Go Wild for Life; Zero Tolerance Towards the Illegal Wildlife Trade

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(This issue is published on the occasion of World Environment/Population Day-2016)

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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 attract 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.

"Go Wild for Life; Zero Tolerance towards Illegal Wildlife Trade" is the theme declared by United Nations Environment Program (UNEP) for the World Environment Day (WED), 2016. The theme really draws the attention against the illegal wildlife trade that has caused extinct of some wild species, and other some in endangered species. It acknowledges wild lives as a beautiful part of the environment and their importance for conserving and maintaining ecosystem and balancing nature and sustainable livelihoods of the people. It encourages to handover environment friendly world 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 several events and relevant environmental campaigns. The Food Security, Agri-Business Promotion and Environment Division (FSABPED) in the Ministry of Agriculture Development (MoAD) is publishing the new issue of Journal of the Agriculture and Environment (Vol.17, 2016). 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 its 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.16) 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 before end of Falgun 2072 (March 15, 2016).

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 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.

For a book: Burkitt, M.C., 1977. The Old Stone Age. New Delhi : Rupa Publication Co.

For a journal article: Manandhar, R. Odeh, I. and Pontius, R.G., 2010. Analysis of twenty years of categorical land transitions in the Lower Hunter of New South Wales, Australia. Agriculture, Ecosystem and Environment 135: 336-346.

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 benefit. 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.

10. Following editorial scrutiny, the manuscripts are subject to rigorous peer review.

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.

12. The Editor-in-Chief deserves final right to accept or reject a submission.

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

14. Manuscripts that do not correspond to the above mentioned instructions can be returned without review.

REVIEWERS' LIST

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STATUS OF FERTILIZER AND SEED SUBSIDY IN NEPAL: REVIEW AND RECOMMENDATION

Diwas Raj Bista[1], Sujan Dhungel[2] and Santosh Adhikari[3]

ABSTRACT

The study focuses on the review of existing programs and policies regarding input subsidy in Nepal especially in seeds and fertilizers. The study aims to review timeline in subsidy programs, budget details and progress based on the gleaning of the secondary information available in the Ministry of Agricultural Development. The assured budget allocation for chemical fertilizers subsidy has led to increment in consumption over the years. Nepal spent 52.29 billion Nepali Rupees in importing chemical fertilizers and 23.19 billion in subsidy in last seven years. Nepal Government has also been promoting organic fertilizers however, the subsidy allocated to this program has not been able to take the pace. Seed subsidy program has been found to be impressive; however, it is confined to wheat and paddy only. The subsidy program is targeted mainly to the small and marginal farmers. The seed subsidy program should be expanded to pulses and oilseed crops as well. The organic fertilizers should be promoted to maintain long-term soil health. Inputs subsidy policy and programs should cover all farmer categories.

Key words: Subsidy, chemical fertilizer, organic fertilizer, seed,subsidy

INTRODUCTION

Nepal predominantly is an agricultural country with 3.8 million (70 percent) farmer household (CBS, 2012, CBS, 2013). Agriculture sector contributes about one third (33.09 percent) share in Gross Domestic Product (MoF, 2014).

Nepalese agriculture is characterized by dominance of small and marginal farm holders following traditional and indigenous farming technology which is regarded as low yielding technology. Over the last 10 years, population has been increasing at 1.35 percent annually (CBS, 2012) while agricultural land has decreased by 129 thousands hectares (CBS, 2013). Increasing population coupled with declining agricultural land and stagnant productivity of major cereals has lead to food and self insufficiency in some districts of the country. 31 out of 75 districts were reported to be experiencing self-insufficiency in food production (MoAD, FAO & WFP, 2014).

Fertilizer, seed and irrigation are major inputs for agricultural production. APP has mentioned that about half of the incremental output can be attributable to increased fertilizer use while National Seed Vision (2013-2025) states that improved seed can contribute 20-30 percent increment in crop yield. Inadequate access of farmers to seed and fertilizer has been identified as major contributing factor for the low production and productivity of agricultural commodities. MoAD aims to achieve food security by increasing agricultural productivity through assured supply of quality inputs. MoAD has been implementing fertilizer and seed subsidy program with special focus on small and marginal farmers.

The Agriculture Perspective Plan (APP, 1995-2014) has envisaged an increase in fertilizer use from 31 kg nutrient/hectare in the base year (1995) to 131 kg nutrient/hectare by 2015. Similarly, Agriculture Development Strategy (2015-2034) has also highlighted the low use of fertilizer as the major reason for low productivity and commercialization. It has envisaged the implementation of voucher system for the effective extension service delivery and input supply including fertilizer. As

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the majority of Nepalese farmers are small and marginal, characterized by low purchasing power of costly fertilizer, adequate and timely supply of quality fertilizer has been the priority of Government of Nepal (GoN). The agricultural Inputs Management Section (AIMS) under ministry is mandated to formulate policy, guidelines for administration and implement the activities regarding inputs management.

METHODOLOGY OF THE STUDY

The study is based on the secondary information available in the Ministry of Agricultural Development and other institutions. The information was collected through published policy documents, progress reports and position papers submitted to Ministry of Finance, National Planning Commission, and Office of Prime Minister and Council of Ministers. Similarly, personal interview using semi-structured questionnaire to the authorized personnel of MoAD was also employed to validate the collected information.

Simple decomposition analysis was also used to assess the effect of area and yield on change in production of paddy, wheat and maize during the period of FY 2065/66 to FY 2071/72.

METHODOLOGY USED FOR DECOMPOSITION ANALYSIS

$$Pn - Po = (Yn-Yo)\,Ao + (An-Ao)\,Yo + (Yn-Yo)\,(An-Ao)$$

Where, Yn= average yield of last three years

Yo= average yield of initial three years

An= average area of last three years

Ao= average area of initial three years

Pn-Po= change in production

(Yn-Yo) Ao= Yield effect

(An-Ao) Yo= Area effect

(Yn-Yo) (An-Ao)= Interaction effect

RESULTS AND DISCUSSIONS

CHEMICAL FERTILIZER SUBSIDY IN NEPAL (BEFORE 2008/09)

Introduction of chemical fertilizer in Nepal dates back to early 1950's with the import of Ammonium Sulphate from India by private traders. However, the systematic effort to import chemical fertilizer started with the establishment of Agriculture Inputs Corporation (AIC) under MoAD in 1966.

With the rise in international price of chemical fertilizer during 1970s, GoN decided to introduce price subsidy. AIC used to receive difference between actual cost and selling price as subsidy. Due to growing demand for the fertilizer and increased international prices, financial burden of Government started to creep up. Government’s failure to allocate sufficient budget for the subsidy resulted into AIC’s loss. AIC became unable to import the quantity as per the demand leading to short supply. Nepal received fertilizer under grant aid from Germany, Canada, Finland and Japan, however, some countries stopped the supply in 1991/92 and others reduced the volume (Shrestha, 2010).

Till 1997/98, AIC was the only agency for fertilizer trade in the country. The failure of Government to allocate sufficient budget caused reduction in import and distribution of fertilizer. In November, 1997, subsidy was completely removed in DAP and MoP while in Urea subsidy was removed in 1999. It also deregulated the price control. To institutionalize the fertilizer deregulation policy Government promulgated Fertilizer (control) Order, 1997 and National Fertilizer Policy, 2002 that paved the way for private traders to stand at equal footing with AIC. In the same period AIC was terminated to form two companies namely, Agriculture Inputs Company Limited (AICL) responsible for fertilizer business and National Seed Company Limited (NSCL) responsible for seed business under Company Act, 1996(Shrestha, 2010).

CURRENT SUBSIDY SCHEME (2008/09 TILL DATE)

The deregulation policy did not contribute to smooth supply of fertilizer in the country. Illegal inflow of fertilizers from India was experienced in early periods due to rise in international prices, subsidy provision of India to its farmers and poor purchasing power of Nepalese farmers. Similarly, due to short supply of quality fertilizers to the farmers, they were forced to rely on fertilizer of unidentified and unauthorized quality available in the market. Moreover, in absence of subsidy, higher price of fertilizer led to higher cost of production and poor capacity to compete in the international market. So, to assure the supply of quality fertilizer to the farmers, MoAD approved a proposal by Council of Ministers in November, 2008. In addition, MoAD in coordination with Ministry of Finance (MoF) developed operational modality of the subsidy administration which was endorsed by Government in March, 2009.

