71* 0.07	0.54 0.01	-0.42 0.12	0.65 -0.15	-0.01 0.09							
NdsNo	0.95** 0.84**	0.94** 0.88**	0.91** 0.75**	0.93** 0.82**	-0.74* -0.50*	0.60 0.50*	-0.22 -0.31	-0.68 -0.65**	0.87** 0.70**	-0.33 -0.49	0.92** 0.76**	-0.20 -0.05						
IstIntL	0.64 0.92**	0.57 0.97**	0.81* 0.79**	0.64 0.88**	-0.36 -0.58*	0.59 0.54*	0.08 -0.39	-0.36 -0.71**	0.58 0.78**	-0.06 -0.56*	0.82* 0.79**	0.46 -0.13	0.74* 0.92**					
LstIntL	0.96** 0.88**	0.88** 0.96**	0.91** 0.81**	0.86** 0.85**	-0.78* -0.55*	0.70* 0.50*	-0.08 -0.36	-0.59 -0.74**	0.79* 0.81**	-0.19 -0.58*	0.91** 0.82**	-0.13 -0.12	0.98** 0.79**	0.72* 0.91**				
PanL	-0.83** -0.52*	-0.84** -0.32	-0.73* -0.18	-0.87** -0.15	0.58 0.68**	-0.47 -0.79**	0.21 -0.39	0.70 -0.01	-0.84** 0.15	0.34 -0.43	-0.75* -0.24	-0.01 0.52*	-0.88** -0.34	-0.80* -0.26	-0.88** -0.32			
LfShL	0.18 -0.51*	0.13 -0.23	-0.03 0.05	0.13 -0.02	-0.58 0.78**	-0.12 -0.86**	-0.23 -0.51*	-0.32 -0.20	0.20 0.30	-0.23 -0.56*	-0.03 0.01	-0.21 0.31	0.08 -0.23	-0.02 -0.27	0.09 -0.19	-0.14 0.73**		
LfBl	0.01 -0.79**	-0.27 -0.58*	0.30 -0.28	-0.24 -0.36	-0.16 0.84**	0.48 -0.89	0.54 -0.24	0.44 0.13	-0.29 -0.08	0.51 -0.22	0.28 -0.32	0.57 0.27	-0.01 -0.56*	0.36 -0.57*	0.05 -0.51*	0.13 0.78**	0.24 0.88**	
LfW	-0.60 -0.59*	-0.44 -0.63**	-0.53 -0.34	-0.43 -0.46	0.32 0.40	-0.57 -0.20	-0.23 0.51*	0.28 0.60*	-0.39 -0.37	-0.11 0.45	-0.54 -0.35	-0.34 0.23	-0.56 -0.60*	-0.63 -0.55*	-0.67 -0.55*	0.71 0.39	0.16 0.17	0.04 0.47

*, **, significantly different from zero at 1 and 5% level respectively

ASSESSMENT OF PRODUCTIVITY AND RESOURCE USE EFFICIENCY OF RICE UNDER DIFFERENT ESTABLISHMENT METHODS AND NUTRIENT MANAGEMENT IN CHITWAN CONDITION, NEPAL

Chandika Lama[1] and Santosh Marahatta[2]

ABSTRACT

A field experiment was conducted in sub humid climate of inner terai of Nepal to determine the productivity and economics of rice under direct seeded and transplanted methods under different nutrient management in strip plot design with three replications in 2013, rainy season. The treatment consisted of three tillage methods, conventional tillage direct seeded rice, unpuddled transplanted rice and Puddled transplanted rice and five nutrient management practices Recommended Nitrogen(N), Phosphorous(P) and Potassium(K), 100:30:30 Kg NPK ha^{-1}; Leaf color chart based N + Recommended PK; Farmers' Practice, 48.30:34.50:0.00 Kg NPK ha^{-1}; 0N + Recommended PK and 150% of Recommended NPK. The result revealed that grain and straw yield were not significant due to crop establishment methods. LCC based N application yield was comparable with 150% of Rec. NPK and Rec. NPK. Saving N on LCC based N management with 41.56 Kg ha^{-1} and 9.44 Kg N ha^{-1} over 150% of recommended NPK recommended NPK respectively. Adoption of CT-DSR reduced the total cost of cultivation by 30.13% and B:C ratio by 45.95% over P-TPR. The lower cost, higher benefit and the same production, revealed that LCC based N management under CT-DSR was the best management practices over the conventional P-TPR.

Keywords: Conventional Tillage Direct Seeded Rice (CT-DSR), unpuddled transplanted rice (UP-TPR), Puddled transplanted rice (P-TPR), recommended (Rec.), Leaf color chart (LCC),

INTRODUCTION

Rice (*Oryza sativa L.*) is the most important food, consumed by half of the world's population. It is staple food of 90% of Asian population and gaining staple value in Latin America and Africa (IRRI, 2015a). In Asia food security is equivalent to rice security. Globally it is grown in 158 million hectares, producing more than 700 million tons annually and nearly 640 million tons of rice is grown in Asia which is 90% of the global production (IRRI, 2015b).

Rice in Nepal is economically important as it has the highest growing area (1.42 million ha, 46% of the total cultivated land) among all the agricultural commodities (MoAD, 2013/14). Share of rice is 20% to the agriculture gross domestic product (GDP) and contributes nearly 50 % of the calorie requirement of Nepalese people (NARC, 2007).

Although rice is major crop of Nepal, the productivity is very low (3.17 t ha^{-1})(MoAD, 2013/14) in Nepalese condition compared to other major rice growing countries and areas (China, 6.72 t ha^{-1} and India 3.61 t ha^{-1}) (IRRI, 2014). It is estimated about 503-544 million tones is to be required by 2030 which requires 1% increase per year by keeping 2010 as the base year (FAO, 2014) globally. The possibility of expanding the area under rice in future is very limited. Therefore, the required extra production has to come through increase in productivity. The major challenge of low yield is to achieve this gain with less water, labor, and chemicals, ensuring long-term sustainability

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(Kumar and Ladha,2011) . Agronomic management and technological innovations are needed to address these issues at present.

Rice is commonly grown by transplanting seedlings into puddled soil. Major Asian countries like Malaysia, Philippines, Thailand and Mekong Delta are thus transferring traditional transplanting of rice (TPR) to direct seeded rice (DSR) which has marked shift of establishment method (Pandey & Velasco, 2002).

Nutrient management is another issue regarding the increased productivity. Among the entire macro nutrient Nitrogen is assimilated in higher amount by plants being almost yield-limiting nutrient in rice and rice based cropping system (Ladha & Reddy, 2003). After green revolution the use of nutrient has been increasing with the highest use of Nitrogen among all which accounts 72% of relative consumption of N, P and K (Ladha, Pathak, Krupnik, Six & Kessel, 2005).

Nitrogen dynamics in puddled rice have been extensively studied (De Datta & Buresh, 1989). Mineral N dynamics in dry land preparation may differ from those in puddling and continuous flooding. In puddled anaerobic conditions, ammonium nitrogen (NH_4^+-N) is available (Reddy ,Patrick & Broadbent, 1984), while under aerobic conditions N is available in the form of nitrate nitrogen (NO_3^--N) (George *et al.*,1992). Increased accumulation of NO_3^--N in the soil profile increases the potential for N leaching to shallow water tables (Al-Kaisi & Licht, 2004). Further, the frequent aerobic-anaerobic phases promote N losses by denitrification (Vlek & Byrnes, 1986). The poor utilization efficiency is further favored by insufficient splitting of N with use of N in excess amount (Singh, Sharma & Prasad, 2001). The nutrient requirement of the dry land preparation is drastically differ from the conventional puddling and flooding due to differential nutrient cycle. Thus, availability of mineral N (NO_3^-- and NH_4^+-N) in the soil and the rate of uptake by rice may differ across tillage practices. If proper splitting can be followed considering the growth stages the loss can be minimized significantly. Thus synchronizing supply of N with crop demand depending on its growth habit and duration will ultimately optimize N use efficiencies and reduce N losses. In this regard, improved technology regarding the higher N use efficiencies should be directed towards the identifying nitrogen need through LCC (Balasubramanian, Ladha, Gupta, Naresh, Mehala, Singh & Singh, 2003)and maximizing uptake and reducing the transformation losses (De Datta, 1986) being a potential solution.

OBJECTIVE

- To assess the effects of different nutrient management on growth and yield of rice established on conventional tilled dry direct seeded and puddled and unpuddled transplanted rice,
- to evaluate the yield and economic performance of conventional tilled dry direct seeded and puddled and unpuddled transplanted rice, and
- to evaluate the nutrient use efficiencies of conventional till dry direct seeded and puddled and unpuddled transplanted rice.

THEORETICAL FRAMEWORK

Cultural practices of rice

Puddling is common traditional method of establishment of rice. It is most commonly operated in wetland by transplanting in the prepared land after irrigating the field. Unpuddled transplanting is quiet laborious and energy consuming method of rice establishment resulting into high cost of production compared with transplanted rice. Production is also low compared with transplanted rice (De Datta, 1981). Its' adoption seems to be non-profitable in most of the cases.

Direct seeded rice (DSR) refers to the process of establishing a rice crop from seeds sown in no till or conventional till field rather than transplanting young seedlings from the nursery to main field. There are three principal methods of Direct seeded rice (DSR) :dry seeding, wet seeding and water seeding. Direct seeding of rice is gaining popularity in Asian countries (Kumar & Ladha, 2011). The major drivers of DSR from transplanted rice are water and labor scarcity.

Nitrogen management

There was increase in plant height with increase in the N applied (Manzoor, Awn, Zahid & Faiz., 2006). According to Patil, Singh, Singh, Mishra, Das, and Henao (2001) all growth parameters, yield, yield associated attributes and N accumulation are significant to N levels at all three years of experiments in DSR, whereas thousand grains weight were non-significant to N levels. According to him the grain yield was significantly responsive to applied N up to 120 Kg N ha^{-1} in direct seeded rice.

Timing is critical factor in N application. The growth and development in rice plant are periodic thus proper timing not only reduces the cost involved for nutrient management but also enhanced yield. Early application of N contributes to the root development. Early application of N at early stage yields higher than applied at mid-season. N applied at flag leaf and heading stages result in high fertilizer N uptake and do not bring substantial increase in grain yield but protein content is increased (Marahatta,2008). Transplanting shock are common which last up to about 7days, so it is very much likely that most N applied may not be used by plant or lost (Marahatta,2008)

The grain yield and straw yield was significant to the time of application as reported by Salam *et al*. (1998). The same scientist reported that the two split applications (half at basal and half at tillering) and three split applications (½ at basal, ¼ at tillering and ¼ at panicle initiation) were significant to produce grain yield of 3.7 t ha^{-1} for both practice and 5.6 t ha^{-1} and 5.7 t ha^{-1} respectively than other practice of splitting.

Nitrogen cycle in a soil plant dynamic is influenced by soil, plant and climatic factor. This cycle involves the biochemical changes of organic and inorganic changes of Nitrogen. The Nitrogen in the soil is majorly depleted by absorption by plant, adsorption by soil colloids, losses as gases through volatilization (Sloan & Anderson, 1955)and denitrification, leaching (Fageria *et al.,*2003) and microbial immobilization (Shimpi & Savant, 1975) into the deeper layer of soil .

METHODOLOGY

The experiment was operated in the research block of agronomy farm of Agriculture and Forestry University Rampur, Chitwan from May to October, 2014. This station comes under subtropical and humid climate. The soil was sandy loam with slight acidity and had medium organic matter, phosphorous and nitrogen and low potassium.

The experiment was laid out in strip-plot design with two factors and three replications having 21 treatment combinationsfor Radha-4 improved rice variety. Two factors taken in experimentation were establishment practices in horizontal strip and nutrient management practices in vertical. Within establishment practices there were three methods: (i) Conventional dry direct seeded Rice (CT-DSR),(ii) puddled transplanted rice(P-TPR) and (iii) unpuddled transplanted rice (UP-TPR). The nutrient management practices involved seven practices: (i) recommended NPK, (ii) LCC based N + recommended PK, (iii) farmers' fertility management practice, (iv) nitrogen omission (0N + recommended PK), (v) 150% of recommended NPK, (vi) phosphorus omission (0P + recommended NK) and (potassium omission (vii) 0K + recommended NP).

Conventional Dry Direct Seeded Rice

Direct seeding of rice involved establishment of rice through seed in the field. This experiment was done through dry bed seeding method.Unpuddled transplanting is commonly practiced mechanically. The nursery raising and transplanting was done on the same day on UP-TPR and P-TPR. Puddled transplanted rice was done by transplanting the rice seedling which was 21 day old in the puddled field.

In treatments which consisted of recommended dose of nitrogen, 100 Kg N ha^{-1}, nitrogen was applied at transplanting (33.33% i.e. 33.33 Kg ha^{-1}), at tillering (33.33%) and at panicle initiation (33.33%). In LCC based nitrogen application, 25% of recommended dose (25 Kg N ha^{-1}) was applied as basal dose. The remaining nitrogen (from urea) was top dressed through LCC reading at critical value at 20 Kg N ha^{-1} in each dose. Fertilizer in farmers' fertility management practice was 48.30:34.50:0.00 Kg NPK ha^{-1}. The nitrogen was applied at transplanting (34.59 Kg ha^{-1}) and at tillering (13.71 Kg ha^{-1}). In 150 % of recommended dose, 150:45:45 Kg NPK ha^{-1} nitrogen was applied at transplanting (33.33% i.e. 50 Kg ha^{-1}), at tillering (33.33% i.e. 50 Kg ha^{-1}) and at panicle initiation (33.33% i.e. 50 Kg ha^{-1}).

RESULT

Effect of LCC readings on N fertilization in rice

The data showed that there was negligible saving of nitrogen under puddled TPR condition and required more nitrogen under unpuddled TPR and CT-DSR as compared to the recommended NPK application in LCC managed N.

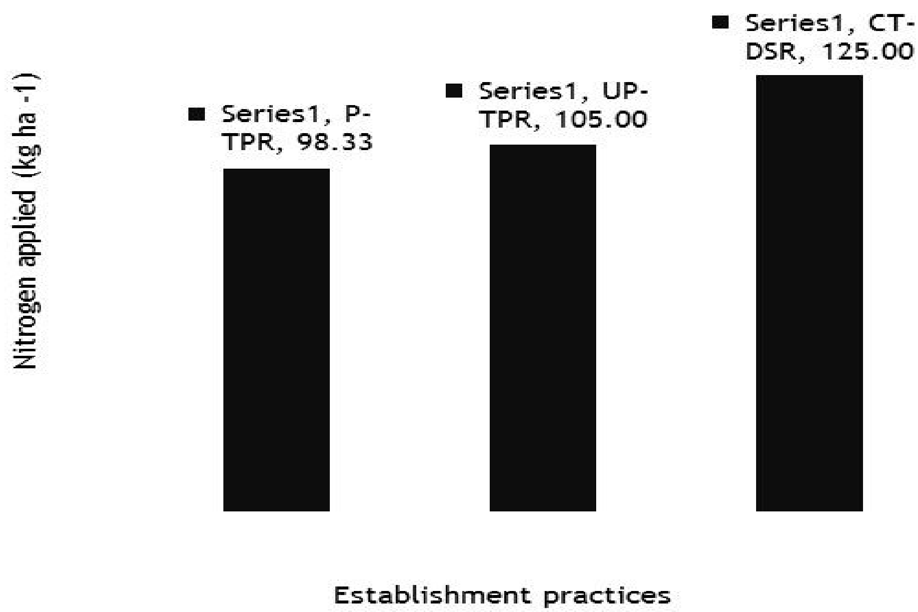

Figure 1: Amount of nitrogen applied in LCC based nitrogen management as influenced by establishment methods and crop growth stages of rice at Rampur, Chitwan, Nepal, 2014

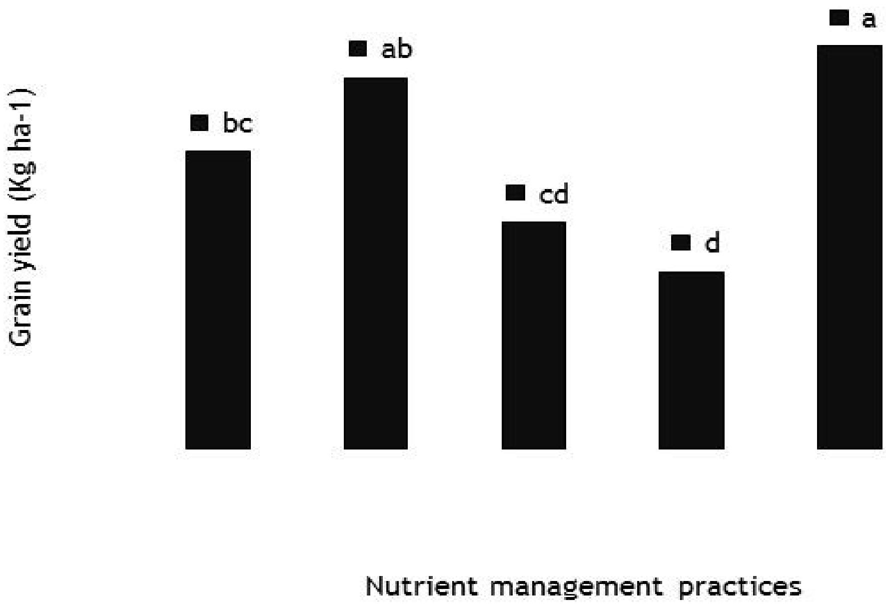

Figure 2: Grain yield (Kg ha-1) of rice as influenced by nutrient management practices at Rampur, Chitwan, Nepal, 2014

Treatments	Number of effective tillers per square meter	Number of grains per panicle	Thousand grain weight (g)
Establishment methods			
CT-DSR	196.69[a]	77	23.26
UP-TPR	163.46[b]	82.11	23.54
P-TPR	171.13[b]	86.93	23.12
Nutrient management			
Rec. NPK	185.20[ab]	82.68[ab]	23.51[ab]
LCC-N + Rec.PK	186.18[ab]	91.29[a]	24.00[a]
Farmers' practice	171.71[b]	80.44[ab]	22.66[b]
0-N + Rec.PK	142.16[c]	68.49[b]	22.43[b]
150 % Rec. NPK	200.22[a]	87.17[a]	23.94[a]

Table 1: Effect of establishment and nutrient management practice in yield attributes of rice at Rampur, Chitwan, Nepal, 2014

The interaction effect of establishment methods and nutrient management practices were not significant but the slight changes in yield under different establishment methods in different nutrient management practices were observed.

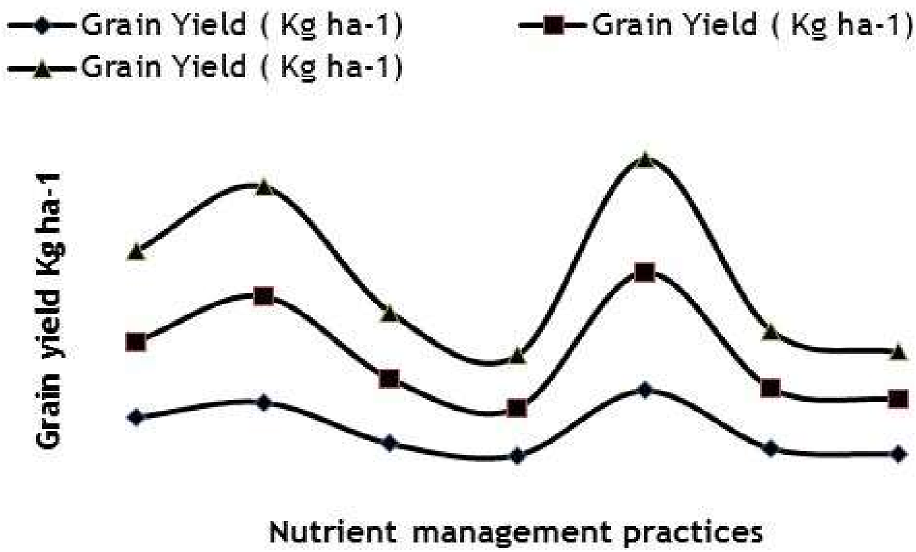

Figure No.3: Interaction between establishment practice and nutrient management practice for grain yield of rice as influenced by the rice establishment methods and nutrient management practices at Rampur, Chitwan, Nepal during 2014

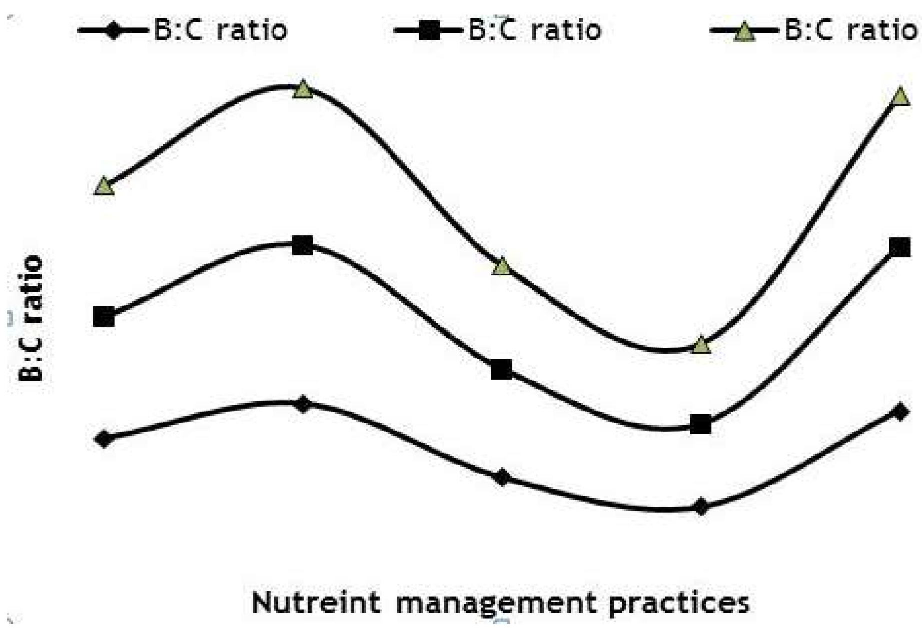

Figure No.4: Interaction between establishment practice and nutrient management practice for B:C ratio of rice as influenced by the rice establishment methods and nutrient management practices at Rampur, Chitwan, Nepal during 2014

DISCUSSION

CT-DSR had higher effective tillers compared to P-TPR by 14.94% as seeds were sown continuously in the rows in CT-DSR which increases the number of plants per unit areas resulted in more number of main culm. In aerobic condition the effective tillers in the main culm is important than secondary tiller (Fageria, 2014) recommending higher seed rate and resulting higher effective tillers. Gathala *et al*. (2011) recorded more number of effective tillers per square meter under DSR compared with TPR.

Number of grains per panicle was higher in P-TPR than CT-DSR but all these are statistically similar. Similar type of finding was reported by Sah *et al*. (2007). Leaf dry weight and stem dry weight at 105 DAS was significantly associated (r = 0.620** and r = 724**) with the number of grains per panicle. As leaf dry weight and stem dry weight both were higher under P-TPR as compared to CT-DSR resulted in higher number of grains per panicle under P-TPR. Thousand grain weight and sterility percentage both were also similar among the establishment methods but comparatively higher under CT-DSR as compared to P-TPR. Direct seeded rice produced higher number of sterile spike (Gathala *et al*., 2011), lower grain per panicle and lower thousands grain weight (Gathala *et al*., 2011) as compared to puddled TPR.

Grain yield was higher in CT-DSR compared to P-TPR and UP-TPR but not significant .Higher number of effective tillers per square meter (r = 0.66**) and slightly higher weight of unit grain (r = 0.64**) was main reason behind the higher grain yield. Straw yield was also higher for CT-DSR than UP-TPR and P-TPR. Thus the above ground biomass at harvest was also higher for CT-DSR compared to other practices. But the harvest index(ratio of b iological yield to straw yield) was lower than both the practices as straw yield was higher compared to the grain yield than both the practices. Several researchers reported DSR systems can produce similar grain yield to TPR (Mabbbayad & Buencosa, 1967). Some reports claim similar or even higher yields of DSR with good management practices (Ho & Romli, 1998).

Cultivation cost for CT-DSR was drastically reduced and significantly beneficial as compared to UP-TPR and P-TPR. The B:C ratio was significantly higher than other two practices. B:C ratio was 45% higher than traditional method of rice establishment i.e. P-TPR. Sah *et al*. (2007) reported that DSR was 51% higher in net return than P-TPR. The land preparation and transplantation cost is high in the conventional method of rice establishment due to higher labor requirement and the increasing wage rate in Asian countries. With the CT-DSR saving of 23% labor could be achieved according to Rehman *et al*. (2008). In Philippines even the labor saving could be carried out of about 40% as reported by Pandey and Velasco (1998).

Nitrogen requirement for LCC based N application under CT-DSR and UP-TPR were 27.12%and 6.78% higher as compared to P-TPR(Figure 1). Nitrogen loss through denitrification, volatilization, runoff and leaching is higher in aerobic condition than in anaerobic puddle condition (Davidson, 1991). Kumar &Ladha(2011) reported higher mineralization in aerobic soil and subsequent loss was a main cause for higher requirement of N under UP-TPR and CT-DSR as compared to P-TPR. The longer crop growth duration in the main field under CT-DSR might be a cause for high need for nutrient requirement under DSR (Kumar & Ladha, 2011) also reported the higher nitrogen requirement under dry tillage as in CT-DSR and UP-TPR than under P-TPR.

The Nitrogen requirement in LCC based N management was 109.44 Kg ha^{-1}, slightly lower as compared to recommended level. In the present experiment, rice yield was responsive till 150% of recommended N but at par with LCC based N management with the saving of 41.56 Kg N ha^{-1}. The LCC based N requirement was higher under CT-DSR followed by UP-TPR and least under P-TPR. The

LCC based N management under P-TPR was slightly lower (1.67%) as compared to recommended N. Marahatta (2008) also reported the lower amount of N requirement by 7.67 Kg ha^{-1} through LCC based N management in comparison to 100 Kg N ha^{-1} under puddled transplanted rice at Rampur.

The effective tillers per square meter were higher for 150% of recommended NPK than any other nutrient management practices (Table 1). It was higher by 7.5 and 8 % in this practice as compared to LCC based N management and recommended NPK (Table 1). According to (Fageria, 2014) tiller per square meter shows the quadratic equation and shows increasing trend up to 150 Kg N ha $^{-1}$. LCC based N management was observed to be higher in number of grains per panicle, panicle length and thousand grain weight. Number of grains per panicle was highest for LCC based N management by 8.6% and 4.12 % as compared to recommended NPK and 150% of recommended NPK respectively. Thousand grains weight was higher by 0.06 g and 0.49 g than 150% of recommended NPK and recommended NPK respectively as compared to LCC based N management. Sterility was higher in 150% recommended NPK. Ota and Yamada (1965) also reported that higher dose of Nitrogen induced sterility.

Marahattha (2008) reported higher number of grains per panicle than other nutrient management practices. Due to synchronized N application with crop demand, the recovery efficiency is high in LCC based N management. The recovery efficiency of top dressed urea during panicle initiation stage could be as high as 78% (Peng & Cassman, 1998). According to Kumara(1956), number of grains per panicle is directly related with N content in leaf blades at 1-4 week before flowering (known commonly as panicle fertilizer in Japan) and according to Wada and Matsushima (1962) effective tillers are related with N adsorbed at 17-18 days before flowering. Nitrogen was applied at every 10 days interval till flowering in LCC managed N; thus the plants' requirement was fulfilled increasing Grain per panicle and effective tillers in the experiment conducted. Top dressing at the time of spikelet differentiation leads to higher accumulation on carbohydrate at the time of heading and maturity (Sato, 1956). Thus LCC based N management till flowering is again beneficial here increasing growth of rice. Panicle fertilizer also contributes to the size of the yield container according to Murata (1969).

The grain and straw yield both were higher for 150% of recommended NPK. LCC managed + Rec. PK followed the former nutrient managed practice for both. Application of 150% of recommended NPK and LCC based N management yielded 35.19 and 24.76% higher grain yield compared with recommended NPK. As already explained, GPP, Thousand grain weight and Effective tillers have positive correlation with yield leading to higher yield in 150% of recommended NPK and sufficient and real time need application of N

LCC based N management and 150% of recommended NPK were both economically beneficial . Both of these practices were profitable by 76.81% and 88.67% compared with 3 split application of recommended N. B:C ratio was the highest for LCC based N application. It was higher by 22.38% and 1.74% than recommended NPK and 150% of recommended NPK. Maiti *et al*. (2004) also favors the use of LCC for management of rice as it is beneficial.

CONCLUSION

Direct seeding of rice under conventional tilled soil was better in terms of yield and economics as compared to transplanting in both puddled and unpuddled field. Unpuddled transplanting was also comparable to puddled transplanting. LCC based N showed the best performance in yield and economics under different nutrient management practices and comparable yield obtained along with saving of nitrogen to be applied. LCC based N application under direct seeded and transplanted rice produced higher yield and benefit enhancing the resource use efficiency under sub humid condition of Chitwan.

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COVERAGE AND ACCESS OF PLANT CLINIC IN NEPAL

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ABSTRACT

Plant clinic is one of the extension approaches that deliver field level services to farmers. In Nepal, this service started in 2008. An assessment of the coverage and access of Plantwise plant clinic in Nepal was conducted from 2013 to 2016 with the view to assess the performance of this approach. The number of plant clinic sessions and queries by farmers increased from 2013 to 2014 whereas in 2015 the numbers of both sessions and queries decreased due to the earthquake that struck the country in April 2015 and disturbances throughout the year. The average number of clinic session run per year was 10.5 and the average number of queries per session was 12. The farmers' gender ratio for female to male who visited the clinic was 45:55. The coverage and access of plant clinics is increasing, but plant clinics are not yet widespread across Nepal.

Key words: access, coverage, crops, gender, plant clinic

INTRODUCTION

The livelihood of the majority of Nepalese people and economic development of the nation are closely associated with the performance of the agricultural sector. Adoption of improved technology is, however, limited due to insufficient agriculture extension services and infrastructure support (FAO, 2010). Thus, there is low productivity and competitiveness of agricultural produces (MoAD, 2014). Low production of agricultural crops due to pests and diseases poses serious threat to food security. Negussie et al. (2011) mentioned that increasing productivity and food security among small-scale farmers requires access to effective, reliable and practical advisory and other support services that enable farmers to address the threats of pests and diseases. Various studies indicated that about 35-40% pre and post-harvest losses are caused by pests in Nepal (PPD & FAO, 2004). Thus, timely diagnostic and management strategies to combat yield loss due to pests and diseases are important aspects. Srivastava (2013) highlighted the importance of plant health security through advisory services like plant health clinics in order to prevent losses occurring from field to fork globally.

The technical service to the huge number of small land-holding farmers in Nepal is challenging and insufficient. According to the agricultural census 2011, there is one agricultural service centre under Minister of Agriculture Development for every 11,269 farmer households in Nepal (MoAD, 2016). Plant clinic is a novel approach in the agricultural extension services of Nepal. It is a demand driven extension service which focuses on diverse crops and technologies (Adhikari et al., 2013), aims to reduce the unnecessary application of chemical pesticides (Bentley et al., 2009). It links research and extension, discovers new crop problems (Boa & Harling, 2008), acts as an early warning system for new pests and diseases, supports quarantine function (Adhikari et al., 2013), provides pest surveillance function in the particular location, updates the extension service providers to solve the

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farmer's technical problems, improves quality of services and provides plant health extension services to small holder farmers. Thus, it has been gaining popularity among farmers in Nepal since its launch. The concept of plant clinic was initiated during 2008 in Nepal.Government of Nepal, MoAD, and PPD initiated the CABI led Plantwise programme in 2011 and entered into an agreement in 2013 for a structured implementation of the programme in Nepal. Presently, there are 40 regular plant clinics in different parts of the country (CABI, 2015). Regular plant clinic sessions were generally conducted every month in the same location. Besides the regular plant clinis, there are also mobile plant clinics operating in Nepal; but are not in the same location and time interval. This paper focuses only on the regular plant clinics because only these currently collect clinic data.

These days, plant clinics are endorsed by the government of Nepal, and have been integrated into the national plant protection programme. CABI, through its global Plantwise programme, is supporting plant clinic and associated activities in Nepal. CABI is an inter-governmental, International, not-for-profit organization set up by a United Nations level treaty. One of the objectives of the Plantwise programme is to enhance a country's responsiveness to agricultural threats by strengthening stakeholder linkages and feedback loops to maintain quality and relevance of advisory services. Given the difficult nature of diagnosing crop problems and giving quality advice in the field, it is necessary to examine the performance of plant clinic to deliver technical services for the farmers. Performance of plant clinic can be assessed by describing the coverage and access as well as the quality of plant health care advice. This paper highlightes the coverage and access of plant clinic between 2013 and 2016 to improve the functioning of agricultural extension services in Nepal.

METHODOLOGY

This study was conducted through plant clinic data analysis. Farmer queries at plant clinics are documented and uploaded to the Plantwise Online Management System (POMS), which is an online tool within the Plantwise knowledge bank that serves as a repository database. The plant clinic data include plant clinic code, plant doctor, date of plant clinic sessions, farmer's details including gender and location, crops, details about the plant health problem (diagnosis) and the recommendation. The data collected in Nepal from September, 2013 to July, 2016 available in POMS were used for this study. The coverage of plant clinics in terms of number and distribution of plant clinics, crops and pest problems at plant clinics and farmers' gender composition were assessed. The queries were categorized into the crop categories such as cereals, fruits, vegetables, pulse and oilseed, spices, flower etc. Number and percentage of crops in each group were calculated and were compared with national data.

RESULTS AND DISCUSSION

NUMBERS OF PLANT CLINIC SESSIONS AND QUERIES

The 25 plant clinics that entered clinic data in POMS are concentrated in the central region of Nepal (Figure 1). Thirteen out of the 25 clinics which uploaded data to POMS are located in the central region, namely Kathmandu, Bhaktapur01, Bhaktapur02, Lalitpur, Kavrepalanchok, Makwanpur, Sindhuli, Sindhupalanchok, Nuwakot, Rasuwa, Dhading, Bara and Parsa. Nine clinics are located in the western part, namely Kaski, Tanahun, Nawalparashi, Rupandehi, Palpa, Syangja, Kapilbastu, Aarghakhachi, and Pyuthan, and 3 in the eastern part of the country, namely Jhapa, Morang and Sunsari districts.

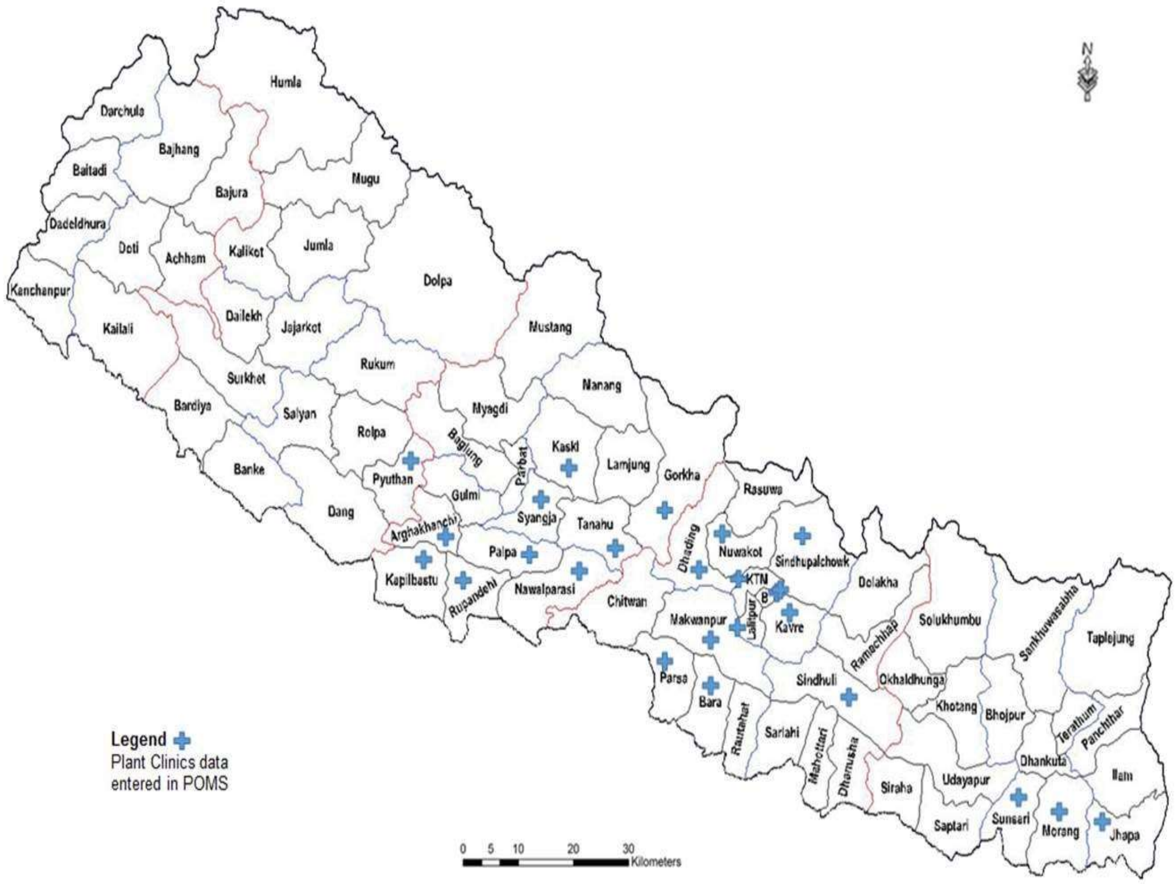

Figure 1: Map of plant clinics in Nepal based on plant clinic data entered in POMS

The coverage of plant clinic in Nepal by Plantwise in terms of number of regular plant clinics increased from 2013 to 2015 (Figure 2). Seven plant clinics were established in 2013, 16 in 2014 and 2 more in 2015. The regular plant clinics operated once in a month in their designated locations. Over the study period, a total of 265 plant clinic sessions were run and 3268 queries made by 1754 farmers (Annex 1). The average number of queries per session and the average number of farmers per session were 12 and 7, respectively. The plant clinics were run by 56 active plant doctors. The highest numbers of plant clinics sessions per year was 7 in 2013 (Bhaktapur district), 12 in 2014 (Kathmandu district) and 13 in 2015 (Gorkha district). In total, there were 288 queries in 7 plant clinics in Nepal during 2013 (based on data from 4 months only). Those numbers increased to 23 clinics with 1868 queries in 2014 and 25 clinics with 968 queries in 2015. Hence, while the number of plant clinics in Nepal increased each year, there was a reduction in numbers of queries in 2015. This was due to the earth quake during April 2015 which killed more than 8,000 people, and continued disturbance for more than a year. These very difficult times, severely hampered the plant clinic activities in Nepal.

Sept., 2013 to July, 2016 has been presented in annex 4.

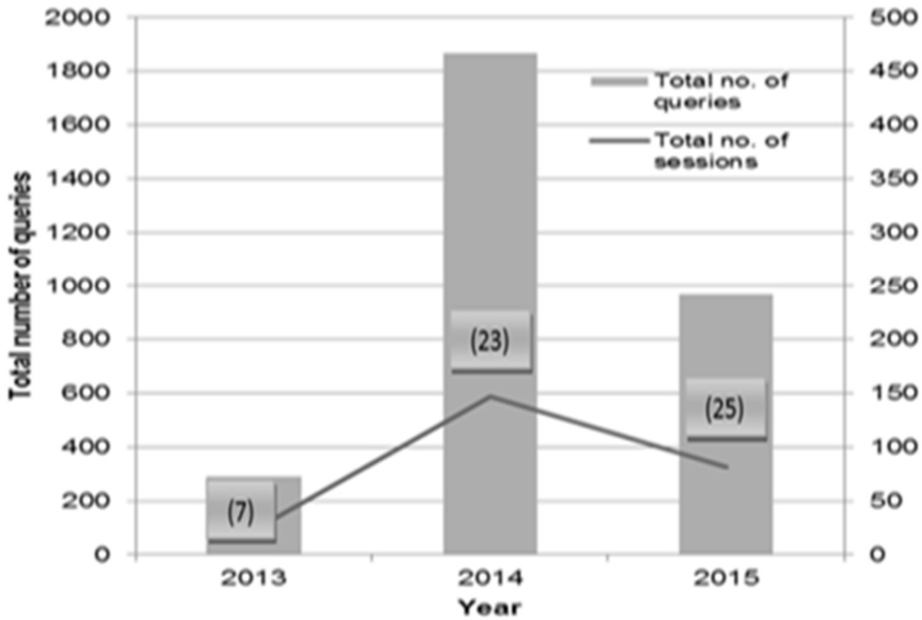

Figure 2: Total numbers of plant clinic sessions and total number of queries in Nepal from September 2013 to 2015. The number in parentheses shows the number of active plant clinics in the respective years.

The coverage of plant clinics during the study period was one-third of the country districts, i.e. 25 of the 75 districts of the country had at least a plant clinic running. The coverage and access of plant clinics in Nepal is increasing though there are still many farmers without access to reliable diagnostic services. Likewise, Adhikari et al. in 2015 also stated the clinic programme has increased access to plant health services by providing wide range of services at one place. The increment of number of plant clinics in Nepal seems to be due to the popularity of the plant clinics among the farmers and also by the contribution of many organizations that considered clinics as an effective tool to provide advisory services to farmers. Similar reason was mentioned by Adhikari et al. (2015).

The average numbers of plant clinic sessions per year varied (1-13) in the regular plant clinics. This variation in numbers of sessions might be due to the some administrative and location specific reasons such as transfer of plant doctors, blockade, fuel shortage and others. The coverage and access of plant clinic need to be increased through planned advertisement, awareness raising for plant health and increased commitment among stakeholders (Adhikari, 2016).

CROP DIVERSITY IN PLANT CLINIC

This study recorded 94 different crops reported in the clinic data from September, 2013 to July, 2016. These crops were categorized into different groups as presented in Figure 3. The vegetables, consisting of 38 different vegetable crops, were the crop group having largest number of crops followed by fruits, pulses & oil seed crops, cereal crops and spices. Statistical information on Nepalese agriculture 2014/15 published by MoAD (2015) indicates 107 major commercial crops. Of these, 76, i.e. 69% crops were covered in the plant clinics in Nepal. Figure 3 shows that, 5 among 6 (83%) cereals, 9 among 16 (56%) pulses and oil seeds, 19 among 24 (79%) fruits, 38 among 56 (68%) vegetables and 5 among 5 (100%) spices crops were reported in the plant clinic data in Nepal. Vegetable crops are most frequently brought to plant clinics. Pulse and oilseed crops were underrepresented at plant clinics while fruit crop were overrepresented. The plant clinic extension method is truly demand-driven. It doesn't give priority to a small number of crops, but allows farmers to ask advisors about any concerns they have. In total, 94 different crops, covering all crop types (major and minor), were brought to plant clinics. Vegetable crops were most frequently brought to plant clinics (67%) followed by fruit (15%) and cereal crops (9%). Two hundred ninety-eight (298) problems of the 94 different crops were diagnosed during the study period. Besides, problems of other minor crops were also recorded.

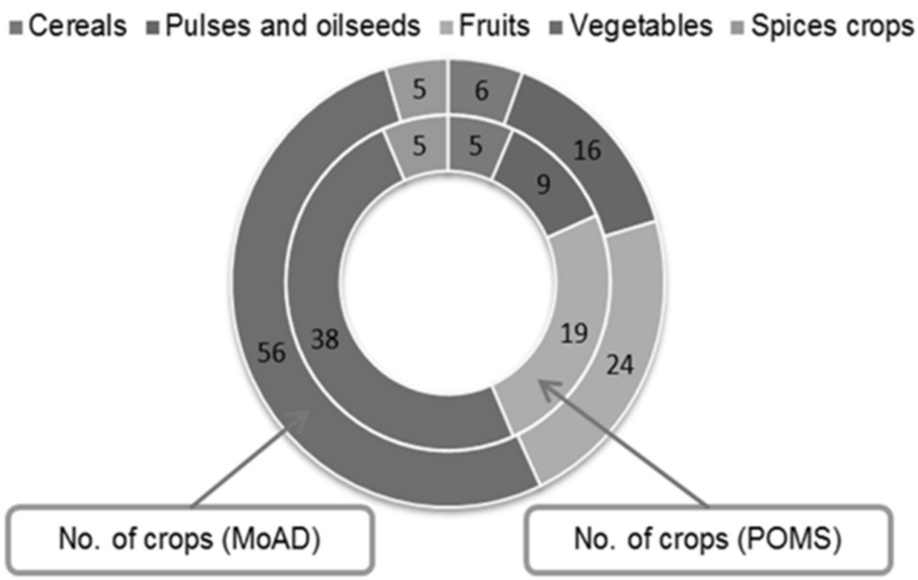

Figure 3: Group of major crops recorded in Ministry of Agricultural Development and data in POMS during September 2013 to July 2016.

The problems diagnosed included insects, fungal diseases and nutrient deficiencies showing that farmers can find solutions for most of the plant health problems at plant health clinics in the majority of queries. The high proportion of vegetable crops brought to clinics (67%) might be due to the higher investment per unit area and the high cash income these crops generate that make the farmers highly interested in seeking advice in order to prevent pest problems from reducing yield.

FARMER'S GENDER IN PLANT CLINIC

The results show that 43% of the queries were brought by female farmers and 53% by male farmers. Information on gender was not available for 4% of the queries. Male farmers submitted more queries in 2014 and 2015, Whereas female farmers submitted more queries in 2013 and 2016 plant clinics of Nepal from September 2013 to July 2016 (Table 1).

Table 1: Genderwise queries in plant clinic in Nepal from September 2013 to July 2016

S N	Year	Total queries	Number of queries by gender		
			Female (%)	**Male (%)**	**Unknown (%)**
1	2013(Sept-Dec only)	288	112 (39%)	106 (37%)	70 (24%)
2	2014(full year)	1868	825 (44%)	1003 (54%)	40 (2%)
3	2015(full year)	968	373 (38%)	578 (60%)	17 (2%)
4	2016(Jan-Jul only)	144	84 (58%)	60 (42%)	0 (0%)
	Total	**3268**	**1394 (43%)**	**1747 (53%)**	**127 (4%)**

The highest proportion of female farmer's participation in plant clinic was recorded in Sunsari district (NPSR01) i.e. 94% followed by Bhaktapur district (NPBP02) 88% and Makwanpur district (NPMW01) 75 % (Figure 4). It might be due to the involvement of women in farming especially vegetable cultivation as an income generation enterprise.

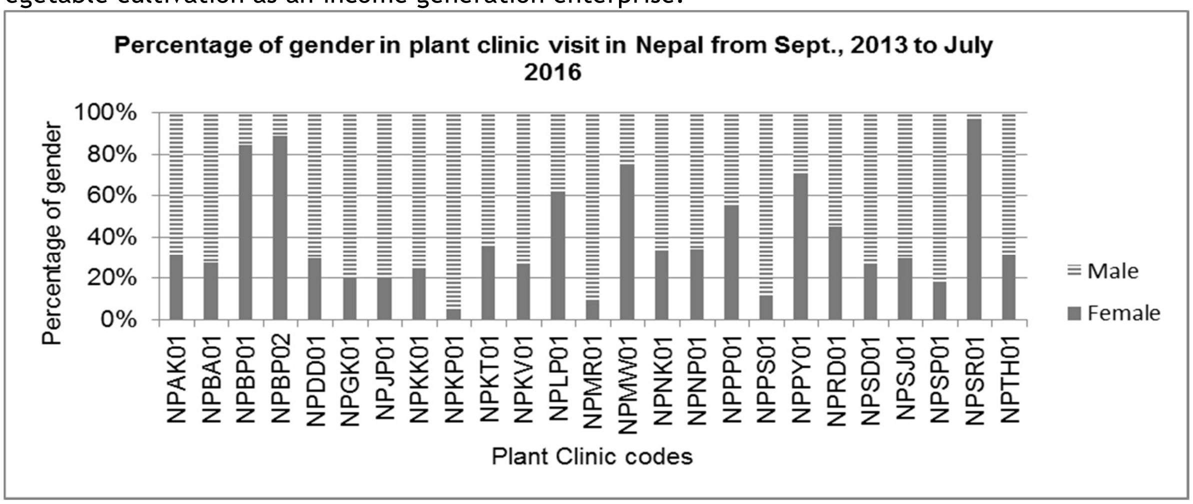

Figure 4: Percentage of gender in plant clinic visit in Nepal from September 2013 to July 2016. The location of the plant clinics is given in Annex 1.

CONCLUSION

Plant health service through plant clinic is a very useful tool for approaching the farmer and creating a familiar and trustful environment where a farmer and plant doctor could have two way communications about the plant health problems. As a whole, plant clinics are providing support to farmers for the pest management to minimize crop losses. The effectiveness and impact of plant clinics could be enhanced by increasing their coverage and accessibility. This is one of the demand-driven extension approaches for the farmers. The location of plant clinic, accessibility, proper advertisement, awareness for crop pest management to minimize losses, quality of plant health services and functional coordination among the stakeholders are important to increase the coverage and access of plant clinic. Establishing plant clinics in regions where they are absent will help increase their coverage and reach to farmers for effective delivery of location specific information. Further research is needed in order to understand why few female farmers attend plant clinics in some regions. Strengthening the plant clinic programme and further implementing it as a component of plant health system in Nepal will facilitate the access of farmers to the information they need to lose less to pests and diseases.

ACKNOWLEDGEMENT

This study was part of Masters of Advanced Studies in Integrated Crop Management (MAS-ICM) in 2016 at University of Neuchatel, Switzerland. We would like to acknowledge CABI, SDC and the Canton of Jura for providing scholarship to accomplish the study. We extend sincere thanks to Ministry of Agricultural Development, Nepal for granting study leave. Plant Protection Directorate, Nepal and all plant doctors of Nepal who provided the information and participated in the survey are highly acknowledged.

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Annex 1: Plant Clinic details in Nepal from September 2013 to July, 2016

S N	Clinic Code	District	Started year	No. of clinic sessions run	Total No. of queries	Avg. No. of queries per session	No. of Farmers' visit	Avg. No. of farmers per session	Farmers visit from No. of villages (Location 3)
1	NPBP01	Bhaktapur	2013	21	332	16	178	8	8
2	NPDD01	Dhading	2013	13	146	11	106	8	23
3	NPKP01	Kavrepalanchok	2013	6	63	11	14	2	5
4	NPKT01	Kathmandu	2013	22	293	13	135	6	unknown
5	NPLP01	Lalitpur	2013	10	104	10	64	6	18
6	NPNK01	Nuwakot	2013	11	109	10	71	6	24
7	NPSP01	Sindhupalanchok	2013	8	87	11	59	7	9
8	NPBA01	Bara	2014	6	117	20	70	12	13
9	NPBP02	Bhaktapur	2014	11	221	20	81	7	unknown
10	NPGK01	Gorkha	2014	21	128	6	80	4	unknown
11	NPJP01	Jhapa	2014	9	108	12	51	6	6
12	NPKK01	Kaski	2014	7	63	9	48	7	9
13	NPKV01	Kapilvastu	2014	6	55	9	38	6	unknown
14	NPMR01	Morang	2014	5	47	9	27	5	18
15	NPMW01	Makwanpur	2014	5	44	9	19	4	unknown
16	NPNP01	Nawalparashi	2014	3	39	13	35	12	unknown
17	NPPP01	Palpa	2014	19	326	17	119	6	16
18	NPPS01	Parsa	2014	4	35	9	31	8	7
19	NPRD01	Rupandehi	2014	10	100	10	79	8	24
20	NPSD01	Sindhuli	2014	13	236	18	92	7	15
21	NPSJ01	Syangja	2014	20	171	9	94	5	19
22	NPSR01	Sunsari	2014	9	93	10	60	7	6
23	NPTH01	Tanahun	2014	13	249	19	108	8	unknown
24	NPAK01	Aarghakhachi	2015	10	86	9	73	7	6
25	NPPY01	Pyuthan	2015	3	43	14	22	7	unknown
Total			**265**	**3295**		**1754**			
Average			**10.6**		**12**	**70.16**		**7**	**13.29**

FARMERS' PERCEPTION ON CLIMATE CHANGE AND ECOLOGICAL HAZARDS IN RIU AND RAPTI WATERBASIN, CHITWAN, NEPAL

H.P.Regmi[1], P.P.Regmi[2], J.P.Dutta[3] and D.R.Dangol[4]

ABSTRACT

A survey research was done to study the farmers' perception on climate change and ecological hazards in Riu and Rapti water basin, Chitwan, Nepal. Altogether 120 households, 60 from each water basin in Riu and Rapti were selected randomly for the study. Pre-tested interview, direct observation, focus group discussion as well as secondary data from Department of Hydrology and Meteorology (DHM), Kathmandu were used to collect the required information. Majority of the farmers' perceived the change in climatic condition in their locality in terms of increase in hotter days, decrease in colder days, variability in the number of rainy days, decrease in rainfall duration, increase in amount and intensity of rainfall, late onset and shift of usual monsoon pattern, prolonged occurrences of dry spells, decrease water level in the river as compared to the past decades. Farmers prioritized the floods/riverbank cutting (61.7%) and drought (63.4%) hazards for obtaining immediate solution/adaptation strategies in Riu water basin; and for drought (60%) and loss of wetland and declining water source (45%) in Rapti water basin. Analysis of the climatic data (last 42 years for rainfall and last 30 years for temperature) showed the increasing trend of annual rainfall (6.83 mm per year) and those of both maximum and minimum temperature (0.019°C per year and 0.069°Cper year, respectively). These analyses strongly support the farmers' perception about the climate change and for which immediately effective adaptation mechanism is required.

Key words: Adaptation. Climatic data, Floods/Riverbank cutting, Trend analysis

INTRODUCTION

Climate change is the global issue at and one of the most complex challenges that humankind has to face in the coming decades. It poses an increasing threat to the sustainability of agricultural production and livelihood strategies of poor and rural people worldwide. Nepal's temperature has increased by 1.7°C during last 30 years (1975 to 2005) with the average temperature increased by 0.06°C per year (Shrestha *et al.*, 1999) and in particular, 0.04°C/year in Terai and 0.08°C/year in Himalayas. A study on aggregated precipitation and average temperature of five meteorological stations (Dhangadi, Surkhet, Pokhara, Kathmandu and Dhankuta) showed an increasing trend in both temperature and total precipitation in Nepal (Gurung, 2007a). In the recent years, the intensity, amount and distributions of rainfall have been changed in unpredictable manner. The number of the rainy days is decreasing by 0.8% day per year, however, it is estimated that the rainfall is increased by 13 mm per year. Consequently, the river flow is increasing at the rate of 1.48 m^3/s per year (Regmi, 2007). Higher increase in summer river flow provides the evidence for faster glacial melt due to higher summer temperature.

Climate change has serious impact on agriculture and livelihood of farming community. Local communities from the Chitwan experienced the change in the climate in recent years (Gurung and Bhandari, 2008). Farmers are experiencing change in temperature and precipitation pattern, in parallel; they are also following some adaptation strategies to respond changing climate in their livelihood and at farm level.

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In this regard, this study was conducted to assess the farmers' perception on climate change and ecological hazards, and answered the questions, whether they perceived climate change or not in terms of change in number of hotter days, number of colder days, number of rainy days, duration, amount and intensity of the rainfall, onset of usual monsoon and dry spells as compared to the past decades. Furthermore, this study analyzes the climatic data of Rampur station, Chitwan for last 30 years to verify the farmers' perception.

MATERIALS AND METHODS

The study was conducted in the central region of inner Terai of Nepal. Chitwan district was purposively selected for the study. The study focuses to explore the perception of marginal farmers on climate change and their adaptation strategies. For this, two water basins namely Riu and Rapti were selected with the consultation of the community level and district level organizations. These settlements are occupied with indigenous farming communities like Tahru, Bote, Majhi and severely affected with the floods and riverbank erosion. The study sites were selected because ethnic and marginal community resides in these areas and are the vulnerable sites in terms of floods and riverbank cutting. Altogether 120 respondents, sixty from each water basin were selected randomly for the study.

The local communities and resource poor farmers who have long experience in autonomous adaptation of the study area were the primary source of information. The pre-tested interview schedule was administered to the respondents to collect primary information. These data were supplemented by information obtained from focus group discussion, direct observation, transect walk and key informant interview. Participatory methods were used to collect data, to share experience and knowledge of vulnerable communities towards climate change. Primary data were collected through interview schedule. Information collected from the field survey was coded first and entered into the computer. Data entry and analysis were done by using computer software package; Statistical Package for Social Science (SPSS 16 version) and Microsoft Excel. Perceptions of farmers on the change of climatic variables and climatic hazards over the time were analyzed by estimating frequency, percentage, charts and diagrams. Climatic data were analyzed by using trend analysis with the following formula:

$Y = b_1 x + C.$

Where, Y = Climatic parameter (Rainfall and temperature)

x = Time horizon (years)

b_1 = Coefficients

C = Constant

RESULTS AND DISCUSSIONS

FARMERS' PERCEPTION ON CHANGE IN NUMBER OF COLDER DAYS, HOTTER DAYS, OCCURRENCES OF HAILSTORMS, WATER LEVEL IN THE RIVERS AS COMPARED TO PAST YEARS

The study revealed that, 58.3% respondents perceived the decrease in number of colder days and 73.3% respondent perceived increase in number of hotter days as compared to past years. Farmers viewed that days become hotter and hotter as compared to the past years (Fig 1). They reported that water level in the river was continuously deepening in the Riu water basin, and were unable to irrigate their field due to the loss of canal as a result of the deepening of the Riu Khola. However during the few days in rainy season, there was huge floods covering wider area and affecting the crops and community settlement. Farmers also perceived the heavy occurrences of hailstorms in past years, but within the 3-4 years, there was no occurrences of such hailstorms at all and even if occur but with very small size.

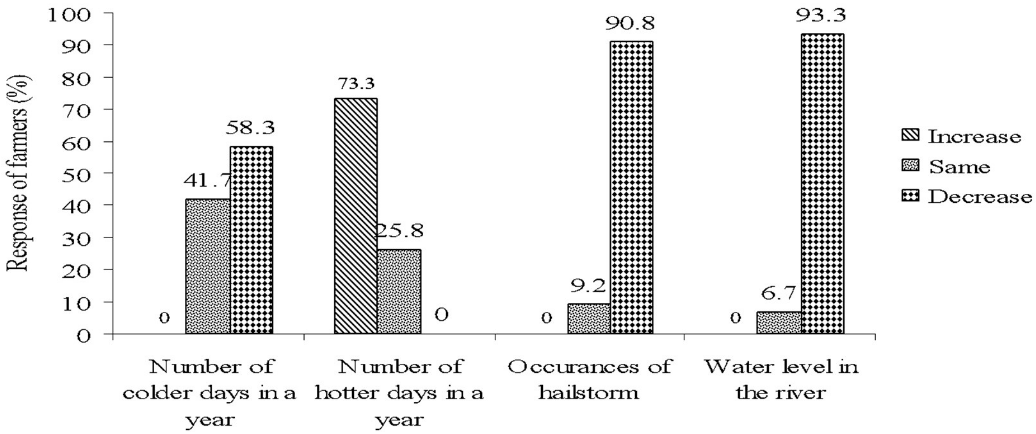

Figure 1: Farmers' perception on climate change

FARMERS PERCEPTION ON CHANGE ON RAINFALL PATTERN

There was wide variation in the rainfall pattern as compared to the past. Majority of the farmers, 83.3%, 75% and 23.24% perceived decrease in duration, number of rainy days and amount of rainfall, respectively, in rainy season (June to September) as compared to the past (Figure 2).

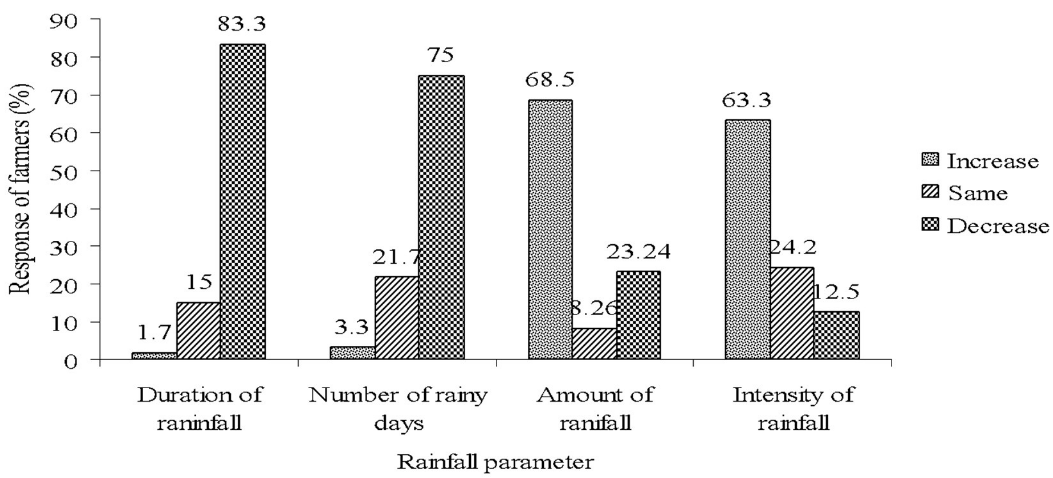

Figure 2: Farmers' perception about the change in rainfall parameter (In rainy season)

Untimely rainfall was the major reason for late planting of many crops including maize and rice. As the other parameters of rainfall was decreasing, 63.3 % farmers' perceived the increased intensity of rainfall in recent years, such a more intense rainfall was major reason for occurrences of floods and riverbank erosion. Gurung (2007a) also reported that, 95% farmers noticed the erratic rainfall as an indicator of climate change in Chitwan.

The study revealed the similar response of farmers about the trend of winter seasonal rainfall except its intensity as of the rainy seasonal rainfall. Majority of the respondents reported decline in number of rainy days, amount and intensity of the rainfall in other season (October - May) as compared to the past (Figure 3). Farmers' reported the decline in winter rainfall was one of the important factor for declining yield of winter crops like wheat, mustard, and different types of vegetables.

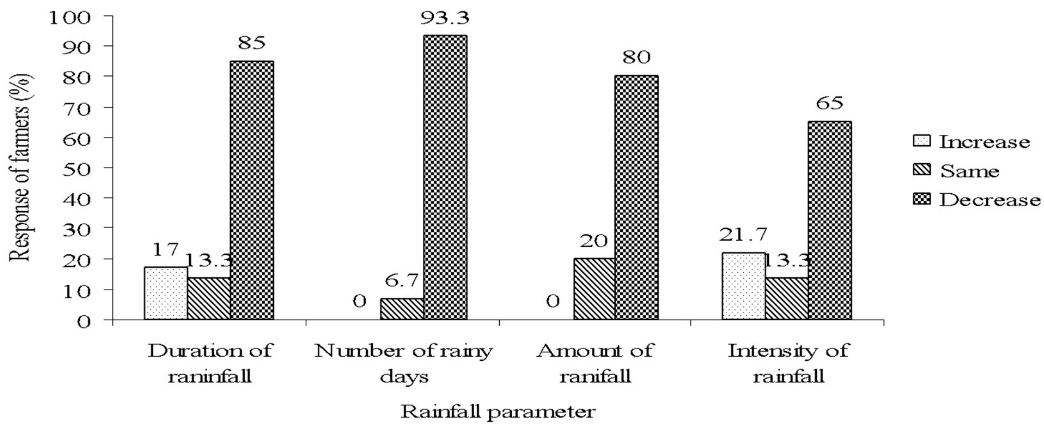

Figure 3: Farmers' perception about the change in rainfall parameter (October- May)

FARMERS PERCEPTION ABOUT BEGINING OF MONSOON AND OCCURANCES OF DRY SPELLS

Timely onset of monsoon is the major governing factor for improving agricultural production. Late onset of monsoon is responsible for declining crop production by delay in planting and shorter growth period of the crops. 93.3% of respondents reported the late onset of monsoon as compared to the past (Table 1). 85.8 % of farmers responded the prevalence of longer period drought as compared to the past. Gurung (2007a) also reported that 95% farmers have used drought and erratic rainfall as an indicator for changing climate in Chitwan. They recall the drying of their maize crops and rice seedlings in the year 2009 due to the late onset of monsoon and pronounced dry spells and harvested poor yield.

Table 1: Farmers' perception about the onset of monsoon and occurrences of dry spells in Riu and Rapti water basin (2010)

Beginning of monsoon as compared to past		Occurrences of dry spells as compared to past	
Timing of monsoon	**Response**	**Duration of drought**	**Response**
Earlier	0(0)*	Longer period	103(85.8)
Same	8(6.7)	Same	17(14.2)
Later	112(93.3)	Shorter period	0(0)
Total	120(100.0)	Total	120(100)

* Figure in parenthesis indicate the percentage

MAJOR CLIMATE INDUCED HAZARDS AND THEIR PRIORITISATION

Key informant survey provides the severity of three major climate induced hazards in the settelement of Riu and Rapti water basin. Major climatic hazards were;

A. Floods and riverbank cutting
B. Drought
C. Loss of wetlands and water sources

Rapti River and Riu Khola were responsible for occurrences of monsoon flooding in the study area. Farmers were asked for ranking the timing of carrying out effective adaptation and coping measures to respond the climatic hazard. Drought (63.4%) and floods/riverbank cutting (61.7%) hazards required urgent and immediate solution in Riu water basin as compared to the loss of wetland and declining water resources (Figure 4). Similarly, floods/riverbank cutting (38.3%) and loss of wetland/water resources (33.3%) required the medium term solution in Riu water basin. The settlement in Riu water basin was very close to the river and in every year, the river approaches towards the community settlement, so they are under the vulnerable situation in terms of flood risk.

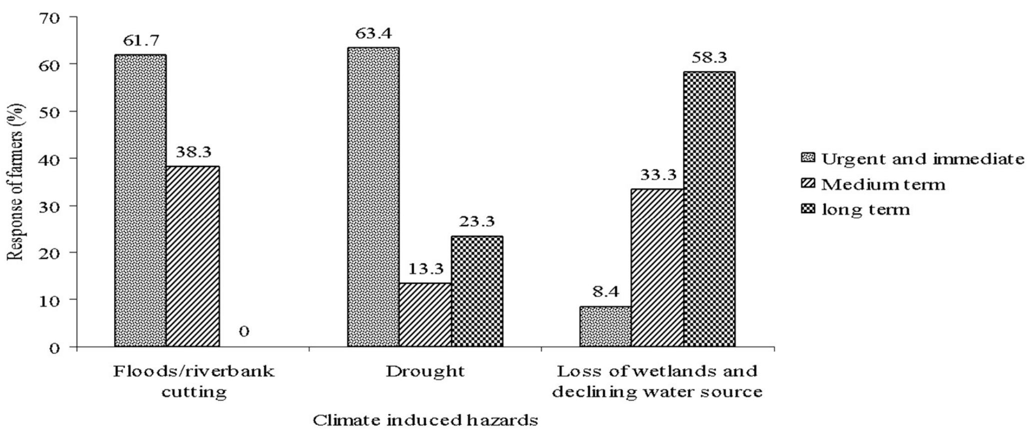

Figure 4: Prioritization and timing of solution for climatic hazards in Riu water basin (2010)

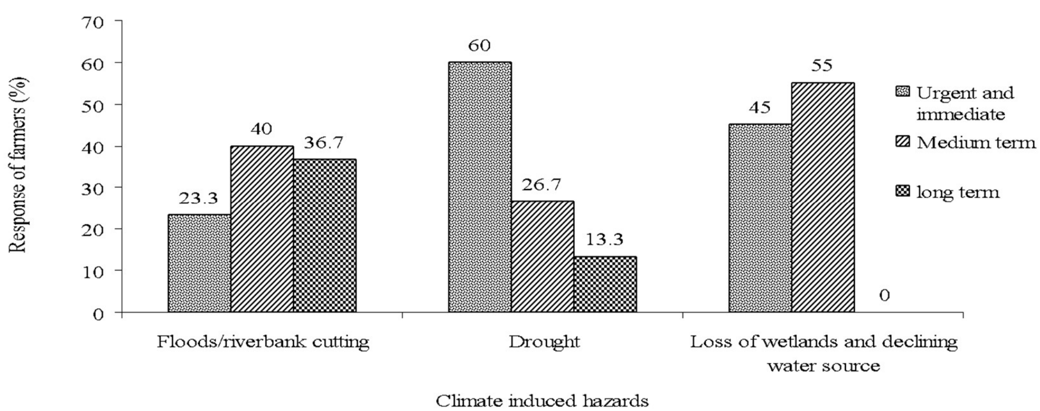

Figure 5: Prioritization and timing of solution for climatic hazards in Rapti water basin (2010)

The study revealed that, drought (60%) and loss of wetlands/declining water source (45%) hazards required urgent and immediate solution, similarly loss of wetland/water sources (55%) and floods/riverbank cutting (40%) hazards required medium term solution in Rapti water basin (Figure5). Lower percentage of the farmers prioritized floods and riverbank cutting as compared to the Riu, because of the more distance between Rapti river and the community settlement. They faced greater problem of drought, declining wetlands and water recharge. ECOS (2002) reported the increment in park area from 932 sq. km to 1182 sq. km due to addition of cultivated private land as a result of shift in river course towards community settlement.

ANALYSIS OF THE RAINFALL DATA OF RAMPUR STATION FOR LAST 42 YEARS (1968-2009)

Analysis of the rainfall data of last 42 years of the Rampur station showed the irregular pattern of rainfall over the year.

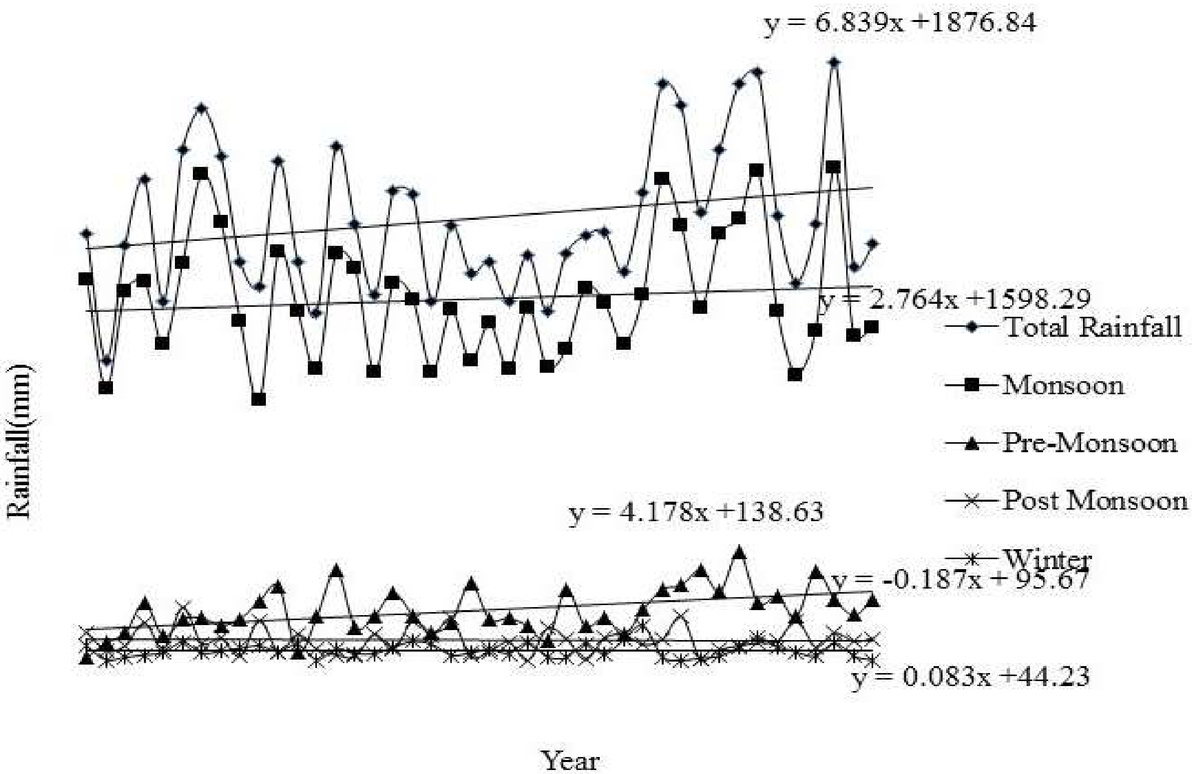

Figure 6. Trend analysis of rainfall data of Rampur, Chitwan (1968-2009)

Total rainfall, pre-monsoon (March-May), monsoon (June-September), post monsoon (October-November) and winter (December-February) rainfall varied across the time horizon. Post-monsoon rainfall showed the decreasing trend but the analysis of the all other rainfall indicated increasing trend over the years (Figure 6). All the seasonal rainfall declined for last two years (2007 and 2008), so, farmers were unable to cultivate their crops in right time and their cropping calendars were shifted. Analysis of the climatic data strongly supports the farmer's perception. Farmers in such scenario couldn't predict the usual rainfall pattern and they were compelled to changed their cropping calendar. The trend analysis showed the 6.83 mm per year increment in total rainfall in

Rampur station, which was higher than the increase in all Nepal average precipitation trend by 5.17 mm per year as reported by Gurung (2007b).

ANALYSIS OF THE MONSOON PATTERN IN CHITWAN IN LAST 10 YEARS

Occurrences of the usual monsoon were shifted towards August instead of June- July in recent years as compared to the past in Chitwan.

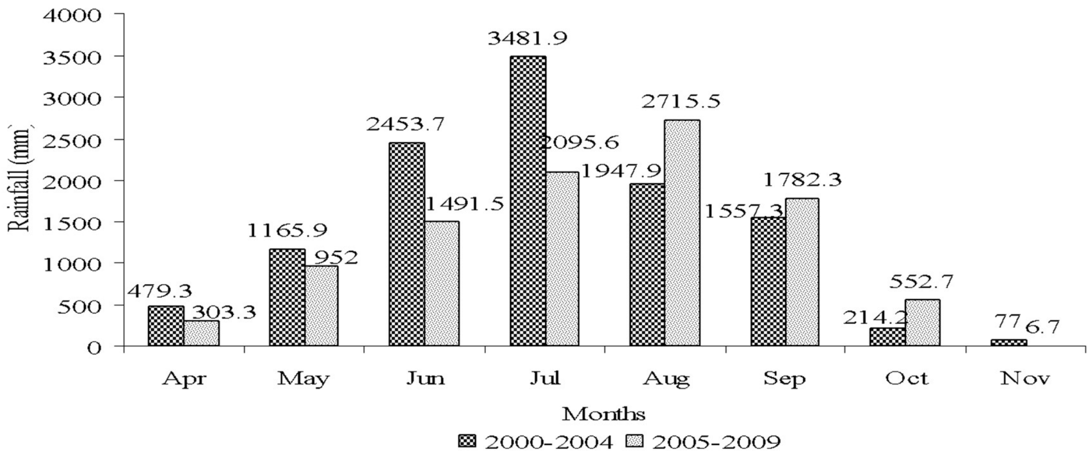

Figure 7: Analysis of the monsoon pattern in Rampur, Chitwan in last 10 years

Total July Precipitation (3481.9mm) was higher for 2000-2004 but August precipitation (2715.5mm) was higher for 2005-2009. Rainfall was declining from month of April to July and then after increases up to October in recent years (2005-2009) than that of 2000-2004. Analysis of the rainfall data strongly support the farmers' perception on higher amount of rainfall in later month of monsoon period in recent year (2005-2009) than that of earlier years (2000-2004) which was responsible for change in crop rotation and cropping calendar as perceived by the farmers.

ANALYSIS OF THE CHANGE IN MAXIMUM AND MINIMUM TEMPERATURE FOR LAST 30 YEARS IN RAMPUR STATION, CHITWAN(1980-2009)

Analysis of the maximum and minimum temperature of last 30 years of the Rampur station showed that both minimum temperature (P<0.01) and maximum temperature (P<0.1) were increased significantly over the time.

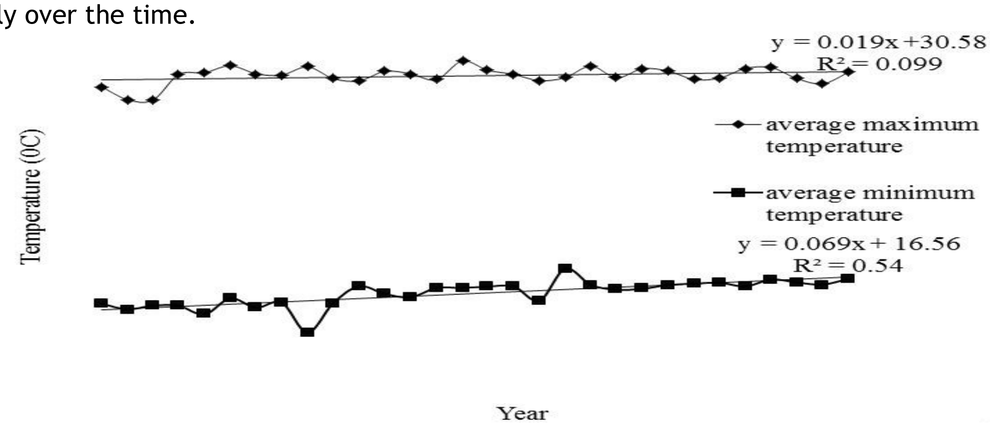

Figure 8: Trend Analysis of maximum and minimum temperature (1980-2009) in Rampur, Chitwan

Trend analysis showed that maximum temperature increased by 0.019°C per year and minimum temperature was increased by 0.069°C per year (Figure 8). Average maximum temperature increased in lower rate than national average of 0.042°C per year (Baidya and Karmacharya, 2007). Trend analysis of temperature strongly supports the farmers' perception as that of hotter summer and less cold winter as compared to the past.

CONCLUSION

Based upon the study it was concluded that most of the farmers perceived the change in climatic parameters at present in terms of change in rainfall pattern, duration, timing, intensity, onset of monsoon, and change in summer and winter temperature in terms of hotness and coldness and which was supported by the analysis of the climatic data. Farmers realized the change in climate and their usual farming practices. Farmers should be aware about the climate change and promote them to practice improved farming packages. It is important to develop and plan sustainable adaptation strategies and make farmers capable to cope with emerging impacts of climate change and its related hazards in forthcoming years.

ACKNOWLEDGEMENTS

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RESPONSE OF ORGANIC MANURES ON POST HARVEST AND SOIL NUTRIENT RESTORATION ON CAULIFLOWER PRODUCTION

M. Basnet[1] S.M. Shakya[2] B.R. Baral[3]

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ABSTRACT

This study was conducted at Ilam Municipality-2, Nepal to determine the response of organic manures on post harvest and nutrient restorative effect of cauliflower. Five manures, viz., bansoon, mustard oil cake, poultry manure, farmyard manure, and vermi-compost were evaluated. The postharvest losses, vitamin C content and soil nutrient restorative behavior were significantly highest with vermi-compost as compared to other manures. The maximum vitamin C content of 10.92 mg/100 gm was found with vermi-compost whereas the lowest of 9.66 mg/100 gm was found at farmyard manure. Moreover, the physiological losses were found to be least with vermi compost and the most with bansoon manure. Moreover, the restorative properties i.e. pH, N,P,K and organic %age were found to be significantly highest with vermi-compost as compared to other organic manures. This study concludes that vermi compost increases vitamin C content, postharvest longevity and improvement of physical and chemical properties of the soil.

Key words: Organic manure, post harvest, soil nutrient restoration

INTRODUCTION

Cauliflower (*Brassica oleracea* L. var. botrytis) belongs to the family Brassicaceae. The Mediterranean region is considered as the center of origin of cauliflower (Lal, 1993). Cauliflower is consumed at large volume as a high nutritive fresh vegetable worldwide (Oowen and Grubbe, 1977). It contains diverse nutrients, vitamins and minerals comprised of vitamin A, B_1, C, protein, fat, carbohydrates, potassium, phosphorus, sulphur, iron, copper, carotenoids, and ß-carotene (Singh and Singh, 1994). Moreover, it has also medicinal values and therapeutic effects as it contains high concentration of glucothiocyanate, which is effective in the inhibition of carcinogenesis (McDonald, 1971).