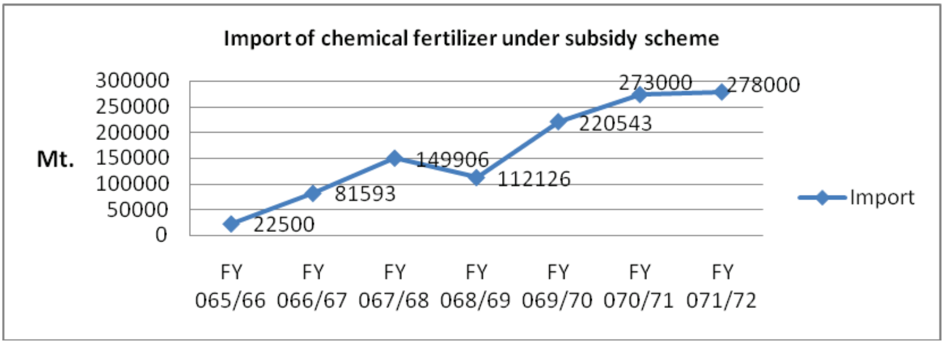
FEATURES OF CURRENT SUBSIDY SCHEME (AS PER THE DECISION OF COUNCIL OF MINISTERS)

- Provision of maintaining selling prices of fertilizer at 20-25% higher than that of India at five import points (Biratnagar, Birgunj, Bhairahawa, Nepalgunj and Dhangadhi).
- Agriculture Inputs Company Limited (AICL) and Salt Trading Corporation Limited (STCL) are responsible to import and distribute the chemical fertilizer.
- The difference amount between actual cost and subsidized price will be provided as subsidy to AICL and STCL (subsidy administration is on cost sharing basis).
- Provision of subsidy distribution management committee chaired by secretary of MoAD. The committee is responsible for price fixation, fund release and overall monitoring and evaluation of the subsidy program.
- Subsidized fertilizer will be available for 0.75 hectare in hilly districts and 4 hectares in terai districts to the technical requirement of three crops per year.
- Subsidized fertilizer is distributed through offices of AICL, STCL and cooperatives.
- Chief District Officer (CDO) of the respective district chairs the Fertilizer Supply and Distribution Management Committee which is responsible for overall management of fertilizer distribution at district level.

STATUS OF CHEMICAL FERTILIZER SUBSIDY

The amount of chemical fertilizer imported within country after the promulgation of current subsidy scheme has increased significantly over the years. The import volume has increased from 22.50 thousand Mt in starting year (FY 2065/66) to 278 thousand Mt in FY 2071/72 (Figure 1).

Figure 1: Amount of chemical fertilizer imported under subsidy scheme



With the rise in import volume, the amount distributed under subsidy has also increased over the years. In FY 2065/66, a total of 7,090 Mt chemical fertilizer was distributed in subsidy throughout the country which increased to 298 thousands Mt in FY 2071/72 (Table 1). The increase in import and distribution indicates that the availability of quality chemical fertilizer has led to increased demand from farmers' side.

Table 1: Amount of chemical fertilizer distributed in subsidy.

(quantity in Mt.)

Fertilizer/FY	2065/66	2066/67	2067/68	2068/69	2069/70	2070/71	2071/72
Urea	5932	50489	85191	97956	108553	146117	190163
DAP	-	25211	22019	43146	65722	81738	101797
MoP	-	2357	2821	3711	2688	5023	6717
Complexal	1158	3788	-	-	-	-	-
Total	7090	81845 (1054)	110031 (34)	144813 (31)	176963 (22)	232878 (31)	298677 (28)

(Source: AIMS-MoAD, 2016)

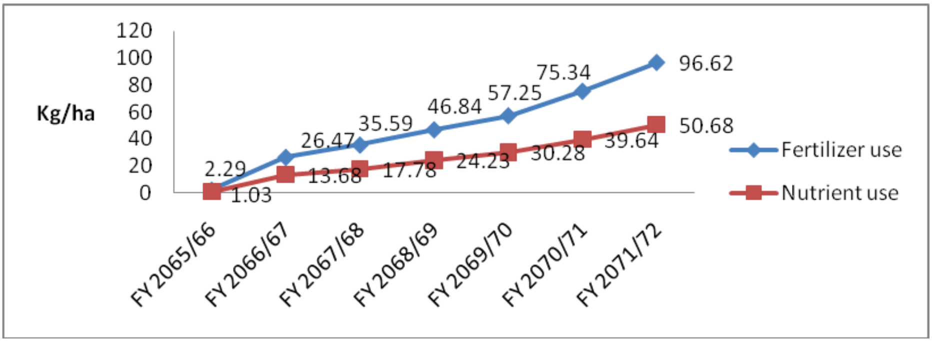
(Figures in the parentheses indicate percent increased compared to previous year.)

After FY 2066/67 the consumption of fertilizer has shown increment of more than 20% each year compared to the previous year.

FERTILIZER AND NUTRIENT USE STATUS

The fertilizer consumption per hectare has increased after the implementation of chemical fertilizer subsidy program. Based on the total consumption of chemical fertilzier in FY 2065/66 the fertilizer and nutrient use per hectare was 2.29 kg and 1.03 kg which has significantly increased over the years and has reached to 96.62 kg and 50.68 kg respectively (figure 2) . The consumption level is far below compared to that targeted by Agriculture Perspective Plan (APP). APP has targeted nutrient use of 131 kg/ha by the end of 2015. The consumption level is very low compared to that of neighbouring countries as well. Fertilizer use of 147 kg/ha, 176 kg/ha, 166 kg/ha and 101 kg/ha has been reported in India, Bangladesh, Pakistan and Sri Lanka respectively in 2009 (Bista *et al*, 2013)

Figure 2: Fertilizer and nutrient use per hectare



(Source: AIMS, Ministry of Agricultural Development)

The budget allocation in chemical fertilizer subsidy has increased significantly from 366 million rupees in FY 2065/66 to 5.32 billion rupees in FY 2071/72. In the period of 7 years (from FY 2065/66 to FY 2071/72) total expenditure on chemical fertilizer will be 52.29 billion rupees while the subsidy expenditure for the program will be 23.19 billion rupees (Figure 4). Government's ability to allocate budget regularly for the program has resulted smooth supply of chemical fertilizer in the country.

Table 2: Budget description for chemical fertilizer subsidy

FY/Description	Cost (in '000 NRs.)	Subsidy (in '000 NRs.)	Subsidy share (%)
065/66	688087	366813	53.30
066/67	2819139	1370518	48.61
067/68	6195372	2526380	40.78
068/69	5415758	3129947	57.79
069/70	11468933	5171837	45.09
070/71	12786106	5308772	41.51
071/72	12919773	5324806	41.21
Total	52293168	23199073	44.36

(Source: AIMS-MoAD, 2016)

The subsidy over the year has declined except for the FY 2068/69 (Table 2). The main reason for the decline in subsidy percentage is decline in international prices and fixed subsidized prices of fertilizer maintained by the Government.

ORGANIC FERTILIZER SUBSIDY

STATUS OF ORGANIC FERTILIZER SUBSIDY

To minimize the negative consequences of chemical fertilizer and maintain the soil health, Ministry of Agricultural Development started organic fertilizer subsidy program with the promulgation of Organic Fertilizer Subsidy Guideline, 2068. According to the guideline subsidy is provided in organic fertilizer produced in the country and registered as per the Organic and Bio-fertilizer Regulation Guidelines, 2068. The Subsidy Distribution and Management Committee, chaired by the secretary of Ministry of Agricultural Development is responsible for overall administration of organic fertilizer subsidy program including fund release, fixing subsidy rate, price and monitoring of the program. Fertilizer Supply and Distribution Management Committee chaired by Chief District Officer (CDO) of in the district is responsible to look after the distribution, monitoring and evaluation of the program at district level. The subsidized organic fertilizer at famers' level is distributed through AICL, cooperatives and cooperative shops.