Cauliflower requires considerable amount of nutrients for growth and development (Chatterjee, 1993; Thakur et al.,1991). It can be grown on a wide range of soil rich in nutrients, adequate soil moisture and on a neutral to slightly acid soils i.e. at pH 6.0 to 7.0. Now a days, in the name of increasing production, haphazard use of chemical fertilizers has deteriorated the fertility status of Nepalese soil (Tripathi et al., 2005). In addition, ecological imbalance, severe health hazards on humans and animals, loss of biodiversity are emerging as major problems for chemical based agriculture production (Khanal and Manandhar, 2004). This situation has aggravated the situation of poor people being non-affordable and unreliable high cost external inputs.

Improvement and maintenance of soil physical, chemical and biological properties are the key features in successful organic vegetable production system (Subedi and Regmi, 2006). In this sense, organic manure is the sustainable option as it increases water-holding capacity of soil; improves soil texture and structure. Organic manure contains a very high population of bacteria, actinomycetes and fungi so that microbiological activity get increased that resulted into increased mineralization

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of organic nitrogen and thus nutrients become available to the plants (Shrestha, 2008; Gupta et al., 2000; Carpenter et al., 2000). Similarly, they provide humic substances, higher cation exchange capacity and heat absorbing capacity that enhances the utilization of nutrients by plants with increasing organic carbon content of the soil (Gaur, 1992).

Physiological loss of cauliflower curd is associated with the losses by weight and quality of produce. Further, loss due to the effect of disease development also implies significant loss during storage. Similarly, chemical changes are associated with the post harvest quality of curds and these are also vulnerable to changes with physical losses, but it depends upon the several factors such as storage environments and pre harvest factors. The organic manures increased the post harvest longevity in terms of spoilage and weight loss is due to the availability of micronutrients which strengthened the cellular and sub-cellular parts of the curd (Bhattarai and Budhathoki, 2005).

OBJECTIVES

- To determine the response of organic manures on post harvest quality on cauliflower production
- To determine the soil nutrient restorative effect of organic manures on cauliflower production.

METHODOLOGY

The experiment was conducted at Ilam Municipality-2, Ilam during 2015 with the financial support from Univeristy Grant Commission (UGC)/Tribhuvan University. Five common organic manures i.e. bansoon (14.4 mt ha^{-1}), poultry manure (14.4 mt ha^{-1}), mustard oil cake (16.3 mt ha^{-1}), farmyard manure (8 mt ha^{-1}), and vermi-compost (11.4 mt ha^{-1}) were selected and were laid out in Randomized Complete Block Design (RCBD) and replicated four times. The treatments and their dose were selected based on the farmer's practices at Ilam district. The crops were planted with the spacing of 60 cm * 60 cm on each plot having 5 rows with 4 plants per row on an area of 7.2 m^2. There were 20 plants in each plot among which 14 plants were considered as boarder plants and 6 inner plants as observational plant.

After harvesting the observational plant, the testing parameters i.e. physiological losses (weight loss and spoilage), vitamin c content and the soil properties were sampled.

DETERMINATION OF VITAMIN C CONTENT

Firstly, 5 ml of working standard solution prepared by dissolving fresh cauliflower curd sample. Then, 10 ml of 4 % oxalic acid added to the standard solution, and titrated against the dye (V_1ml) until the appearance of pink color (end-point), thus the amount of dye consumed is equivalent to the amount of ascorbic acid. To make known volume (100 ml), 0.5–5 g sample was extracted on 4 % oxalic acid and centrifuged. Then, 5 ml of supernatant was pipette out and 10 ml of 4 % oxalic acid added. It was titrated against the dye (V_2ml) until pink color develops. Finally, amount of ascorbic acid (vitamin C) calculated with the following formula:

$$\text{Amount of ascorbic acid (mg/100 gm of curd)} = \frac{1000.5 \text{ mg} \times V_2 \text{ ml} \times 100 \text{ ml}}{V_1 \text{ml} \times 5 \text{ ml} \times \text{wt. of sample}}$$

Where, V_1 = Titrated volume of standard solution against dye

V_2 = Titrated volume of sample solution against dye

MEASUREMENT OF PHYSIOLOGICAL AND SPOILAGE LOSS

Physiological loss

The physiological loss by weight (PLW) of randomly selected five sample curds with and without their jacket leaves was examined by keeping them in normal room condition (20 ± 3 °C temperature and 60 ± 5 % relative humidity) for a week. PLW calculated by using following formula:

$$\text{PLW (\%)} = \frac{\text{Initial weight of sample} - \text{Final weight of sample}}{\text{Initial weight of sample}} \times 100$$

Spoilage loss

The spoilage loss of randomly selected five sample curds with and without their jacket leaves was examined by keeping them in ordinary room condition (20 ± 3°C temperature and 60 ± 5 % relative humidity) for a week. It was by using following formula:

$$\text{Spoilage loss (\%)} = \frac{\text{Weight of spoiled curds}}{\text{Original weight of curds}} \times 100$$

DETERMINATION OF SOIL PROPERTIES

Soil samples from four replication blocks of the experimental field were analyzed before and after experiment conduction at Soil Testing Laboratory, Jhumka, and Sunsari.

The data obtained were entered into the MS Excel, analyzed and interpreted through MSTAT.

RESULT AND DISCUSSION

VITAMIN C CONTENT

The vitamin C content was significantly highest with vermi-compost (10.92 mg/100gm) followed by mustard oil cake (10.60 mg/100 gm), while the lowest vitamin C content was recorded at farmyard manure (9.66 mg/100gm).

Subbiah (1994) found that the easily available organic manure increased vitamin C and crude protein content of cauliflower curds. The highest vitamin C content with vermi-compost could be due to the essential elements present in it which enhanced vitamin C synthesis. Organic crops contained significantly more vitamin C, iron, magnesium, phosphorus, substantially significant mineral with lower amounts of some heavy metals and significantly less nitrates than conventional crops (Carl and Winter, 2006).

Effect of different organic manures on vitamin C content of cauliflower curd

Treatments	Vitamin C content (mg/100gm)
Bansoon	10.08ab
Mustard Oil Cake	10.60a
Poultry Manure	9.69b
Farmyard Manure	9.66b

Vermi-compost	10.92a
F test	*
LSD 0.05	0.828
SEm±	0.269
CV %	5.3

* Denotes significantly different at P<0.05. Means within column followed by the same letter are non-significantly different at 5 % level.

PHYSIOLOGICAL LOSS

Weight loss and spoilage loss

Physiological loss by weight without jacket leaves was highest with the application of bansoon (48.98%) and lowest with vermi-compost (33.81%). Similarly, the physiological weight loss of curd with jacket leaves was highest at bansoon (30.09%) and lowest with the application of vermi-compost (24.45%). Similarly, the minimum spoilage loss along with and without jacket leaves was recorded to be 40.66% and 42.95% respectively with vermi-compost application whereas the maximum spoilage loss along with and without jacket leaves was found to be 49.55% and 61.79% respectively with bansoon application.

Effect of organic manures on physiological loss by weight and spoilage loss of curds

Treatments	Physiological loss in weight (%)		Spoilage loss (%)	
	(without jacket leaves)	(with jacket leaves)	(without jacket leaves)	(with jacket leaves)
Bonsoon	48.98a	30.09a	61.79a	49.55a
Mustard cake	37.49d	26.41c	48.02d	40.94c
Poultry Manure	41.00c	28.60b	53.77c	41.46c
Farmyard Manure	44.87b	28.89b	59.12b	45.50b
Vermi-compost	33.81e	24.45d	42.95e	40.66c
F test	**	**	**	**
LSD 0.05	0.857	0.684	0.5017	1.019
SEm±	0.278	0.2220	0.1628	0.331
CV %	1.3	1.6	6	1.5

** and denotes significantly different at P<.001 and P<0.05 respectively. Means within column followed by the same letter are non-significantly different at 5 % level.

EFFECT OF ORGANIC MANURES ON SOIL PROPERTIES AFTER HARVEST

The following table showed the chemical properties viz., pH, organic matter (OM), available nitrogen (N), phosphorus (P_2O_5) and potash (K_2O) of experimental soil after crop harvest. The effect of different organic manures was found to be significant on soil pH, organic matter, N, P_2O_5 and K_2O. The highest soil restorative effect i.e. organic matter (3.92 %), N (0.19%), P_2O_5 (352.64 kg ha^{-1}) and

K_2O (401.29 kg ha^{-1}) was observed on the vermi-compost applied field. Similarly, the amendment of pH level towards normal level was found to be significant (6.67) with vermi- compost as compared to other organic manures.

Effect of organic manures on soil properties after harvest

Treatments	pH	OM %	N %	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})
Bansoon	5.54ab	3.65bc	0.174ab	321.68c	310.10c
Mustard oil cake	5.68ab	3.72b	0.175ab	319.02d	345.21b
Poultry manure	5.06b	3.73b	0.177ab	319.80d	345.43b
Farmyard manure	5.66ab	3.62c	0.170b	341.10b	288.61d
Vermi-compost	6.67a	3.92a	0.19a	352.64a	401.29a
F test	*	**	*	**	**
LSD 0.05	0.3894	0.0905	0.0073	1.172	1.629
SEm±	0.1264	0.0294	0.00238	0.380	0.529
CV %	4.4	1.6	2.7	0.2	0.3

** and * denotes significantly different at P<.001 and P<0.05 respectively. Means within column followed by the same letter are non-significantly different at 5 % level.

CONCLUSION

It is found that vermi-compost has a significant effect on physiological losses i.e. lowest weight and spoilage loss, highest vitamin C content and highest soil nutrient restorative properties as compared to other manures. Thus, it is recommended to use vermi-compost during organic cauliflower production.

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FOOD SECURITY IN SOUTH ASIA AND SELF-RELIANCE IN PADDY

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ABSTRACT

South Asia is world most densely populated region and houses the largest population of undernourished people. It remains the world's second poorest region with more than 500 million people living on less than US$1.25 per day. Firstly this paper attempts to show the general situation and production trend of paddy, secondly, scrutinizes the role paddy has been playing in the economy and food security so far and that it is still the most potential means to improve the food security situation and tackle severe under-nutrition as other sectors are, until now, far less furnished to address this issue. This paper probes into various economic and historical perspectives of rice economy and culture in this region, and shows that self-sufficiency in paddy production is paramount to its domestic food security, and thereby proposes that emphasis should be given on increased rice production which is decelerating amid expansion of modern economic sectors.

***Keywords**: Food security, Paddy, Self-sufficiency, South Asia, Gross Domestic Product*

INTRODUCTION

South Asian houses well over 1/5th of the world's population and nearly 1/5th of world's undernourished people. Despite unprecedented economic progresses in past three decades, millions of people remain food-insecure. The Green Revolution has immensely influenced various aspects of food security in India, tripling its food grain production between 1960 and 2000 (Estudillo et al., 2010) and thus halving the percentages of food insecurity and poverty. In Asia, food security has traditionally been defined as maintaining stable prices for rice in the major urban markets of a country (Asia foundation, 2010) where it is the staple food of more than 50% of the population. For South Asia the figure is around 70% (FAOSTAT) which is highest in the world, and hence food security is essentially a reflection of rice security in this region. And thus achieving self-reliance in rice production is an effective way to promote national level food security. Indeed, this analysis considers the many supporting facts. Firstly, the countries in this region share significant similarities in terms of livelihood, diet, culture, lifestyle and socio-economic status and are characterized by widespread poverty, under-nutrition and low literacy rate. Thus, it assumes implementation of a somewhat identical measure to face an issue as local and as global as food insecurity. Secondly, it is a developing region and the economy is chiefly agrarian. 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. Last but not least, natural disasters, political instability, mal-governance and transnational crime are widespread in South Asia and continue to cripple development issues and opportunities. No significant interventions are possible in such cases to ameliorate the condition of food security, irrespective of production status.

Nepal is a land locked and least developed country, having a population of more than 28 million people with the annual growth rate of 1.35%. It is estimated that the country's population in 2025 will reach 40.5 million, with anticipated difficulties of fulfilling the food requirements (FAO, 2006). It is frequently exposed to varieties of human made and natural disasters. It is also likely to face

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strong effects of climate change. Economic growth was primarily in non-agricultural sectors, which target 7.2% while for agricultural growth 4.7% per annum in the coming 14th three year plan (NPC, 2016). Apart from the small holding, other sources of income are livestock, wages, remittance, etc. Nearly 50% of the small and marginal farmers and majority of the landless agricultural workers live below the poverty line. Chronic poverty and deep-rooted social divisions and discrimination in terms of caste, ethnicity, gender, culture and religion creates much vulnerability to poverty, food insecurity and malnutrition. Country poverty is root cause for food insecurity, under-nutrition, social and education and employment deprivations. Low productivity in agriculture is a major contributor to poverty and food insecurity. Country's poverty is decreased by 21.6% during 2013/14–2015/16, with wide variations in areas, gender, caste and ethnicity (NPC, 2016). Poverty is worst in the remote hills and mountains of Far and Mid-Western Nepal, about 60% of the population lives below nation poverty line and local production is generally sufficient for only three to six months (CBS, WFP and WB, 2006). Price of food commodities are hiking and income of miserable people is stagnant, rather decreasing. Due to insufficient food production and limitation of agricultural income, farmers are compelled to do other activities for livelihoods. However, due to low wage and seasonal engagement, incomes from those activities are not sufficient to maintain the needs as well as food secure.

MATERIAL AND METHODS

This paper is mainly based on review of secondary sources. This paper focuses on five South Asian countries namely India, Nepal, Bangladesh, Sri Lanka and Pakistan and main data sources are from their ministries of agriculture. Other sources include the World Bank, FAOSTAT, IRRI, International Food Policy Research Institute (IFPRI), Bangladesh Rice Research Institute (BRRI), Consultative Group on International Agricultural Research (CGIAR), United States Department of Agriculture (USDA) and CBS, Nepal and research papers. India and Bangladesh rank among top five global producers and the two largest producers and consumers of rice in South Asia, and also because their rice consumption plays a vital role in the rice economy of South Asia and the whole world. The agricultural growth is weak in Nepal compared to other countries in South Asia, and in recent years, the rate has slowed (MoAC, WFP and FAO, 2009). According to a detail report on agriculture policy and strategies for poverty alleviation and food security, agriculture poor performance reflects two closely related problems (FAO and UNDP, 2003). First, little arable land that is not presently farmed, so any expansion of cultivated area is either at the expense of forests, or onto low potential marginal lands, in addition to severe soil erosion, the result is shrinking average farm size and increasing fragmentation, leading to growing poverty and food insecurity.

FINDINGS AND DISCUSSIONS

1. Paddy profile

In paddy production, South Asia has made a quantum jump since the spread of the green revolution in 1960s. With 41% arable land, it is currently the second largest rice producing region in the world (Gumma et al., 2011). Paddy is a staple for the majority of the 1.7 billion South Asian population and a source of livelihood for more than 50 million households. Apart from its economic and strategic importance, rice is deeply engraved in the rich tradition and culture of many South Asian countries. In India and Nepal, rice offerings to bring good health and prosperity to family members are common on many auspicious occasions. The significance of rice extends beyond life for Hindu communities in the region with offerings given to the departed soul. One can find many religious and cultural uses of rice throughout South Asia. The region cultivates rice on 60 million hectares and produces slightly above 225 million tons, accounting for 37.5% of the global area and 32% of global production in 2013. Within South Asia, both India and Bangladesh are major rice-growing countries. The Pakistan, Nepal and Sri Lanka—together have slightly above 5.6 million hectares and produce 19.5 million tons in 2016. The majority of this production increase in the past five decades has come from yield growth, with harvested area growing by only 20% from 50 million hectares in the late 1960s to 60 million hectares now (IRRI, 2016).

India and Bangladesh has become the world's second and fourth largest rice producing nation with the largest rice harvesting area (USDA, 2016). According to data from the last 40 years, the per capita rice consumption rate in Bangladesh is 171.73 Kg per person per year. In Pakistan, wheat is the staple food yet. Paddy production in Sri Lanka for 2015/2016 recorded high of 4.5 million tons. South Asia imported 0.66 million tons of rice in 2016, with Nepal the largest buyer. Only India and Pakistan are self-sufficient in rice production; Sri Lanka, Bangladesh and Nepal are not yet self-sufficient and depend on imports from other countries (Figures 1 and 2).

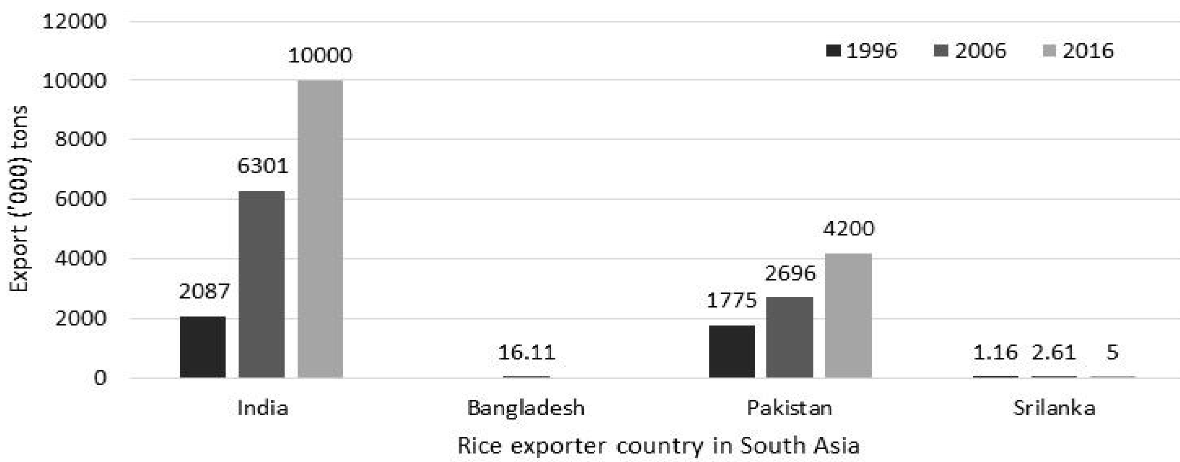


Figure 1: Rice exports in thousand tons by year **Source: USDA, 2016**

Figure 1 Shows that India is the major exporter of rice from South Asia selling about 100 million tons in 2016. Pakistan is the only other exporting country but the volume is much lower compared to India.

Figure 2: Rice imports in thousand tons by year **(Source: USDA, 2016)**

Figure 2 Shows the trend of rice import by Nepal, Bangladesh and Sri Lanka. Nepal is highly dependent on import from others countries and the biggest importer of rice in South Asia. India is the only one self-sufficient country in the region in 2016.

Rice occupies about 46.5% of total cropped area and contributes 54% of total cereal production in Nepal in 2016. During the mid 1990's Nepal had national food deficit of 14.3% however this varied greatly by region with 79% in the mountains and 36% in the Hills, with the Terai region being the only area to produce a surplus, 7% (Gill, et al, 2003). The 1995-97 periods saw a dramatic increase in food insecurity and deprivation up to 26% of the population, with a wide geographic distribution, potentially related to political turmoil (FAO, 2003). An estimate by MoAD indicates a food grain shortage of 1,32,910 Mt for 2008/09 but in 2012/13, there was a food surplus of 4,08,442 Mt (MoAD, 2014/15). Dalit were worst affected and most critical months for food insecurity are March, April, July, August and September (50% food insecurity in July- September) due to severe flood, road obstruction, rise in food prices, and decreased production. In general, food security situation will be achieved in November–December due to harvesting season of the paddy. Agriculture production is generally poor in the hills and mountain region of Nepal, particularly food deficit and more vulnerable to drought. The low production is largely due to the predominance of rainfed agriculture, traditional farming practices, limited agri-input, inadequate technical advice for farmers due to poor extension services, poverty and limited availability of credit, and frequent droughts and floods.

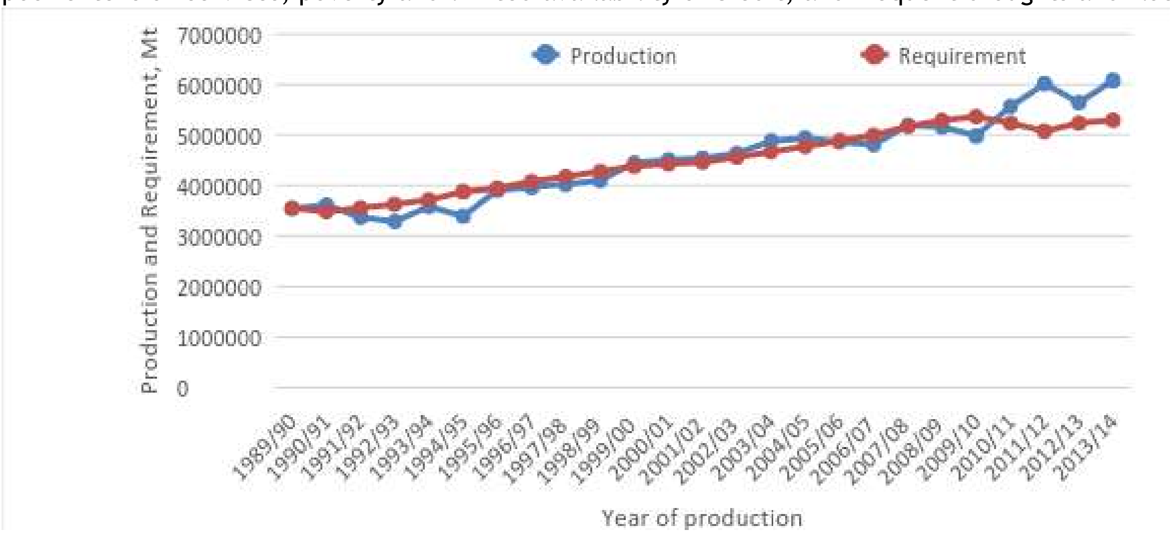


Figure 3: Food availability and requirement of Nepal **(Source : MoAD, 2014/15)**

Figure 3 shows the trend of food availability for consumption and requirement from 1989/90 to 2013/14. During this period, 2005/06, 2006/07, 2008/09 and 2009/10 were the year of food deficit and other periods are the year of food surplus.

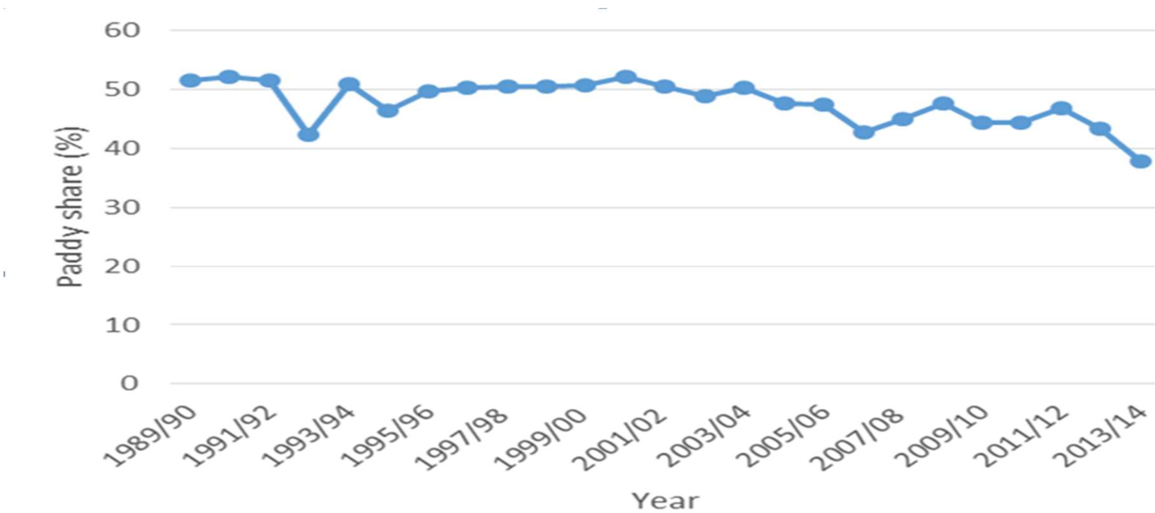


Figure 4: Paddy share among total production for consumption Source: MoAD, 2014/15

The figure 4 showed that paddy share was above 50% before 2000 and found declining and reached below 40% in 2013/14 in total production among cereal crops. Contribution of rice in food security was found decreasing in recent years. The reason behind this may be the unavailability of rice in hill and mountain, lack of transportation facility to transport from terai to mountain, increased in price per Kg and increased population and also the consumption pattern of the consumer.

2. Share of Paddy in agriculture and Gross Domestic Product (GDP)

Agriculture has historically been a dominant sector in South Asian economy, employing about 60% of the labor force and contributing 22% of the regional GDP. In Nepal, agriculture remains the principal economic activity, employing 60.5% of the population and providing 32.6% of GDP (Economic survey, 2015/16. Sri Lanka's rice sector contributes 30% to the agricultural GDP (Mendis, 2009). Rice is the single most important crop occupying 34% (0.77 million hectares) of the total cultivated area in Sri Lanka. In 2003, India and Bangladesh together contributed 28% (22 and 6 respectively) of global rice production and 33.57% in 2009 (26 and 7.5 respectively). However, the share of rice in total agricultural output (Figure 5) and total GDP has been declining. In 1961, rice accounted for 8.4% of GDP in South Asia, declined to 2.7% in 2007.

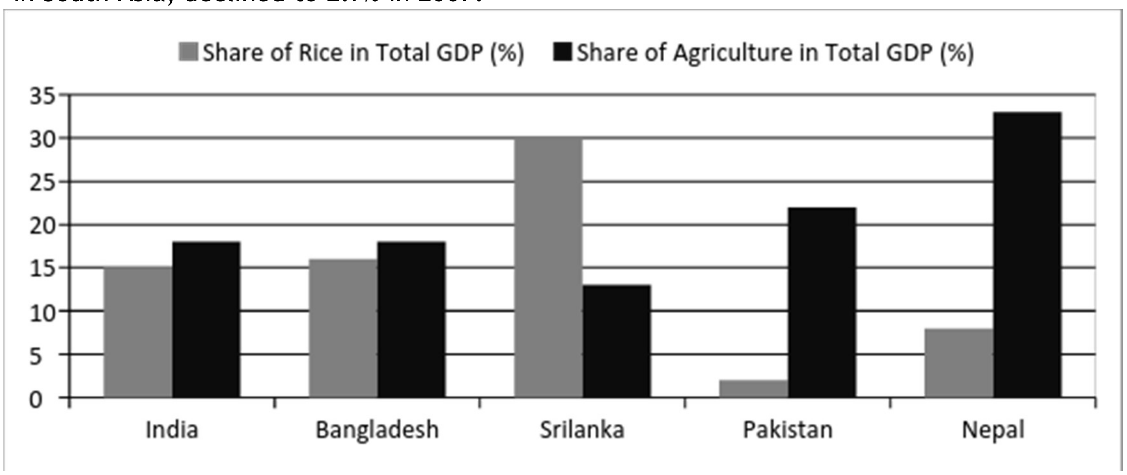


Figure 5: Share of rice and agriculture in total GDP, 2010-11

Figure 5 shows the percentage share of agriculture and rice in total GDP in 2010/2011. Pakistan's agricultural share in total GDP is higher than that of India and Bangladesh but contribution of rice to total GDP remains much lower. Rice contributes the lions share in GDP for Sri Lanka, while India and Bangladesh show a similar pattern of dependency on rice. For Nepal, agriculture has the biggest share in total GDP comparing to the other four countries but shows that contribution of rice to GDP is comparatively higher.

3. Importance of rice and consumption pattern in South Asia

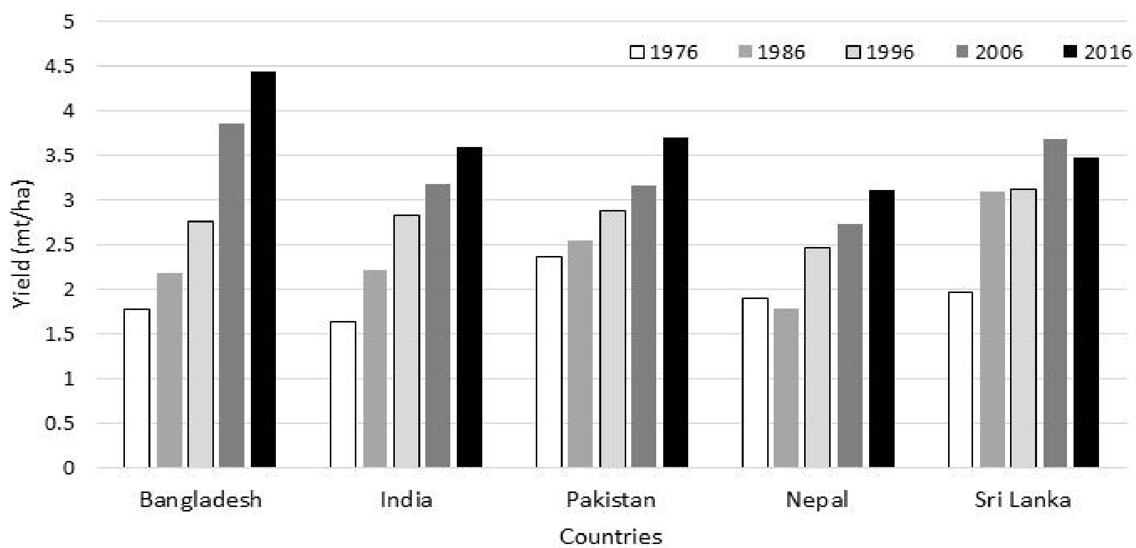
Rice is the cheapest and most effective means available in this region that is likely to eradicate acute under-nutrition. Many studies have revealed that there is a great potential to increase the rice production and productivity in South Asia. India, Bangladesh and Sri Lanka are among the most disaster-prone countries in the world. Recurrent floods, cyclones, earthquakes, landslides and droughts hugely affect the production in these countries. Still they have maintained a steady growth for the last three decades (Figure 7). And now with the advent of modern breeding strategies, which has proved to be much more efficient than conventional techniques, and environmental stress-tolerant varieties, the whole scenario for rice production appears better than ever. The Indian subcontinent has a tradition which is inseparably mingled with rice, is more than mere livelihood and has shaped the history, culture, art, and lifestyle of its population in many ways. It is regarded as a sign of fortune and well-being in many South Asian societies. In weddings, seasonal festivals, and rituals, rice plays an inevitable part. The amount of rice consumed in this region explains how important rice is in their lives (Table 1). The so-called Rice-Lentil soul and curry is an iconic menu seen across the entire Indian subcontinent. Bhat (cooked rice) is the term for meal in many South Asian languages. In Hindu rituals, paddy is an indispensable item. Two panicles of paddy appear on many logos, monograms and bank notes in Bangladesh.

Table 1: Per capita consumption pattern in South Asia

Country	Per capita Consumption(Kg/person/year)			
	1970-1972	1989-1991	1999-2001	2011-2013
Bangladesh	150	153	155	171.73
India	69	79	76	69.49
Nepal	82	106	99	87.75
Pakistan	29	14	13	12.25
Sri lanka	95	93	94	109.72

Source: adapted from FAOSTAT database.

Table 1 shows that in terms of per capita consumption, Bangladesh is the largest consumer of rice which explains why it depends on imports every year despite having the highest production rate. Sri Lanka holds the second position in per capita consumption of rice. Nepal and India show a similar rice-consumption pattern. Pakistan is the country least dependent on rice.



Source: United States Department of Agriculture

Figure 7: Paddy yield (Mt/ha)

Figure 7 Shows that Bangladesh, Pakistan and Sri Lanka has been the highest rice yielding nations since 1976 in South Asia. All the countries except Nepal have shown an increasing yield since 1976. The lowest rice yield was found in Nepal compared to other south Asian countries.

4. Future prospects and importance of rice research in South Asia

The population in South Asia is predicted to exceed six billion by the end of the century and may face a severe food shortage unless production can keep pace with the increased demand. Also, there are many crucial problems including water scarcity, decreasing size of agricultural land, inadequacy of agrochemicals, power shortage and poor infrastructure. Yet there is a ray of hope shed on the future of rice by biotechnology which ensures greater productivity. Additionally, sub continental soil is suitable for rice and production per unit of land is considerable. However, the demand for food is only rising and is being met by constantly diminishing resources. To boost production, increasing amounts of fertilizer and pesticides are being used and aggravating environmental and ecological problems. Thus the need for a sustainable intervention to these urgencies necessitates innovation in rice technology and development of varieties which are not only high yielding but also can be produced in more eco-friendly ways. The development of high yielding varieties(HYVs) and bio-fortified, disease-, insect-, flood-, drought-,saline-, herbicide- and stress-resistant rice has opened anew era in the history of rice and will boost rice production in near future. Genetic engineering has offered rice cultivars resistant to herbicide, salinity and drought. Malnutrition, being a widespread problem in this region, requires an immediate intervention which may be very effectively addressed by bio-fortified rice. Rice bio-fortified with iron and zinc can protect against certain deficiency diseases and people who have no access to commercially marketed fortified foods and supplements will greatly benefit from it. Golden rice, which is a genetically modified strain of rice and enriched with beta-carotene, has the potential to save millions of children from blindness and other deadly consequences of acute vitamin A deficiency. More and more biotechnologists around the world are working to develop such micronutrient-rich rice varieties which were not possible by conventional breeding technologies. Field trials are also being undertaken to estimate any potential health impacts of the newly innovated rice cultivars. Gene banks have a major role to play in preserving the native cultivars and the artificially designed ones. From a food security perspective, gene banks are invaluable as they provide all the past cultivar options and if a variety fails to due to certain causes, farmers still can turn to gene banks for the varieties that were previously available. Food security has four pillar like, availability, access, utilization and sustainable. South Asian countries had focused on availability section. Remaining three pillars had also played great role to achieve food security. Remittance and introduction of Nepal Food Cooperation (NFC) has changed the food habits in Nepal. People living in remote districts depend on rice for food due to availability of food through NFC and remittance has increased the purchasing capacity of people. Therefore, the country has to focus on food habits of the people and promote the local foods for consumption. Not only self sufficiency in rice but also changing in food habits may play crucial role to achieve food security in near future.

5. Regional rice economy

Food security is a multifaceted issue influenced by national and international policy making; social, economic, environmental and demographic variables being the most prominent ones. Rice is not only the staple crop of South Asia, it is also a political crop. Large rice stocks are maintained by many countries and remain untraded until market prices rise abnormally high, and consequently food scarcity remains a common scenario across many poor areas. Though South Asian Association for Regional Cooperation (SAARC) countries has launched the South Asia Food Security Program, there is still a lot to be done. Lack of mutual cooperation has long debilitated the region's socioeconomic development. Shockingly, in terms of regional trade, South Asia is the world's least integrated territory, trade between the countries accounting for less than two percent of the gross domestic production (GDP) of the region. Promoting regional cooperation and integration with neighboring organizations like Association of Southeast Asian Nations (ASEAN) can prove to be phenomenal in alleviating poverty and achieving food security. Cross-border trading, mutual work on scientific and technological research, and improved communication will greatly facilitate the region's political, economic, and social welfare and would enable the countries to mitigate against food crisis and other related issues more effectively. It is therefore of utmost importance to strengthen regional cooperation and build ties across political borders to increase trade and improve regional food security.

6. Rice production and Nepalese context

Table 2: Production trend of cereal crops in Nepal and Rice contribution ('000 Mt)

Cereal Crops	1964/65	1984/85	1994/95	2012/13	2013/14	2013/14 Percentage
	3270	4210	5440	8817.6	9562.3	
Paddy	2201	2709	2906	4504	5047	52.78
Maize	854	820	1302	2078	2283	23.88
Wheat	126	534	942	1882	1883	19.69
Barley	26	23	37	37	35	0.37
Millet	63	124	253	306	304	3.18
Buckwheat				10.6	10.3	0.11

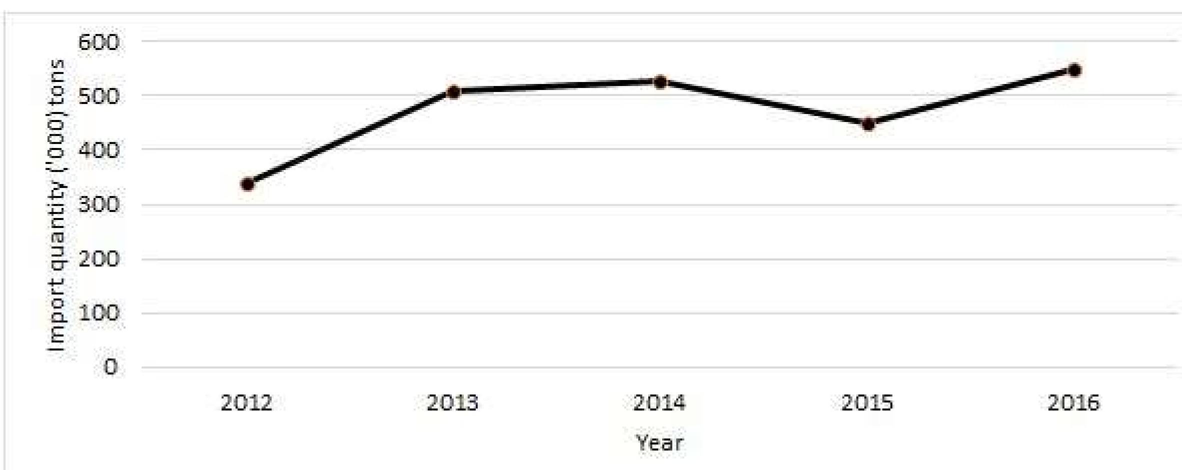


Figure 8: Import of rice by Nepal in differtn years Source : USDA, 2016

From table 2, among cereal crops, rice contributes more than 50% of the total production as well as edible grain production. Rice is the major crop for food security of any households. Majority of the people consumed rice two times per day. Food balance sheet in Nepal includes edible portion of the major cereals—rice, maize, wheat, millet and barley (MOAD, 2014). Availability of the edible portion of the food grain from domestic production shows that rice contributes nearly a half (48%) to the total edible food grain production. Another half of the food grain is contributed by maize and wheat. Mostly people consumed rice everyday. Therefore, rice production determines the food security of the individual or family. If agricultural production in Nepal is adversely affected by the climate change, the livelihoods of two-thirds of the labor force, particularly of the rural poor will be at threat. Food sufficiency at the national level during good crop harvest, however, not necessarily mean food security at the household and individual levels in the country due to unavailability, poor access, poor utilization and vulnerability at different parts of the country. Figure 8 shows the import quantity of rice was increasing by Nepal since 2012 and reached to 550,000 tons in 2015.

CONCLUSION

It is apprehensible that sustained production of rice is central to food security. Sub-continental land is quite capable of being self-sufficient in rice production and India and Pakistan have already proved that. Since poverty is another direct cause of food insecurity, people can move out of stark poverty if they can be employed in agricultural activities and many such projects are already in operation in many countries. From the present South Asian perspective, there is no other easier way to promote national food security than through gaining self-sufficiency in rice production. Raising agricultural production is evidently the most direct way to tackle food insecurity in agronomic countries and agronomy is essentially rice economy in South Asia. The fact that most of the poor and undernourished people of South Asia are living in rural areas, and that they are largely dependent on agriculture for their livelihood can be a problem and a solution at the same time. Since agriculture is the mainstay of its economy, and the ratio of rice land to arable land is high in the subcontinent, there remains an opportunity to expand domestic rice production by creating employment and income generating opportunities in the face of ever increasing demand for rice. If self-sufficiency is achieved, it will create scope for surplus production. Also, having a surplus of rice will allow rural people to profit and can lift them above the poverty line. In a strict sense, income generation and food security initiatives go hand-in-hand and this reality makes rice more important to food security in South Asia. This paper thus substantiates that agriculture is the backbone to the South Asian economy and that rice, being the staple agricultural product, holds the capacity to pull people out of stark poverty and ensure sustainable availability of food for the food-insecure population. Food required in Nepal is largely met by domestic production and food inadequacy during bad production years is about five percent of the total consumption. The bad production comes mainly from widespread droughts and sometimes from localized floods. Food sufficiency at the national level during good crop harvest, however, not necessarily mean food security at the household and individual levels in the country due to unavailability, poor access, poor utilization and vulnerability at different parts of the country and for many households.