The second year of program implementation showed some increment in amount distributed which went on to decrease on following year (Table 3). Despite budget allocation and increase in subsidy percent over the years, the program has not been found to be impressive.

Table 3: Status of Organic fertilizer subsidy

Description/FY	**2068/69**	**2069/70**	**2070/71**
Quantity purchased (Mt)	3139	1861	1900
Actual sales (Mt)	788	3177	2615
Cost ('000 NRs.)	67670	39872	27084
Subsidy ('000 NRs.)	39419	23123	19248
Subsidy percentage	58.25	57.99	71.06

(Source: AIMS-MoAD, 2016)

The farmers are interested in chemical fertilizers due to its quick response to the crop. Moreover, practice of using locally available farm yard manure, compost and organic fertilizer is popular among farmers. However, ministry is implementing programs for shed improvement, supporting vermi-compost preparation at local level and establishment of organic fertilizer industries throughout the country to promote organic fertilizer.

STATUS OF SEED SUBSIDY

Subsidy on improved seed was started with the promulgation of Guidelines for subsidy on improved seed in 2068. The Guidelines has made the provision of high level Seed Supply and Distribution Management committee chaired by the secretary of Ministry of Agricultural Development. The committee is responsible for overall administration of the program, determination of quantity under subsidy, fund release and monitoring. The program envisages providing subsidy in major cereals, pulse and oilseed; however, the program has been confined to paddy and wheat only. The reason for exclusion of other crops in the scheme is limited availability is quality seeds within country. District Agricultural Inputs Supply Committee chaired by Chief District Officer (CDO) of the respective district is responsible for overall administration, distribution and monitoring of the seed subsidy program at district level. Seed subsidy can be provided in paddy, wheat, maize, millet, lentil, gram, pigeon pea, green gram, pea and mustard. Subsidy scheme has the provision to provide seed for 2.66 ha in terai and 2 ha in hills per year per farmer. The subsidized seed at farmers' level is distributed through dealers of NSCL.

Table 4: Status of Seed subsidy

Description/FY	**2068/69**	**2069/70**	**2070/71**	**2071/72**
Sales Quantity (Mt.)	579	10	6550 (4769 Mt. wheat and 1781Mt. paddy)	7826 (5457 Mt. wheat and 2369 Mt. Paddy)
Subsidy ('000 NRs.)	6530	475	111073	155379
Subsidy percentage	25-40	100	15-35	30-35

(Source: AIMS-MoAD, 2016)

The subsidy program on improved seeds has been impressive. The program initiated in FY 2068/69 with the distribution of 579 Mt. improved seeds of paddy which increased to 7826 Mt. (5457 Mt. wheat and 2369 Mt. paddy) in FY 2071/72. The program could not function in FY 2069/70, however, in the year only 10 Mt of paddy seeds were distributed freely in flood hit districts of far western region. The subsidy percent in the first year of subsidy program was 25-40% of market price which was 30-35% in paddy and 35% in wheat in FY 2071/72 (Table 4).

EFFECT OF SUBSIDY ON MAJOR CEREAL CROPS

The decomposition analysis of major cereals (paddy, maize and wheat) shows that the increase in production between the period of FY 2065/66 to FY 2071/72 is due to increase in yield of the crop.

In case of paddy and maize entire increment in production is due to yield effect. In case of wheat increment in production is due to area, yield and interaction of area and yield effect; however the increment is largely due to yield effect which is 82% (Table 5).

Table 5: Decomposition analysis of paddy, maize and wheat

Crops	**Change in production (Mt.)**	**Area effect**	**Yield effect**	**Interaction effect**
Paddy	444236	-0.43	1.49	-0.06
Maize	191211	0.01	0.98	0.001
Wheat	365002	0.15	0.82	0.03

(Source: AIMS-MoAD, 2016)

The yield of crop depends on seed, fertilizer, irrigation and management. Improved seed and quality fertilizer play important role in crop productivity. The smooth supply of chemical fertilizer under subsidy scheme and increasing amount of improved seed distribution must have played role for positive yield effect.

Assured supply of fertilizer and improved seeds will have positive impact on production and productivity. The subsidy program has assured the supply of inputs in the country and has impacted positively on production and productivity of crops.

SWOT ANALYSIS OF INPUT SUBSIDY MECHANISM

STRENGTH

- Provision of separate section (Agriculture Inputs Management Section) in MoAD for the specific task of fertilizer and seed subsidy.
- Already defined policy framework and guidelines for program implementation.
- The program to support subsidy in Nepal is under First Priority Program (P1) thereby assuring the regular budget allocation.
- Involvement of Agriculture Inputs Company Limited (AICL) and Salt Trading Corporation Limited (STCL) in import and distribution of fertilizers and National Seed Company Limited (NSCL) in seed subsidy administration provides the opportunity to utilize their business expertise.

WEAKNESS

- Insufficient human resource at bottom level implementation units (DADOs).
- Insufficient number of fertilizer and seed inspectors in DADOs to monitor and regulate the program.
- Lack of separate section in Department of Agriculture and Regional Agricultural Directorate to administer input subsidy program.
- Complicated procurement procedure under public procurement act leading difficulty in timely supply of fertilizer and seed on season.
- Current fertilizer subsidy policy targets cereal crops only.
- The budget allocation is far below compared to the requirement of chemical fertilizer.
- Subsidy is limited only to the Urea, DAP and MoP fertilizers.
- Subsidy on seed is confined to major cereals only.
- Due to undulated geographical terrain and transport facility, the subsidy scheme has not been able to cover the farmers of remote areas.
- Program targets small and marginal farmers only.

OPPORTUNITY

- Increasing commercialization is demanding more of improved inputs like chemical fertilizer and improved seeds.
- Government is conducting a rigorous feasibility study to establish chemical fertilizer plant within the country.
- Ministry is providing trainings to produce and capacitate more number of fertilizer and seed inspectors for regulatory works.
- Existing network of DADOs and Service center at bottom level to effectively implement the program.
- Involvement of cooperatives for distribution at farmer level makes the distribution mechanism more transparent.

THREAT

- Fertilizer supply is entirely dependent on import.
- Price fluctuation of chemical fertilizers in international market.
- Distortion of fertilizer market due to subsidy scheme leading to dismal participation of private sector in the business.
- Increasing use of chemical fertilizers may result to decline in soil health in long term.
- Porous border of Nepal and India possesses threat of drain of subsidized fertilizer to India.

CONCLUSION

The budget allocation and the amount of chemical fertilizer and seed distributed have increased over the years. In case of organic fertilizer, the program has not been impressive. Organic fertilizer production in Nepal is still in initial phase of commercialization thereby leading to limited choice among the farmers. Moreover, locally available farm yard manure and compost are popular among the farmers which shares large proportion of organic fertilizer consumption. With the experience of slow pace of organic fertilizer subsidy program, MoAD has promulgated Organic Fertilizer Subsidy (district level) Guideline, 2072. As per this provision farmers are independent to purchase the fertilizer of their choice at subsidized rate and the respective District Agriculture Development Office will refund the subsidy amount to the organic fertilizer seller. This is expected to increase the completion among the organic fertilizer producers and helping the farmers to choose the quality fertilizer.

Government's priority for assured supply of seed and fertilizer as well as increased allocation of budget over the year has led to increased supply and consumption of seed and fertilizer in country.

RECOMMENDATION

- The fertilizer subsidy scheme should cover medium and large farmers also. The minimal participation of private traders and exclusion of large and medium farmers from the subsidy has resulted into unavailability of chemical fertilizer to the large and medium farmers.
- The subsidy scheme focuses for food crops and does not address the requirement for the commercial crops. There should be provision for fertilizer subsidy to commercial crops as well.
- The provision of 4 ha in terai and 0.75 ha in hills looks unfair from regional balance point of view. The area limitation for hill should be increased.
- The current scheme releases subsidy amount to AICL and STCL in advance. The subsidy should be provided in actual sales basis of fertilizer so that burden of Government will be minimized.
- The program of distribution of Farmer Identification Card (Kisan Parichaya Patra) should be tied with the subsidy program. The card will identify small, medium and large farmers. Ministry should look to provide subsidy to all the farmers but in different rates.
- National Fertilizer Policy, 2002 also envisages providing equal opportunity to private and cooperative sectors in fertilizer trade but due to direct involvement of Government in fertilizer trade, private traders are unable to compete. Government should look to introduce a voucher system that is valid for fertilizer and seed purchase by the farmers and based on the purchased amount of fertilizer and/or seed subsidy amount should be refunded to farmers' account.
- AICL and STCL as well as MoAD should maintain a comprehensive data base of total fertilizer sales, regional and district wise distribution as well as monthly distribution pattern so that the data would be handy to analyze the consumption pattern according to season and crop.

- MoAD should maintain the buffer stock of fertilizer as envisaged by the National Fertilizer Policy, 2002.
- The seed subsidy program should be widened to pulses and oilseed crops as well. Besides, purchasing and distributing seed in subsidy, Ministry should look to assure production of quality seeds within country.
- The seed subsidy program is confined to the terai region. So, the program should cover mid hills and high hills regions as well to increase the access to quality seeds.
- The distribution of organic fertilizer should be done at local level through District Agricultural Development offices. The operation at local level will create opportunity to compete the producers thereby leading to increased choice for farmers.
- Ministry should look for the program to support organic fertilizer producing farmers groups and cooperatives to produce at local level.
- As the productivity of crops also depends on other factor along with seed and fertilizer, ministry should look to conduct studies on impact of the seed and fertilizer subsidy on crop production and productivity as well as livelihood of farmers.

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PRODUCTION PRACTICE, MARKET AND VALUE CHAIN STUDY OF ORGANIC APPLE OF JUMLA

P.N. Atreya[1] and A. Kafle[2]

ABSTRACT

This study was undertaken to explore the market and value chain of apple in Jumla and Nepaljung in January 2014. Primary and secondary data were used for this study. All together 10 respondent farmers were selected for production related data, five retailers from Jumla and Nepaljung, one wholesaler from Nepaljung and 10 consumers for market study. Highest wholesale price was observed in May/June - June/July (NRs. 145/kg) while lowest was in Sept./Oct.-Oct./Nov. (NRs. 83/kg). Similarly highest retail price (NRs. 185/kg) was in the month of June/July and lowest (NRs. 115/Kg) was in Sept./Oct-Oct./Nov. The average farm gate price of apple is too low (NRs.26.93/kg) as compared to wholesale, retail and consumers prices. The producers, traders, transporters, wholesalers and retailers were the main marketing actors of apple. Contractual system before and during production were observed in marketing. Price spread of Jumla apple was assessed with the different actors (contractors, traders, wholesalers, retailers and consumers) in value chain. Apple is the major commodity for income generation so better knowledge on production marketing and value addition through processing should be imparted to the farmers.

Key words: Apple, marketing channel, value chain

INTRODUCTION

Among deciduous fruits, apple is the most important crop in terms of area, production, and household economy in remote mountain districts of Nepal. Apple is a prominent and one of the important prioritized high value cash crops in the high hills of Nepal (APP, 1995). It is the fourth most extensively produced deciduous fruit crop worldwide (FAO, 2010). Largest productive area under apple in Karnali zone is found in Jumla district (2,900 ha) followed by Kalikot (1,613 ha), Mugu (950 ha), Dolpa (850 ha) and Humla (450 ha) respectively (FDD, 2015). According to MoAD (2015), export of fresh apple is 22.9 mt (worth NRs. 83,226) to India and China while its import is about 56,447.02 mt (worth NRs. 1,923,637,048) from China, India and USA and it indicates the high demand for this crop. Nepal government introduced apple in Jumla in 1970s and all 30 VDCs of the district have equally suitable climate for apple farming (DADO, 2012).

The general objective of the study was to know the present production situation, market and value chain of Jumla's apple and explore bottleneck areas in production and marketing of apple in Jumla through questionnaire based survey.

METHODOLOGY

Two basic approaches were adopted in conducting the study and to fulfill the objectives. First, the study had followed Systematic Secondary Information Collection and Analysis Approach (SSICA). For primary information field survey, personal interview, Participatory Rural Appraisal (PRA), Rapid Marketing Appraisal (RMA) & Focus Group Discussion (FGD) techniques were used for obtaining information on cost of cultivation and production and supply situation of organic apple of Jumla.

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Nepalgunj is the major outlet of organic apple of Jumla. So for market and value chain study wholesale market of Gurudwara and Nepalgunj retail markets were purposively selected. The population for this study was apple growers of each pocket area of Dillichour, Kartikswami, Talium and Mahatgaun where 10 respondents were randomly selected for production situation study. Similarly, five wholesalers, retailers and consumers were selected for market and value chain analysis. The obtained data were analyzed by using MS Excel program. Simple indexing technique was also used for analyzing different production and marketing related problems.

RESULT AND DISCUSSION

SOCIOECONOMIC CHARACTERS OF THE RESPONDENTS

The average age of the respondents was 46 years with family size of 6.5 persons (Table 1). The average annual income of respondents was NRs 84,500 while average landholding size was 10.3 *ropani*[1].

Table 1: Socioeconomic characters and annual income

S.N.	Age	Family size	Land holding (ropani)	Annual income (Rs.)
1	36	7	15	200000
2	34	3	20	115000
3	60	12	7	132000
4	59	7	7	90000
5	71	7	6	45000
6	48	7	5	52000
7	32	5	1	16000
8	20	7	14	50000
9	45	5	19	90000
10	55	5	9	55000
Average	**46**	**6.5**	**10.3**	**84500**

Source: Field Survey, 2014.

Different types of landholding patterns like *khet* land, *bari* land and other (rangeland) were identified during the survey and average landholding of different types is presented in Table 2. The average *bari* land distribution was highest (4.89 *ropani*) followed by others including rangeland (4 *ropani*) and khet land (3.89 *ropani*) and average total land distribution was 10.3 *ropani*.

Table 2: Landholding pattern

S.N.	landholding in *Ropani*			
	Khet land	*Bari* land	Others (rangeland)	Total
1	3	7	5	15
2	5	15		20

[1] It is Nepalese unit of land area and one ha is equal to 20 ropani.

3	7			7
4	2	3	2	7
5	3	1	2	6
6	3	2		5
7		1		1
8	4	3	7	14
9	5	8	6	19
10	3	4	2	9
	3.89	**4.89**	**4**	**10.3**

Source: Field Survey, 2014

Information related to duration of apple cultivation, average area, planting density, and average productivity per plant were collected from survey. Farmers were cultivating apple since 14.7 years back on an average in 5.4 ropani land with planting density of 24.45 plants per *ropani* (Table 3). Average productivity of apple was found 31.9 kg/plant during survey while it was 11.2 kg/plant in DADO report (2013). The density of plant was found higher than recommended density (15 plants per *ropani*).

Table 3: Distribution of area and production of apple in 2013

S.N.	Years of apple cultivation	Area in *Ropani*	Number of plants per *Ropani*	Average production (Kg/Plant)	Average production (kg per *Ropani*)
1	20	5	34	21	714
2	15	4	11.25	50	562.5
3	18	14	27.86	40	1114.4
4	15	3	26	20	520
5	20	6	27.83	20	556.6
6	10	5	25	23	575
7	11	1	34	40	1360
8	5	7	13.57	10	135.7
9	19	5	20	50	1000
10	14	4	25	45	1125
Average	**14.7**	**5.4**	**24.45**	**31.9**	**766.32**

Source: Field Survey, 2014

Apple is the perennial crop and production varies according to age and management practices, highly productive age is 10 years onwards but production starts from 3-4 years if planting is done through grafted plants. Thus, the apple plants were grouped into 6 categories for determining distribution of plants (Figure 1). Maximum number of plants of the surveyed areas were of 1 to 5 years age (458 no.) followed by 15 to 20 (353 no.), 5 to 10 (259 no.) and 10 to 15 (234 no.). It was found that the large number of plants were recently planted after implementation of Apple Self Sufficiency Program (ASSP) and that signifies the great potentiality of expanding area through the implementation ASSP and increasing production and productivity in future.