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ASSESSMENT OF TOMATO CONSUMPTION AND DEMAND IN NEPAL

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ABSTRACT

Tomato is also known as the poor man's apple in Nepal. China is the largest producer of tomato in the world. Tomato is grown throughout the year in recent years in Nepal with the introduction of plastic house for off season production. Secondary information is used to assess the consumption pattern and national demand of tomato in 2015/16 for Nepal. The result showed the import from India is increasing compared to previous years. The reason behind this might be increase in consumption of tomato in recent years in Nepal. The central development region is the highest consumer of tomato compared to other regions of the country. The average national consumption of tomato was found 11.97Kg/person/year in Nepal.

***Key words**: Tomato, production, consumption, demand, eco-belt*

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the important crops used as a fresh vegetable as well as in a variety of processed products such as ketchup, sauce, juice, puree, pasta sauce, salsa, tomato-based powders, sun-dried tomatoes, curries and ready-to-eat products (Subramanian, 2016). The largest producer of tomato is China (One quarter) followed by India and the United States (FAOSTAT Database, 2016). There are different varieties of tomato mostly producing red berry and there are also some tomato varieties that produce yellow, orange, pink, purple, green and white berry. They are also an excellent source of lycopene, which is the pigment that makes tomatoes red and has been linked to the prevention of many types of cancer (Giovannucci, 1999). The best sources of lycopene are found in processed tomato products, such as ketchup and other tomato products (Giovannucci, 1999). The world dedicated 5.02 million hectares in 2014 for tomato cultivation and the total production was about 188.2 million tons with world average farm yield was 37.46 tons/ha (FAOSTAT Database, 2016). Tomato farms in the Netherlands were the most productive in 2012, with a nationwide average of 476 tons/ha, followed by Belgium (463 tons/ha) and Iceland (429 tons/ha). In 2012, tomato production was valued at 58 billion dollars and tomatoes were the 8th most valuable agricultural product worldwide (FAOSTAT Database, 2012).

There are around 7,500 tomato varieties grown for various purposes (FAOSTAT Database, 2012). Heirloom tomatoes are becoming increasingly popular, particularly among home gardeners and organic producers, since they tend to produce more interesting and flavorful crops at the cost of disease resistance and productivity (Gentilcore, 2010).

Majority of Nepalese people depend on agriculture for their livelihoods and has contributed about 32.6% of nation's GDP alone by the agricultural sector in the year 2015/16 (WB, 2016). In the year 2014/15, the average economic growth was confined to 0.77% where agriculture sector growth rate was only 1.3% due to devastating earthquake and blockade by India (MoF, 2016). Traditional and conventional subsistence farming system, lack of rural infrastructures facilities, lack of proper market information system, inadequate technological extension as well as marketing support system, unavailability of sufficient quantity of quality production inputs and weak linkages among

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the stakeholders are hindering the rapid development of the agriculture sector. Nevertheless, agriculture commercialization and production of high value crops is gradually increasing. Fresh seasonal and off-season vegetables have been categorized as high value crops. Different promotional campaigning for the commercial production of vegetables has been initiated by government as well as private sector to increase the income of farmers and generation of employment opportunities at rural areas of the country resulting into significant increment of vegetable production. In the year 2013/14, the area of vegetable crops was 2,54,932 ha, total production was recorded at 34,21,035 mt and the yield was recorded at 13,419 kg/ha (MOAD, 2016).

In Nepal, there is a great potentiality of growing large number of vegetable crops because of the availability of a wide range of agro-climatic and topographical conditions from subtropical, temperate to cold climate. Nepal produces vegetables worth NRs 55 billion annually and around 70 percent of total household of country are being involving in vegetable farming with about NRs 12 billion investment in farming every year. Terai is the major vegetable growing area with an annual production of 1,437,921 mt, followed by hilly region with 1,261,041 mt. Of the total production, 39% (1.10 million mt) is used for household consumption and 61% (1.71 million mt) for sale (PACT, 2012). Tomato is most important vegetable crop having high market potentialities. While open field cultivation during Autumn-Winter is common in Terai, inner Terai and foot hills, cultivation inside plastic tunnels in Summer-Rainy season in the hills is getting popularity which is sold as off-season product fetching higher prices in Terai of Nepal and nearby Indian markets. Thus, there is comparative advantage for mid and high hills for income generation and improve the livelihood through tomato farming. Some popular tomato varieties among farmers in Nepal are Abinash, Allrounder, Trishul, Sirjana, Manisha, Shamjhana, Dhanalaxmi, Indira, Roma, Pusa Ruby, NBL-1 and others.

Tomato is labor intensive crop, wage alone constituting half of the total cost of production. Production peaks in summer in the Hills (from May to September) when it is off-season in Terai. On the other hand, it can be produced in the Terai in winter (from November to March) when it is too cold in the Hills. Market demand and prices also vary with season and locations of the country. Most of the tomato produced in Nepal is used for kitchen purpose, only small quantity used for industrial purpose. Import of fresh tomato as well as tomato paste for industrial purpose from India and China is in practice to make tomato ketchup. Tomato consumption has been increasing in Nepal during recent past resulting in high market demand throughout the year. The trend of using plastic house for off season tomato production has been increasing. Though this practice needs higher investment, it also means higher profit due to higher yield and higher prices compared to open field cultivation. The product flow and relationship among the actors is crucial to find out the gap for increasing chain efficiency of the product. Present study is an effort to analyze existing scenario of tomato, national level demand and supply situation, value chain and recommend market oriented solution for further intervention.

METHODOLOGY

Secondary information was used in assessing the demand and supply of tomato and its value chain. Secondary information were collected from district agriculture development office (DADO) publication, regional and central level organizations like Ministry of agriculture development (MoAD), Market research and statistics management program (MRSMP), Kalimati fruit and vegetable wholesale market (KFVWM) and central bureau of statistics (CBS). Publication of concerned stakeholders and unpublished office records were collected and analyzed. Two types of tomato production systems: open field cultivation in Terai region and plastic house cultivation in mid hill region was assessed.

RESULTS AND DISCUSSION

1 Production and Productivity

The required temperature regime exists in different agro-climatic regions of Nepal at different times of the year allowing almost year-round production in the country. There are two main groups viz. processing tomato—normally cultivated in open fields and table tomato—cultivated in open fields or in greenhouses. With ideal level of inputs and management practices open field cultivation can produce 100-120 mt/ha, while greenhouse cultivation can yield up to 500 mt/ha.

The national figures show that tomato was cultivated on a total 19,726 ha producing 2,98,594 mt in 2012/13 and decreased to 17,273 ha producing 2,32,897 mt in 2013/14. Average productivity was reported to be 15.1 mt/ha in 2012/13 and reduced to 13.5 mt/ha in 2013/14 which is quite low compared to other countries (Table 1). Among the 15 ecological/development belts, Central hill (which includes Kathmandu valley) produced largest volume of tomato followed by Eastern hills and Central Terai, respectively.

Table 1: Productivity of Tomato in the world, 2016

S.N.	Country	Productivity (kg/ha)	S.N.	Country	Productivity (kg/ha)
1.	USA	81000	7.	Iran	35800
2.	Spain	74000	8.	Turkey	33100
3.	Brazil	60700	9.	Mexico	30500
4.	Italy	50700	10.	India	21200
5.	China	48100	11.	Others	22600
6.	Egypt	39500	12.	World average	32800

Source: Subramanian, 2016

Table 2: Area, Production and Productivity Trend of Tomato in Nepal, 1991/92-2013/14 (MOAD, 2016)

Year	Area ('0,000 ha)	Production (Million mt)	Yield (kg/ha)
1991/92	14.05	1.13	8028
1992/93	14.05	1.18	8391
1993/94	14.05	1.20	8523
1994/95	14.05	1.21	8623
1995/96	14.44	1.33	9194
1996/97	14.65	1.36	9266
1997/98	15.00	1.45	9664
1998/99	14.02	1.34	9578
1999/00	14.90	1.49	9996
2000/01	15.72	1.65	10518
2001/02	16.10	1.74	10792
2002/03	16.60	1.80	10844
2003/04	17.26	1.89	10952

2004/05	18.08	2.07	11421
2005/06	18.98	2.19	11537
2006/07	19.19	2.30	11977
2007/08	20.81	2.54	12200
2008/09	22.52	2.75	12233
2009/00	23.51	3.00	12777
2010/11	24.41	3.20	13124
2011/12	24.50	3.30	13463
2012/13	24.64	3.30	13400
2013/14	25.49	3.42	13419

Table 3: Area, Production and Yield of Tomato by Region (2012/13-2013/14)

Ecological belt	Development region	2012/13			2013/14		
		Area (ha)	Production (mt)	Yield (mt/ha)	Area (ha)	Production (mt)	Yield (mt/ha)
Mountains		**906**	**10544**	**11.6**	**915**	**10407**	**10.6**
	Eastern	101	973	9.6	110	1086	10
	Central	527	6499	12.3	532	6481	12
	Western	51	694	13.6	38	509	13
	Midwestern	94	704	7.5	85	514	6
	Farwestern	133	1674	12.6	150	1817	12
Hills		**11417**	**166708**	**14.6**	**9284**	**146778**	**15.6**
	Eastern	2499	48957	19.6	2689	52066	19
	Central	6604	80692	12.2	4157	55813	13
	Western	1426	25171	17.7	1417	24989	18
	Midwestern	522	6464	12.4	653	8506	13
	Farwestern	366	5424	14.8	368	5404	15
Terai		**7403**	**121342**	**16.4**	**7085**	**113613**	**15.98**
	Eastern	1899	30679	16.2	1535	27156	18
	Central	2984	44608	14.9	2596	37902	14.9
	Western	937	21057	22.5	994	21632	22
	Midwestern	1435	23148	16.1	1280	21268	17
	Farwestern	148	1850	12.5	680	5655	8
Nepal		**19726**	**298594**	**15.1**	**17274**	**232896**	**14.6**

	Eastern	4499	80609	17.9	4324	80308	19
	Central	10115	131799	13.0	7285	62294	9
	Western	2414	46922	19.4	2449	47130	19
	Midwestern	2051	30316	14.8	2018	30288	15
	Far-western	647	8948	13.8	1198	12876	11

Source: Ministry of Agricultural Development, 2016

It was found that small scale growers were not interested in grading and proper packaging, whereas 80 percent of commercial farmers were found to use plastic crates for packaging and then transportation. All wholesalers and about 90 percent retailers use grading of their products before selling as they are aware that graded tomato fetch high prices. Similarly, plastic crates have been used for safe keeping and transportation of the product. Almost all traders (wholesalers and retailers) mostly like mature ripe tomato of large size with good fresh content. This type of tomato is needed especially for raw use (salad) in hotels and restaurants. Household level consumers prefer to buy small sized tomato for pickle.

2 Demand, Supply and consumption trend of Tomato in Nepal

Table 4: Percentage of tomato consumption by source

Region	Home production (%)	Purchase (%)
Nepal	**21.8**	**78.2**
Eastern	27.0	73.0
Central	9.2	90.9
Western	20.6	79.4
Mid-western	51.0	49.0
Far-western	51.7	48.3
Eco-belt		
Mountain	51.2	48.8
Hill	24.7	75.3
Terai	13.5	86.5

Source: NLSS_III, CBS, Nepal

The results showed that consumption of tomato is highest in central development region through purchase (90.9%) followed by western but the far western and western region purchased less than 50% of their requirement. The mountain belts purchase less than 50% of their demand of tomato while hill has around 75% demand meet by purchased tomato and Terai belt has higher purchased tomato (86.5%) (Table 4). The reason is around 50% of the population resides in Terai belt and higher the population, the demand will be higher. Besides this, around 25-30 lakhs population resides in Kathmandu valley only.The Terai belt are unable to produce tomato during rainy reason due to flooding and the Terai belt is known as the granary of cereals and all land is covered by paddy. So, only one winter season is allowed to produce tomato. The supply is less than demand of tomato in Terai. So, the source is purchased rather than home production.

Table 5: Consumption of tomato/person/Kg

Region	Tomato consumption			Population Estimate (million)			
	Kg/day	Kg/month	Kg/year	2013	2014	2015	2016
Nepal	**0.033**	**0.984**	**11.97**	**27.26**	**27.65**	**28.04**	**28.43**
Eastern	0.034	1.025	12.48	5.93	5.99	6.06	6.12
Central	0.033	0.997	12.13	10.00	10.18	10.36	10.54
Western	0.033	0.984	11.97	5.02	5.06	5.11	5.16
Mid-west	0.032	0.967	11.77	3.66	3.72	3.78	3.84
Far-west	0.027	0.812	9.87	2.63	2.67	2.72	2.76
Eco-belt							
Mountain	0.028	0.835	10.16	1.81	1.82	1.84	1.85
Hill	0.032	0.968	11.78	11.64	11.77	11.89	12.02
Terai	0.034	1.018	12.39	13.80	14.05	14.30	14.55

Source: NLSS-III, 2014

The results showed that average consumption of tomato is around 12 kg/year/person (Tale 5). The far western region has the lowest consumption of tomato (9.875 Kg/year/person) compared to other four development region (around 12 Kg). In case of belts, mountain belt has lowest consumption of tomato (10.84 Kg) compared to hill and Terai belts.

Table 6: Estimated Tomato requirement in Mt.

Region	2015			2016		
	mt/day	mt/month	mt/year	mt/day	mt/month	mt/year
Nepal	**919.7**	**27591.0**	**335690.8**	**932.6**	**27978.3**	**340403.2**
Eastern	207.1	6212.1	75580.8	209.2	6277.0	76370.1
Central	344.2	10325.2	125623.7	350.3	10508.2	127849.2
Western	167.7	5032.1	61224.3	169.3	5079.3	61798.3
Mid-western	121.9	3658.5	44511.2	123.9	3717.8	45233.3
Far-western	73.5	2206.1	26841.0	74.7	2241.0	27265.7
Eco-belt						
Mountain	51.2	1536.7	18696.3	51.6	1548.9	18845.3
Hill	383.9	11515.7	140107.7	388.0	11640.1	141620.7
Terai	485.3	14559.1	177135.6	494.0	14819.9	180308.1

Source : NLSS-III, 2014

Nepal required 919.7mt of tomato for daily consumption in 2015, the demand will reach to 932.6 mt in 2016. Far western region required 73.5mt, the lowest compared to other regions for daily consumption while it reached to 74.7 mt per day in 2016. Mountain belt consumed lowest tomato (51.2mt per day) in 2015 compared to Terai 485.3mt per day in 2016. The tomato demand in mountain will reach to 51.6 mt while in Terai,reached to 485.3 mt per day in 2016 (Table 6).

3. Trade

A study conducted by Central Bureau of Statistics (2010) indicates that 57 percent of tomato production is consumed by producers themselves and remaining 43 percent inters into market chain. On this basis nearly 128,395 mt of domestic production was traded out of which 27 mt was exported to India and nearly, 8,006 mt was imported from India in the year 2012/13. This means that a total of 136,374 mt was traded in the country. Large quantity of processed tomato products such as purée, paste, ketchup and sauces being imported from several countries including India, China and Thailand are not included in above figures. Kathmandu is one of the major domestic markets for tomato at national level. Most of the tomato is distributed from the Kalimati Fruit and Vegetable Wholesale (KFVW) market in Kathmandu. Data available from KFVWM showed that the market traded a total of 27,758.6mt tomato in 2069 BS (13/04/2012 to 13/04/2013). The total volume of tomato marketing is in increasing trend within inside valley but the imported volume from India is also increasing. The tomato volume imported from India was 5.28% in 2012/13 but it was found 12.75% in 2014/15.

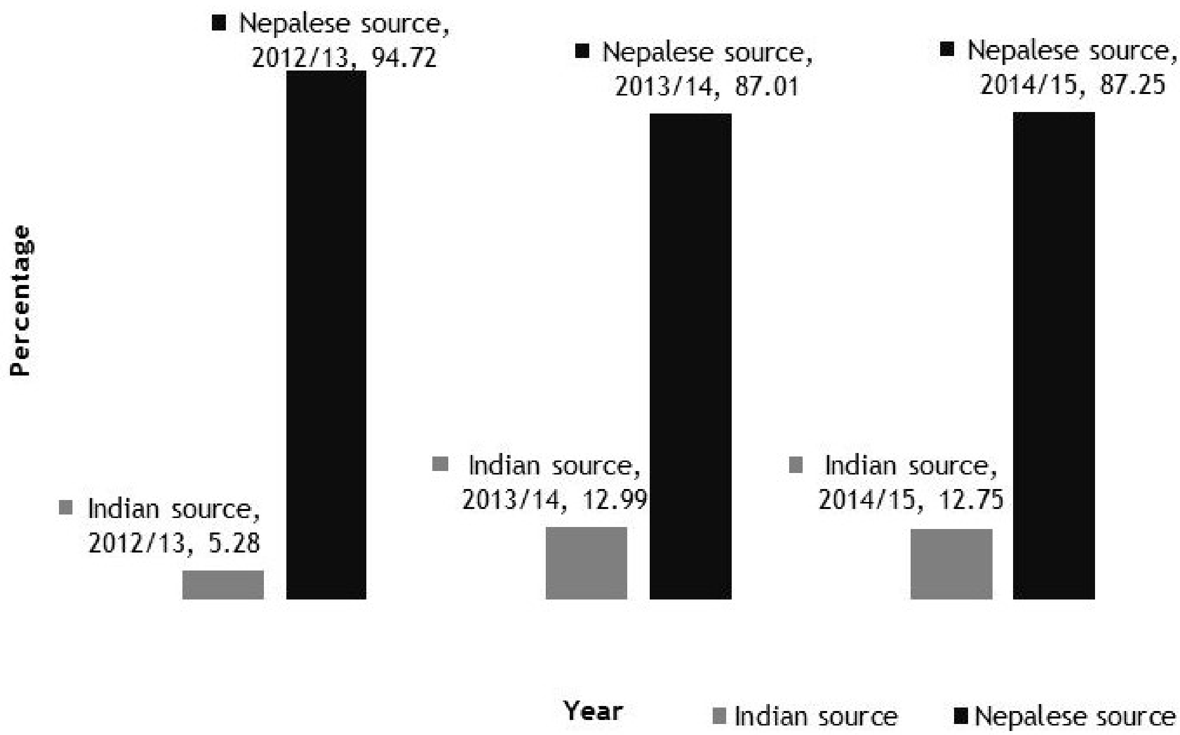


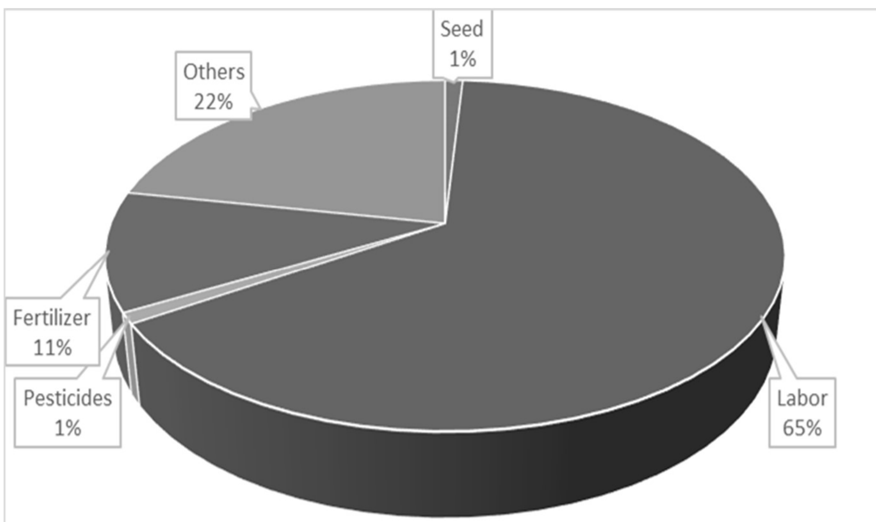
Figure 1: Percentage share of tomato from Nepal and India at Kalimati market from 2013-15

The lowest volume trade was recorded in September/October due to offseason while the highest volume of tomato trade was found in May/June due to seasonal production both in open and plastic house (KFVWM, 2016).

COST AND BENEFITS

1 Production Level

Initial investment in plastic house construction is the major cost of production for plastic house production. Seeds, fertilizers, pesticides, wages, and irrigation are other major cost items in production of plastic house and open field tomato. According to the MRSMP in 2015/16, the average farm gate price for tomato was Rs 20.25/Kg during January-February 2015. Local collectors spent about Rs 2.75/kg in collection, packaging, storage and transportation. They sold the product to wholesalers at about Rs 28/kg, making a profit of almost Rs 5.25/kg. Finally, average retail price in major market was Rs 42/kg. Considering packaging, transportation and handling cost of Rs 5/kg, it is obvious that intermediaries received large part of profit in fresh tomato chain. Traders reported that the high difference between producer and consumer price was due to high transportation cost and storage loss. It was estimated that post-harvest losses in fresh tomato was about five percent each at producers, collectors, wholesalers and retailers level. Higher land productivity is maintained by higher use of chemical fertilizers and pesticides. Frequent spraying with fungicide is common in tomato farming.



Source : MRSMP, 2016

Figure 2: Share of different cost items for tomato production per hectare in open field

Major cost of production of tomato in open field comprises five major cost items. They are seed, wage labor, fertilizer, pesticides, manure and stacking. Wage was recorded to be the highest cost component that comprised of 65% of total cost, followed by land rent, management cost and interest (22%), manure and fertilizers (11%), seed (1%) and pesticides (1%) (Figure 2).

PRICES AND PAYMENT SYSTEM

Producers do not have control on pricing of potato. Buyers usually fix the price of tomato depending upon domestic market demand and export/import opportunities. Wholesalers/traders observe the market signals, instruct commission agents accordingly and collect through those commission agents or directly from producers. There is no contract farming systems adopted among producers and buyers though there is often some commitment to buy according to going market price. There is also no system of price fixation before harvest and buy back guarantee to the producers, which is often, used in fruit crops such as orange. Some cooperatives and local traders also buy from producers with assurance that a fixed proportion of prices to be prevailed at terminal market on expected sales date will be provided to producers.

Payment system differs by stakeholders and locations. The commission agents generally buy in credit from producers and pay when they get payment from wholesalers. The wholesalers normally sell to the retailers in credit and get payment within mutually agreed date. Stakeholders reported that the informal payment system prevailing in domestic market often created disputes in the past, which were resolved by mutual understanding or through mediator within the chain. There is huge demand of fresh tomato in Indian markets during June to October which is off-season in plain areas of bordering states of India. However, Nepal is unable to catch up those big markets due to Indian restriction for Nepali agro products. Though small amount of tomato goes to India during those months through informal channels, most of the benefits go to intermediaries operating either side of the border.

Tomato being highly perishable the price is not stable in comparison of other vegetables. Difference between monthly minimum and maximum price was recorded from Rs 21 in May 2015 to Rs 43 per kg in April 2016 in KFVW market (Figure 8). Traders in KFVW market reported that price differences of up to Rs 20 per kg were observed within a day mainly because of mismatch between demand and supply. It was also revealed that bigger size tomato are sold at higher prices compared to smaller size as bigger sizes are preferred by restaurants and processors.

The average price is found lowest Rs. 20-25/Kg during April-June and around 30-40 during December-March, then the average price increased upto Rs. 60/kg in remaining months but range of price of big tomato is found Rs. 20-60 during the whole year (Table 10).The average price is found lowest Rs. 18 per Kg in June, January and February, then the average price increased up toRs. 50/kg in remaining months but range of price of small tomato is found Rs. 18-50 during the whole year (Figure 4).

Table 9: Monthly prices of Big and Small Tomato at Kalimati markets, 2015/16

Months	Monthly price (Rs.)					
	Tomato Big			Tomato Small		
	Minimum	Maximum	Average	Minimum	Maximum	Average
April	28.00	65.00	44.30	12.00	65.00	39.82
May	35.00	75.00	46.57	30.00	80.00	53.48
June	28.00	70.00	51.59	30.00	70.00	45.65
July	35.00	65.00	50.13	40.00	80.00	55.14

August	22.00	50.00	37.06	24.00	60.00	37.15
September	28.00	65.00	42.49	12.00	35.00	22.72
October	25.00	100.00	52.55	10.00	100.00	40.31
November	45.00	100.00	65.94	30.00	75.00	53.04
December	38.00	60.00	47.25	15.00	60.00	35.84
January	35.00	50.00	42.66	15.00	35.00	22.59
February	28.00	50.00	37.67	20.00	40.00	26.74
March	25.00	40.00	33.92	22.00	50.00	35.73
Average	**22.00**	**100.00**	**46.01**	**10.00**	**100.00**	**39.02**

Source: KFVWM, 2016

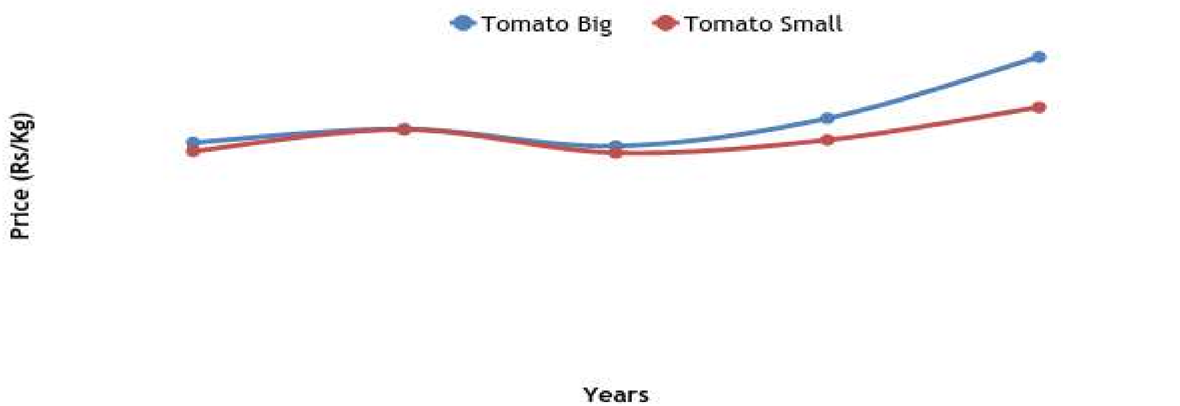


Figure 3: Comparison of price of big and small tomatoes in five years

Average price of both type of tomatoes was found quite similar from 2066-68. After 2069, the price was found differ and price of big tomato was found higher than small tomatoes. In 2070, the price was Rs. 44/Kg for big tomato while it was Rs. 35/Kg in 2070.

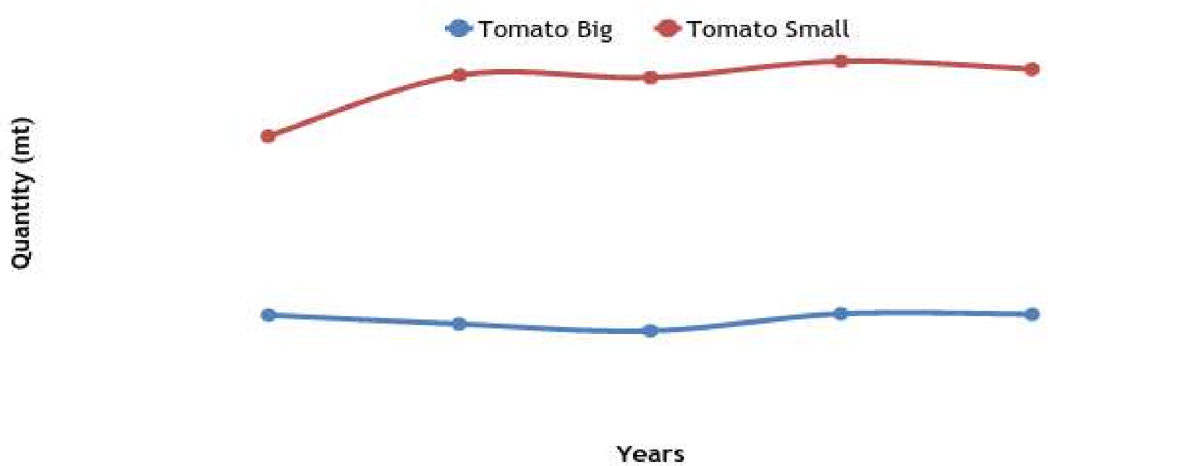


Figure 4: Comparison of quantity consumption of big and small tomatoes from 2066-2070

The quantity consumption of small tomatoes was found three times higher than big tomatoes in these 2066 but reached to four times after 2067 (Figure 8). The quantity consumption of small tomato was 15 million in 2066 but reached to above 20 million after 2067 onwards.

SUMMARY AND CONCLUSION

Tomato and its importance in Nepalese culture can be understood from the fact that it reaches to kitchen of every Nepalese household, irrespective of economic status and ethnicity, the difference being only of quantity and regularity. Diverse agro-ecological conditions in Nepal within short latitudinal distance offered comparative niche advantages for production of tomato in different seasons. There is great feasibility of production of off-season tomato along the mid-hills ecology. The market potential of such tomato is good both within and outside the country such as Tibet of China, bordering states of India and Bangladesh. Mostly seeds of hybrid varieties imported from abroad like Thailand, India, Korea and Japan are used in the production of off-season tomato. There is no strong research and testing of these hybrid varieties before introduction to the farmers' field. Considering large number of farmers, especially small and marginal farmers in the hills, being involved in tomato (off season) cultivation and large scope of export in international market.

The major problems observed in the tomato/vegetables export from Nepal were quick quality deterioration due to high moisture content, faulty packaging and packaging materials and lack of proper grading and proper handling during transportation. Hence, research is needed on quality production and also improvement in packaging, storage, transportation and handling. The off-season vegetable producing farmers' groups need to be provided technical support in the production of quality seeds within the country and production of fresh tomato in potential pockets with no or minimum use of inorganic chemicals.

Opportunities in this sector include scope of increasing the production area and overall productivity; increasing price through improved post-harvest practices like cleaning, grading & sorting; product and market diversification; import substitution; increasing employ of women and disadvantaged groups in production as well as processing activities and increasing earning of foreign currency through export.

The public sector should encourage farmers with certain subsidy on irrigation and postharvest handling along with support on infrastructure development like poly house. Farmers are lured toward tomato farming but they lack technical knowhow. Furthermore, tomato based industries should be promoted with especial benefit packages along with enabling environment for export of processed product.

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AN OVERVIEW OF PESTICIDE MANAGEMENT IN NEPAL

Parashu Ram Adhikari[1]

ABSTRACT

Agriculture is a wider sector where 54% people are engaged and one-third GDP contributed to the nation. Due to diverse climatic regions, farmers grow different types of agricultural commodities and presence of different pests reduces their production and thus need to apply pesticides. Pesticide Registration and Management Division under the Department of Agriculture is a legal authority to register as well as restrict or ban certain pesticides used in the agricultural sector in Nepal. The paper also emphasizes how Nepal has doing pesticide reduction for the pest management in agriculture considering the food safety, animal and human health and environment protection. And it also focuses on the legal aspects on pesticide management and status of registered, restricted and banned pesticides in the context of neighboring countries and addresses to fulfill the obligations of the international convention related to pesticides and industrial chemicals.

Key words: Agriculture, banned pesticides, pesticides, pests, pesticide management

INTRODUCTION

Nepal a land locked country where 54% population is engaged in agriculture and one-third GDP contributed to the nation (ADS, 2016; NPC, 2016). Nepal has a diverse climate- from sub-tropical to alpine climate, but a number of factors explain the weak growth performance of agriculture as compared to the neighboring countries. Variety, irrigation, use of chemical fertilizer, pesticide, and intercultural operations play an important role to increase the productivity of crops. About 15-25% food products are being lost annually in pre and post harvest activities caused by pests and if the loss is minimized, it can play a significant role in food security.

Certain industrial chemicals and pesticides used in human health and agriculture sector cause harmful effect on human health, wild lives and pollute environment when they are not handled properly. International organizations and national legislative measures play an important role for the management of industrial chemicals and pesticides.

METHODOLOGY

The study have done on the basis of reviewing of published reports, documents, articles and presentation by the government of Nepal and other international organizations working in the fiels of pesticide management.

FINDINGS

PESTICIDE management

Institutional arrangements for the enforcement of law

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Nepal imports pesticides from India, China and other countries and those pesticides are used for vector control, external parasites in animals and pest management in agriculture. For the better management of pesticides, country has prepared the Pesticide Act, 1991 and Pesticide Regulation, 1993 and enforced them from July 16, 1994.

The pesticides either in use, production, formulation, distribution or professional applicators, should be registered or regulated under the Pesticide Act and Pesticide Regulation of Nepal. Under the Act, there is provision of Pesticide Management Board. The board advises to the government in the formulation of a national policy regarding pesticides to maintain co-ordination between private and government in production and distribution of pesticides, regulate and control the quality of pesticides, and prepare standard of pesticides. Under the Board, technical, legal and pesticide disposal implementation sub-committees have been established. Pesticide Registration and Management Division (PRMD), under Plant Protection Directorate is responsible for pesticide registration, monitoring and management in central and 75 pesticide inspectors are responsible in district level (Pesticide regulation, 1993).

Monitoring and supervision mechanism

There is provision of Pesticide inspectors and district pesticide management committee in the Act for the management of pesticides in the districts. Act has given the legal authority to the pesticide inspectors for pesticide import and check the pesticide shop, go down and factories to monitor the quality and valid license.

Requirements for pesticide registration

At present, due to lack of pesticide quality checking laboratory facilities and experts, Nepal has to rely on foreign analysis result of pesticides. The pesticides are registered on the basis of trade name. Pesticide Registration and Management Division demands the following documents during the registration:

a. Summary of intended use pattern

b. A statement of the need to use in Nepal

c. Evidence that the product is registered overseas (copies of registration certificates, affidavits or approved labels)

d. Three copies of the original label of the product to import and sale

e. Report of EIA (Environmental Impact Assessment) for more than 10 mt

f. For research no attachments are necessary

Any persons, institutions, or companies can submit by attaching the required documents for the registration of pesticides, the board may make necessary inquiry during the process of registration and grant the retailer license.

Notified pesticides

According to the Pesticide Regulation Section 9, the government should publish the name of the registered pesticides in the Nepal Gazette after recommendation by the board. Those pesticides other than notified ones, are not to be imported, exported, produced, used and distributed (Pesticide Act, Section, 11). All the terms and conditions are specified in the license and should meet required minimum standard.

Registration situation

The pesticide registration situation varies country wise in the world. Generally, pesticide is registered after evaluation of country specific risk analysis. Pesticide handling, disposal and management training is provided to the technicians and resellers. The registered pesticides and information related to pesticide management in Nepal is presented in Table 1 and 2, respectively.

Table 1: Pesticides registered in Nepal

	Commonname	Trade name
Insecticides	51	1288
Acaricides	6	23
Fungicides	38	564
Bactericides	1	13
Herbicides	22	288
Rodenticides	2	29
Molluscides	1	2
Biopestcides	9	78
Herbal	3	4
Total	132	2289

Source: PRMD, 2016

Table 2. Information related to pesticides management

Particular	Number
Registered pesticides (trade name)	2289
Registered pesticides (common name)	132
Pesticide handling training for reseller	11242
Pesticide license	9954
Pesticide formulators	6
Pesticide applicators	15
Pesticide importer	160

Source: PRMD, 2016

PESTICIDE IMPORT AND CONSUMPTION

Use of pesticides

Pesticides are mainly used in vector control external parasites of animals and agriculture for pest control for pre- and post- harvest loss reduction. The total area covered by agriculture is 35912 square kilometer and use of pesticide amount depends upon the crops. Pesticides are used mainly in vegetables, tea, legumes, rice and maize. About 80% pesticides are used in vegetables. A recent study shows that the average pesticide used in Nepal is about 396 gm/ha (PPD, 2014), which was only 142 gm/ha in 1995 (IUCN, 1995).

Table 3: Cultivated area by different geographical regions

SN	Geographical region	Area of the country (km^2)		Total cultivated area of the country (%)	Percent of cultivated area
		Total	Cultivated		
1.	Himalayan	51313	1436	4.0	2.8
2.	Hills	61816	9337	26.0	15.0
3.	Terai	33851	25138	76.5	17.0
	Total	**147181**	**35912**	**100.0**	**24.0**

Source: MoAD, 2014

Table 4: Pesticide consumption by crops

SN	Crops	Total cultivated area (ha)	Total pesticide used (a.i. kg)	Pesticide quantity (a.i.kg/ha)
1.	Cereals	953.379	43.975	0.046125
2.	Vegetables	320.290	513.967	1.604693
3.	Cash Crops	69.266	12.921	0.186542
4.	Pulses	42.916	2.178	0.05075
5.	Fruits	66.880	1.952	0.029187
	Total	**1452.730**	**574.993**	

Source: PPD, 2015

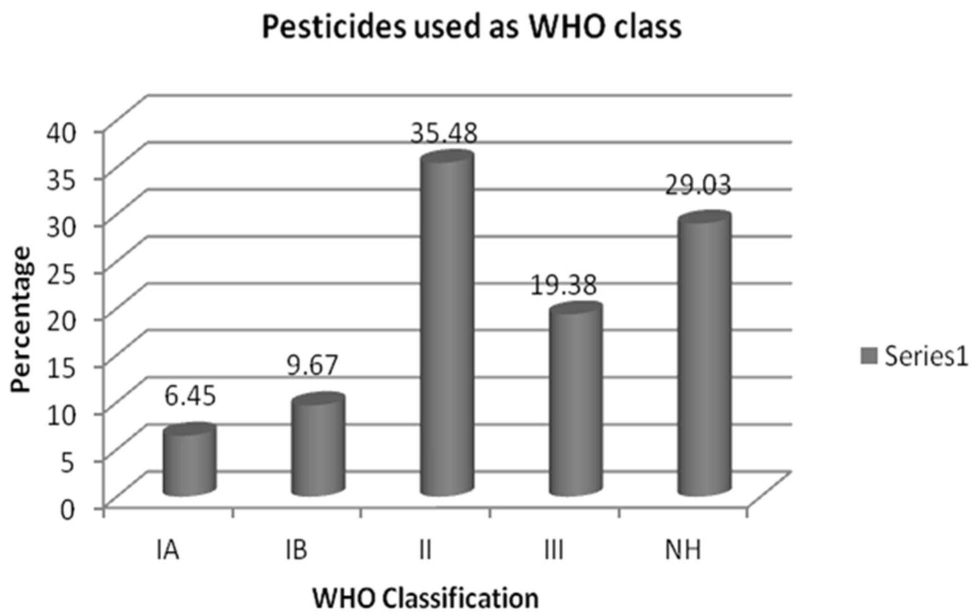


Figure 1. Pesticide used by WHO classification (Source: Sharma, 2014)

According to WHO classification, Nepal has registered Ib, II, III and U pesticides, and try to reduce the register and use of highly hazardous (Ib) and moderately hazardous (II) pesticides by advocating the consequences of pesticides and promotion of IPM and use of bio-pesticides.

Table 5: Pesticide consumption in Nepal

SN	Pesticides	Total quantity (mt)	Total quantity a.i. (mt)	Value ('000 US$)
1.	Insecticide	113.88	162.32	2855.56
2.	Fungicide	27.69	19.22	1315.29
3.	Bactericide	0.03	0.0031	8.96
4.	Herbicide	19.27	9.01	859.49
5.	Rodenticide	1.45	0.98	89.47
6.	Bio-pesticide	0.63	0.0071	34.84
	Total	**1629.50**	**454.5**	**5163.61**

Source: PRMD, 2014 (1 US$ = NRs 106.9)

Misuse/overuse of pesticides

The proper use of pesticide give results increase in agriculture production and vector control while misuse effect on health and environment. Baker and Gyawali (1994) highlighted the misuse of pesticides in four thematic issues, viz. health effect, environment damage, yield reduction and financial expenses. Within in these issues, there are many such consequences in case of Nepal.

GOVERNMENT STRATEGY

Especially during the 1970s, pesticide use increased with the beginning of agricultural technology transformation in the farmers to increase production for food security. Cotton Development Committee, Agricultural Inputs Corporation, Government Agriculture farm and Research Stations, District Agriculture Development Offices and Frontline Extension Workers are the main promoters of pesticide in Nepal. Besides, sectorial plans, programs and activities also emphasized the promotion of pesticides.