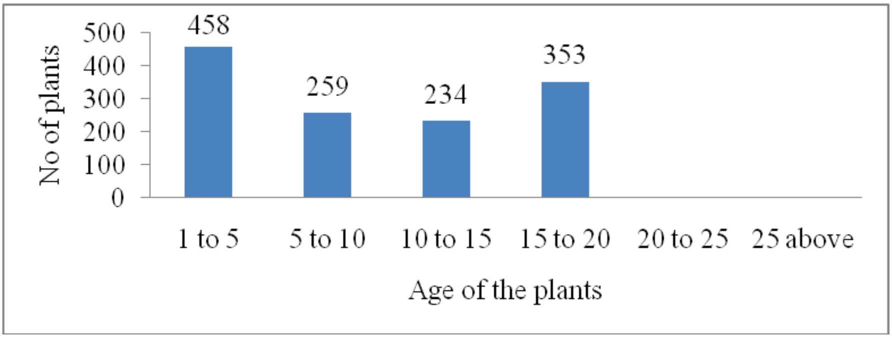


Figure 1: Age wise distribution of apple plants during 2014.

Production of apple depends on the type of sapling used (seedling origin or grafted). All the farmers were using apple saplings produced through grafting. Digging pit at least one month prior to planting and filling with compost are the most important operations. Almost all the farmers fill pit with compost and transplant saplings.

INSECT PEST AND DISEASES

The productivity of apple is dependent upon insect pest and disease situation. Apple is affected by several types of insect/pest during growth and production phase, the major ones are wooly aphid, scale, borer and caterpillar (DADO, 2013). Among the insects identified through survey, wooly aphid was the major followed by apple borer (Table 4). Similar to insect/pest disease is also major problem. Diseases such as apple scab, powdery mildew, twig blight, papery bark, and crown gall were identified in the district (DADO, 2013). Among the diseases, papery bark was the major problem followed by root rot in the respective study area (Table 5).

Table 4: Major insects/pests of study area

S.N.	Major Insects	Score			Total	Index value (Σfisi/N)	Priority ranking
		3	2	1			
1	Wooly aphid			9	9	1	I
2	Borer		8	1	17	1.88	II
3	Grub	3			9	2.25	III

Source: Field Survey, 2014.

Table 5: Major diseases of study area

S.N.	Major diseases	Score			Total	Index value (Σfisi/N)	Priority ranking
		3	2	1			
1	Papery bark			10	10	1	I
2	Root rot		5		10	2	II
3	Sooty mould	2	1		8	2.66	III

Source: Field Survey, 2014.

COST OF CULTIVATION

The production of apple depends on the levels of inputs used like labor, manure, pesticide, number of productive plants per unit area and training and pruning practices. In order to determine variable cost and items per year after the establishment of apple orchard, cost on fertilizer, insecticides, equipment, and labor cost obtained are tabulated in Table 6. As Jumla is declared as organic district, only organic fertilizers and disease and pest control practices were followed by the farmers. The average cost of cultivation per *ropani* was NRs. 10,718. Among the cost items, the highest cost incurred was in labor (NRs. 6,960). The per kg cost of production of apple was Rs 13.92 during survey year.

Table 6: Variable cost of cultivation of apple

S.N.	Cost of cultivation per *Ropani*				
	Organic fertilizer cost (Rs)	Organic insecticides/ fungicides (Rs)	Equipment cost(Rs)	Labor cost(Rs)	Total (Rs)
1	3400	2040	680	10000	16120
2	1012.5	787.5	225	5000	7025
3	2785.72	1671.6	612.92	8000	13070.23
4	1300	1300	572	9000	12172
5	1948.34	1669.8	556.6	7000	11174.73
6	1625	1250	500	7500	10875
7	2720	1360	748	5400	10228
8	950	678.5	298.54	5500	7427.04
9	1600	1100	460	6000	9160
10	1875	1250	600	6200	9925
	1921.65	**1310.74**	**525.31**	**6960.00**	**10717.70**

Source: Field Survey, 2014.

METHOD OF HARVESTING APPLE

The farmers did not followed scientific technology recommended for harvesting apple, as hand plucking is most common practice observed in the study area (Figure 2). Shaking apple plants and use of stick is another common mode followed by the farmers.

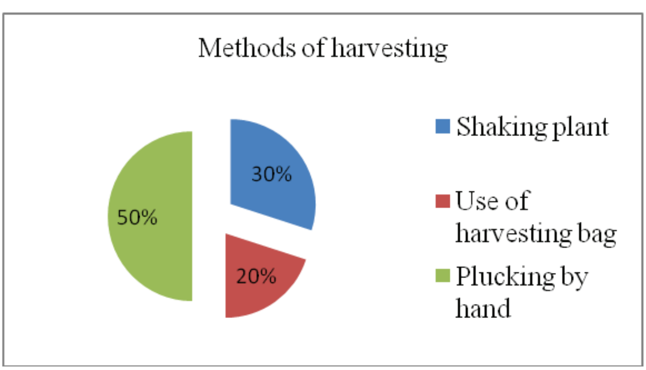


Figure2: Common methods of apple harvesting

HARVESTING AND SELLING BASIS OF APPLE

Postharvest life of apple is dependent on the stage of harvesting. Too ripe and too green apple is not suitable for marketing. Most of the farmers harvest apple when they are 75% ripe followed by harvesting at 50% ripe stage. Weighing was the most common practice for selling apples while counting is still praciced (Table 7). Grading is not common among the farmers. Grading is done by traders and middleman. Usually, they grade apple in three categories according to size i.e. large, medium and small.

Table 7: Basis of selling of apple fruits

S.N.	Basis of selling		
	Estimation	Counting	Weighing
1		1	
2	1		
3		1	
4			1
5			1
6			1
7			1
8			1
9			1
10			1
	1 (10)	2 (20)	7 (70)

Source: Field Survey, 2014

Figure in parenthesis indicates percentage

MODE OF SELLING

Apple in Jumla is sold in the market through different ways. Selling to the local traders is the most common mode of selling apples (Table 8). The local traders collect apples in major collection and market centers and supply them out of the district markets like Surkhet, Nepaljung and Kathmandu too. It was found that District Cooperative Federation collects organic apples at Jumla airport and sends to Kathmandu. Large apple producers bring their produce to Surkhet and Nepalgung themselves. Some of the farmers collect other farmer's apple from their field and brings to wholesale market of Nepaljung.

Table 8: Common selling practices of apple

S.N.	Place of selling			
	Local market	Local trader	Trader from Nepalgunj	Cooperative
1			1	
2		1		

3		1		
4				1
5				1
6		1		
7		1		
8		1		
9		1		
10		1		
		7(70)	1(10)	2(20)

Source: Field Survey, 2014.

INFORMATION ABOUT PRICE AND RETURN

Farm gate price

Minimum and average price of apple from August/September to December/January were analyzed. The average minimum price per kg was NRs. 20.0, maximum price NRs. 35 and average price was Rs 26.93 at farm gate level (Table 9).

Table 9: Average farm gate price of apple

S.N.	Farm gate price (NRs./kg)		
	Min.	Max.	Average
1	27.5	30	28.75
2	15	35	25
3	26	26	26
4	25	45	35
5	20	32	26
6	25	30	27.5
7	20	30	25
8	15	25	20
9	25	30	27.5
10	26	31	28.5
	22.45	31.4	26.93

Source: Field Survey, 2014.

CRITERIA FOR PRICE FIXATION

Different criteria for fixing price were asked to the farmers and scoring technique was used. For fixing price most of the farmers took reference of the last year's price and quality of apple produced at their farm (Table 10). The role of trader followed by group decision were the major influencing factors for price fixation.

Table 10: Criteria for fixing price of apple

S.N.	Criteria	Score				Total	Index value (Σfisi/N)	Priority ranking
		1	2	3	4			
1	Last year's price	10				10	1	I
2	Quality	4	6			16	1.6	II
3	Market demand		4	5	1	27	2.7	III
4	Number of fruits per plant			2	8	38	3.8	IV

Source: Field Survey, 2014

PROFIT ANALYSIS FROM APPLE AND OTHER AGRONOMICAL CROPS

The cost of cultivation, gross return, and profit/loss from the apple and other agronomical crops(rice and buckwheat) is presented in table 11. Cost of cultivation per ropani was lower in apple with higher return as well as profit in comparison to other possible agronomical crops in the surveyed area. The B/C ratio is also higher showing highest potentiality of apple as high value crop over other crops.