In 1996, when brown planthopper (*Nilapervata lugens*) outbreak occurred in rice and caused an estimated loss of US$ 212201. Then government of Nepal emphasized integrated pest management (IPM) strategy for the management of such pests by educating the farmers through farmer field school (FFS) in their own community. Nepal has been emphasizing the IPM from the beginning to date with the technical and financial support of FAO and some outputs are as follows:

- Technical Cooperation Project (FAO/TCP): 1997-1999
- Community IPM program : 2000
- National IPM Program –Phase I : 2003 - 2007
- National IPM Program –Phase II: 2008- 2013

Due to climate change, new and secondary pests have been increased (*Mythimna seperata* or *Spodoptera mauritia*), causing severe damage to crops, vegetables and fruits, giving birth to the climate field school in climate vulnerability communities.

The National Plant Quarantine Programme (NPQP) has developed 33 national standards harmonizing with ISPM, starting to build fumigation chamber (ISPM 15), pest database and beginning preliminary database of 20 tradable crops, pest risk analysis of some important crops, initial work on pest free areas (ISPM No. 4), and conducted training for plant health inspectors.

The new Plant Protection Bill 2017 has been prepared harmonizing with IPPC guidelines, Protocols and the WTO/SPS Agreement and is in the process of discussion in parliament for approval.

Community IPM

Table 6: Participation in different programs

SN	Training/workshop	No	Participants/Organization
1.	Strategy development, policy, and curriculum workshop	3	MOA, DOA, PPD, NARC, FAO
2.	Season long Rice IPM TOT officer level	1	30 APPOS, 1 NARC, NGOs
3.	Vegetable IPM TOT	1	30 GOs and 4 NGOs officers
4.	Season long Rice IPM TOT (JT level)	1	17 JT/As (GO) and 17 JTs NGO
5.	Training on Participatory planning	2	39 IPM trainers
6.	Training on Science by farmers	2	36 IPM trainers
7.	Farmer TOT	5	156 farmers
8.	Rice FFS by official trainer	404	10100 farmers
9.	Vegetable FFS by official trainer	23	575 farmers
10.	Farmer to farmer FFS	246	6150 farmers
11.	Farmer Science	14	350 farmers

Source: PPD, 2015

Table 7: IPM training

SN	Major activities	Numbers (Up to 2015)
1.	Officer level IPM ToF(Subject Matter Specialist)	179
2.	Non officer levels IPM ToF (JT/JTA)	276
3.	Farmers Facilitators	882
4.	Season Long IPM FFS	4425
5.	Yearlong IPM FFS	196

Source: PPD, 2015\

Production and use of bio-pesticides

Due to the negative effects of chemicals pesticide in crops, residue in foods, and environment pollution, use of bio-pesticides has been gradually increasing their use in vegetables at FFS conducted communities and started to register such eco-fiendly products. Farmers have started plant based bio-pesticides who learnt from the FFS and training. The amount of use of bio-pesticide is negligible as compared to chemical pesticides.

Table 8: Registered bio-pesticides

SN	Bio-pesticide	Trade name	Category
1.	Azadirachtin	10	Plant based
2.	Beauveria bassiana	8	Fungus
3.	Metarhizium anisopliae	3	Fungus
4.	NPV	2	Virus
5.	Pseudomonas fluorescene	6	Bacteria
6.	Trichoderma viride	8	Fungus

7.	Trichoderma harzianum	1	Fungus
8.	Verticillium lecani	4	Fungus
	Total	**42**	

Source: PRMD, 2014

Five community IPM Resource Centers were established in districts to support the IPM farmers and 21 farmers were trained on lab handling and bio-agent rearing. The products are used by the group members and sold as per need within the district. Such local measures used to control pests have been found effective and cheap.

Disposal of obsolete pesticides

Nepal was facing a problem for disposal of pesticide and even in 1990, about 150 mt of obsolete pesticide were stored in different locations of Nepal, of which 114 mt were disposed, including 16 mt reused, 23 mt reformulated and 75 mt disposed by land spreading and buried. Later in 2007, Nepal disposed 74.5151 mt of date expired pesticides including POPs (33.668 mt) and 43 cylinders (50kg each cylinder) methyl bromide with the help of German government (MoEST, 2007).

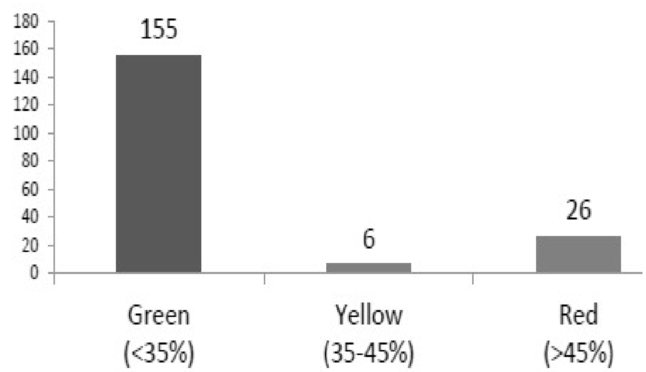
Establishment of RBPR analysis laboratory

TheGovernment of Nepal is decided to establish the Rapid Bioassay of Pesticide Residue (RBPR) laboratory in Kalimati fruits and Vegetable Market to check the pesticide residue in vegetables before sell. The laboratory is established in 18 June, 2014 under the supervision of Plant Protection directorate. RBPR technology is developed by Taiwan Agriculture Research Institute in 1985 to check the residue of organophosphate and carbamates groups of pesticides and fungicides residue in certain level through Enzymatic reaction: AchE (Acetyl cholinesterase) Test to screen the residues of acetyl cholinesterase-inhibiting in fruits and vegetable.Test gives only inhibition percentage from which the result is withdrawn below 35% is edible, 35- 45% need quarantine for few days and warning and more than 45% considered as not edible in toxicological sense. The RBPR/TARI program pack is recorded the AchE reaction and calculated the inhibition percentage through Spectrophotometer. The increasing absorbance for sample at 412 nm is recorded and compared to the insecticide free blank (normal) AchE reaction, and the inhibition percentage is calculated.

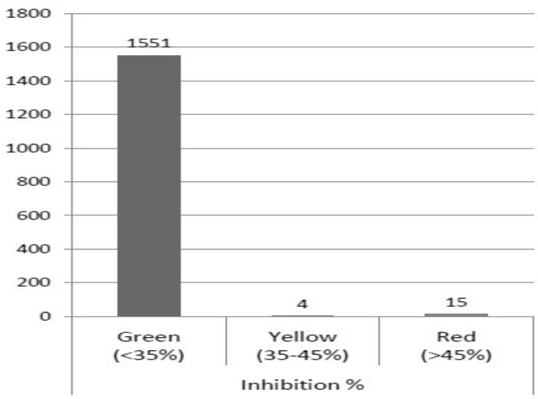
$$\%\text{inhibition} = \frac{\text{Absorbance(normal)} - \text{Absorbancechange (Sample)}}{\text{Absorbancechange(normal)}} \text{X100}$$

We have got the following result of residue of pesticides in fruits and vegetables in Kalimati fruits and Vegetable Market in three year after establish the RBPR laboratory.

In 2014,out of 187 samples, the inhibition percentage of 155 samples (82%) found below 35%(edible),6 samples (3%) found in 35- 45% (quarantine) ie need to wait for some days to consume and rest 26 smaples (14%)above 45%(non edible) to be dump.

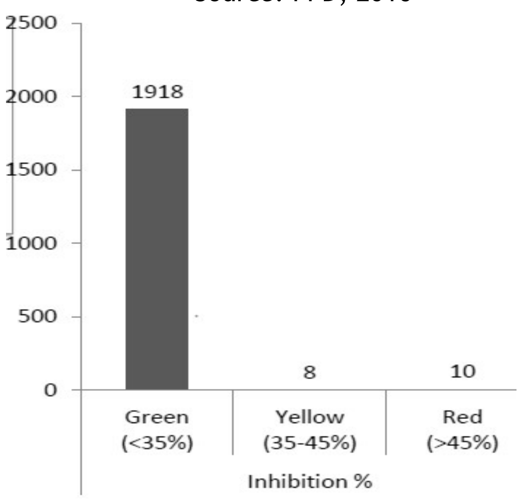


Source: PPD, 2016



In 2015, out of 1570 samples, the inhibition percentage of 1551 samples (98.7%) found below 35%(edible),4 samples (0.2%) found in 35- 45% (quarantine) ie need to wait for some days to consume and rest 15 samples (1%) above 45% (non edible) to be dump.

Source: PPD, 2016



In 2016, out of 1918 samples, the inhibition percentage of 1551 samples (99.1%) found below 35%(edible),8 samples (0.4%) found in 35- 45% (quarantine) i.e. need to wait for some days to consume and rest 10 samples (0.5%) above 45% (non edible) to be dump.

The three year analysis result showed that the farmers have increased the knowledge of waiting period pesticide or they used the safe level of pesticide in vegetables, fruits and potato. The region may be those marketing commodities which may have higher pesticide residue may be sold another market rather than the Kalimati.

Source: PPD,

Source: PPD, 2016

We can draw the conclusion by the three year analysis report of RBPR laboratory Kalimati, farmers have aware the safe use of pesticide for market their products, District Agriculture Offices and Regional Training Centers also have conducted the safe use of pesticide and consciousness raised in the consumer level. So due to its positive impacts on the program, Government of Nepal have started to establish RBPR laboratory in Jhapa (Birtamod),Sarlahi (Nawalpur), Kaski (Pokhara), Rupandehi (Butwal), Banke (Nepalgunj),Kailali (Attaria).

National action of the Rotterdam Convention

Nepal is a party of Basel, Rotterdam and Stockholm Conventions and should fulfill the obligations. Ministry of Agricultural Development has Designated National Authority (DNA) of industrial chemicals and pesticides of Rotterdam Convention. The Government of Nepal has decided to band fifteen following pesticides and chemicals for their import, production and use.

Table 9: Banned pesticide in Nepal

SN	Name of pesticide	Category on RC	SN	Name of pesticides	Category on RC
1.	Aldrin	Annex A	9.	Organo mercury compound	
2.	BHC	POP	10.	Mirex	Annex B
3.	Chlordane	Annex A	11.	Phosphamidon	SHPF
4.	DDT	Annex B	12.	Toxaphene	Annex B
5.	Dieldrin	Annex A	13.	Methyle parathion	SHPF
6.	Endrin	Annex A	14.	Monochrotophos	
7.	Heptaclor	Annex A	15.	Endosulfan	
8.	Lindane	Annex B			

Source: PRMD, 2012, MoAD, 2015

The important source of information on pesticides in Asia and Pacific is pesticide database of Asia Pacific Plant Protection Convention (APPPC) website, which contains among others information on the list of registered pesticide and the list of banned and restricted pesticide in Asia. According to the recent report developed by the Asia Pacific Plant Protection Convention, the statuses of banned pesticides in the region are as follows:

Table 10: Prohibited and banned pesticides in listed countries of Asia

Countries	Number of prohibited and banned pesticides
China	58
India	72
Indonesia	101(Including pesticides banned in rice)
Laos	55
Malaysia	45
Nepal	15
Srilanka	40
Thailand	40
Vietnam	203 (including industrial chemicals)

Source: Paper presented on “Sub -Regional Workshp for the Designated National Authorities on the Rottardam Convention focusing on Increasing Notification “at Surabaya, Indonesia on March 13-17, 2017 and organized by FAO/APPPC, Rottardam Convention Secretoriate and Ministry of Agriculture, Indonesia

Obligations to international plant protection convention

Members of International Plant Protection Convention have to submit reports on national obligations, viz. description of NPPO, legislation (phytosanitory requirements, restriction, prohibition), entry points, list of regulatory pests, pest reports (33 commodities), organizational arrangements of plant protection, rational for phytosanitary requirements, non-compliance, pest status, emergency actions. Organizational arrangements of plant protection, rational for phytosanitary requirements, non-compliance, and emergency actions. In this line, in 2005, a list of banana (*Musa sapientum* L.) diseases of regulated pests, in 2011, new insect in mango, red banded mango caterpillar (*Deanolis sublimbalis*), and in 2016, South American tomato leaf miner (*Tuta osbsoluta*) have been observed and reported to IPPC.

3.7 Pesticide Association of Nepal

Pesticide Association of Nepal (PAN) is an umbrella organization of pesticide professionals established in 1977 to integrate the Nepali firms, companies and individuals involved in the import, distribution and marketing of pesticides. The association specially focuses to aware on the safe use, handling and disposal of pesticides through training and mass communication and facilitates the licensing training for participants. This organization has been involving in most of pesticide activities conducted by the PRMD.

NATIONAL CHALLENGES

Most of the pesticides used in Nepal are imported from India and China. The government has not provided any subsidy in pesticides. The pesticide market has been taken over by whole sellers and retailers. More than 60% farmers are consulting the pesticide resellers for seeking advice to their problems while most of the resellers are non-technical persons, and so increase chances of misuse and improper handling of pesticide. Different kinds of national challenges on the national prospective are as follows:

- Landlocked country and porous border where pesticides can easily penetrate.
- Illegal entry of pesticides and distribution in local market.
- Pesticide whole sellers and retailers have not sufficient knowledge on agriculture and pesticide transport, storage, use and disposal.
- Due to open and porous border situation, there may be chances of movement of non-registered and banned pesticides as well.
- Disposal problems of date expired pesticides.
- Lack of laboratory facility for identification and quality residue and analysis.
- Lack of knowledge of farmers about the pesticides handling, use and disposal.
- Resellers cannot supply standard bio-pesticides in sufficient quantity.

WAY FORWARD

Afer the development of high yielding new varieties of crops, vegetables, and fruits the use of pesticides have increased due to succeptability of disease and pests in those varieties.Off-season vegetable and year round production of other crops also increased the demand of pesticides. Pesticide Registrationand Management Division has doing for the registration, monitoring, banned of highly peaticides and resion of program in the management of pesticides with in the country. Some immediate and urgent actions to be taken in the field of pesticide managent are:

- The new pesticide management bill in the parliament with appropriate decision might help to manage the pesticide in the new perspective.
- Highly hazardous pesticide (Ia) of WHO class are to be replaced by other alternatives and prohibit their registration in coming days.
- Mass campaign and advocacy is necessary on the safe production, safe selection, and safe use, personal safety during application, enough waiting period, and proper disposal of pesticides.
- Timely actions are required for the promotion of organic production, IPM technology, use of biochar, bio-pesticide, lures and pheromones for the pest management and reduction in pesticide residues.
- Good linkage and coordination is needed with relevant Regional and International organizations for technical and financial support in pests and pesticide management.

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EFFECT OF IRRIGATION AND POTASH LEVELS ON GROWTH AND YIELD OF POTATO

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ABSTRACT

The experiment comprising four levels of irrigation (25, 30, 35 and 40 mm CPE) and four levels of potash (0, 100, 125 and 150 kg/ha) was conducted in Haryana Agricultural University, Hisar during winter season of 2010-11 and 2011-12 to find out the optimum level of irrigation and potash for better growth and yield of potato. The potato variety used for the investigation was Kufri Bahar. The treatments were laid out in a split plot design with three replications keeping a net plot size of 3.6x3.6 m. The plant height at 45, 60, 75 and 90 days after planting, number of leaves per stem, leaves weight per hill, stem weight per hill, leaf area index and total and marketable tuber yield were significantly high with irrigation level 35 mm CPE and potash @ 150 kg/ha. The two years results suggest that the irrigation level 35 mm CPE in combination with potash @ 150 kg/ha has shown the best treatment combination for potato production under semiarid conditions of Hisar (Haryna).

Keywords: Growth, irrigation, potato,potash, tuber yield

INTRODUCTION

Potato is a short duration, high yielding and nutrients exhaustive tuber crop. There are number of factors that play a crucial role in deciding the growth and yield of potato, however, irrigation and fertilization are the most predominating among them. Potato crop responds favorably to soil moisture but moisture in excess or in deficit declines its yield. Improper irrigation management practices not only waste the expensive and scarce water resources but also reduce the tuber yield and quality (Singh *et al.*, 2002). Hence, it is possible to increase the production of potato by adopting well-scheduled irrigation programs throughout the growing season (Kashyap and Panda, 2003). Besides improving tuber quality, potash also plays an important role in growth and development of potato crop (Imas and Bansal, 2002), energy status of the plant, translocation and storage of assimilates and maintenance of plant-water relations (Marschner, 1995). It was, therefore, essential to formulate the efficient, reliable and economically viable irrigation management strategy with the use of potassium nutrient in order to produce higher potato yield.

MATERIALS AND METHODS

The present experiment was conducted at Research Farm of the Department of Vegetable Science Hisar during 2010-11 and 2011-12. The experimental soil was sandy loam in texture with pH 7.85, EC 0.23 dSm^{-1}, organic carbon 0.44% and the available N, P_2O_5 and K_2O 156, 15 and 277 kg/ha, respectively. The treatments comprising four irrigation levels (25, 30, 35 and 40 mm CPE) and four potash levels (0, 100, 125 and 150 kg/ha) were laid-out in split plot design with three replications, keeping the irrigation levels in main plots and potash levels in sub-plots, and the depth of irrigation was kept 5 cm. Individual net sub-plot was consisted of 12.96 m^2 (3.60x3.6 m) with 6 rows, each row containing 18 plants. The crop was planted on 25th October in 2010 and 1st November in 2011. Two third dose of N and full doses of P and K were applied at the time of planting in furrows and the

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remaining one third dose of N was top dressed 5 weeks after planting. Disease free pre-sprouted seed tubers of variety Kufri Bahar weighing approximately 40-60 g were planted at a spacing of 60 cm between rows and 20 cm within row. Irrigation was scheduled as per the previous day pan evaporation data. Furrow method of irrigation was used to irrigate the experimental crop. The 1st post-planting common irrigation was given just after planting and the 2nd common irrigation was applied a week after 1st irrigation, thereafter, the differential irrigations were scheduled as per treatment. The recommended cultural practices were followed for raising a healthy crop. Ten plants were randomly selected from each plot to record the plant height (cm) at 15 days intervals starting from 45 days after planting (DAP) to 90 days. The data on number of stems per hill, number of leaves per stem, leaf weight per hill (g), stem weight per hill (g) and leaf area index were recorded at the time of haulm killing and on marketable and total tuber yield (q/h) at harvest. The potato crop was dehaulmed 100 DAP and harvested 15 days after dehaulmed. The data recorded for various parameters were analyzed by using the techniques of analysis of variance (ANOVA) suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

PLANT HEIGHT

The irrigation levels differed significantly with respect to plant height at 45, 60, 75 and 90 days after planting during both the years (Table 1). The uppermost mean value for plant height at 45 (55.7 and 54.8 cm), 60 (62.9 and 60.4 cm), 75 (63.9 and 62.9 cm) and 90 (64.1 and 63.6 cm) DAP was recorded with irrigation level 35 mm CPE and the lowest with irrigation level 25 mm CPE in 2010-11 and 2011-12, respectively. The data indicate that the plant height increased with the increase in irrigation level up to 35 mm CPE, and thereafter, it started declining with further increase in irrigation level (40 mm CPE). It might be due to the fact that the crop encountered the favourable soil moisture conditions, which enhanced the availability of nutrients essentially required for the enlargement and elongation of plant cells. However, under excessive moisture (25 mm CPE) conditions especially in soils that are not too much porous, the plant roots are unable to get too much oxygen, which is very much essential for root respiration and uptake of nutrients ions.The results of present study are in conformation of the findings of Patel and Patel (2001), who noticed significant increase in plant height up to a CPE ratio of 1.75.

Table 1: Effect of irrigation and potash levels on plant height (cm) of potato at 45, 60, 75 and 90 DAP

Treatments	Plant height (cm) days after planting (DAP)							
	2010-11				2011-12			
	45	60	75	90	45	60	75	90
Irrigation levels (I)								
25 mm CPE (I_1)	51.5	56.3	60.1	61.6	50.1	54.8	56.7	58.0
30 mm CPE (I_2)	53.0	60.0	62.2	62.6	52.6	58.9	61.1	62.3
35 mm CPE (I_3)	55.7	62.9	63.9	64.1	54.8	60.4	62.9	63.6
40 mm CPE (I_4)	54.3	62.0	63.1	63.9	53.3	59.0	61.6	62.3
CD at 5% level	**3.16**	**3.12**	**NS**	**NS**	**3.15**	**3.10**	**2.17**	**2.18**

Potash levels (K)								
0 kg/ha (K_1)	49.8	53.4	57.3	58.5	49.6	51.7	55.7	58.0
100 kg/ha (K_2)	53.5	58.0	61.3	62.3	52.8	56.3	60.8	63.1
125 kg/ha (K_3)	55.2	60.3	62.9	62.9	54.9	58.1	62.3	64.6
150 kg/ha (K_4)	56.7	61.2	63.6	64.7	55.8	59.6	64.4	66.8
CD at 5% level	**3.58**	**4.00**	**4.00**	**3.70**	**2.58**	**2.42**	**5.03**	**5.03**
Interaction (IxK)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

In case of potash levels, all the treatments differed significantly with respect to plant height during both the years. The plant height of potato at 45, 60, 75 and 90 days after planting increased with the increase in potash level up to 35 mm CPE. The maximum plant height at 45 (56.7 and 55.8 cm), 60 (61.2 and 59.6 cm), 75 (63.6 and 64.4 cm) and 90 (64.7 and 66.8 cm) DAP was recorded with potash application @ 150 kg/ha in 2010-11 and 2011-12, respectively and the lowest with no potash application. The increments in plant height as a result of potash fertilization might be due to the role of potash in cell division and cell elongation, which as a result increased the plant height. Sharma (1994) also found that each successive increase in potash level from 0 to 90 kg/ha significantly increased the plant height and recorded the maximum plant height with potash application @ 90 kg/ha (45.30 cm) and minimum (33.85 cm) with no potash application. Similarly, the present results are in good accordance with those obtained by Noor *et al*. (2011).

NUMBER OF STEMS PER HILL

The effect of various irrigation levels on number of stems per hill was not significant during both the years (Table 2). This might be due to the application of two common irrigations for uniform emergence of tubers, which might influence the number of stems per hill during the emergence. The number of stems per hill increased with the increase in potash level up to 150 kg/ha. The maximum mean number of stems per hill (3.83) was recorded with potash @ 150 kg/ha followed by potash @ 125 kg/ha (3.73) during the year 2010-11 and 2011-12. The results of present study corroborate the findings of Mahmoud and Hafez (2010), who found that the number of stems per hill increased significantly with increasing level of potash (100-120 kg/ha). The interaction effect of irrigation and potash levels with respect to number of stems per hill was noticed statistically non-significant during both the years.

NUMBER OF LEAVES PER STEM

The effect of irrigation and potash levels played a vital role in the number of leaves per stem. The number of leaves per stem increased significantly with increasing levels of irrigation up to 35 mm CPE during both the years (Table 2). In potato, applying irrigation at 5 cm depth with irrigation level 35 mm CPE showed the maximum mean number of leaves per stem (13.7 and 13.6) followed by the irrigation level 40 mm CPE (13.0 and 12.9), while the plants with irrigation level 25 mm CPE showed the minimum number of leaves per stem (11.3 and 10.8) in 2010-11 and 2011-12, respectively. The results are in close compliance with the findings of Islam *et al*. (1990), who attained the significantly maximum number of compound leaves per plant (11.40) at irrigation level 40% depletion of available soil moisture in Bangladesh.

It is evident from the data that the effect of different potash levels concerning the number of leaves per stem differed significantly from each other. The number of leaves per stem increased remarkably with the increase in potash level up to 150 kg/ha (Table 2). The maximum number of leaves per stem was observed with potash application @ 150 kg/ha (13.5 and 13.3) followed by potash @ 125 kg/ha (13.0 and 12.8) in 2010-11 and 1011-12, respectively. The results of present study are similar to the findings of Mahmoud and Hafez (2010), who noticed that the number of leaves per stem increased significantly with increasing level of potash (100-120 kg/ha) and the inimum number of leaves per stem with no potash application.

Table 2: Effect of irrigation and potash levels on number of stems per hill, number of leaves per stem, leaves weight per hill (g), stems weight per hill (g) and leaf area index at haulm pulling

Treatments	2010-2011			2011-2012		
	No. of stems per hill	No. of leaves per stem	Stems weight (g) per hill	No. of stems per hill	No. of leaves per stem	Stems weight (g) per hill
Irrigation levels (I)						
25 mm CPE (I_1)	3.61	11.3	53.4	3.55	10.8	52.4
30 mm CPE (I_2)	3.63	12.5	54.0	3.62	12.0	53.8
35 mm CPE (I_3)	3.74	13.7	54.8	3.75	13.6	54.7
40 mm CPE (I_4)	3.68	13.0	53.8	3.73	12.9	53.3
CD at 5% level	**NS**	**1.62**	**NS**	**NS**	**1.94**	**NS**
Potash levels (K)						
0 kg/ha (K_1)	3.43	11.5	50.0	3.39	11.4	49.9
100 kg/ha (K_2)	3.68	12.4	53.5	3.69	12.3	53.2
125 kg/ha (K_3)	3.73	13.0	55.2	3.73	12.8	55.0
150 kg/ha (K_4)	3.83	13.5	56.9	3.83	13.3	56.3
CD at 5% level	**0.24**	**0.50**	**3.44**	**0.29**	**0.46**	**3.25**
Interaction (IxK)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

STEM WEIGHT PER HILL

The data presented in Table 2 show that the irrigation treatments not differed significantly with respect to stem weight per hill in both the years. In case of potash levels, all the treatments differed significantly with respect to stem weight per hill during both the years. The stem weight of potato increased with the increase in potash level up to 150 kg/ha. The maximum mean stem weight per hill (56.9 and 56.3 g) was recorded when the potash was applied @ 150 kg/ha followed by potash @ 125 kg/ha (55.2 and 55.0 g) and the lowest stem weight (50.0 and 49.9 g) was found with no application of potash in 2010-11 and 2011-12, respectively. The potash level 100 (53.5 and 53.2 g), 125 (55.2 and 55.0 g) and 150 kg/ha (56.9 and 56.3 g) were statistically at par with each other during 2010-11 and 2011-12, respectively. However, Mahmoud and Hafez (2010) reported that a potato crop supplied with potash @ 120 kg/fed produced the maximum fresh weight of stems at 90 days after planting.

LEAVES WEIGHT PER HILL

The leaves weight per hill increased significantly with the increase in irrigation levels up to 35 mm CPE (Table 2). In 2010-11, the significantly highest mean value for leaves weight per hill was recorded with irrigation level 35 mm CPE (149.0 and 146.2 g) followed by 40 mm CPE (144.2 and 144.3 g) in 2010-11 and 2011-12, respectively. The minimum leaves weight per hill (136.6 and 134. 0 g) was measured with irrigation level 25 mm CPE in both the years. The irrigation level 25 (136.6 g) and 30 mm CPE (139.6 g) were statistically at par with each other in 2010-11. Similarly, during 2011-12, the irrigation level 25 (134.0 g) and 30 mm CPE (136.6 g) and 35 (146.2 g) and 40 mm CPE (144.3 g) were statistically at par with each other. The results of present study confirmed the findings of Amanullah *et al*. (2010), who found that irrigation at IW/CPE ratio of 1.00 produced the statistically highest fresh weight of haulms per hill.

The average leaves weight per hill increased significantly with the increase in level of potash up to 150 kg/ha. The maximum leaves weight per hill (151.2 and 149.9 g) was noted with potash @ 150 kg/ha and the minimum with no potash application (128.3 and 128.7 g) in 2010-11 and 2011-12, respectively. Similar results were obtained by Mahmoud and Hafez (2010), who observed that the fresh weight of leaves increased significantly with increasing potash level from 40 to 120 kg/fed and obtained the maximum weight of leaves per hill with potash application @ 120 kg/fed and the minimum with potash @ 40 kg/fed at 90 days after planting.

The interaction effect of various irrigation and potash levels differed significantly for various treatment combinations. The significantly maximum (156.9 and 154.7 g) average leaves weight per hill was recorded with treatment combination irrigation level 35 mm CPE and potash 150 kg/ha and the minimum (124.4 and 123.1 g) with treatment combination irrigation level 25 mm CPE and potash 0 kg/ha in 2010-11 and 2010-12, respectively. These results support the findings of Noor *et al*. (2011). Nitrogen and phosphorus application to all the treatments at constant rate in combination with potash might enhance the nitrogen use efficiency, and thus, the availability of nitrogen in proper quantity might increase the leaves weight.

LEAF AREA INDEX

In potato, leaf area index is an indicator of growth and it explains the rate of leaf expansion due to irrigation and potash treatments. The irrigation treatment 35 mm CPE showed the significantly highest value for leaf area index during both the years (Table 3). The maximum mean leaf area index (2.77 and 2.60) was recorded with irrigation level 35 mm CPE followed by 40 mm CPE (2.69 and 2.53), while the lowest value for leaf area index (2.57 and 2.39) was observed with irrigation level 25 mm CPE in 2010-11 and 2011-12, respectively. This indicates that the effect of irrigation treatment on leaves longevity as well as on the maximum leaf area or percent ground cover might influence the net carbon gain (Wolfe *et al.*, 1983) but Khalak and Kumaraswamy (1992) obtained the significantly highest leaf area index with 40 mm at IW/CPE ratio of 1.0.

Table 3: Effect of irrigation and potash levels on , leaves weight per hill (g) and leaf area index at haulm pulling, marketable and total tuber yield of potato (q/ha) at harvest

Treatment	2010-11				2011-12			
	Leaves weight (g) per hill	Leaf area index	Marketable yield (q/ha)	Total yield (q/ha)	Leaves weight (g) per hill	Leaf area index	Marketable yield (q/ha)	Total yield (q/ha)
Irrigation levels (I)								
25 mm CPE (I_1)	136.6	2.57	306.3	326.5	134.0	2.39	279.6	300.5
30 mm CPE (I_2)	139.6	2.63	352.9	370.5	136.6	2.48	317.2	337.2
35 mm CPE (I_3)	149.0	2.77	389.2	406.4	146.2	2.60	357.3	374.6
40 mm CPE (I_4)	144.2	2.69	367.6	381.5	144.3	2.53	336.5	349.6
CD at 5% level	**3.08**	**0.03**	**18.3**	**23.2**	**6.92**	**0.03**	**16.1**	**22.2**
Potash levels (K)								
0 kg/ha (K_1)	128.3	2.49	300.0	319.8	128.7	2.34	278.5	298.0
100 kg/ha (K_2)	141.3	2.64	352.2	370.0	138.5	2.48	315.7	334.0
125 kg/ha (K_3)	146.2	2.72	371.5	388.2	144.0	2.56	337.5	354.9
150 kg/ha (K_4)	151.2	2.81	392.3	406.7	149.9	2.64	358.8	374.9
CD at 5% level	**4.22**	**0.03**	**17.4**	**18.0**	**4.94**	**0.02**	**12.2**	**16.1**
Interaction (IxK)								
I_1xK_1	124.4	2.34	264.2	285.7	123.1	2.19	241.2	263.9
I_1xK_2	133.5	2.54	304.8	325.8	131.8	2.36	270.5	292.7
I_1xK_3	142.7	2.65	321.9	341.5	138.3	2.45	293.2	313.5
I_1xK_4	146.0	2.74	334.4	352.7	142.9	2.55	313.3	332.0
I_2xK_1	127.9	2.46	292.1	312.1	125.5	2.32	272.4	294.2

I_2xK_2	138.5	2.61	353.7	372.3	134.5	2.46	309.4	330.0
I_2xK_3	142.7	2.67	373.7	391.3	139.7	2.53	332.3	351.9
I_2xK_4	149.3	2.78	392.0	406.0	146.8	2.61	354.7	372.7
I_3xK_1	142.7	2.62	331.0	351.3	135.3	2.46	308.1	326.4
I_3xK_2	137.3	2.75	383.3	400.7	144.0	2.58	353.1	370.1
I_3xK_3	148.8	2.81	404.7	421.3	150.9	2.65	371.7	389.4
I_3xK_4	153.0	2.89	437.9	452.2	154.7	2.72	396.1	412.3
I_4xK_1	131.7	2.53	312.5	329.9	131.0	2.37	292.2	307.6
I_4xK_2	144.3	2.66	367.0	381.3	143.8	2.51	329.7	343.4
I_4xK_3	148.2	2.73	385.8	398.8	147.0	2.59	352.9	365.0
I_4xK_4	152.4	2.83	404.9	416.0	144.3	2.66	371.1	382.5
CD at 5% level	**8.44**	**0.06**	**34.8**	**36.0**	**9.88**	**0.04**	**24.4**	**32.2**

Increasing level of potash up to 150 kg/ha increased the leaf area index, and the maximum value for leaf area index was recorded with potash application @ 150 kg/ha during both the years. Similar effect of potash on leaf area index was reported by Saikia *et al*. (1987), who observed a beneficial influence of potash application on leaf area index and also in retaining more leaf area until maturity and recorded the maximum leaf area index (0.81) with potash level 150 kg/ha and minimum with no potash application (0.66).

The interaction among the treatment combinations differed significantly from each other with respect to leaf area index in 2010-11 and 2011-12. The present results indicated that the interaction effect showed considerable variation among the treatment combinations for leaf area index. The treatment combination irrigation level 35 mm CPE along with potash application @ 15 kg/ha showed the best result with respect to leaf area index. The increase in leaf area index might be due to better root and shoot growth, generally enhanced by potash with beneficial soil moisture regime. The increase in leaf area index is closely related to leaf area duration (Wolfe *et al*., 1983) or to cumulative light interception (Jefferies and Mackerron, 1993).

TOTAL TUBER YIELD

The total tuber yield per hectare improved markedly with the increase in irrigation level up to 35 mm CPE (Table 3). The maximum mean value for total tuber yield (406.4 and 374. 6 q/ha) was recorded with irrigation level 35 mm CPE followed by 40 mm CPE (381.5 and 349.6 q/ha) and the smallest mean value (326.5 and 300.5 q/ha) with irrigation level 25 mm CPE in 2010-11 and 2011-12, respectively. Similar effect of irrigation on total tuber yield (q/ha) was reported by Sharma and Dixit (1992), who found that the irrigation at 33 mm CPE gave the maximum tuber yield (q/ha). This might be due to the increase in yield contributing characters and higher uptake of nutrients. Potato showed a reduction in yield in the treatment receiving water at 25 mm CPE. This treatment also produced many tubers with enlarged lenticels, which might be a response of potato crop to excessive moisture conditions.

The levels of potash differed significantly from each other with respect to total tuber yield. The total tuber yield per hectare enhanced remarkably with the increase in potash level up to 150 kg/ha. The maximum total tuber yield was attained when potash was applied @ 150 kg/ha (406.7 and 374.9 q/ha) followed by potash @ 125 kg/ha (388.2 and 354.9 q/ha) and the lowest total tuber yield with no potash application (319.8 and 298.0 q/ha). Similar effect of potash on total tuber yield (q/ha) was reported by Deka and Dutta (2000), who obtained the highest tuber yield with potash application @ 100 kg/ha.

The interaction of various irrigation levels with different levels of potash indicated remarkable variation for total tuber yield. The maximum total tuber yield (452.2 and 412.3 q/ha) was harvested from a treatment combination irrigation level 35 mm CPE and potash @ 150 kg/ha and the minimum (285.7 and 263.9 q/ha) from the treatment combination of irrigation level 25 mm CPE with no potash application during 2010-11 and 2011-12, respectively. The increase in tuber yield (q/ha) might be attributed to improved haulm growth, increased photosynthesis and greater mobilization of photosynthates towards tuber formation sites due to best combination of soil moisture and nutrients availability.

MARKETABLE TUBER YIELD

The marketable tuber yield per hectare improved significantly with the increase in irrigation level up to 35 mm CPE (Table 4). The maximum mean value for marketable tuber yield (389.2 and 357.3 (q/ha) was recorded with irrigation level 35 mm CPE followed by 40 mm CPE (367.6 and 336.5 q/ha) and the smallest mean value for marketable tuber yield (306.3 and 279.6 q/ha) with irrigation level 25 mm CPE in 2010-11 and 2011-12, respectively.

The potash levels differed significantly from each other with respect to marketable tuber yield (q/ha), which enhanced remarkably with the increase in potash level up to 150 kg/ha. The maximum marketable tuber yield was attained when potash was applied @ 150 kg/ha (392.3 and 358.8 q/ha) followed by potash @ 125 kg/ha (371.5 and 337.5 q/ha) and the lowest with no potash application (300.0 and 278.5 q/ha) in 2010-11 and 2011-12, respectively. Similar effect of potash on marketable tuber yield was reported by Deka and Dutta (2000), who noticed that the application of potash significantly increased the marketable tuber yield. In fact, potash is known to play an important role in the synthesis and translocation of photosynthates from leaves to the tubers (Reddy *et al*. 1986).

The interaction of various irrigation levels with different potash levels indicated incredible variation in marketable tuber yield per hectare. The maximum marketable tuber yield per hectare (437.9 and 396.1 q/ha) was obtained with a treatment combination irrigation level 35 mm CPE and potash @ 150 kg/ha and the minimum (264.2 and 241.2 q/ha) with treatment combination irrigation level 25 mm CPE and no potash application during the year 2010-11 and 2011-12, respectively. The increase in marketable tuber yield might be attributed to better haulm growth, increased photosynthesis and greater mobilization of photosynthates towards tuber production sites due to the best combination of soil moisture and nutrients availability. These results concur with earlier reports of McDole (1978).

CONCLUSION

Based on experimental results, it is concluded that the various levels of irrigation and potash improved the growth and yield of potatoes. Irrigation level 35 mm CPE with potash @ 150 kg/ha was superior for best growth and yield of potato under semi-arid conditions of Haryana.

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PERFORMANCE OF BHOTE TYPE GARLIC GENOTYPES UNDER KARNALI REGION OF NEPAL

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ABSTRACT

Advance Yield Trial on different Bhote type garlic genotypes collected from different districts of Nepal was carried out at Horticultural Research Station, Rajikot, Jumla for two consecutive years 2013/14 and 2014/15 to evaluate garlic genotypes suitable for the Karnali region of Nepal. Minimal work has been done in past on garlic, almost all of which centered at terai and mid hills that's why this study was carried out to select suitable bhote type garlic genotypes for high hill. Eleven different garlic genotypes were tested on Randomized Complete Block Design (RCBD) with three replication. Tested genotypes differed significantly for vegetative as well as yield parameters. During 2013, the highest bulb yield (47.41 t/ha) was recorded from ARM 01 followed by Mugu Local (47.01 t/ha), ARM 04 (46.98 t/ha), Kathmandu Local (45.41 t/ha), Chinese (37.91 t/ha) and the lowest from ARM 08 (20.1 t/ha). Similarly, during 2014/15, the highest bulb yield was observed from ARM 01 (50.32 t/ha) followed by Mugu Local (49.91 t/ha), Kathmandu Local (41.62 t/ha), Chinese (29.60 t/ha) and the lowest from ARM 05 (12.51 t/ha). Based on the average result of both years, ARM 01, Mugu Local, Kathmandu Local, ARM 04 and Chinese showed the better productivity ranged from 29.6 t/ha to 50.32 t/ha which are the promising garlic genotypes for the Karnali region of Nepal.

Key words: Advance Yield Trial, Bhote type garlic, Parameters, Yield

INTRODUCTION

Garlic is an indispensable commodity of our kitchen. Its demand and consumption is increasing day by day however the production is almost stagnant far behind the domestic demand. Nepal is a net spices importing country, garlic being a major component, a huge amount of which is imported every year from neighboring countries. This account for a large sum of money outflow from our economy.

Though garlic cultivation started years back, lack of quality genotypes and appropriate package of practices (POP), has led to it being not very popular for commercial cultivation in Nepal. None of the garlic genotypes has been recommended, registered or released from NARC for cultivation in Nepal. There is subsistence cultivation of few land races and few other exotic germplasm introduced from adjoining country at different dates. Very few studies have been carried out in garlic. None of the variety is characterized and standard farming technology is yet to be developed.

Physio-morphological variation, crop duration and yield potentiality in Nepalese garlic germplasms for both qualitative and quantitative characters were studied by KC et.al, 2007. Eight different natural groups of more similar characteristics were identified on the basis of cluster analysis. Among 179 accessions, 21 including six Bhote Lasun adapted to summer cultivation in high hills of Nepal were unable to form bulbs under Chitwan (inner terai) condition. All Bhote Lasun, bore flowers in an umbel.

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Similarly, Subedi and Bhandari, 2004 found 3rd week of September to 1st week of November was the most appropriate time of planting of garlic for foot hills and river basin areas of mid-western development region of Nepal

In Jumla, cultivated area under garlic is 5 ha and the production is 10 mt. Similarly, in the Karnali region, garlic has been cultivated under an area of 142 hectare with a total production of 420.6 Metric ton (MOAD, 2015). This accounts for only 1.99% of area and 0.94% of production of national area and production (7119 ha. and 44723 MT).

However, the productivity of garlic in the Karnali region is 2.96Mt/ha whereas the national productivity is 6.28 MT/ha which is far below than the national average (ABPSD, 2014/15). Similarly, total area cultivated in Jumla is 5 ha and production is 10 MT under garlic (DADO Jumla, 2015). This indicates the possibility of both vertical and horizontal expansion of garlic cultivation in this region by identifying the suitable genotypes and package of practices.

The demand of spices is at peak in October due to festive season and there is short supply of garlic. However, the agro-climatic condition in high hill allows production and supply to low lying areas during this peak period which fetches very high price. Moreover, being a non-perishable commodity, it can be easily stored under ordinary conditions incurring minimal postharvest losses.

Minimal work has been done in past on garlic, almost all of which centered at terai and mid hills. In spite of great production potential of high hills, garlic imported from Tibet to Kathmandu reaches the Karnali region via airways and vehicle incurring very high cost. This is a great misfortune of this region.

Several land races and few exotic germplasm are under cultivation and great deal of variability exists between them. A careful selection of locally adapted genotype and better crop husbandry can bring about improvements in qualitative and quantitative traits.

In the context of no any recommended, registered or released variety of garlic, an elaborate study of the same crop is must for germplasm selection, improvement and release as a new variety along with appropriate package of practices for commercialization of garlic. This may contribute to mass production leading to import substitution and export promotion of the same commodity.

MATERIALS AND METHODS

Eleven different germplasm of garlic collected from different districts of Nepal were tested under Advanced Yield Trial during 2013/2014 and 2014/2015 after conduction of observation nursery of 15 different garlic germplasm collected from different districts. The advanced yield trial was conducted at HRS, Rajikot, and Jumla. Eleven different germplasms: ARM 01, ARM 02, ARM 03, ARM 04, ARM 05, ARM 07, ARM 08, ARM 09, Mugu Local, Kathmandu Local (Ktm local) and Chinese, selected from observation nursery of garlic were tested. The plot size was assigned 0.75 m2 (1m x 0.75 m). The plots were fertilized with 20 t compost/ha. Selected cloves were planted with 15 cm x 10 cm spacing. Randomized Complete Block Design (RCBD) with three replications was used. Planting and harvesting was done on the first week of Aswin and 3rd week of Asadh respectively. The necessary data for growth, yield and yield parameters were recorded and analysed with MSTATC.

RESULT AND DISCUSSION

During 2013/14, plant height, number of leaf per plant, width of leaf were found statistically non significant among the tested garlic genotypes. The tallest plants (79.93 cm) were measured from genotype Mugu Local followed by Kathmandu Local (76.4 cm) whereas the shortest (48.27 cm) plants were measured from ARM 04.

Number of leaf per plant was counted maximum from Kathmandu Local (9.67) followed by ARM 01 (8.67) and ARM 07 (8.67) whereas the minimum number of leaves per plant were counted from ARM 04. Garlic genotype Chinese produced the longest leaves (46.67cm) followed by Mugu Local (42.44 cm) and ARM 01 (42.33 cm) and ARM 04 produced the shortest leaves (23.78 cm).

Width of leaf was maximum (2.05 cm) in genotype ARM 01 followed by Chinese (2.01 cm) and the narrowest leaves were recorded from ARM 03. Number of bulbs per ha was counted maximum from genotype ARM 07 (666667) followed by ARM 09, Mugu local, Kathmandu local (657778) whereas lowest (382222.3) from ARM 04.Diameter of bulb was maximum in genotype ARM 01 (59.33 mm) followed by Chinese and the lowest (38.67 mm) from ARM 04. Height of bulb was maximum (51.67 mm) from genotype Mugu local and minimum from 27.89 mm).

Number of cloves per bulb were counted maximum from Mugu local (23.67) followed by ARM 07 (14) and the least from ARM 04 (6.33). Yield of bulb was recorded the highest from genotype ARM 01 (47.41 t/ha) followed by Mugu local (47.01 t/ha) and the lowest (20.1 t/ha) from ARM 08.

During 2014/15, all most all the vegetative and yield parameters were found statistically significant except number of cloves per bulb. The tallest plants (74.18 cm) were measured from genotype Mugu Local followed by genotypes Kathmandu Local (72.57 cm), ARM 04 (66.22 cm) and the shortest (49.35 cm) plants were measured from genotype Chinese. Number of leaves per plant was counted maximum (9.23) from genotype Kathmandu Local followed by Mugu Local (8.93), Chinese (8.55), ARM 07 whereas the least number (7.4) from genotype ARM 08. The longest leaves (42.42 cm) were measured from genotype Chinese followed by genotype ARM 01 (39.67cm), Kathmandu Local (38.67 cm), Mugu Local (38.67 cm) whereas the lowest (24.50 cm) from ARM 02. Width of the leaves were found maximum from genotype ARM 04 (2.11 cm) followed by genotype ARM 01 (2.01 cm), Chinese (1.88 cm) and the narrowest leaves (0.88 cm) were found from genotype ARM 03. Number of bulbs were counted maximum (666666.69) from genotype Mugu Local followed by ARM 02 (650000), ARM 01 (633333.31) and the lowest number of leaves (513333) were counted from genotype ARM 05.

Diameter of bulb was measured maximum (63.61 mm) from genotype ARM 01 followed by Kathmandu Local (61.78 mm), ARM 04 (55.23 mm) and the lowest (40.16 mm) from genotype ARM 08. Height of the bulb was measured maximum (41.81 mm) from genotype Kathmandu Local followed by Mugu Local (41.35 mm), ARM 03 (41.25 mm) and the minimum (32.69 mm) from genotype Chinese. Though the number of cloves per bulb was statistically non-significant, genotype Mugu Local produced the maximum cloves (19.3) per bulb and the minimum (7.4) from genotype ARM 01. Bulb yield per ha was maximum (50.32 ton) from genotype ARM 01 followed by genotype Mugu Local (49.91 ton), Kathmandu Local (41.62 ton) whereas the genotype ARM 05 produced the lowest (12.51 ton) bulb.

Colour of bulb was found white in ARM 01, ARM 02, ARM 04, ARM 05 and ARM 08. Light onion colour was observed in ARM 03, ARM 07, ARM 09. Similarly, onion colour was recorded in Mugu local and Kathmandu local.

ARM 01 was found slightly bitter and more pungent, ARM 09 and Kathmandu local were found more pungent. Similarly, ARM 04 (slightly bitter), ARM 07 and ARM 08 were medium pungent whereas ARM 02, ARM 03, ARM 05, Mugu local, Chinese were less pungent.

Significant differences among the vegetative as well as yield parameters show the wider genetic diversity as well as variability among the tested garlic genotypes. Significantly more bulb yield from ARM 01 (47.41 t/ha and 50.32 t/ha) during 2013/14 and 2014/15 among the tested garlic genotypes was obtained. In addition to these, Mugu Local (47.01 t/ha and 49.91 t/ha), Kathmandu Local (45.41 t/ha and 41.62 t/ha), ARM 04 (46.98 t/ha and 32.05 t/ha) and Chinese (37.61 t/ha and 29.60 t/ha) were also high yielders among the tested garlic genotypes. This result clarifies their genetic potentiality to perform better under high hill conditions and uplift the lower productivity of the garlic. Though the yield potentiality of ARM 01 and ARM 04 was high, these genotypes may be suitable for industrial purpose due to slight bitterness and few number of large size cloves. Mugu local, Kathmandu local and Chinese are better for kitchen/spice purpose. In addition to this, Chinese matures earlier than the high yielding genotypes listed herewith.

Table 1: Advance Yield Trial of garlic during 2013/14 at HRS, Rajikot, Jumla

SN	Treatments	Plant ht (cm)	No. of leaf	Length of leaf (cm)	Width of leaf (cm)	No. of bulbs/ha	Diameter of bulb (mm)	Height of bulb (mm)	No. of cloves/bulb	Bulb yield (mt/ha)
1	ARM-01	58.87	8.67	42.33 ab	2.05	404444.3	59.33	43.33 a	6.67 c	47.41 a
2	ARM-02	61.27	7.93	27.89 bc	1.27	533333.3	46	51.11 a	10 bc	23.36 bc
3	ARM-03	61.53	8.4	32.78 abc	1.11	608889	43.94	46.22 a	8 bc	25.61 abc
4	ARM-04	48.27	4.8	23.78 c	1.54	382222.3	38.67	27.89 b	6.33 c	46.98 a
5	ARM-05	61.27	8.33	30.34 bc	1.5	617778	43.61	42.11 a	10.33 bc	25.58 abc
6	ARM-07	67.93	8.67	32.33 abc	1.38	666667	45.78	47.11 a	14 b	36.71 abc
7	ARM-08	56.87	7.53	28.44 bc	1.5	635555.7	39.22	40.34 ab	9.33 bc	20.1 c
8	ARM-09	70.27	8.27	33.56 abc	1.46	657778	48.94	47.89 a	13 b	37.08 abc
9	Mugu	79.93	8.73	42.44 ab	1.37	657778	50.5	51.67 a	23.67 a	47.01 a
10	Ktm Local	76.4	9.67	41 ab	1.8	657777.7	51.72	50.33 a	10.67 bc	45.41 ab
11	Chinese	54.33	8.13	46.67 a	2.01	644444.3	56.17	48.67 a	11 bc	37.91 abc
	P	ns	ns	*	ns	ns	ns	*	***	*
	CV (%)	21.36	18.23	22.07	35.32	24.53	22.85	16.94	28.93	33.3
	LSD			13.04				13.03	5.509	19.74

Table 2: Advance Yield Trial of garlic during 2014/15 at HRS, Rajikot, Jumla

SN	Treatments	Plant ht (cm)	No. of leaf	Length of leaf (cm)	Width of leaf (cm)	No. of bulbs/ha	Diameter of bulb (mm)	Height of bulb (mm)	No. of cloves/ bulb	Bulb yield (mt/ha)
1	ARM-01	54.70 de	8.48 abcd	39.67 a	2.01 a	599999.98 e	63.61 a	37.93 abc	7.4	50.32 a
2	ARM-02	56.42 de	7.53 cd	24.50 c	1.02 cd	650000 b	51.94 bc	40.97 a	12.8	30.12 abc
3	ARM-03	57.38 d	7.93 bcd	29.75 bc	0.88 d	633333.31 c	51.46 c	41.25 a	8.8	25.21 bc
4	ARM-04	66.22 bc	7.88 bcd	31.83 b	2.11 a	550000 g	55.23 abc	33.89 c	7.8	32.05 abc

5	ARM-05	55.63 de	8.25 abcd	28.42 bc	1.29 cd	513333.34 i	41.76 d	34.56 bc	7.8	12.51 c
6	ARM-07	64.30 c	8.40 abcd	27.75 bc	1.19 cd	523333.34 h	53.63 bc	37.87 abc	10.8	21.21 bc
7	ARM-08	52.22 de	7.40 d	24.75 c	1.37 bcd	566666.66 f	40.16 d	34.10 c	10.1	16.16 c
8	ARM-09	64.45 c	7.98 bcd	29.84 bc	1.20 cd	593333.34 e	53.85 bc	40.34 ab	12.6	30.49 abc
9	Mugu	74.18 a	8.93 ab	38.67 a	1.15 cd	666666.69 a	57.22 abc	41.35 a	19.3	49.91 a
10	Ktm Local	72.57 ab	9.23 a	38.67 a	1.55 abc	623333.34 d	61.78 ab	41.81 a	10.9	41.62 ab
11	Chinese	49.35 e	8.55 abc	42.42 a	1.88 ab	620000 d	53.56 bc	32.69 c	9.5	29.60 bc
	P	***	*	***	***	*	***	**	ns	**
	CV (%)	7.61	7.99	10.76	25.88	10.57	11.46	10.13	31.38	40.34
	LSD	6.668	0.950	5.033	0.530	9077	8.788	5.543		17.96

CONCLUSION AND RECOMMENDATION

Based on the results of observation nursery, only 11 different garlic genotypes: ARM 01, ARM 02, ARM 03, ARM 04, ARM 05, ARM 07, ARM 08, ARM 09, Mugu Local, Kathmandu Local and Chinese were selected and tested under Advance Yield Trial during 2013/14 and 2014/15. During both of the years, ARM 01, Mugu Local, Kathmandu Local, ARM 04 and Chinese perform better with respect to productivity ranging from 29.6 t/ha to 50.32 which is 5 to 8 times higher than the national productivity (6.28 t/ha). Similarly, these genotypes perform better with respect to vegetative parameters too. Plant height of these genotypes ranged from 49 cm to 79 cm, no. of leaves per plant ranged between 8 and 9, length of leaf ranged from 38 to 46 and width of leaves ranged between 1.15 and 2.05. All these vegetative parameters supports in more photosenthesis which ultimately results in more yield. As per the result of both of the years, ARM 01, Mugu Local, Kathmandu Local and Chinese are the promising garlic genotypes for Jumla and similar locations of Karnali Region of Nepal.

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CLIMATE CHANGE RELATED POLICY ENVIRONMENT IN AGRICULTURE AND FOOD SECURITY IN NEPAL

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ABSTRACT

Agriculture is the main stay of Nepal's economy. This provides about one-third of national GDP and two-third of national employment. Agriculture is highly vulnerable to climate change due to more marginal farmers with small landholding, limited irrigation, low income level, limited institutional capacity, and greater dependency on climate-sensitive natural resources. The adverse effect of climate change on agriculture impacts on farm revenue, employment, income and GDP. Policy formulation in agriculture and food security sector concerning to climate change has become an imperative for poverty reduction, livelihood improvement and economic development. Compliance with global and national agreement, review of existing policy will provide an essential foundation to policy makers, planners and development workers to reform process. This paper intended to find the strength and weaknesses of existing plans, policies, strategies, acts which will support stakeholders in agricultural development.

INTRODUCTION

Agriculture is major economic sector in Nepal, it contributes about one-third of the national gross domestic product (GDP), represents 13% of total foreign trade and two-third of the employment to economically active population (CBS 2012). About21% of the land is cultivated, of which 54 % has irrigation facilities and land holding size is only 0.68 ha per household. Over 50% of farmers are small holders cultivating land usually less than 0.5 ha. Agriculture in Nepal is mostly rain-fed and which is climate sensitive.

Nepal is the fourth most vulnerable country after Bangladesh, India and Madagascar (Maplecroft, 2012). The countries with the most risk are characterized by high levels of poverty, dense populations, exposure to climate-related events; and their reliance on flood and drought prone agricultural land in Nepal is highly vulnerable to climate change due to its rugged terrain with steep topography, tectonically active geology and related risks of the natural disasters. On contrary, some experiments have shown opposite results, increasing crop yield particularly rice and wheat with increase in climate variables (Malla, 2008). Large proportion of marginal farmers with small landholding, limited irrigation, low income level, limited institutional capacity, and greater dependency of agriculture on climate-sensitive natural resources increase the degree of vulnerability (Regmi and Adhikari, 2007; World Bank, 2008).

In general, a policy is principle, rule, and guideline formulated and adopted to reach long-term goals to influence and determine all major decisions and actions, and all activities take place by the governing institutions. It is a deliberate system of principles to guide decisions and achieve rational outcomes, which is implemented as a procedure or protocol. There are many plans, policies and strategies developed by government of Nepal for agriculture and food security related to climate

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change. The strength and weakness of the plans, policies and strategies need to be studied for long-term planning to address climate change and environment issues.

In this regard, this paper tries to communicate the strength of agriculture and food security related current legal documents, plans, policies, strategies and programmes to insight the policymakers, development workers, climate change advocates and producers for addressing the adverse effects of climate change.

MATERIALS AND METHODS

This paper is based on review of various national documents of agricultural and livestock sectors. The national legal documents, plans, policies, strategies, programmes and projects related to agriculture and food security were collected from concern ministry, departments, directorates and offices of programme and projects.

Scanning and skimming, and positive sorting was adopted during reviewing. Climate change and environment related important matter were marked and drawn for the study from the Nepal's plans, policies, strategies and programmes. The current plans, policies, strategies, acts, regulations and institutional policy documents were also studied and deliberated briefly.

DISCUSSIONS

Based on the review of current legal documents, plans, policies, strategies, acts, regulations and institutional documents, the following keen points were drawn which are very much related to climate change in agriculture and food security.

LEGAL PROVISIONS

NEPAL CONSTITUTION 2072 BS

Nepal's constitution strongly focused on food sovereignty and Article (36) Right relating to food explained that every citizen shall have the right relating to food, the right to be safe from the state of being in danger of life from the scarcity of food and the right to food sovereignty in accordance with law.

Article 51 (e) Policies relating to agriculture and land reforms stated, inter alia,to make land management and commercialization, industrialization, diversification and modernization of agriculture, by pursuing land use policies to enhance agriculture product and productivity, while protecting and promoting the rights and interests of the farmers, to make proper use of lands, while regulating and managing lands on the basis of productivity, nature of lands and ecological balance; and to provide for the farmers' access to agricultural inputs, agro products at fair price and market.

Under article 51 (h), Policies relating to basic needs of the citizens: point (12) provisioned to provide for sustainable production, supplies, storage, security, and easy and effective distribution of foods by encouraging food production in tune with climate and soil, in consonance with the concept of food sovereignty, while enhancing investment in the agriculture sector.

Article (30) Right to clean environment stated in point (1) every citizen shall have the right to live in a clean and healthy environment, (2) the victim shall have the right to obtain compensation, inaccordance with law, for any injury caused from environmental pollution or degradation, and (3)

The Article shall not be deemed to prevent the making of necessarylegal provisions for a proper balance between the environment and development,in development works of the nation.

Sustainable Development Goals (SDG), 2016-30

Nepal has agreed to the commitment of the United Nations Sustainable Development Goal (SDG) in UN Summit on September 25, 2015. Among 17 Goals, goal two focused on "End hunger, achieve food security and improved nutrition and promote sustainable agriculture". And Goal thirteenth on "Take urgent action to combat Climate change and its impact".

National Development Plan

Goal of the thirteenth plan was up scaling of Nepal from least developed country to the level of developed country by 2022, and climate change is considered one of the challenges to overcome barriers to reaching to the goal. Including natural resource and environment conservation, agriculture was one of the important priorities among 7 priorities of the plan. There was mandatory of implementing climate change adaptive development initiatives keeping current and future negative impact of climate change in mind.

Priority of 14th Plan (approach paper)

The Fourteenth Plan stated that in spite of increasing the production and productivity of agriculture for supply of increasing population food and other basic needs, Nepal is importing agriculture commodity every year. It clearly stated that agriculture system has likely to failed completely due to youth migration for employment, poor supply of agriculture inputs, loss of soil fertility, high cost of production, competition with import products, stratified agriculture land and change in land utilization, variation in weather because of climate change, So, it is urgent need to result oriented actions with effective agricultural plans for future commercial agriculture.

Fourteenth Plan specified as challenge of transformation of subsistence agriculture in competitive and commercial for industrial development and climate change adaptation action to reduce energy crisis and possible disaster for socio-economic development efforts. Since large number of small and medium farmers in agriculture, it has challenge to build adaptive capacity to climate change and various natural disasters. This plan has taken strategy to develop and disseminate climate smart agriculture technology for reducing the negative effect of climate change and disaster.

Strategies and visions

AGRICULTURE DEVELOPMENT STRATEGY (ADS) 2015

ADS has vision of agricultural sector growth through four strategic components including governance, productivity, profitable commercialization, and competitiveness. The acceleration of inclusive, sustainable, multi-sector, and connectivity-based growth is expected to result in increased food and nutrition security, poverty reduction, agricultural trade competitiveness, higher and more equitable income of rural households, and strengthened farmers' rights. All outcomes, outputs, and activities of the ADS will contribute to improve food and nutrition security either directly or indirectly.

Among four components, Component two of the ADS focused on productivity for food and nutrition security by (i) increasing the volume of food production in Nepal in a sustainable way through higher productivity and sustainable use of natural resources; and (ii) reducing vulnerability of farmers through improved food/feed/seed reserves, improved preparedness and response to emergencies, and climate smart agricultural practices.

ADS's Climate Change and Natural Resource Management:

Available evidence on climate change in Nepal indicates increasing temperatures and different patterns of monsoon precipitations. The impact of climate change on agriculture in Nepal is currently studied, but even the preliminary evidence suggests the need of introducing appropriate adaptation mechanisms to increase resilience of farmers to climate change. At the same time it is important to understand the feasibility of mitigation mechanisms including clean development mechanisms and disaster risk reduction that could be beneficial to farmers. The issue is how to ensure sustainable modernization of agriculture and commercialization while strengthening resilience to climate change.

Improved productivity of land and labor is at the cornerstone of the ADS. Agricultural productivity requires the adoption of appropriate technologies and know-how to increase efficiency and sustainability of agricultural production consistently with market demand and food security needs of subsistent farmers. Among four measures to raise agricultural productivity efficient and sustainable practices and use of natural resources (land, water, soils, and forests); and increased resilience to climate change and disasters are climate change related.

Though, the Millennium Development Goals (MDG) Progress Report 2010 stated that the decreased poverty rate and reduction in the population suffering chronic food insecurity. The report also focused that greater attention to environmental conservation and adaptation to climate change.

SEED VISION 2013-25

The Seed Vision aims to increase crop productivity, raise income and generate employment opportunities through self-sufficiency, import substitution and export promotion of quality seeds. Seed visioning assignment was implemented for the many reasons, inadequate location specific varietal choices and limited number of crop varieties mostly due to climate change is a major one.

Among four major significant direct and indirect impacts the two impacts i.e. ensuring food security and reducing poverty, and contributing in biodiversity conservation and adapting to adverse impact of climate change which is related to climate change.

Biodiversity conservation and climate change

The chapter includes the context of changing climate scenario in Nepal, it also focused particularly in developing and promoting climate resilient crop varieties (drought, flood and heat tolerant, etc.) using rich biodiversity. The promotion of climate resilient seed varieties will sensitize farming communities on climate change and allows for climate adaptation options in terms of food production. This will have impact on stabilizing food production and reducing risks of farming communities, resulting in increased livelihood options and strengthened capacity to adapt adverse effect of climate change.

NARC strategic vision 2011-30

The vision of the Nepal Agricultural Research Council (NARC) is to tap institutional, human, and financial resources from the government and a wider spectrum of stakeholders—civil society, research centers, donors, and ultimately the private sector—to move the system from agricultural research and development to agricultural research for development.

NARC has given future research priorities will be based on creating and scaling up technologies for environmental sustainability including food security, poverty reduction, value addition, export promotion and cost effectiveness.

NARC's Natural Resource Management and Climate Change Thematic Area

Environment problems such as deforestation, nutrient mining, soil erosion and land degradation, eutrophication of surface water, increased encroachment of marginal lands for cropping, degradation of range and pasture lands and reduced level of agro-biodiversity are directly related to increased pressure on land and water. There is need to maintain long-term balance between sustainable agriculture, natural resources, and ecological security which is possible through continuous research and development in the sectors. In spite of all those, NARC also needs to further refine its policy on conservation of agro-biodiversity and agricultural genetic resources through in-situ and ex-situ conservation strategies.

It also focused on agro-ecological diversity and environmental sustainability, due consideration has given in creating and adjusting the technologies (Indigenous knowledge, traditional practices and local resources) to exploit benefits arising and counter any negative effect brought out by climate change.

POLICIES

NATIONAL AGRO-BIODIVERSITY POLICY 2007 (2063 BS)

This policy vision is to conserve and sustainable use of agricultural genetic resources / materials and associated traditional knowledge with the participation of concerned stakeholders for present and future generations. In national and international level, effort has been made to conserve biological diversity. The policy intends to recognize agro-biodiversity as an integral component of biodiversity based on the spirit of international treaties/ agreements and national initiatives in order to ensure social, economic and environmental benefits to the Nepalese people.

The objectives focused, *inter alia,* to enhance agricultural growth and ensure food security by conserving, promoting and sustainably using agro-biodiversity; to create effective management, commercialization and use of agricultural genetic resources in the present context of exploiting local national and international markets and in international regulations on trade; to contribute in maintaining sustainable ecological balances(ecosystems services) over time, and to promote the conservation and use of agro-biodiversity in the contexts of national seed, food quality and safety, and product marketing regulations.

NATIONAL AGRICULTURE POLICY, 2004 (2061)

The objective of this policy is to create an enabling environment for agriculture-led rural development. It emphasizes competitiveness of agriculture sector encouraging farmers to go for commercial production. The policy aims at increasing productivity and promoting natural resources to utilize them in the interest of farmers. The long-term vision of the agriculture sector is to bring improvement in the living standards through sustainable agricultural development by transforming subsistence agricultural system into a commercial and competitive agricultural system. The policy emphasizes on increased agricultural production and productivity, making agriculture competitive in regional and world markets with commercial agriculture system, and conserving, promoting and utilizing natural resources, environment and bio-diversity.

NATIONAL SEED POLICY, 2000 (2056 B.S.)

The main aim of formulating this policy is to effectively manage production, processing and testing of high quality seeds and their timely availability to the farmers. The Seed Act of 2045 B.S. and Seed Regulation, 2054 B.S. signifies contribution of the quality seeds in agricultural production. The objectives ensure the availability of quality seeds of different crops in a required quantity, production of quality seeds and promotion of export, and conservation of genetic characteristics of the indigenous seeds and maintain patent right. The main feature of the policy which is directly and indirectly related to climate change; it has focused on conservation of agro-biodiversity and establishment of breeders rights over new variety of seeds. It proposed for conducting 'research' (which may also be construed as risk assessment) on GMO seeds.

NATIONAL FERTILIZER POLICY, 2002 (2058 B.S.)

This policy was formulated to support agricultural production by ensuring supply (production, import and distribution) of good quality fertilizer. This Fertilizer Policy is sub-component of the Government's broad National Agriculture Policy as set out in the Agriculture Perspective Plan (1995-2015). The aim of this policy is to enhance agricultural productivity through improvement in soil fertility and thereby contribute to the national goal of poverty alleviation. Specifically, this policy emphasizes on the provision of conditions (policy and infrastructure management) for enhancing fertilizer consumption; and promotion of integrated plant nutrients management system for efficient and balanced use of fertilizer. The policy adopts the strategy which relates climate change for sustainable use of manures among other strategies to achieve its objectives i.e. to manage Integrated Plant Nutrients System.

The use of chemical fertilizers causes GHG emission. The policy need to focus on alternate of chemical fertilizers with discouraging strategies.

IRRIGATION POLICY, 2014 (2070 B.S.)

There are many climate related risks associated with the irrigation infrastructure and their utilization. The water resources management and variability of water supply is the major issue related to the irrigation sector. Drought conditions reduce the effectiveness of irrigation systems and can cause long term damage to infrastructure and losses in crop production. Similarly, flooding causes direct destruction of infrastructure and sedimentation within irrigation systems. The vision of this policy is to avail the sustainable and reliable year round irrigation facilities to all the agricultural lands so as to contribute to agricultural productivity. Extension of irrigation services is important in the context of meeting the objectives of increasing agricultural production and reduction of poverty.

This demands promotion of conjunctive use of ground and surface water based irrigation systems along with new/non-conventional irrigation systems such as rain water harvest, pond irrigation; sprinkler irrigation, drip irrigation and treadle pump irrigation. In the country, the irrigation systems developed so far are limited to run-off the river system. To make the system good for round the irrigation, it is necessary to develop storage so that the problem of low flow of rivers during the winter season can be mitigated to some extent. The policy emphasizes implementing reservoir-based and inter-basin water transfer types of water sector strategy development and integrated water resources management. The policy aims to develop irrigation facility for the achievement of the objectives related to the climate change, to avail round the year irrigation facility through effective management of existing water resources; develop institutional capacity of water users for sustainable management of existing systems; and enhance knowledge, skills and institutional working capability of technical human resources, water users and NGOs relating to development of irrigation sector.

RANGELAND POLICY, 2012(2068)

In high hill and mid-hills region, livestock farming is the main source of livelihood of people and rangeland is the major basis for livestock production. Rangeland management is expected to contribute to livelihood improvement and food security of the people, reduce internal migration and minimize the effects of climate change. For providing clear direction for managing uncontrolled extraction or harvesting of rangeland resources like herbs and NTFPs, preventing the declining rangeland productivity and biodiversity due to uncontrolled grazing, minimizing the effects of climate change and environmental degradation, evaluating their roles in carbon sequestration, and promoting indigenous knowledge, skills, technologies, this policy was formulated and implemented, *inter alia*, recognizes the Department of Livestock Services as the lead agency for rangeland management, considers rangelands as under constant and serious threats, which require urgent attention, envisages sustainable use and development of natural rangeland with a view to support livelihood of the local people and also about the development of livestock sector through sustained feed supply and grazing management.

NATIONAL LAND USE POLICY, 2012 (2069 B.S.)

This policy was formulated considering the growing concerns about increasing fragmentation of fertile land and unplanned urbanization. The policy, *inter alia*: to ensure optimum use of land and control land fragmentation; help establish a link between agricultural with industrial sectors, and encourage optimal use of land for agriculture; categorize for the first time in the country, land into seven categories — agricultural, forest, residential, commercial, public, industrial, and others; to make sure that fertile land is used for farming only, and bar dealings in land allocated for agriculture; and establish the Land Use Management Department, which will have experts from agriculture, irrigation, environment, urban development and management sector.

LAND USE POLICY, 2015

This policy was formulation to manage the settlements safely from the natural disaster, after the devastating earth quake in April 2015. This realized the problems, *inter alia*, adverse condition of food security due to reduction of agriculture production and productivity because of increased use of fertile land in unproductive purposes, most of land under fallow and uncontrolled fragmentation. Soil erosion, floods landslides and desertification due environmental pollution and climate change causing to loss of natural resources like environmental degradation and loss of bio-diversity and forests. Ensure food security increasing agricultural production and productivity through conservation and best utilization of agricultural land, and reducing climate change impacts, natural disaster, biodiversity and environmental conservation are major challenge. These things are strongly considered in objectives, sectoral policies and strategies of the policy.

AGRICULTURAL MECHANIZATION PROMOTION POLICY, 2014

Labor shortage has become a challenging issue in recent years for agriculture development due to migration of young farmers from the rural areas of Nepal. Thousands of youths have out-migrated for finding employment (in the urban centers and abroad). To address this challenging issue and modernize agriculture, agricultural mechanization policy has been formulated. Agricultural mechanization involves use of different types of power: human, animal, mechanical and electrical. It helps to achieve timeliness in field operations, increased productivity and reduced cost of production, and minimized farm drudgery. It also imparts dignity to farm work and makes farming attractive to educated rural youth. The policy's salient features includes, *inter alia*, increasing competitiveness, modernizing and commercializing Nepalese agriculture through appropriate mechanization, and focusing on environment, women and youth farmer-friendly agricultural mechanization.

BIOTECHNOLOGY POLICY, 2006 (2063B.S.)

In order to address the existing challenges of a developing country like ours, this policy formulated to obtain the potentials opened up by biotechnology. The implementation of this policy may assist in increasing the production of food grains through biotechnology, developing a new technology of medical treatment, controlling environmental pollution and promoting various industrial sectors.

The vision of this policy is to increase production and productivity by means of research and development of biotechnology as well as transfer of technology, and improve the living standard of Nepali people by achieving a significant progress in the field of public health and environment.

The overall objective of this policy is to make contribution to the reduction of poverty by developing and expanding biotechnology with its use in the sectors of comparative benefit and its application as a basis of key substitute for the development of the country as well as environment protection and public welfare. The salient features includes, *inter alia*, fulfill a minimal need of food grains and nutritious food for growing population, thereby assisting in the reduction of poverty, and encourage research and development of biotechnology contributing for developing the forests, agriculture and food sectors in an internationally competitive and environmentally sustainable manner.

CLIMATE CHANGE POLICY, 2011 (2067 B.S.)

Nepal formulated targets-based Climate Change Policy in 2011 to address climate change impacts, and help develop people's coping capacities. The main goal of this policy is to improve the livelihood by mitigating the adverse impacts of climate change, adapting to it, adopting low carbon emission socio-economic development path and promoting the support and cooperation as per the commitments at the national and international mechanism related to climate change. Main features of the policy, *inter alia*, consider the importance of the sectors that are vulnerable to climate change; enhance the climate adaptation and resilience capacity of local communities for optimum utilization of natural resources and their efficient management; adopt the low carbon development path by making socio-economic development climate change friendly and resilient; allocate at least 80 percent of the total budget directly at program implementation level/areas; establish a semi-autonomous climate change center to coordinate the programs and projects; develop the capacity for identifying the present and future impacts of climate change, quantifying the impacts, adopting adaptation measures to be safe from the risks and adverse impacts of climate change; and establish a separate Climate Change Fund for implementing programs related to climate adaptation and resilience, and low-carbon development, identifying risks, carrying out studies and research and developing and utilizing technologies.

PLANS AND PROGRAMMES

PLANS

AGRICULTURE PERSPECTIVE PLAN (APP)

Government of Nepal has been implementing a 20-year Agriculture Perspective Plan (APP) since 1997 with a view to commercialize agriculture, develop overall economy and alleviate poverty. This plan has identified priority inputs and outputs for consolidated investment in order to commercialize agriculture sector. High value horticultural commodities and agriculture business are priority outputs of APP. It has also proposed to establish strong forward and backward linkages of agricultural production. As focused by the APP, commercialization of agriculture and thereby increasing production and income of farmers is the main strategy of Three Year Plan (2011-2013).

APP design gave priority to certain key inputs (i.e. irrigation, fertilizer, technology, roads and power, and financial credit for agriculture), and key outputs (i.e. livestock, high value crops, agribusiness, and forestry), that were envisaged to deliver the policy’s expected social, economic and environmental impacts. These priorities remain relevant to in the present context, in addition to current and emerging issues though the period of the plan was completed. The ADS 2015 has been developed following the National Agriculture Policy 2004.

ZERO HUNGER CHALLENGE NATIONAL ACTION PLAN (2016 - 2025)

The country adopted ZHC initiative as a national agenda holding the vision for preparing a National Action Plan to eradicate hunger by 2025. To move ahead with this process, a roadmap was prepared by MoAD to launch the ZHC initiative and then formulate the National Action Plan covering a period of ten years starting from 2016 till 2025. The objective is to ensure “rights to food” by improving food and nutrition security of people to achieve a society free of hunger and malnutrition by 2025. In this regard, it emphasizes on fostering right based access to food and its proper utilization. Its specific objectives are, *inter alia*, strengthen sustainable production process for accelerated growth of the agriculture sector; improve food and nutritional status of all people in the country; and improve social protection system for the poor suffering from hunger, poverty and malnutrition.

NATIONAL BIODIVERSITY STRATEGY AND ACTION PLAN 2014-2020

The description and analysis of past efforts and achievements, and formulation of strategies and actions are focused around six thematic areas: (a) Protected Areas, (b) Forests outside Protected Areas, (c) Rangelands, (d)Wetlands, (e) Agriculture, and (f)Mountains.

In Nepal, biodiversity is closely linked to the livelihoods and economic well-being of most people. The subject touches upon almost every aspects of Nepalese life, including agricultural productivity, food security, climate, water resources and aesthetic value for society. Agro-biodiversity is the backbone for sustainable development of agriculture, food security and poverty alleviation as it provides both the immediate needs and long-term sustenance of the country’s farming communities.

Diversity of crops and animals is particularly vital to the country's marginalized communities for maintaining their food security.

PROGRAMMES

Programmes and projects will be real image of the policies and plans of any sectors. A national flagship program (FANUSEP) that includes subprograms on Nepal Agricultural and Food Security Project (NAFSP), Food and Nutrition Security Plan of Action (FNSP), and a new comprehensive program on food and nutrition security that will be developed and started over the course of the first 5-year period of the ADS.

Nepal has implemented Pilot Program on Climate Resilience (PPCR) has been implemented among 9 countries in year 2009 with support of climate investment fund, World Bank and Asian development bank. Building Resilience to Climate-related hazards project is one among 5 projects which was initiated by Government of Nepal in coordination with Ministry of Population and Environment (MoPE).

CONCLUSION

Nepal's main economic sector, agriculture is adversely impacting due to climate change. Climate change has negative impacts on crop and livestock production and productivity, pest and disease infestation, land degradation, soil fertility, animal fertility and behavior, quality and quantity of food, feeds and fodder, biodiversity, gene pool and others. The adverse effect in food security and livelihoods at national, household and individual level affects farm revenue, employment, income and finally on GDP. Study of existing state of the policy documents are required to capitalize to policy maker, researchers, academia and development workers on existing provision for addressing climate change and environmental issues in the agriculture and food security. The studied plans, policies and guidelines have played an important role in order to adapt and minimize the impacts of climate change regarding agriculture and food security in Nepal. It has helped to reduce the hunger, increase sustainable products, end poverty, malnutrition, control land fragmentation and building resilience against climate change hazards, support research in terms of agriculture, food production and forestry.

Nepal Constitution 2072, Sustainable Development Goals, Agriculture Development Strategy, National Agriculture Policy, Climate Change Policy, Agriculture Prospective Plan, Zero hunger challenge and National Action Plan has helped directly for the formation of climate change related policies for agriculture and food security whereas, National Seed Policy, National Agro-biodiversity Policy, Irrigation Policy, Rangeland policy, National Land use Policy, Biotechnology Policy, Agricultural Mechanization Promotion Policy has indirectly helped in the formation of climate change policies related to agriculture and food security. Policies and plans formulated before climate change policy 2011, has very less consideration of climate change and environment aspects and the policies and plans after 2011, have gradually included and addressed climate change aspects in form of mitigation or adaptation.

There is adequate space in existing policy, plans and strategies for integrating the medium and long term adaptation measures to reduce vulnerability to the impacts of climate change in agriculture and food security.

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GOVERNMENT INTERVENTION ON ORGANIC FERTILIZER PROMOTION: A KEY TO ENHANCING SOIL HEALTH AND ENVIRONMENT

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ABSTRACT

Unilateral use of chemical fertilizers, devoid of organic sources, has led to gradual deterioration of soil health, exacerbating the agricultural productivity. This study focuses on the review the performance, effectiveness and modality of organic manure promotion programmes intervened by MoAD, using secondary datas. Major programmes intervened are: Vermi-compost production, cattle shed improvement, organic fertilizer industries establishment and price subsidy to farmers purchasing organic fertilizers. Study shows that these programs are effective to reduce soil health deterioration by making nutrient rich manure available at local level. Moreover, it has helped to reduce dependency of fertilizers on other countries and to promote sustainable agriculture. Altogether 1495 vermi-compost pits were constructed and 33746 cattle sheds were improved all over the country till FY 2072/73. Converting farm and household organic wastes into organic manure, improvement of the nutrient content of FYM, utilization of cattle urine for plant protection measures were the benefits of these programs. Furthermore, in long run it helps to create green economy by reducing pollution by keeping environment safe and clean.

Key words: Organic fertilizer, soil health, vermi-compost, cattle shed

INTRODUCTION

Green revolution of 1960s tremendously enhanced the agricultural production mainly due to the abundant use of chemical fertilizers and pesticides. However, unilateral use of chemical fertilizers and pesticides, devoid of organic sources led to gradual deterioration of soil health, putting agricultural productivity at risk. Nepal, predominantly, is an agrarian country. It contributes one third to gross domestic product (GDP) and provides employment to two third of country's population. With the advent of green revolution, use of chemicals has increased in Nepal over the years. Increased use of chemicals has increased the soil pH and deteriorated the soil health. However, farmers now have realized the disadvantages of chemical fertilizers and pesticides and are trying to adopt healthy agricultural practices. Minimization of chemicals used and encouraging farmers towards organic fertilizer has been the priority of Ministry of Agricultural Development (MoAD) over the past years.