Table 11: Profit analysis of apple and other agronomical crops in study area

S.N.	Cost/*ropani*		Gross return/*ropani*		Net profit/ropani		B/C ratio	
	Apple	Other crops	Apple	Other crops	Apple	Other crops	Apple	Other crops
1	16120	6000	10000	6000	-6120	0	0.62	1
2	7025	10000	30000	20000	22975	10000	4.27	2
3	13070.23	8000	28000	12000	14929.77	4000	2.14	1.5
4	12172	15000	30000	15000	17828	0	2.46	1
5	11174.73	20000	55000	30000	43825.27	10000	4.92	1.5
6	10875	25000	30000	25000	19125	0	2.76	1
7	10228	6000	15000	3000	4772	-3000	1.47	0.5
8	7427.04	15000	35000	20000	27572.96	5000	4.71	1.33
9	9160	8000	20000	8000	10840	0	2.18	1
10	9925	7500	22000	8000	12075	500	2.22	1.07
	10717.7	12050	27500	14700	16782.3	2650	2.78	1.19

Source: Field Survey, 2014

This table shows that the cost of cultivation of apple per *ropani* is lower than other agronomical crops while return is higher with B/C ratio of 2.78.

PROBLEM ANALYSIS

Production problems

Apple production in Jumla is limited by several biotic and abiotic factors. Among abiotic factor of production, training followed by the inadequacy of subsidy on production inputs like saplings and training and pruning equipments were the major problems of apple production identified through survey (Table 12).

Table 12: Major Problems of apple production in Jumla district

S.N.	Major problems of apple production	Score					Total	Index value (Σfisi/N)	Priority ranking
		1	2	3	4	5			
1	Training	5	5				15	1.5	I
2	Subsidy	5	3	1		1	19	1.9	II
3	Storage	3	3	4			21	2.1	III
4	Grading/packaging		1	4	3	2	35	3.5	IV
5	Transportation			1	5	4	41	4.1	V

MARKETING PROBLEMS

Appearance related problems (sooty mold in fruits) as a major marketing problem as Jumla is declared as organic district followed by lack of proper grading.

Table 13: Major marketing problems of apple

S.N.	Marketing problems	Score					Total	Index value (Σfisi/N)	Priority ranking
		1	2	3	4	5			
1	Appearance	4	1				6	1.2	I
2	Lack of grading	1	2	2			11	2.2	II
3	Poor packaging		2	2	1		14	2.8	III
4	Poor keeping quality			1	4		17	3.8	IV
5	Poor taste					5	25	5	V

Source: Field Survey, 2014

INFORMATION ON PRICE

Price analysis was done based on the information obtained from the wholesalers and retailers of Jumla and Nepalgunj. The traders of Nepalgunj sell apple produced in Jumla from August/September to December/January, in other time they sell apple imported from China and India. The major hike in price was observed from February/March to July/August).

WHOLESALE PRICE

The wholesale price analysis was done based on the information obtained from the wholesalers of Nepalgunj and Jumla. The average wholesale price per kg was NRs. 117.8 (Table 14). Highest wholesale price was observed in May to June/July (NRs. 145/kg) while lowest was in September to November (NRs. 83/kg).

Table 14: Analysis of wholesale price of apple

S.N.	Wholesale price (Rs/Kg)												Average
	Sept/Oct	Oct/Nov	Nov/Dec	Dec/Jan	Jan/Feb	Feb/Mar	Mar/Apr	Apr/May	May/June	June/July	July/Augu	Augu/Sept	
1	140	140	140	150	150	160	170	180	180	180	180	170	161.6
2	70	70	150	150	120	130	130	130	130	140	130	90	120
3	100	100	100	100	100	110	110	120	120	110	70	70	100.8
4	55	55	100	100	100	150	150	150	150	150	55	55	105.8
5	50	50	75	110	110	135	140	140	145	145	54	54	100.6
	83	83	113	122	116	137	140	144	145	145	97.8	87.8	117.8

Source: Field Survey, 2014

RETAIL PRICE

For analyzing retail price, interview with retailers of Jumla and Nepalgunj was carried out. The average retail price per kg was NRs. 153.5 (Table 15). Highest retail price was in the month of June/July (NRs. 185/kg) while lowest was in September to November (NRs. 115/kg).

Table 15: Analysis of retail price of apple

S.N.	Retail price (Rs/kg)												
	Sept/Oct	Oct/Nov	Nov/Dec	Dec/Jan	Jan/Feb	Feb/Mar	Mar/Apr	Apr/May	May/June	June/July	July/Augu	Augu/Sept	Average
1	170	170	170	185	185	185	240	240	240	240	240	200	205.42
2	90	90	180	180	180	160	175	160	175	180	160	100	152.5
3	120	120	120	130	130	130	140	140	140	140	100	100	125.83
4	80	80	120	120	120	180	180	180	180	180	75	75	130.83
	115	115	147.5	153.7	153.7	163.7	183.7	180	183.7	185	143.75	118.7	153.6

Source: Field Survey, 2014

CONSUMERS' PRICE

Direct interview with consumers of Jumla and Nepalgunj was carried out to analyze consumer price. Semi structured questionnaire was administered and information were obtained through recall basis for getting yearly price information. The average consumers price per kg was NRs. 160.50 (Table 16). Highest consumers price was in the month of June/July (NRs. 193/kg) while lowest was in September to November (NRs. 118.75/kg).

Table 16: Analysis of retail price of apple

S.N.	consumer's price (Rs/kg)												
	Sept/Oct	Oct/No v	Nov/Dec	Dec/Jan	Jan/Feb	Feb/Mar	Mar/Apr	Apr/May	May/June	June/July	July/Augu	Augu/Sept	Average
1	170	175	175	190	190	190	242	250	244	245	250	210	210.92
2	95	96	188	185	185	170	180	165	180	185	165	110	158.67
3	125	127	128	135	135	140	145	145	145	150	110	110	132.92
4	85	90	125	130	128	185	187	187	195	192	84	86	139.50
	118.75	122	154	160	159.5	171.25	188.5	186.75	191	193	152.25	129	160.50

Source: Field Survey, 2014

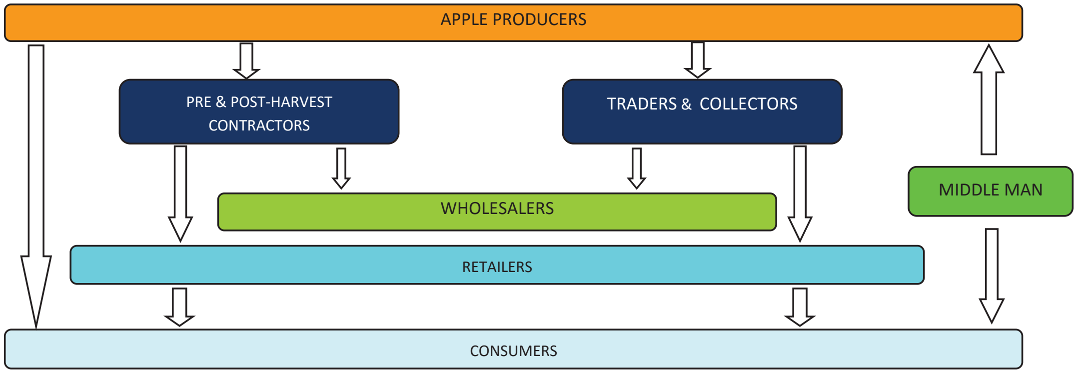
MARKETING CHANNEL OF APPLE PRODUCED IN JUMLA

The farm product which reaches to the ultimate consumers through the hands of various marketing agents is called the marketing channels. Marketing channel helps to determine price. Higher the numbers of marketing players, higher will be the price and vice versa. Market itself organized the intermediaries so that market functions well.

The invisible roles of the intermediaries are organized by market. The farm products of districts are brought to collection center through marketing agents or farmers themselves or group of farmers or cooperatives. From pocket areas through the road heads and hubs it is brought to Jumla, Surkhet, Banke and Bardiya and other market centers for sale.