Agriculture has been rooted since long in the country with rich heritage of eco-friendly agricultural technologies. Farming in the hills is based on compost and Farm yard manure (FYM) application, which are the main external source of plant nutrients (Sherchan and Gurung 1996). In Nepal,

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compost is prepared from plant materials and animal dung whereas FYM is prepared from animal dung only. FYM refers to the decomposed mixture of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle. On an average well decomposed FYM contains 0.5 percent N, 0.2 percent P_2O_5 and 0.5 percent K_2O. The entire amount of nutrients present in farmyard manure is not available immediately. About 30 percent of nitrogen, 60 to 70 percent of phosphorus and 70 percent of potassium are available to the first crop. The present method of preparing farmyard manure by the farmers is defective. Urine, which is wasted, contains one per centnitrogen and 1.35 percent potassium. Nitrogen present in urine is mostly in the form of urea which is subject to volatilization loss. During storage nutrients are lost due to leaching and volatilization. Although it is practically impossible to avoid losses altogether, it can be reduced by following improved method of farmyard manure preparation. The existing practice of leaving manure in small heaps scattered in the field for a very long period leads to loss of nutrients. These losses can be reduced by spreading the manure and incorporating immediately after application, by ploughing (TNAU AGRITECH PORTAL, 2017).

Due to unavailability on adequate amount of chemical fertilizers in time and subsequent increase in the price of chemical fertilizers, increasing the use of organic fertilizers has became the only alternative for farmers to fulfill plant nutrients demand and to sustain soil fertility. For country like Nepal where transportation is difficult and supply of chemical fertilizer is entirely dependent on import, preparation and utilization of organic fertilizer at local level is very important to follow sustainable agricultural practices. However, scientific method of composting is not properly followed by farmers.Collecting of litter and dumping in a pit itself is called composting by most of farmers (Jaishy et. al. 1997). The manure is not turned over and loss of nutrients by leaching and runoff is high. Sharma, 1983 as cited by Khadka and Chanda 1987, estimated a loss of 50% nitrogen and 90% potash from compost heaps, particularly during the rainy season.

Soil health is deteriorated from various factors; indiscriminate use of chemical fertilizers/pesticides, regular cultivation of crops which demand higher nutrients, no crop rotation, lower/unmanaged use of farm yard manure (FYM) etc. Improper/unmanaged used of FYM leads to loss of nutrients. So, to minimize the losses and to reduce the risk factor of soil health deterioration and to promote soil environment; MoAD has implemented program for promotion of organic fertilizer use. Among various organic practices vermi-culture technology, cattle shed improvement program, organic fertilizer production plant establishment program and price subsidy in purchase of organic fertilizer programs have been implemented in the country. There is no chemical fertilizer factory in Nepal and the present combined demand of urea, DAP and MoP is 785,000 tons per annum creating a considerable demand and supply gap. This justifies the major concern of MoAD to promote organic fertilizers (MoAD, 2015/16).

METHODOLOGY

The review was based on the secondary information. The secondary data were collected from the various publications of Ministry of Agriculture Development (MoAD) and Soil Management Directorate (SMD). Similarly case study report has been taken from District Agriculture Development Office (DADO), Sindhuli.

RESULT AND DISCUSSION

1. **PROGRAM ON SOIL HEALTH IMPROVEMENT**
   With the aim of enhancing food security by promoting organic production and reducing the dependency on imported chemical fertilizers, Soil Management Directorate (SMD) in

co-ordination with District Agriculture Development Offices (DADOs) has initiated various programs under Department of Agriculture (DoA), as discussed below.

A. Vermi-compost Production Program

Vermi-composting is an excellent technique for recycling green waste using earthworms. As many as 5,500 species of earthworms have been described worldwide. There are 12 species commonly found in Nepal. Commonly used earthworms for vermi-composting in Nepal are *Eisenia foetida, Perionyx excavatus*, and *Lampito mauritii*. They convert organic matter both physically and chemically to increase the soil porosity, and therefore, they are also called as 'ecosystem engineers' (Pandey, 2012).

Table 1: Earthworm species commonly found in Nepal.

Alolobophora caliginosa	*Lumbricus spp.*	*Metaphire posthuma*
Eutyphoeus napalensis	*Octochaetona beatrix*	*Megascolex spp.*
E pharpingianus	*Perionyx macintoshii*	*Lampitto mauriti*
E lippus	*Drawida nepalensis*	*Perionyx fabats*

(Source: Pandey, 2012)

Considering the higher price of chemical fertilizers and low purchasing power of farmers, DoA has launched the vermi-compost production program to enhance availability of organic fertilizers at farm level since FY 2014/15.

Modality of program

Farmer group or co-operatives of districts in co-ordination with respective DADOs can make vermi-pit for production of vermi-compost at local level. Vermi-pits should be constructed in cluster and amount of NPR 25,000 per household or 50% of the cost incurred whichever is less, is provided as subsidy.

Program effects

- 1495 vermi-compost pits have been constructed; 707 in FY 2014/15 and 788 in FY 2015/16.
- 1495 households were benefited
- It helped in cleaning the environment by utilization of organic wastes from household and farm as raw material for the preparation of vermi-compost.

(Source: SMD, 2015/16)

B. Cattle Shed Improvement Program

There is an increasing trend of youth out migration for employment in rural community creating a deficiency in farm work force. Consequently, rearing large herds and managing wastes produced from them, as done traditionally, has became more challenging in rural communities. Moreover, due to the improper construction of sheds, urine and water flows towards the animals and stagnate in pools deteriorating the quality of urine, cattle manure and litter which further has a negative impact on the quality of compost produced using it. Realizing these facts, DoA had initiated the cattle shed improvement as a mission program in FY 2013/14, aiming effective management of cattle manure and urine by improving the shed floor and urine collection. These practices along with the proper composting and application in soil has led to better soil health and crop production, improving rural environmental.

Modality of program

Farmer group or co-operatives of districts in co-ordination with respective DADOs can improve cattle shed floor along with the construction of urine collection tank and shed for cattle dung (as specified in annex 2). For this work program provides subsidy amount of NPR 5,200 per household or 50% of the cost incurred whichever is less.

Program implementation

- 33746 improved cattle shed were constructed till FY 2015/16.
- 33746 households were benefited

Program long term effects

- Improves the nutrient content of FYM/protects nutrients loss
- Cattle urine can be used on plant protection measures
- Promote the soil health
- Promote food security through sustainable agriculture development

(Source:SMD, 2015/16)

Case of Cattle Shed Improvement Program in Sindhuli District of Nepal

Before the program, farmers were not familiar with the benefits of improved shed management. They were doing composting practices in their traditional way; collecting cattle dung in unmanaged way, which was left in direct contact of sunlight and rain. Cattle urine normally infiltrate from the shed as there was no cemented floor in the shed. After implementation of mission program farmers became familiar with the nutrient loss incurred from their practices and thus, were motivated for cattle shed improvement. With the support of District Agriculture Development Office, farmers constructed the improved cattle shed consisting urine canal, urine collection tank and a shed for dung too. Farmers started using this improved manure and urine in their field. Subsequently, soil became more fertile with time and crops started yielding higher. They found significant difference in crop production and soil health after adopting this practice. Mr. Buddhiraj Shrestha, one of the farmers of Ranichuri VDC-5 of Sindhuli district, said that they became aware of the importance of proper management of cattle manure and urine with the intervention of program. He emphasized cattle urine also nourished the soil, increase the microbial activities and disinfect the soil creating better soil health and higher crop yield.

(Source, DADO, 2014/15)

Besides these, in order to promote green environment through farm waste management, MoAD has promoted establishment of organic fertilizers production plant by providing 50 percent subsidy for entrepreneurs. By 2015/16, a total of 25 organic fertilizer plants with annual production capacity of 100600 mt were established (Table 2).

Table 2: Status of Organic Fertilizer Manufacturers in Nepal.

S.N.	Name of organic fertilizer manufacturers	Production capacity (MT/year).
1	Bansun Agro Organics Pvt. Ltd, Chitwan	5000
2	Tribeni Bio Research and Development Center Pvt. Ltd, Bara	1000
3	Prakritik Susma Jibanu fertilizer industry, Rupandehi	300
4	Small Farmer Agriculture Cooperatives Ltd, Dhanusa	1000
5	Sahayogi Saving and Credit Cooperative Ltd, Rautahat	1000
6	Organic Agriculture Production Center, Chitwan	5000
7	Lumbini Agro Products and Research Center, Rupandehi	5000
8	Janakpur Fertilizers Industries, Morang	10000
9	Buddha Organic Fertilizer Industry, Dhanusa	10000
10	Praramva Bio Tech Pvt. Ltd, Kathmandu	300
11	Lumbini Agro Organic Fertilizer Pvt. Ltd, Rupandehi	1000
12	Nepal Integrated Model Agro Firm Pvt. Ltd, Kavrepalanchowk	5000
13	Unique Bio Tech Organic Pvt. Ltd, Chitwan	20000
14	Kanchan Organic Fertilizer Industry, Kanchanpur	2000
15	Kishan Agriculture Cooperatives Ltd, Siraha	2000
16	Manakamana Agro Organic Fertilizer Industry Pvt. Ltd, Chitwan	1000
17	Suryasakti Supar Organic Fertilizer Production Center, Dang	5000
18	Nepalese Waste Management, Mustang	500
19	Annapura Agriculture Fertilizer Industry, Morang	10000
20	Buddha Organic Fertilizer Industry, Mahendranagar	
21	Eco Nest Technology Pvt Ltd. Kaski	2800
22	Sauvagya Organic Fertilizer Industry, Rupandehi	3000
23	Uchit Biological Fertilizer Industry, Lalitpur	700
24	National Biotech Pvt. Ltd, Lalitpur	5000
25	Northfield Organic Fertilizer Factory, Gorkha	4000
	Total	**100600**

(SMD, 2015/16)

Similarly, to promote organic fertilizers produced from the subsidized plants, MoAD is providing price subsidy to the farmers purchasing the organic fertilizers. MoAD provides NPR 10 per kg or 50 percent of the sales price whichever is less, as subsidy on purchase of organic fertilizers. Amount of subsidized organic fertilizer distributed is listed in table 3.

Table 3: Distributions of subsidized organic fertilizers in Nepal.

Fiscal Year	Targeted quantity of subsidized organic fertilizer (MT)	Quantity of subsidized organic fertilizer distributed (MT)
2011/12	788	788
2012/13	3977	3177
2013/14	10000	2615
2014/15	10000	1128
2015/16	10000	4053

(MoAD, 2015/16)

Organic fertilizer subsidy program has not been found to be impressive (Table 3). Bulky nature of organic fertilizers and difficulty in transportation, lack of quality assurance of the organic fertilizers are the major issues for its low consumption at farmers' level. Moreover, most of the farmers are producing organic fertilizer locally for their own use.

POLICIES AND GUIDELINES FOR ORGANIC PROMOTION

A few policies and guidelines promulgated for organic promotion in the country are given below:

a. **The constitution of Nepal 2015**: "Right Regarding Environment and Health" as the fundamental right of a citizen."

b. **National Fertilizer Policy, 2002:** emphasized IPNS and curtailed direct subsidies, but the state has recently reinstated some price subsidy.

c. **National Agriculture Policy, 2004:** has a provision to support organic farming and organic products certification (sn31).

d. **Agribusiness Promotion Policy, 2006:** has provision for development of organic production zone.

e. **The 3-Year Interim Plan (2010/11-12/13)**: promotion of organic farming in strategy (p.70) and support and subsidies on FYM/compost/urine management,

f. **Guideline for Organic Fertilizers/ Vermi-compost Production Support Program through Farmer Group and Co-operative, 2014,**

This guideline especially focuses on

- Production and use of vermi-compost as well as improved FYM.
- Decreasing the cost of production by minimizing the use of chemical fertilizers.
- Enhancing the production and productivity
- Maintaining the soil fertility by reducing the negative impact of unbalanced use of chemical fertilizers.
- Food and nutritional security through sustainable agriculture production.

g. **Guideline for Cattle Shed Improvement Mission Program, 2013**

This guideline especially focus on

- Enhancing the organic practices by production and utilization of improved FYM.
- Decreasing the cost of production by minimizing the use of chemical fertilizers.
- Food and nutritional security through sustainable agriculture production.

h. Guideline for Organic Fertilizer Industry Establishment, 2011

This guideline especially focus on

- Gradually reducing the extensive use of chemical fertilizers and promoting the use of organic fertilizers to maintain the soil fertility.
- Promoting organic fertilizer production factories in the country by providing subsidy.

i. Guideline for Organic and Biological Fertilizer Regulation, 2011

- This guideline provides legal support on organic fertilizer production, testing, import and registration.
- It regulates the import of raw material required for organic fertilizer production.

j. Guideline for Organic Fertilizer Subsidy (District Level), 2015

This guideline especially focus on

- Promotion of organic fertilizer use at local level by providing subsidy to purchase.
- Increase competition among manufacturer for quality supply.

LINKING ORGANIC FERTILIZER WITH RURAL DEVELOPMENT

Production and promotion of organic fertilizers within the country, on one hand reduces the fertilizer dependency on other countries and decreases expenditure on chemical fertilizers on the other hand. Utilization of organic manures reduces environmental pollution, caused by the use of chemical fertilizers, and helps to create healthy soil and environment which leads to sustainable crop production eventually enhancing household economy and reducing the rural poverty.

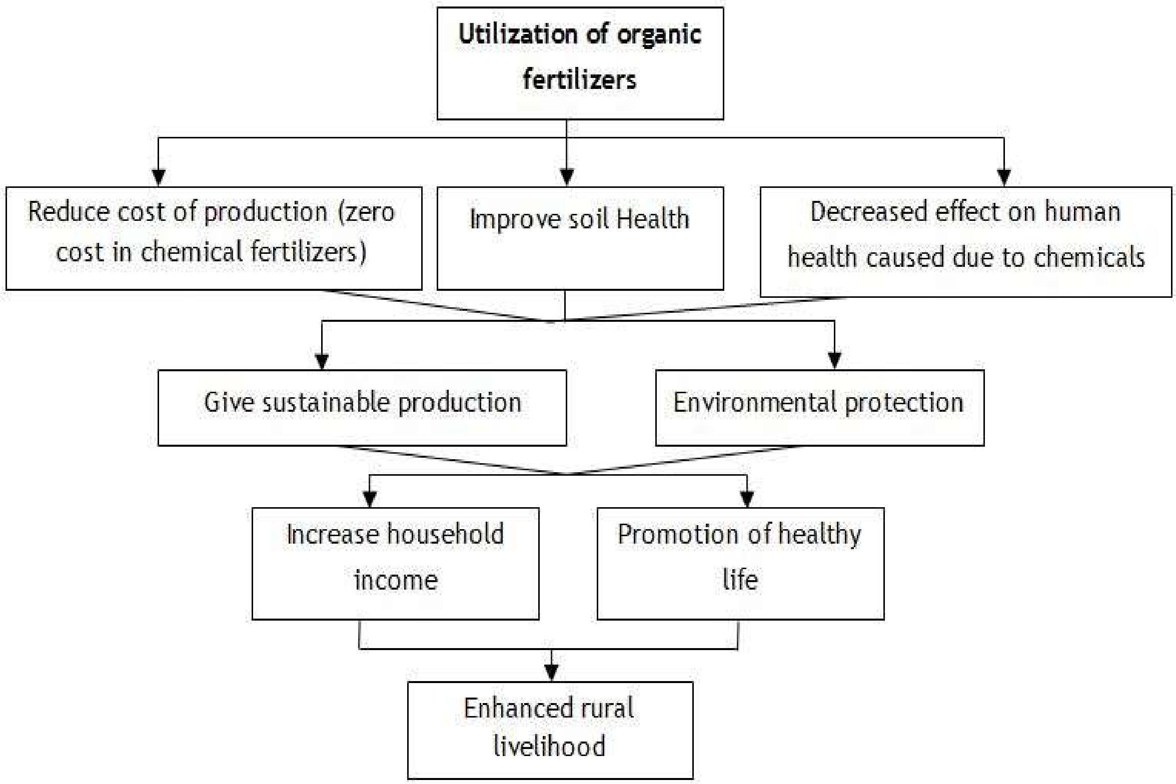

Fig 1: Linking Organic Fertilizer with Rural Development

CONCLUSION AND RECOMMENDATION

Organic manures, though having less nutrient concentration, contains many of the essential nutrients for plant growth and releases them slowly for longer period. Thus, they have an advantage over chemical fertilizers which contain single to some nutrients which are available to plant for a shorter period. Nepal, in verge of commercialization in agriculture, is facing short in fulfilling the demand of plant nutrients from sources like chemical fertilizers; due to lack of its own production industries, and organic fertilizers; due to less number of production plants and improper management of organic manures at farmer's level. Moreover, soil health is deteriorating in the country due to imbalanced use of chemicals. Considering these facts, MoAD has launched various organic intervention programs; to enhance soil health, to decrease chemical fertilizers dependency and to reduce crop production cost. Among these, vermi-composting, cattle shed improvement, organic fertilizer plant establishment and price subsidy programs are implemented in different FYs within the country.

These programs are in initial phase of implementation. It needs a considerable amount of time to access their impacts, however these programs has been found to be effective to make farmers aware regarding importance of organic manure for enhancing soil health. It has played important role to organic waste management and improved crop and livestock husbandry. These programs have created a demonstration effect on village level and thus farmers not involved in programs are inspired to manage the organic manure produced at their household level in proper way.

However, the program price subsidy in purchase of organic fertilizers is not able to meet the target setup by MoAD. This may be due to the current modality of program planning where targets are setup by central agencies. To mitigate this, program planning should be devolved to the local level (DADOs) to create the ownership of farmers and government agencies working at local level and to encourage wider participation. Harsh topography in hilly and mountain regions, unavailability in time and establishment of production plants far away from the demand centers are other problems hindering the successful implementation of programs. These problems can be mitigated by promoting establishment of production plants in and around demand centers and hilly and also in mountain areas rather than establishing in cluster in urban areas.

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INCREASING PRODUCTIVITY OF AN INTENSIVE RICE BASED SYSTEM THROUGH SITE SPECIFIC NUTRIENT MANAGEMENT IN WESTERN TERAI OF NEPAL

Santosh Marahatta[1]

ABSTRACT

Improving nutrient management through site specific nutrient management (SSNM) can increase grain yield and maintain appropriate yield attributes per unit of fertilizer applied through harmonized uptake, utilization and metabolism of major nutrients. On-farm experiments were conducted from 2011-2013 at Sunawal, Nawalparasi. SSNM dose was calculated by accounting for indigenous nutrient supply, yield goal, nutrient demand and fertilizer efficiency. SSNM decreased nitrogen and phosphorus application by 4 and 28% while demanded 80% more potassium and increased grain yield by 6% over recommended practice. As compared to the farmers fertility management practice (FFP), SSNM increased grain yield by 35%. Reducing 25% of SSNM dose was equally effective as recommended practice of nutrient application. Only improving the potassium application (+32 kg ha^{-1}) on FFP, yield was increased by 17%. Leaf color charts (LCC) improve nitrogen management and proved as crucial component of SSNM as 0.3 t ha^{-1} more yield over three split nitrogen applications of SSNM dose.

Key Words: Indigenous nutrient supply, Nitrogen use, Nutrient uptake, Site-specific nutrient management

INTRODUCTION

Food security of Nepal is threatened by the stagnating the yield of staple crops especially the rice. The average yield of rice in Nepal is very low (3.2 t ha^{-1}) (FAOSTAT, 2016) as compared to potential yield (8.0 t ha^{-1}) (Devkota *et al.*, forthcoming).The green revolution technology increased the rice yield by 1.6% per annum from 1970 to 1990 (FAOSTAT, 2012) but stagnating there after (Ladha, 2003). At present, the productivity and sustainability of rice based systems are threatened by inefficient use of agro-inputs; decline in soil fertility and loss of soil organic matter; increasing scarcity of resources, especially irrigation water and labor; changing climate; rising cost of cultivation and socioeconomic changes such as urbanization, migration of labor, preference of nonagricultural works. Identifying the process governing the sustainability of rice based system is crucial for developing the sustainable agronomic management and technological innovations.

Nutrient balance, which describes nutrient stock and flows in specific farming systems are powerful tools in determining the present and future productivity of agricultural lands as well as undesirable environmental effects such as nutrient mining or pollution of surface and ground water. Quantification of the soil's capacity for supplying N, P and K is essential to predict the additional requirement of nutrients and improving nutrient use efficiencies. On farm trails demonstrated that indigenous supply of N, P and K was highly variable among farms (Adhikari *et al.*, 1999). Therefore, a new concept SSNM in rice based systems is being developed (Dobermann and White, 1999). In SSNM approach, scientists quantify crop nutrient requirement based on an economically efficient yield target; measure the potential indigenous supply of N, P and K; estimate the P and K balance for sustaining soil P and K reserves without depletion; monitor plant N status during critical period of rice growth to optimized fertilizer N efficiency and apply diagnostic criteria for identifying micronutrient disorders (Dobermann and White, 1999).

SSNM is a low-tech, plant need-based approach for optimally applying mainly major nutrients N, P, and K (IRRI, 2006). It enables farmers to dynamically adjust fertilizer use to fulfill the deficit

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between the crop nutrient needs and the nutrient supply from natural sources (Pampolino *et al*., 2007). The SSNM approach aims to apply nutrients at optimal rates and times to achieve high yields and high efficiency of nutrient use by the crop. It does not specifically aim to either reduce or increase fertilizer use (Buresh *et al*., 2005) as it is based on nutrient supplying capacity and fertilizers required for certain target yields. In addition to soil variability and nutrient management practices, crop management has a significant role in utilization of the inherent and applied nutrients. Viewing these facts, the present study was conducted to formulate the site specific nutrient management strategies for rice to improve the present yield growth for intensive rice based system.

MATERIALS AND METHOD

EXPERIMENTAL SITE

The experiments were conducted in the farmers' fields of Sunawal in Nawalparasi District (representing inner terai) during the rainy season of 2011, 2012 and 2013 from June to November. The site is located 22 km east from the business city Butawal, Rupendehi. This location is situated at 27°36'N latitude and 83°38' E longitude. Soil texture varied from sandy loam to clay loam. The area has a subtropical climate highly influenced by the southern monsoon. Those farmers' who adopted the rice based farming system were selected randomly varied on soil physical and chemical characters.

PHYSIO-CHEMICAL PROPERTIES OF EXPERIMENTAL SOIL

Composite soil sample were randomly taken from different spots from 0 – 15 cm depth using tube auger to record the initial soil physico-chemical properties of the experimental site. Soil sample was air dried, grounded and sieved through 2 mm sieve and tested for their properties. The total nitrogen was determined by Kjeldhal distillation unit, available phosphorus by modified Olsen's method by using spectrophotometer and available potassium by ammonium acetate method (Estefan *et al*., 2013). Organic matter was determined by Walkey and Black method, pH (1:1 soil: water suspensions) by Beckman Glass Electrode pH meter and soil texture by hydrometer method (Estefan *et al*., 2013). Physico-chemical properties of the soil of the experimental farmers' field are presented in Table 1. From the analysis, soils of the experimental sites were varied largely among the farmers' field. Soil pH that affects the availability of mineral nutrients varied from 6.31 to 7.56 with the average of 7.06. The total carbon and nitrogen ranged from 0.54 to 0.84% and 0.057 to 0.117% respectively with the average of 0.70 and 0.086 percent. Available P and K also varied greatly among the farmers' field but both these micronutrients were in medium availability on an average. Soil texture varied among the field from sandy loam to clay loam. The percent of sand, silt and clay ranged from 37 to 54%, 24 to 43% and 16 to 25% respectively.

Table 1. Physico-chemical properties of the soil (0-15 cm) before start of experiments at Sunawal, Nawalparasi, Nepal, 2013

Farm #	Sand (%)	Silt (%)	Clay (%)	Texture	Soil pH	Organic C (%)	Total N (%)	Available P (kg ha^{-1})	Available K (kg ha^{-1})
1	51.00	21.00	28.00	Loam	6.31	0.79	0.089	58.00	163.54
2	37.00	20.00	43.00	Loam	7.56	0.84	0.089	48.00	98.47
3	41.00	31.00	28.00	Clay loam	7.07	0.63	0.066	37.00	115.00
4	54.00	16.00	30.00	Sandy loam	7.27	0.54	0.068	47.00	111.97
5	53.00	21.00	26.00	Sandy clay loam	6.33	0.68	0.117	32.00	84.96

6	40.00	25.00	35.00	Loam	7.42	0.83	0.080	43.00	143.23
7	52.00	24.00	24.00	Sandy clay loam	7.44	0.63	0.057	24.00	98.47
Mean	46.86	22.57	30.57	Loam	7.06	0.70	0.086	41.29	116.52

CLIMATIC CONDITION DURING EXPERIMENTATION

The experimental site lies in the subtropical humid climate belt of Nepal. The metrological data for cropping season of 2013 was recorded from the metrological station of National Wheat Research Program (NWRP), Bhairahawa, Rupendehi about 25 km far from the research site (Figure 1). The total rainfall of 2406.86 mm was received during the entire period of experimentation whereas 1954 mm of rainfall was recorded in the rice growing period (after transplanting, 2nd week of July to harvesting, 4thweek of October). The highest rainfall was recorded during August (895 mm) and minimum rainfall in a month of October (135 mm) of crop growth period. First three months of rice growing period, the crop received more or less uniformly distributed rainfall with a monthly average not less than 400 mm. Sharma *et al.* (1991) also recorded that rainfall of 1250 mm was required for vegetative growth of rice. The mean maximum temperature during the experimental period ranged from 24.20^{0}C to 38.20^{0}C during experimentation period. It was the highest during July and the lowest during October. Similarly, the mean minimum temperature during cropping period ranges from 20.00^{0}C to 30.00^{0}C. It was the highest during June and the lowest during October.

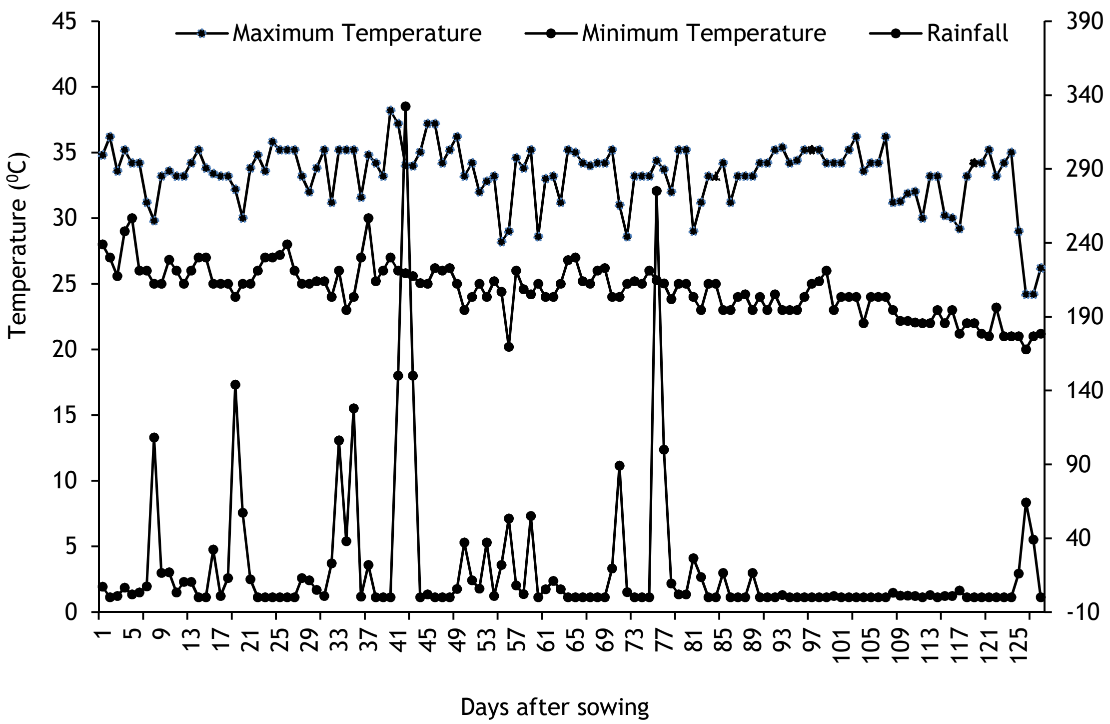

Figure 1.Weather condition during the experimentation period at Sunwal, Nawalparasi, Nepal from 22 June to 31 October 2013.

EXPERIMENTAL DETAILS: LAYOUT AND TREATMENT

The experiments were conducted in farmers' fields from 2011-13. In 2011 and 2012, the indigenous nutrient supplying capacity was determined from farmers' field by omission plot experiments with 6 treatments namely nitrogen omission (0N+ample of PK), phosphorus omission (0P+ample of NK), potassium omission (0K+ample NP), recommended NPK (100:60:40 kg NPK ha^{-1}), FFP (different among farmers) and ample NPK (150% of recommended dose) on 36 farmers' field. Site-specific nutrient management experiments (Table 2) was conducted in 7 representative farmers' field in 2013. The plot size was 20-60 m^2 depending upon the farmers field and each filed was considered as one replication. All treatments were accommodated in the same fields that receive farmers' management on fertility in preceding crops. Plots (treatments) were separated by bunds to check any over flow of nutrient through water from one to another.

Table 2. Details of treatments in experiment during June to November 2013 at Sunawal, Nawalparasi, Nepal

SN	Treatments	N, $P_2O_5$and K_2O dose (kg ha^{-1})	Symbol
1	SSNM* at yield target at 7.0 t ha^{-1}	95.82 + 42.98 + 72.00	T_1
2	75% of SSNM* dose at yield target at 7.0 t ha^{-1}	71.86 + 32.23 + 54.00	T_2
3	SSNM P & K, LCC based N application**	N + 42.98 + 72.00	T_3
4	Farmers' fertility management practices***	52.50 + 25.91 + 8.30	T_4
5	Farmers dose of N and P, Rec. dose of K	52.50 + 25.91 + 40.00	T_5
6	Recommended dose¶	100.00 + 60.00 + 40.00	T_6

Notes:

Phosphorus (from DAP, 18%N and 46%P_2O_5) and potash (from MOP, 60%K_2O) was applied as basal dose in all treatments. Nitrogen was applied from Urea (46%N) in all plots.

* SSNM dose was calculated on yield target of 7 t ha^{-1}. In SSNM and 75% of SSNM treatments, ½ N was applied as basal and ½ N applied at tillering and PI as two equal split.

** In LCC based N application, 1/4th of recommend dose N (25 kg ha^{-1}) was applied as basal dose. The remaining nitrogen will be top dressed as LCC reading <4 with 20 kg N ha^{-1}.

***Fertilizer dose on farmers' fertility management practices was calculated on the basis of farmers' survey in 2012 from 42 households. 1/3rd N (17.50 kg ha^{-1}) was applied as basal and remaining 2/3rd N (35 kg ha^{-1}) applied at tillering and PI as two equal split.

¶ ½ N was applied as basal and ½ N applied at tillering and PI as two equal split.

CALCULATION OF SSNM DOSE

Estimation of target yield:The mean simulated Y_{max} of current rice varieties grown in inner terai of Nepal is around 8.87-9.47 t ha^{-1} in main season, with a mean of 9.08 (Regmi, 2003). The target yield is around 75-80% of the potential yield (Witt *et al.*, 1999). So, 7 t ha^{-1} was considered as the target yield for this study.

Estimating nutrient requirements to get the target yield:In order to get a target yield of 7 t ha^{-1} rice plants must be sullied with 102.90 kg N, 41.70 kg P_2O_5 and 122.27 kg K_2O.

Estimating indigenous nutrient supply from soils: Indigenous nutrient defined as nutrients that crop uptake and accumulate to produce grain yield in the plots without fertilizer application. To determine indigenous nitrogen supply from soil omission plot experiments were conducted during 2011 (n=19) and 2012 (n=17), in which no anymore nitrogen fertilizer is added to the plots but the ample application of P and K (150% 0f recommended dose). The contribution of nitrogen to produce grain yield in this plot is called indigenous nitrogen and the similar cases for phosphorus and potassium. The mean of grain yield in the omission plots for nitrogen was 3.74 t ha^{-1} and then the amount of nitrogen supply from soils as 54.99 kg N ha^{-1}. Similarly, the yield in omission plots for phosphorus is 4.84 t ha^{-1} and then the amounts of phosphorus supply from soils as 28.81 kg $P_2O_5ha^{-1}$. Again, grain yield in omission plots for potassium is 4.94 t $ha^{-1}$and then the amounts of potassium supply from soils as 86.27 kg K_2O ha^{-1}.

Calculating fertilizer requirements: Nutrient requirement is defined as the amounts of nutrients needed by a crop for producing the target yield minus the amounts of indigenous nutrient (soils and other sources). While fertilizer recovery (%) was the percentages of nutrients absorbed by a crop out of the total amounts of fertilizers applied. Suppose the amounts of nutrients come from other sources are small, then the nutrient requirements were calculated as:

Nitrogen requirements:	102.90 -	54.99 =	47.91 kg N ha^{-1}
Phosphorus requirements:	41.70 -	28.81 =	12.89 kg $P_2O_5ha^{-1}$
Potassium requirements:	122.27 -	86.27 =	36.00 kg K_2O ha^{-1}

Fertilizer recovery (%) for nitrogen in 2012 was 45-50%, 25-30% for phosphorus and 40-50% for potassium. Thus, the amounts of nutrient required to apply in was calculated by the following formula and result in SSNM dose of 95.82 kg N ha^{-1}, 42.98 kg $P_2O_5ha^{-1}$ and 72.00 kg K_2O ha^{-1}.

$$\text{The amounts of nutrient required} = \left(\frac{\text{Nutrietn requiremnet} \quad x \quad 10}{\text{FR of Nutrient}}\right)$$

= 95.82 kg N ha^{-1}
= 42.98 kg P_2O_5 ha^{-1}
= 72.00 kg K_2O ha^{-1}

CULTIVATION PRACTICES

Wet bed nursery were prepared and seedlings of 22-26 days were transplanted on well prepared puddled fieldwith three seedlings per hill maintaining 20 cm × 20 cm row to row and plant to plant distance. Gap fillings were done after a week of rice transplanting in some plots to maintain the desired plant population. The doses of fertilizers were applied as accordance to treatments (Table 2). Two hand weeding were done in the plots to reduce the competition between weeds and crop for nutrients at 20 days and 45 days after transplanting. Two to six irrigations were given in the field as per requirement that depends upon the individual farmers' field. About 5 cm water was maintained either through irrigation pump or channel irrigation regularly up to grain filling stage of rice crop. The crop from the net plot area (12 m^2) was harvested manually with the help of sickles. Harvested plants were left in-situ in the field for 3 days for sun drying. Threshing was done with mini thresher and grains thus obtained were cleaned by winnowing and weighted at their exact moisture.

PROXIMATE COMPOSITION AND NUTRIENT ANALYSIS OF PLANT SAMPLE

Grain samples were oven dried at 65^0C for five to seven days. Representative of subsamples of straw (200-300 g) were taken immediately after weighing the total fresh weight to avoid the moisture loss. The subsamples are also oven dried 65^0C for five to seven days and oven dry weight of samples was calculated. Both oven dried samples of grain and straw were ground using grinder machine and kept in brown paper bag until nutrient analysis. For estimating total nitrogen content, leaf and grain samples were digested with concentrated sulphuric acid and digestion mixture in micro Kjeldahl's assembly. For phosphorus and potassium determination, straw and grain samples were digested with diacid mixture (HNO_3: $HClO_4$ in 10: 4 ratio), after predigesting with concentrated nitric acid, till colorless white precipitate is obtained. The precipitate was then dissolved in 6N HCl and filtered and filtrate was made up to 100 ml using distilled water.

OBSERVATION RECORDED

Leaf color chart (LCC) reading: For N top dressing under real time nitrogen application treatments, LCC reading was taken at an interval of 10 days on fixed 10 plants from 14 days after transplanting (DAT) to the beginning of flowering in each replication. Readings were taken on the top most fully expanded leaf of randomly selected fixed 10 disease free plants by placing its middle part on top of the color strips in the chart. If six or more leaves read bellow a set critical value (4), predetermined rate of N was applied as 20 kg N ha^{-1}.

Yield attributing characters of rice: Effective tillers per square meter, length of panicle, grains per panicles, sterility percentage and thousands grain weight were recorded.

Biomass yield, grain yield and harvest index: Biomass yield, straw yield and grain yield were taken at harvesting from net plot of 12 m^2 area. The crop was dried, threshed, sun dried; cleaned and final weight was taken. The grain yield per hectare was computed form each treatment from the net plot yield. The moisture percentage of grains was recorded from the moisture meter (Model: Willy 55). Finally grain yield was adjusted at 14% moisture using the formula as

Gain yield (Kg ha^{-1}) at 14% moisture $=\frac{(100-\mathrm{M}\quad) \times \text{plot yield (kg)} \times 10000\ (\mathrm{m}^2)}{(100-14) \times \text{net plot area}\ (\mathrm{m}^2)}$

Where, MC is the moisture content in percentage of the grains.

Straw yield was also recorded from the rows of net plot and then translated into hectare. Harvest index (HI) was computed by dividing grain yield with the total dry matter yield as per the following formula.

H.I. % = (grain yield × 100)/ (grain yield + straw yield)

*Yield gap calculation:*Three types of yield gap were calculated. The yield gap I is the difference between maximums attainable yield (80% of the climatic yield) and the SSNM yield at first yield target in farmers' field. The second gap (Yield gap II) is the difference between attainable yield and FFP in farmers' field. The third yield gap (Yield gap III) is the difference between the SSNM yield at first yield target and yield obtained in FFP in farmers' field.

*Nutrient uptake:*Grain and straw nutrient uptake were calculated as

Nutrient uptake in grain = $\left(\frac{\text{Nutrient Concentration in grain} \times \text{Oven dry weight of grain}}{100}\right)$

Nutrient uptake in Straw = $\left(\frac{\text{Nutrient Concentration in Straw} \times \text{Oven dry weight of straw}}{100}\right)$

Total nutrient uptake (TNU) = Nutrient uptake in grain + Nutrient uptake in Straw

STATISTICAL PROCEDURE

Analyses of variance (ANOVA) of the recoded parameters were performed in randomized complete block design (RCBD) considering each farmer as a replication. Means were separated by Duncan's Multiple Range Test (DMRT) at 0.05 level of significance. A simple correlation and regression analysis was run between selected parameters. Regarding the software programs, Microsoft word 2007 was used for word processing, MS excels for tables, graphs, and GenStat-15 and SPSS-16 computer programs were used for running statistical analysis.

RESULTS AND DISCUSSION

EFFECT OF NUTRIENT MANAGEMENT ON YIELD ATTRIBUTES AND CROP YIELD

Nutrient management practices had significant effect on the grain and straw yield (Table 3). Application of LCC-N + SSNM-P & K had produced significantly higher grain yield than other nutrient management practices except SSNM. SSNM had also produced significantly higher yield than farmers' nutrient management practice implies the lack of nutrient input in farmer's practices. It clearly indicated that farmers' yield could be increased by proper nutrient management. Farmers generally applied nitrogenous (52.50 kg ha^{-1}) and small amount of phosphorus (25.91 kg ha^{-1}). Only 47.22% farmers apply potassium with an average of 8.27 kg ha^{-1} (based on survey of 36 farmers). Regmi *et al*. (2002) reported rice yield reduced in terai was due to lack of phosphorus and potassium. Significantly lower yield in the FFP suggests that the insufficient use of nutrient especially nitrogen by the farmers was one of the factors for low yield in farmers' field. In Nepal, crops are harvested close to the ground level and straw is removed from the field, thus recycling of potassium through the straw is negligible. So the potassium content of cereal crop field is very low. Thus the grain yield gap between FFP and FFP - N and P + Rec. K could be attributed to the lack of K in the farmers' field. Application of fertilizer at recommended dose had yielded similar yield to that of 75% SSNM that clearly indicate the saving of nutrients (41.91 kg ha^{-1}) with the help of balance application of nutrients and recommendation need to be revised.

Table 3: Effect of nutrient management on yield and yield attributes of rice at Sunawal, Nawalparasi district, Nepal, 2013

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	HI (%)	ET per m^2	Grains per panicle	TGW (g)	Sterility (%)
SSNM	6.35^{ab}	5.89^{a}	48.13	277.14^{ab}	100.58	24.98^{a}	15.61^{b}
75% SSNM dose	5.88^{bc}	5.71^{a}	47.18	263.64^{ab}	98.76	24.90^{a}	16.36^{b}
LCC-N and SSNM-P & K	6.66^{a}	5.98^{a}	48.98	280.29^{a}	102.76	25.36^{a}	13.36^{c}
FFP	4.62^{d}	4.71^{b}	45.62	224.86^{c}	94.94	24.26^{bc}	18.07^{a}
Rec. K and FFP N and P	5.41^{c}	5.26^{ab}	46.59	252.14^{b}	99.17	24.04^{a}	16.76^{ab}
Rec. NPK	5.90^{bc}	5.58^{a}	47.84	269.74^{ab}	96.98	24.83^{ab}	15.85^{b}
SEm (±)	0.16	0.23	1.19	8.31	3.49	0.20	0.52
LSD (=0.05)	0.48	0.66	3.43^{ns}	24.01	10.08^{ns}	0.59	1.51
CV, %	7.50	11.02	6.63	8.42	9.34	2.18	8.66
Grand mean	5.80	5.52	47.39	261.30	98.87	24.73	16.00

ns, non significant. HI, harvest index; ET, effective tillers; TGW, thousand grains weight; SSNM, site specific nutrient management; LCC, leaf color chart; FFP, farmers fertility practice, Rec., Recommended. Means in the column followed by the same letter(s) are not significant different by DMRT at 0.05 level of significance.

Effective tillers per square meter, thousand grains weight and sterility percentages were significantly influenced by the fertility management practices but grains per panicle was not (Table 3). LCC-N + SSNM - P & K had highest effective tillers per square meter which was significantly higher than the FFP and farmers' N and P + rec. K applied treatments but statistically at par with SSNM, 75% SSNM and recommended NPK (Table 3). Lowest effective tillers were observed in the FFP. A significant correlation (r=0.80**) was found between tillers per square meter and grain yield

(Table 4). In the experiment, highest number of grains per panicle and thousand grain weight were observed in LCC-N + SSNM - P & K followed by SSNM (Table 3). There was significant correlation (r=0.53**) between grains per panicle and grain yield (Table 4). Significantly lowest sterility was observed in LCC-N + SSNM- P & K treatment than all other treatments (Table 3). Nitrogen stress during heading and flowering had significantly increased the sterility in lower N applied treatments like FFP and FFP- N and P + Rec. K. Sterility percentage had significantly reduced (r=-0.41**) the grain yield (Table 4).

The highest straw yield is obtained in the LCC-N + SSNM - P & K applied plot which was significantly higher than the FFP but statistically similar to other treatments (Table 3). Higher fertilizer input especially K in these treatments could be the possible reason for the higher straw yield. Nutrient management practice had not significant effect for the harvest index obtain. Comparatively higher harvest index was obtained in higher dose of nutrient applied plots and lowest in the farmer practice. Addition of potassium on the FFP increased the harvest index due to fully utilized N and P but in FFP, N and P were not fully utilized by the rice plant due to lack of K. Significant positive correlation (r = 0.46**) was found between the harvest index and grain yield (Table 4).

Table 4: Correlation analysis between yield and different yield components of rice in nutrient management at Sunawal, Nawalparasi, Nepal, 2013

Parameters	GPP	TGW (g)	Sterility (%)	GY (t ha^{-1})	SY (t ha^{-1})	HI (%)
ET m^{-2}	0.07^{ns}	0.114^{ns}	-0.236^{ns}	0.799**	0.655**	0.306*
GPP		-0.091^{ns}	-0.185^{ns}	0.532**	0.532**	0.119^{ns}
TGW (g)			-0.366*	0.250^{ns}	0.078^{ns}	0.243^{ns}
Sterility (%)				-0.409**	-0.385*	-0.091^{ns}
GY (t ha^{-1})					0.777**	0.464**
SY (t ha^{-1})						-0.186^{ns}

ns, non-significant; * significant at p = 0.05; ** significant at p = 0.01. ET, Effective tillers; GPP, Grains per panicle; TGW, Thousand grain weight; GY, Grain yield; SY, Straw yield; HI, Harvest index

EFFECT OF NUTRIENT MANAGEMENT ON NUTRIENT UPTAKE

The grain, straw and total N, P and K uptake were significantly differing among the fertility management practices (Table 5). Grain N uptake in LCC-N + SSNM-P & K and SSNM was statistically at par and similar trend was observed in total N uptake. But statistically similar straw N uptake was in LCC-N + SSNM-P & K, SSNM, 75% SSNM and recommended NPK applied plots. Significantly lowest total N uptake was recorded in FFP indicating the lower fertilizer dose had reduced the total N uptake and hence grain yield. But application of recommended dose of K along with farmers N and P had significantly increased the grain, straw and total N content over FFP because of better utilization of N in higher K level. K application enhances protein and amino acid content in grain crops due to optimum translocation of amino acids, nitrates and incorporation of N into protein (Koch and Mengel, 1974).

Table 5: Effect of nutrient management on rice nitrogen, phosphorus and potassium uptake (kg ha-1) at Sunawal, Nawalparasi, Nepal, 2013

Treatments	N uptake (kg ha^{-1})			P uptake (kg ha^{-1})			K uptake (kg ha^{-1})		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
SSNM	63.91^{a}	49.70^{a}	113.62^{a}	18.09^{b}	8.47^{a}	26.57^{ab}	16.04^{ab}	106.10^{ab}	122.14^{ab}

75% SSNM dose	56.45^{b}	44.80^{ab}	101.25^{b}	17.37^{bc}	8.30^{a}	25.67^{bc}	14.77^{b}	93.92^{ab}	108.69^{b}
LCC-N and SSNM-P & K	67.30^{a}	49.98^{a}	117.28^{a}	20.10^{a}	8.45^{a}	28.55^{a}	17.53^{a}	112.56^{a}	130.09^{a}
FFP	42.44^{c}	32.09^{c}	74.54^{c}	13.46^{d}	7.02^{b}	20.49^{d}	11.05^{d}	63.53^{c}	74.58^{c}
Rec. K and FFP N and P	53.43^{b}	40.65^{b}	94.09^{b}	15.90^{c}	7.75^{ab}	23.65^{c}	13.12^{c}	90.37^{b}	103.48^{b}
Rec. NPK	57.63^{b}	43.98^{ab}	101.61^{b}	18.23^{ab}	8.10^{a}	26.33^{ab}	14.78^{b}	99.14^{ab}	113.92^{ab}
SEm (±)	1.81	2.60	3.47	0.65	0.32	0.81	0.54	6.18	6.16
LSD (=0.05)	5.23	7.51	10.03	1.89	0.92	2.33	1.55	17.83	17.78
CV, %	8.42	15.80	9.15	10.07	10.55	8.46	9.77	17.33	14.97
Grand mean	56.86	43.54	100.40	17.19	8.02	25.21	14.55	94.27	108.82

ns, non-significant. HI, harvest index; ET, effective tillers; TGW, thousand grains weight; SSNM, site specific nutrient management; LCC, leaf color chart; FFP, farmers fertility management practice, Rec., Recommended. Means in the column followed by the same letter(s) are not significant different by DMRT at 0.05 level of significance.

FFP had lowest rice grain P uptake that indicates P could also be a rice yield limiting factor in farmers' field. Straw P uptake of different fertility management practices was statistically similar except the FFP. The total P uptake was significantly influenced by fertility management practices; the highest uptake was recorded in LCC-N + SSNM-P & K which was statistically at par with SSNM and Rec NPK. Significantly lower uptake in 75% SSNM treatment indicates the nutrient demand of rice was not fulfill by lowering the SSNM dose. Lowest uptake was observed in the FFP followed by Rec. K + FFP N and P.

Grain, straw and total K uptake were highest in LCC-N + SSNM P & K and lowest in the FFP. Grain K uptake of LCC-N + SSNM P & K and SSNM were statistically similar while straw K uptake were similar among LCC-N + SSNM P & K, SSNM, 75% SSNM and recommended NPK applied treatments. Similarly, total K uptake in LCC-N + SSNM P 7 K, SSNM and recommended NPK were also at par. Application of recommended K in FFP increased the K uptake in grain as well in straw.

POTENTIAL YIELD AND EFFECT OF NUTRIENT MANAGEMENT ON YIELD GAP

Climatic potential yields were calculated using climatic parameter like daily rainfall, solar radiation, minimum and maximum temperatures and genetic coefficients like thousand grain weight, days to flowering and maturity, duration of tillering and grain filling. The mean simulated Y_{max} of current rice varieties grown in inner terai of Nepal is around 8.87-9.47 t ha^{-1} in main season, with a mean of 9.08 (Regmi, 2003). The mean yield obtained in the LCC-N + SSNM-P & K treatment was 6.66 t ha^{-1}, thus the rice yield gap (yield gap I) was 0.68 t ha^{-1} (9.26%) indicating the a potentiality of increasing the rice yield in Nepal. The gap would be narrowed if the nutrient would be applied for higher yield target. The yield gap II (based on average yield obtained in the FFP) was calculated as 2.72 t ha^{-1} (37.10%). This wider gap suggests that there is enormous scope to increase rice yield in foot hills and terai region of Nepal. The yield gap III was based on the average yield obtained in LCC-N + SSNM-P & K and farmers practice was 2.04 t ha^{-1} indicate that with practice of LCC based N management and SSNM based P and K management only increased the rice yield by 30.67%. The total crop area under rice in Nepal is 1420570 ha. Considering the 80% of potential yield as the target yield and current average FP yields, rice yield could be increased by 110.04% and 100.26% respectively by practicing the SSNM and LCC-N + SSNM-P & K strategies in Nepal.

Table 8: Climatic potential yield and yield gaps (t ha-1) with best nutrient management practice of rice at Sunawal, Nawalparasi, Nepal, 2013

Climatic potential yield (t ha^{-1}) (A)	80% of climatic potential yield (t ha^{-1}) (B)	Average yield obtained in LCC-N + SSNM-P & K (C)	Yield gap I (t ha^{-1}) (B-C)	Average yield obtained in FFP (t ha^{-1}) (D)	Yield gap II (t ha^{-1}) (B-D)	Yield gap III (t ha^{-1}) (C-D)
9.17	7.34	6.66	0.68 (9.26%)	4.62	2.72 (37.10%)	2.04 (30.67%)

Note: SSNM, site specific nutrient management; LCC, leaf color chart; FFP, farmers' fertility practice.

CONCLUSIONS

SSNM enables to dynamically adjust nutrient use to fill the deficit between the nutrient needs of a high-yielding crop and the nutrient supply from naturally occurring indigenous sources such as soil, crop residues, and manures. Significant increase in grain yield and nutrient uptake because of SSNM were observed. As compared to FFP, SSNM increased the yield by 35.25% with increased the NPK application by 43.32, 17.07 and 63.70 kg ha^{-1}. With 25% lowering the SSNM was also equally effective as recommended NPK by saving of 28.14 and 27.77 kg ha^{-1} N and P respectively while 14.00 kg K ha^{-1} was required more than recommended dose. LCC is an effective, low-cost tool that can assist farmers in improving their N management by adjusting the N application to match the needs of the crop need and can be used as an important component of SSNM for rice as the yield advantage of 0.31 t ha^{-1}.

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POLLINATORS DIVERSITY AND THEIR EFFECTS ON RAPESEED (*Brassica campestris L. var. toria*) PRODUCTION AND PRODUCTIVITY IN CHITWAN, NEPAL

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ABSTRACT

Crop pollination is crucial for increasing yield, ensuring food security and improving livelihoods. To quantify the response of pollinators on rapeseed, an experiment was conducted in randomized complete block design (RCBD) at three agro-ecological sites: Semi-natural (Megauli), organic (Fulbari) and intensive agriculture (Jutpani) Village Development Committees of Chitwan district in 2012/013 and 20013/014. The treatments were: i) open pollination; ii) plants caged with honeybees (Apis melifera L.*); iii) hand pollination; and iv) control (plots caged without pollinators) replicated four times. Pollinators visiting rapeseed flowers, plant height, branch number, siliqua/plant, pods weight/ siliqua, test weight, and seed yield/hectare were recorded. The dominant pollinators were Hymenopterans mostly honeybees. The impact of pollinators on each system resulted in significantly increased yield attributes compared to no-pollination, which clearly indicates the need of integrating managed pollination and pollinators' conservation to sustain rapeseed production in Chitwan through biodiversity-based ecosystem services.*

Key words: Honeybees; Intensive agriculture; Open pollination; Pollinators; Rapeseed; Semi-natural;

INTRODUCTION

Oilseed is the dominant winter season cash crop of Nepal. It is mostly grown after monsoon maize in upland and after early rice in lowland of Terai, inner Terai and mid-hills of Nepal. Oilseed occupied 213706 ha and produced 176186mt in 2010/11, and its area and production increased to 214835 ha and 179145mt, respectively in 2011/2012 (MoAC, 2011/2012). In oilseeds, rapeseed (*Brassica campestris* L. var. *toria*) alone occupies about 85% of the area in the country (Basnet, 2005). However, its productivity is low, i.e. 0.83 mt/ha. Due to self incompatibility it requires sufficient pollinating agents for better pollination and seed production.Over 80% of pollination is performed by insects, and among insects bees contribute nearly the same (Kevan and Phillip, 2001; Kwapong, 2007).

Honeybees visit rapeseed flowers for collection of both pollen and nectar, which in turn results into cross-pollination of florets (Sharma *et al.*, 2004). Thus, the main significance of honeybees in beekeeping is pollination, whereas the hive products (honey, wax etc.) are of secondary value (Verma, 1990). Studies have shown that insect pollination increased pollen deposition in canola/rapeseed crops leading to increased fruit set and seed production per plant, and decreased the variance of seed sets, and also enhanced better quality,uniform ripening and plant vigor (Winston 2005; Thapa, 2006; Garibaldi *et al.*, 2010; Klien *et al.*, 2007). Rapeseed pollination by

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honeybees *Apis cerana* F. and *Apis mellifera* L increased oil content by 3.17% and 1.44%, respectively over open pollination and by 6.86% and 5.07% over caged plants (Dhakal, 2003).

Evidences have shown that low pollinator abundance and diversity have been appearing in different parts of the world (Kasina *et al.*, 2009). In Nepal, it was reported that after heavy use of chemical pesticides all domesticated bees were wiped out in Ilam and Nuwakot, and also many colonies were destroyed in Chitwan (Sharma, 1994; Thapa, 1994).

In this context, the efforts were directed to improve crop yield by applying other production inputs rather than pollination but did not bring desired results without the use of honeybees to enhance the productivity of different cultivated crops (Verma, 1992). The manmade agro-ecosystem exerted pressure and forced to decline pollinators and their diversity, which resulted in reduced agricultural productivity again threatening biodiversity (Thapa, 2006). Current evidence suggests pollinators need to be conserved and managed sustainably. It also requires long-term studies to assess the stability of pollination service for each crop because the pollinating insects are known to show high temporal variation as well as changes brought about by habitat changes (API, 2006). Therefore,this study was conducted to assess pollination deficit in rapeseed crops under farmers' managed agricultural systems, which could be useful in formulating strategies to improve utilization of pollination for crop production.

MATERIALS AND METHODS

RESEARCH SITE AND RESEARCH DURATION

The research was conducted in three sites, i.e. very close to natural habitat (Meghauli), organic farming (Fulbari), and intensive agriculture practiced site (Jutpani), of Chitwan district for two years (2012/013 and 2013/014).The experiment was laid out in randomized complete block design (RCBD) with four treatments: i) open pollination; ii) hand pollination; iii) bee supplementation with *Apis melifera* L.; and iv) control (without pollination) replicated four times in each agro-ecosystem. The plot size of each treatment was 3 m x 5 m (15m^2). Two framed broods of *A. mellifera* L. were evaluated in bee supplemented plots). In case of hand pollination, the treatment was evaluated in 1 m^2 area. When the crop started anthesis (during October), honeybee colonies were placed on the respective experimental plots caged by mosquito nets (5m x 3m x 1.5 m) starting from initial to cessation of flowering. For assessing the pollinators' diversity and intensity, a standard plot of 25m x 50m was also selected at farmers' fields (FAO, 2011).

Rapeseed (variety: Pragati) was broadcasted on 10 November, 2012 and 30 October, 2013 @ 6 kg/ha in well pulverized soil. The fertilizers applied were FYM @20 mt/ha, NPK @ 60:60:40 kg/ha and Sulphur @30 kg/ha, respectively. Full FYM, half nitrogen, full phosphorus and potassium were applied as a basal dose and remaining nitrogen as top dressing at 25 days after sowing (DAS) and other cultural practices followed as per improved cultivation practices.

The weight of 1000 seeds, number of seeds per siliqua was assessed by randomly sampling five plants per plots. From each plant, 20 pods were collected starting from the tip of the main inflorescence and the number of seeds in each pod was counted. Insect visits were observed and recorded at 10%, peak and 10% remaining flowers by counting the number of flower visitors per m^2 for five minutes. The observations were made at 10-11 am under sunny weatherconditions with temperature above 17°C. Collected data were analyzed in computer using Excel and MSTATC software programs.

RESULTS

POLLINATOR ABUNDANCE AND DIVERSITY

Hymenopteran pollinators appeared in greater number in all sites during the both years. The relative abundance of pollinators in different sites during two years is shown in Table 1. It shows that the mean population of Diptera, Lepidoptera, Coleoptera and other insects groups were higher in intensive agriculture sites in 2012/013. The population of flies was the highest in year 2013/014 in intensive agriculture site followed by Coleopteran, Lepidopteran insects, respectively. However, higher numbers of Coleopteran and Lepidopteran flower visitors were crop pests in intensive agriculture field, which were resistant pests due to massive use of pesticides.

Table 1.Abundance of insect pollinators in rapeseed field of different agro-ecosystems in 2012/13 and 2013/14 at 10%, peak and 10% remaining to flowering

	Semi-natural					Organic					Intensive Ag.				
	10%F *	Peak F*	10%R F*	Total	%	10%F	Peak F	10%R F	Total	%	10%F	Peak F	10%R F	Total	%
Year 2012/013															
Hymenoptera	55.8	83.0	55.8	194.6	56.2	71.0	70.9	54.2	196.1	55.9	28.0	23.0	30.0	81.0	35.1
Diptera	20.0	30.3	20.3	70.6	20.4	24.0	28.7	19.0	72.1	20.6	13.0	8.8	17.0	38.8	22.1
Coleoptera	14.0	16.3	13.5	43.8	12.7	13.0	15.0	13.0	41.3	11.6	12.0	11.0	8.0	31.0	16.2
Lepidoptera	6.7	8.5	7.0	22.2	6.4	7.0	8.2	9.5	24.7	7.0	4.3	13.0	4.8	22.1	22.5
Hemiptera	1.7	3.0	2.8	7.5	2.2	3.2	2.8	2.2	8.2	2.3	2.2	1.2	1.3	4.7	1.8
Orthosptera	2.3	2.7	2.5	7.5	2.2	2.5	2.7	3.8	9.0	2.6	2.2	1.7	2.3	6.2	2.3
Total				346.2	100				351.4	100				183.8	100
Year 2013/014															
Hymenopera	47.3	58.8	55.3	161.4	64.8	54.0	75.8	45.0	175.1	63.7	52.0	39.0	34.0	125.0	39.9
Diptera	8.8	22.4	14.0	45.2	18.1	12.0	13.2	8.8	34.1	13.8	20.0	16.3	9.1	45.0	41.9
Coleoptera	14.2	25.2	23.8	63.2	25.4	19.0	17.8	13.0	49.3	19.9	11.0	11.0	7.0	29.0	7.9
Lepidoptera	9.0	7.0	10.2	26.2	10.5	12.0	10.7	12.0	34.7	14.2	11.0	9.7	14.0	34.7	11.3
Hemiptera	1.7	2.3	3.0	7.0	2.8	4.7	2.3	2.7	9.7	3.9	4.7	2.8	3.5	11.0	5.2
Orthoptera	1.2	2.7	5.5	9.4	3.7	3.8	5.0	1.8	10.6	4.3	1.5	2.2	1.2	4.9	1.7
Total				312.4	100				313.5	100				249.6	100

*10% F = 10% flowering, Peak F= peak flowering, 10%RF = 10% remaining of flowering

Abundance of pollinators at different agro-ecosystems: Different types of pollinators visiting in rapeseed field were: Hymenopterans (*A. cerana, A. melifera, A. dorsata, A. florea*, *Andrena* sp, *Xylocopa* sp, *Bombus* sp, and other wasps), Diptera (*Syrphus s*p, Eristalis sp, *Muscus* sp and *Tachinid* sp), Lepidoptera (*Pieris brassicae nepalensis*, *Pelopidas* sp, *Lampides boeticus*, *Nyctemers streama*) and Coleoptera (*Coccinella* sp, *Aulacophora fobicolis* and *Mylabri*s sp). In general, Hymenopterans were the major pollinators found in all agro-ecosystems (Figures 1, 2).

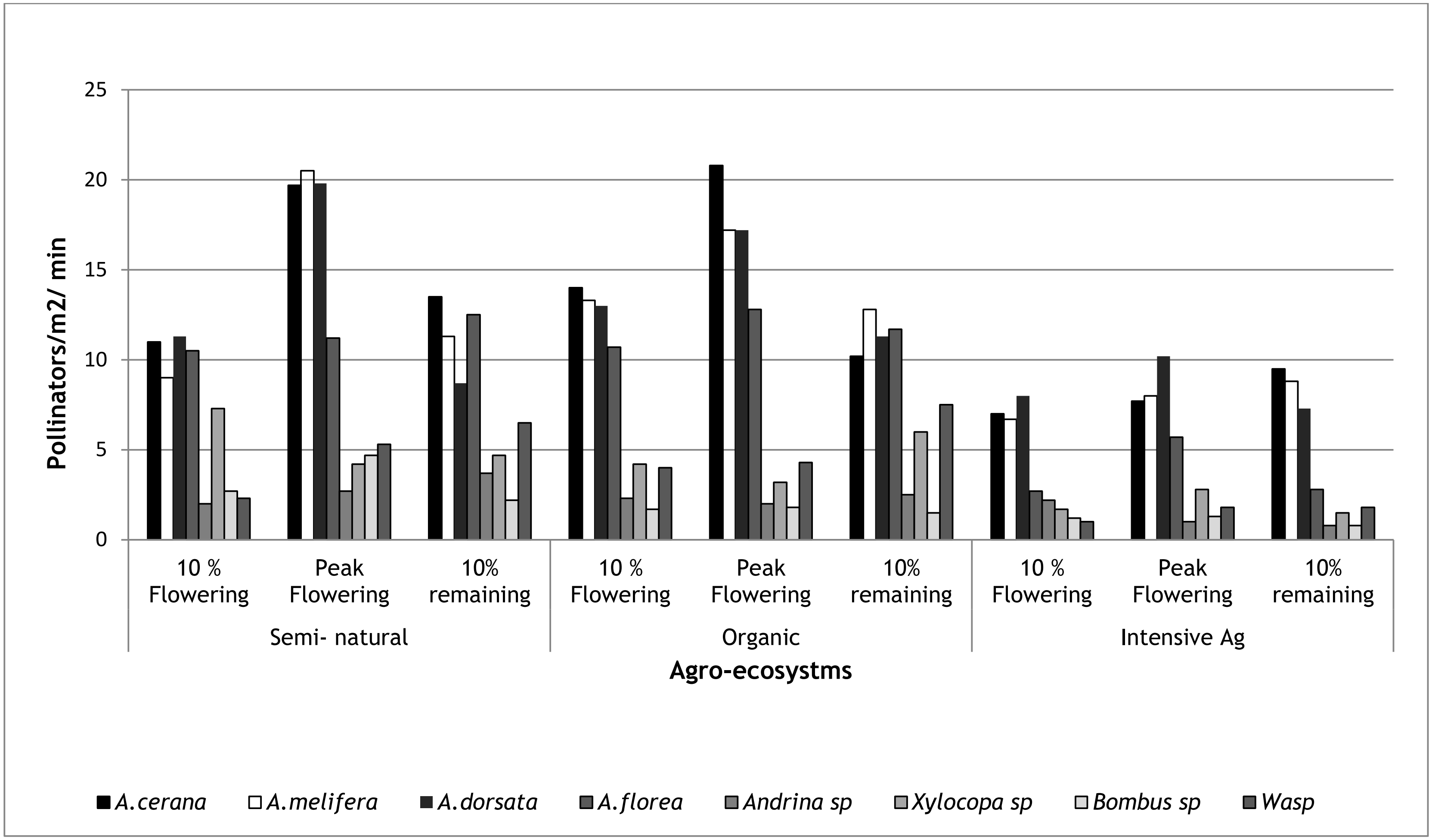

Figure 1. Abundance of insect pollinators in semi-natural, organic and intensive rapeseed fields of Chitwan at 10%, peak and 10% remaining of flowering in 2012/013

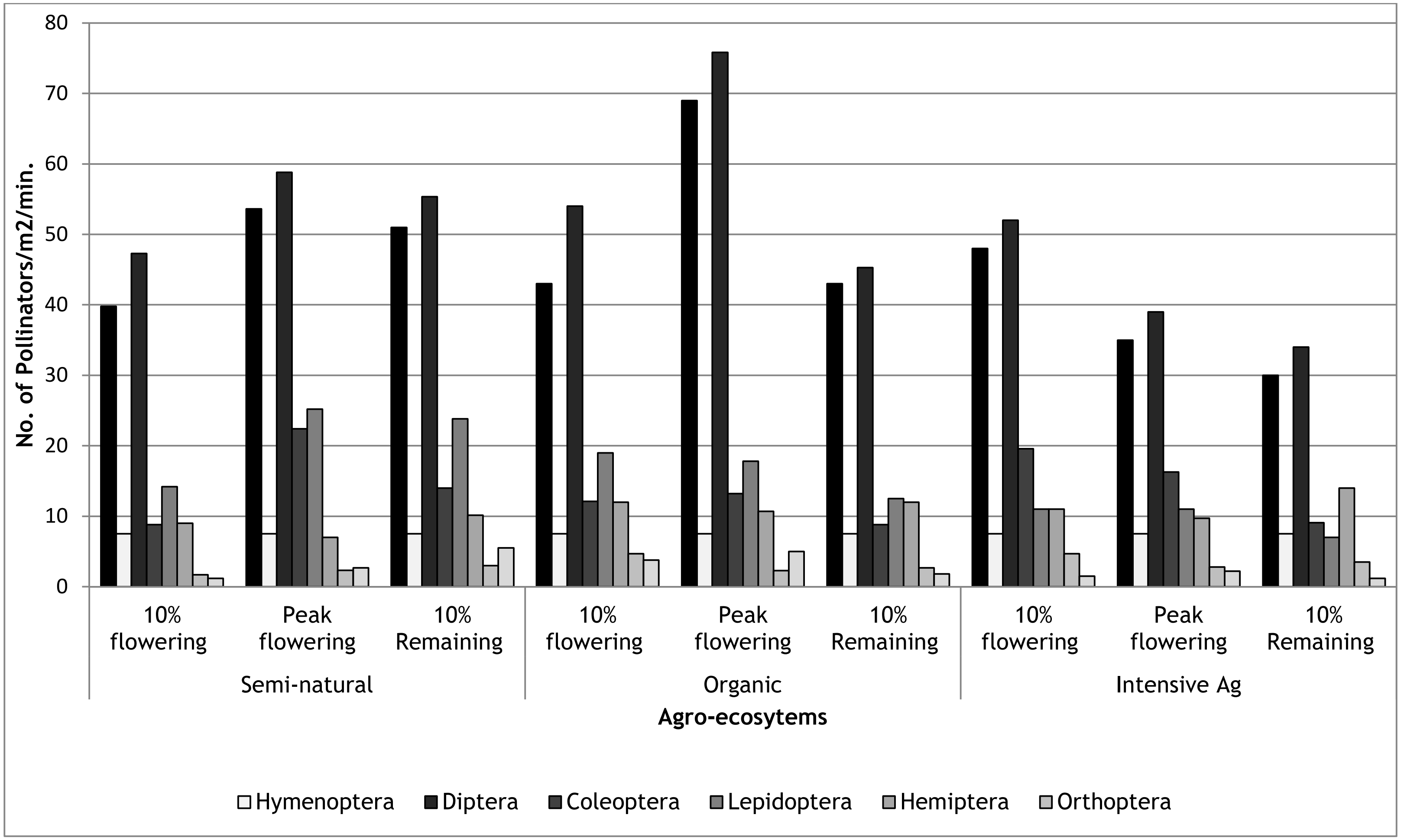

Figure 2. Abundance of insect pollinators in semi-natural, organic and intensive rapeseed fields of Chitwan at 10%, peak and 10% remaining of flowering in 2013/014

Figure 1 shows that Hymenopteran pollinators were higher in number followed by Diptera, Coleoptera, Lepidoptera, Hemiptera and Orthoptera in 2012/013. Increasing number of pollinators was observed in the year 2013/014 with similar trends and dominancy of Hymenoptera (mostly bees) also in 2013/014. The pollinators were found in higher numbers in semi- natural and organic sites as compared to intensive agriculture practiced site during the both years. The lower number of pollinators in intensive agriculture system might be due to commercial farming (higher application of chemicals, hybrid varieties), low organic matter incorporation in the soil and the distance from the natural habitats of pollinators.

EFFECT OF POLLINATION IN PRODUCTION

The treatments in each agro-ecosystems resulted in significant differences in observed characteristics. The effect of pollinators on yield attributes is shown in Tables 1 and 2.

Table 1: Effect of treatments on rapeseed plant height and number of branches under different agro-ecosystems during rapeseed growing seasons of 20 12/013 and 2013/014[1]

Agro-ecosystem	Treatment	Plant height (cm) †		No. of branch†	
		2012/013	2013/014	2012/013	2013/014
Semi-natural	Open pollination	66.5[b]	69.8[c]	4.8[c]	4.3[c]
	Bee supplementation	70.9[b]	70.6[b]	4.5[c]	4.8[bc]
	Hand pollination	76.2[a]	81.7[a]	6.0[b]	5.8[b]
	Control	77.3[a]	83.2[a]	7.3[a]	7.3[a]
Organic	Open pollination	67.7[c]	68.9[d]	4.5[c]	3.3[c]
	Bee supplementation	71.0[bc]	74.8[c]	6.3[b]	4.3[b]
	Hand pollination	75.5[b]	80.3[b]	6.3[b]	4.3[b]
	Control	83.6[a]	87.9[a]	7.0[a]	7.0[a]
Intensive-Ag	Open pollination	67.9[a]	69.2[b]	4.8[b]	3.5[c]
	Bee supplementation	71.2[a]	68.9[b]	4.5[b]	4.3[b]
	Hand pollination	77.9[b]	84.3[a]	6.3[a]	4.3 [b]
	Control	86.5[a]	86.3[a]	7.5[a]	6.5[a]
	F-value	*	*	*	*
	LSD value (≤0.05%)	5.1	5.1	1.022	1.022
	CV%	4.75	4.75	13.44	4.75

[1]Randomized Complete Block Design Combined over locations and years

† Means followed by the same letter in each column are not significantly different by DMRT at≤ 0.5 level

In 2012/013, the effects of pollination treatments on plant height varied significantly in each agro-ecosystem, i.e. plant height in open pollination, bee supplementation and hand pollination plots were significantly lower as compared to the control at each agro-ecosystem. Similarly, the plant height was significantly lower in pollination treatments than in the control in the year 2013/014 too.

The highest plant heights were recorded on control plots. The branch number was lower in semi-natural and organic sites as compared to control at each site.

Table 2: Effect of treatments on the seeds/siliqua, 1000 grains weight and seed yield in different agro-ecosystems in 2012/013 and 2013/014[1]

Agro-ecosystem	Treatment	Siliqua/ plant†	Seeds/ Siliqua†			1000 grain weight (g)†		Seed yield (mt/ha) †	
		2012/ 2013	2013/ 2014	2012/ 2013	2013/ 2014	2012/ 2013	2013/ 2014	2012/ 2013	2013/ 2014
Semi-natural	Open pollination	49.8^{b}	58.5^{a}	12.5^{a}	11.3^{a}	2.875^{a}	3.063^{a}	1.254^{a}	1.097^{a}
	Bee supplementation	61.3^{a}	62.0^{a}	12.8^{a}	13.0^{a}	2.625^{ab}	2.947^{ab}	0.993^{ab}	1.093^{a}
	Hand pollination	46.5^{b}	45.3^{c}	12.3^{a}	11.5^{a}	2.2^{bc}	2.475^{b}	0.823^{b}	0.861^{a}
	Control	49.3^{b}	51.8^{b}	4.8^{b}	7.8^{b}	1.975^{c}	1.775^{c}	0.447^{c}	0.479^{b}
Organic	Open pollination	50.5^{b}	56.5^{a}	11.5^{a}	11.3^{a}	3^{a}	2.9^{a}	1.184^{a}	1.226^{a}
	Bee supplementation	58.3^{a}	60.0^{a}	13.5^{a}	13.0^{a}	2.85^{a}	2.7^{a}	0.819^{b}	1.091^{a}
	Hand pollination	42.5c	46.3^{c}	12.8^{a}	12.8^{a}	2.275^{bc}	2.525^{a}	0.754^{bc}	0.926^{a}
	Control	49.3^{bc}	51.8^{Ab}	5.5^{b}	7.8^{b}	2^{c}	1.65^{b}	0.51^{c}	0.488^{b}
Intensive-Ag	Open pollination	47.3^{b}	47.8^{b}	9.8^{b}	11.0^{b}	2.532^{a}	2.625^{a}	0.898^{b}	0.907^{a}
	bee supplementation	61.3^{a}	61.3^{a}	13.8^{a}	14.3^{a}	2.675^{a}	2.625^{a}	1.081^{a}	1.188^{a}
	Hand pollination	46.3^{b}	47.5^{b}	13^{a}	13.5^{a}	2.2^{ab}	2.4^{ab}	0.829^{b}	0.951^{a}
	Control	35.3^{c}	35.5^{c}	4.8^{c}	$9..3^{b}$	2.1^{b}	1.775^{b}	0.535^{c}	0.476^{b}
	F -value LSD (≤0.5%)	* 6.88	* 6.88	* 2.436	* 2.436	* 1.78	* 1.78	* 0.5456	* 0.5456
	CV%	21.13	21.13	11.64	11.64	11.42	11.42	15.72	15.72

[1] Randomized Complete Block Design combined over locations and years.

† Means followed by the same letter in each column are not significantly different by DMRT at≤ 0.5 level

Pollination treatments showed significantly increased number of seeds/siliqua, 1000 grain weight and grain yield as compared to control. Number of siliqua per plant did not differ in all locations. Seeds weight was higher in semi-natural and organic fields with higher number of seeds/siliqua at all sites and test weight was significantly higher in open pollinated plots. In the case of grain yield, open pollination and bee supplementation treatments resulted in increased yield as compared to hand pollination. In each site, grain yield was significantly higher in pollinated treatments as compared to the control. Hence, in each agro-ecosystem, the role of pollination on yield attributers was significantly justified.

DISCUSSSION

Rapeseed field harbored many species of bees that collected nectar and pollen. Even though there were no hives near the rapeseed field, there were honeybees. The open field attracted bees in higher number, which were beneficial for both nectar and pollen collectors. The semi- natural and organic sites harbored greater number of bee pollinators than the intensive agriculture site due to the least disturbance upon the environment and suitable nesting places. Hence, there was no necessity to supplement bee hives for pollination purpose in the semi-natural and organic sites. However, the main pollinators, i.e. honeybees and solitary bees were low in intensive agriculture which needed supplementation to increase pollination as well as production of crops.

The effect of pollinators on yield of rapeseed depends on the density of the pollinators. This study showed the potential yield improvement that can exist in semi-natural or organic or intensive agricultural agro-ecosystems due to presence of pollinators. In Quebec, improvement in seed yield upto 46% was in the presence of three honeybee hives per hectare as compared to no bee hives (Sabbahi *et al*., 2005) in rapeseed. In another research in oilseed rape (*B. napus*), there was 13% seed yield increase in plots with bees as compared to those without bees (Abrol, 2007). The low production of rapeseed in the intensive agriculture sites might be due to lower numbers of bee populations because this site was four km. away from the natural forest and shrub areas. Regression analysis predicted by Manning and Boland (2000) indicated that the number of pods/plant decreased @15.3 pods/plant (equivalent to a 16% loss) as distance increased 1000 m from an apiary. Shortening the blooming periods by 3-5 days in the research observed in semi-natural and organic field is similar to Abrol (2007) that pollinators can contribute to bring uniformity and early pod setting, which reduce blooming period of Argentine canola (*B. napus*) by 3.8 days, with reduced number of flowers that the plant had to produce to reach its carrying capacity (Sabbahi *et al*., 2006). Simon Fraser University in British Columbia found that bee abundance was the greatest in canola fields that had more uncultivated land within 750 m of field edges and seed set was greater in fields with higher bee abundance (Morandin and Winston, 2006); this could be the reason for higher yield in semi-natural fields. Considerable yield in intensive agriculture was obtained in the condition of low population of bees which could be supported by the availability of dipterans population especially syrphid flies, because study has showed that some species of hover flies (Syrphidae) also significantly increased seed set and yield in canola (Jauker and Wolters, 2008).

Research conducted in different parts of world shows that in natural or undisturbed land or in organic land, there was conservation of pollinators with higher densities and diversities. The risk seen everywhere is insecticide applications that reduced pollinators' abundance in the field. Diversity was related to the number of flowering plants and insect pollinators, which increased the number of pods, seeds per pod, seed weights per plant, and seed germination (Atmowidi *et al*., 2007). This research is concurrence with the view of Gallai *et al*. (2009), and Ricketts (2004) that the decrease in honeybee populations (lack of native pollinators) can cause losses in productivity in intensive agriculture site as the higher number of bee abundance and diversity were reported in semi-natural habitats than agricultural fields (Mackenzie and Winston, 1984; Banaszak, 1996; Calabuig, 2001). The variation in pollinators in this study was similar to Moradin (2005) that about 30, 23 and 40% variation in bee abundance was recorded in organic, conventional and GM fields, respectively. According to finding of Osborne *et al*. (1991) and Svensoon *et al*. (2000), availability of nesting sites for wild bees created favorable habitat for bees on semi-natural land as compared to agriculture land. The population of wild bees is declining in agricultural areas due to habitat loss, which is finding of Allen-Wardell *et al*. (1998). Undisturbed landscapes would increase the likelihood of solitary bee pollinator services in agricultural landscape (Morandin *et al*., 2007) which acts as a proxy for increasing wild pollinator densities (Melathopoulus *et al*., 2015). A recent study has demonstrated, for instance, that the benefit to crop yield from animal-mediated pollination depends on pest control levels (Lundin *et al*., 2013). However, pollinator-mediated yield is strongly conditioned by cultivar and their spatial arrangements in fields (Bell*et al*., 2012; Klatt *et al*., 2014), as well as environmental conditions and farm management practices (Boreux *et al*., 2013; Groeneveld *et al*., 2010; Hoover *et al*., 2012; Lundin *et al*., 2013; Melathopoulos *et al*., 2014).

CONCLUSIONS

Rapeseed (*Brassica campestris* L. var. *toria*) which was not pollinated by bees resulted in taller plants height, higher branch numbers and lower yield. Plants that were pollinated by bees reduced flowers longevity and increased seed number per pod, and test weight ultimately producing higher seed yield. The numbers of pods/plant and yield were found to be significantly different among the treatments, i.e. with and without bees ($P \leq 0.05$). The impact of pollinators on each system has resulted in significantly increased yields as compared to restricted pollination. There is deficit in pollination in intensive agriculture field, which has greatly reduced rapeseed yield. Hence, the suitable hibernating places, availability of pollen and nectar source, less human intervention and less chemical pesticide resulted in the higher population of visitors among the flowers. Integrating conservation and suitable management of pollinators is therefore crucial to sustain agriculture productions through optimized management of agronomic inputs and biodiversity-based ecosystem services.

While considering the pollination management, rational decision of growers includes cultivation and maintenance of “bee pastures”, consisting of diverse native or non-native flower-rich plantings maintained in fallow areas, field margins, and conservation of buffer strips to conserve bee pollinators. Hence, it is necessary to take steps to improve ecosystem service (by pollinator) properly for the betterment of people as it leads to sustainable production and food security.

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