Then from district centered market these fruit are sold to retailer, bicycle vendor, brokers, schools, hotels/restaurants, and distant wholesaler and also to exporters. In these case also various marketing agencies or middlemen are involved. The retailer to consumers and sometimes directly from wholesale markets the fruit gets into the hand of consumers but most of the time small vendors and bicycle vendors walk to door to door to sale these apple and ultimately reaches in the hand of

consumers. Figure 3: Marketing channel of organic apple of Jumla



Source: Field Survey, 2014

Marketing of apple encompasses all the activities being performed in moving apple from producers to the hands of ultimate consumers. Marketing system creates time, space and form utilities of the farm produce for the consumers. The producers, traders, transporters, wholesalers and retailers were the main marketing actors of apple (Adhikari, 2011).

VALUE CHAIN STUDY OF APPLE PRODUCED IN JUMLA

Jumla is the leading district of Karnali zone for producing apples. Annually more than 12,00,000 grafted saplings of apples are produced from 103 nurseries. Agro-vets and private nursery as well as Rajikot Farm in Jumla are the major actors of sapling supply in the district. Farmers group, cooperatives and individual farmers are involved in production. The entire value chain of apple including functions, primary actors and support organization is enlisted in figure 4.

VARIETIES

There were about 10 varieties of apples being cultivated in Jumla-mostly the delicious varieties: Red, Royal and Golden Delicious. This constituted approximately 80% of the total production. The rest included Jonathan, Chocolate and Macintosh varieties.

TRADE AND MARKETING OF JUMLA APPLE

Producers directly sell apple to consumers in Jumla headquarter but large apple producers bring their produce to Surkhet and Nepalgunj themselves. Growers, especially in Talium belt-who collect from other farmers as well and send the produce to the Nepaljung's wholesalers as well as retailers.

APPLE PROCESSING

Several enterprises - including the largest called RN Organic-have started production of dried apple slice on a commercial scale, both for local consumption and export out of the district to major markets in Nepal. Similarly, RK Distillery in Jumla has started producing apple brandy. The general opinion is that dried apple has the most potential (lightweight) but they have to compete with the good quality apples coming from Mustang.

PRICE SPREAD OF JUMLA APPLE ALONG THE VALUE CHAIN (2014)

Price spread of Jumla apple was assessed with different actors in value chain. Farmers were getting very low price of NRs. 26.93 per kg of their apple while the consumer's price was NRs. 160.5 per kg.

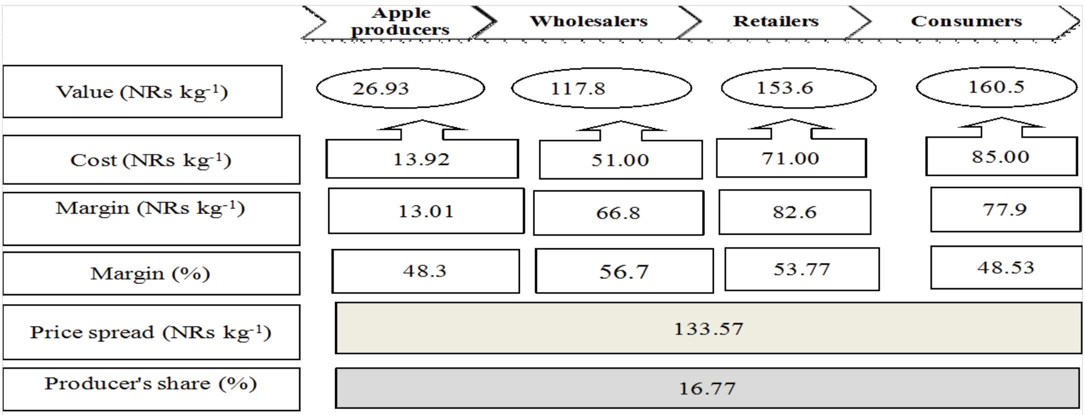


Figure 4: Price spread of Jumla apple along the value chain

There is a wide gap between farm gate price and consumer's price. Both cost involved in post harvest handling and margin of different actors was high. Producers share in consumer's price was only 16.77 percent.

SUMMARY, CONCLUSION AND RECOMMENDATION

SUMMARY

Apple is the important commodity for food security through income generation in Jumla district. Apple is grown in all 30 VDCs of Jumla district and is the major high value commodity. Most of the farmers residing in the districts are engaged in apple cultivation. Apple is the major source of income generation as most of the farmers are actively engaged in apple production. The return of apple is higher than other commodities cultivated in the district. Insect and pest especially the wooly aphid, and borer and papery bark were the major problems for the production whereas The price fixation was major marketing problems of the farmers. The major marketing problem was poor appearance of apple in the market followed by lack of grading. The average farm gate, wholesale and retail price of apple in Jumla were found NRs. 26.93, NRs. 117.8, and NRs. 153.6 respectively. Apple produced in Jumla is supplied to the Nepalgunj only from August to November , in other season demand of apple is fulfilled by the supply from China and India.

CONCLUSION

Apple is the important source of income generation for the farmers. Most of the farmers are engaged in its cultivation due to its uniqueness, price and taste. Apple produced in Jumla is organic in nature and the demand is high in Nepalgunj but due to the lack of proper storage, market demand is not fulfilled by the apple from Jumla. There is the huge potentiality for organic apple production in Jumla through coordinated approaches from different stakeholders and agencies.

RECOMMENDATIONS

- Training for appropriate production packages and post harvest handling of apple should be done in a coordinated way through stakeholders like DADO, NGO's and INGO's mobilizing the groups and cooperatives.
- Quality improvement is necessary for better price. Thus proper harvesting techniques, picking up the produce in right time without affecting the productivity in the next year is prominent and the action plans from the extension agencies are to be prepared and implemented.
- Horizontal and vertical linkages between and amongst the production, marketing and processing industries and integration among them are needed to enhance the value chain linkages so as to fetch higher return.

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FORAGE MISSION FOR ALLEVIATING FEED DEFICIT SITUATION OF LIVESTOCK IN NEPAL

Dr. Banshi Sharma[1]

ABSTRACT:

Nepal is divided in five agro-ecological zones. There is feed deficit in every zones except in high mountain regions. There is 34% deficit in animal feed (Singh, 2002). The forage mission is carried out in 49 districts of the country with the aim of providing sufficient green and dry matter to improved livestock of the country to yield more milk from cattle and buffalo. Similarly more meat from buffaloes, sheep and goats has been obtained. Pasture land improvement is in high mountain areas. In mid hills, cultivation of forages such as stylo, molasses, mulato, setaria, joint vetch, leucaena, napier , forage peanut, desmodium and climbing legumes such as fodder peas have been promoted. In Terai, intensive cultivation of fodder crops: basically winter forages- oat, berseem and vetch is going to be popular. Feeding the legumes and non-legumes forage plant in suitable ratio helps a great extend in livestock production.*

Key words: *Egg,forage, feed deficit, livestock,legume and non-legume,meat, milk*

INTRODUCTION

Nepal is an agricultural country with focus on large number of livestock farmers in rural areas. Agriculture contributes 36% on national GDP. Livestock subsector contributes 26.8% of agricultural GDP; which is nearly 11% of national GDP (MOLD, 2016). Nepalese livestock are underfed and milk and meat production does not meet the requirement amount. The per capita consumption of milk, meat and eggs is 62 kg, 11 kg and 32 eggs per year (MOLD, 2016). Therefore, huge sum of hard earned foreign currencies was used to import meat, milk and eggs to cope with growing needs. The per capita consumption of milk, meat and eggs requirement is 91 kg, 14 kg and 48 eggs per year (MOLD, 2016). Therefore, government of Nepal has committed to fulfil the requirement of eggs, meat and milk by one, two or three years period.

The forage cultivation is focus on improved cattle and buffalo. There has been National Artificial Insemination programme which gives nearly 200,000 calves of cow and buffaloes. They need pasture and forage for their nutrition requirement. Therefore, the government of Nepal has decided to have forage mission in commercial dairy pocket areas.

The forage cultivation may be of winter, summer and perennial types. Winter forage shortage can be fulfilled by winter forage such as oat, vetch, berseem and fodder pea. The oat cultivation may have coverage of 12,000 ha areas currently (NPAFC, 2015).

Teosinte, bajra, sudan and sorghum are major summer forage crops in Nepal. Perennial forage crops may be of stylo, desmodium, napier, para grass, ipil ipil, sumba setaria,atro paspalam , white clover, Rye grass etc.Nepal is the small and landlocked country which extends from the highest peak in the world to the plains of the Terai. The forage mission is focus on Terai region with livestock potential areas of hills and mid hills area.

FORAGE MISSION PROGRAMME

First phase:

Eastern region: Ilam, Jhapa, Morang, Sunsari ,siraha and Saptari
Central region: Kathmandu, Lalitpur, Kavrepalanchowk, Chitawan, Makawanpur, Dhanusa, Mahottari
Western region: Kaski, Palpa, Tanahu, Nawalparasi, Kapilvastu, Rupandehi

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Mid western: Dang, Banke and Surkhet
Far western region: Kailali, Kanchanpur

Second phase:

Eastern region: Panchthar, Dhankuta, Udayapur

Central region: Dhading, Nuwakot, Bhaktapur, Ramecchap, Parsa, Bara and Rautahat

Western region: Baglung, Gorkha, Aarghakhanchi, Gulmi

Mid western:

Far western region: Doti, Dadeldhura

Third phase:

Eastern region: Sankhuwasabha, Okhaldunga, Khotang

Central region: Sindhupalchow, Rashuwa, Dolakha

Western region: Lamjung, Gulmi, Parbat

LAND USE

Nepal has distinct land use patterns as it is influenced by climatic variation, altitude and micro environment. Land use in the hills differs from that of the plains. After the eradication of malaria in 1958 there has been a massive migration of people from the hills and mountains to the Terai. Since then, the area under forest decreases every year and land under crops was increasing until recently when the government started a massive campaign against deforestation to check falling soil fertility caused by soil erosion and landslides. The Chure region is very much vulnerable to soil erosion, therefore fodder tree plantation has been practiced massively.

AGRO-ECOLOGICAL ZONES

Nepal is divided into five agro-ecological zones: Mountain, High hill, Mid hill, Shivalik and Terai. This broad division is based on the altitude, crop and livestock production systems.

LIVESTOCK

Livestock production is an important agricultural sub-sector in Nepal. Livestock ensures sustainability of the hill agriculture by contributing to soil fertility maintenance and agricultural draft power. Livestock is equally valued for family nutrition and social prestige. Livestock provides about 20 percent of the total house hold income in the hills from sale of its products such as milk and meat (TLDP, 2002). However, there is an enormous ruminant livestock population, which puts considerable pressure on land resources. The ruminant population is greatest in the Hills, followed by the Terai and is least in the Mountains

FEED SOURCES

Fodder is collected from all land use systems and the major sources are: cropland, forest, grassland, shrubland and non-cultivated inclusions. Forests are lands with tree crown cover above 20 %; shrub lands are degraded forests where there are trees with less than 20 % crown cover; lands without trees or with only a few scattered trees with grass cover are described as grasslands (GON, 2002). Forest, shrub and grasslands are generally owned by the government and are under the control of the Ministry of Forests and Soil Conservation. Non-Cultivated Inclusions (NCI) are government or privately owned lands consisting of degraded forests, permanent fallow, abandoned terraces and homesteads.

(i) Cropland. The majority of cropland is in the Terai (52%) and in the Middle hills (40%). Crop by-products and crop residues commonly used for livestock feed are straws, stovers, pulse residues, oil crop residues, maize cobs, sugarcane tops, rice bran, wheat bran, barley bran, mustard cake and molasses. In the country as a whole, crop by-products and residues contribute about 42 % of the total available TDN (Singh, 2002). Agricultural land contributes substantial fodder in the Middle-hills and Terai, where there are large livestock populations but little grassland. In crop growing areas, rice straw, wheat straw and maize stovers are widely fed, sometimes with cereal bran and oil seed cakes, along with a little grain.

(ii) Forest. The area of forest is 5.96 million hectares or 40.36 % of the total land (DFRS, 1996). ADS has suggested of forest areas of 39%. Forest land is almost evenly distributed between the High hills (34%), Middle hills (33%) and the Terai (34%). Fodder is collected from the forest for feed and bedding which is subsequently used as manure. Uneaten branches and twigs are used as fuel. Forest contributes 21 % of the total available TDN.

(iii) Shrubland. The area of shrubland is 0.7 million hectares or 4.8 % of the total. There is little shrubland in Terai, (9%); most is in the Middle hills (57%) and the High hills (34%) (FAO, 2008). Fodder from shrubland is used to feed the animals and for bedding. In the country as a whole, shrubland contributes 6.5 % of the total available TDN.

(iv) Non -Cultivated Inclusions (NCI). The area of non-cultivated inclusions is 0.99 million hectares or 6.8 % of all land. There are few non-cultivated inclusions in the High hills (15 %) and the Terai (18 %); most is in the Middle hills (67 %). NCI lie fallow throughout the year and fodder is collected either by cut-and-carry or grazed by animals of nearby households. Fodder from non-cultivated inclusions contributes 17.6 % of the total available nutrients (Singh, 2002).

(v) Grassland. The area of grassland is 1.7 million hectares or 11.8 % of the land area. In the High hills grassland is the most important fodder source. Most of the grassland is in the High hills (79.3%) and the Middle hills (16.7%). More than half of the grassland is in the high mountains. The Terai and Siwaliks together have (4%). Grassland contributes 12.6 % of available TDN (Singh, 2002).

MAJOR PROBLEMS ASSOCIATED WITH FEEDS AND FEEDING

Major problems associated with feeds and feeding, include both their quality and quantity during winter and summer, be it in migratory, sedentary or stall fed systems. Shrinkage of pasture and community (public) grazing land, decreasing feed resources, unavailability of cereal and legume by-products for feeding animals etc. have led to the quantity related problems. The available feeds and forages are mostly poor in nutritive value. Grazing in the forest area has been prohibited to a great extent causing some problems in the availability of feeds and fodders. Heavy dependence on poor quality roughages and degraded pasture and grazing lands has reduced the availability of forages and hence production and productivity of the livestock does not meet the required expectation of farmers.

FEED BALANCE

The feed deficit is severe in the hills region (-56%) followed by the Terai (-42%). The Mountain region is at surplus (26%) (DLS, 2002). This clearly indicates that feed, particularly in the form of green fodder is the major factor limiting livestock production. Because, when animals are underfed, they would unquestionably get more susceptible to diseases and parasites. In the shortage of fodder, farmers try to compensate the nutrients deficit by supplementing the diet with expensive concentrate feed. The increasing cost of treatment against various diseases and nutritional disorder and concentrate feeds has led to higher cost of animal production in Nepal. This would have a serious implication on the competitiveness of domestic products with imported products and the sustainability of the agriculture system in the long run.

Table-1: Livestock Feed Balance

Sources	Area ('000 ha)	Bari Risers/ Bunds	Khet Risers/ Bunds	Fallow	Tree Fodder	Kitchen Residue	Total TDN ('000 MT)	Per cent Supply
Agricultural land - Pakho - Khet	 819 1551	353.8	223.3	79.2	179.8	209.7	1067	17.6
Forestland - Coniferous - Hardwood -Mixed wood - Shrubs	 2247 1332 1932 1283						1672 112 227 186 1146	27.5
Grazing lands	1757						764	12.6
Crop residues							2569	42.3
Total							6072	100
Requirement							9300	
Deficit							3228	34.7

Based on Land Resource Mapping Project (1988) and MOAC (1999/2000), and (Singh, 2002)

The data on the above table clearly indicated that the overall annual feed deficit in the country is estimated at 34.7per cent on TDN basis.

FEED UTILIZATION

Most farmers do not know about the quality of improved fodder, they harvest the crops when they are over-mature and fibrous but the dry matter yield is at its maximum. Farmers store heaps of maize stalks, wheat straw, millet straw and rice straw under the sky so the quality of these residues is already poor under traditional storage practices. The proper conservation and utilization techniques of these feeds should be demonstrated further.

i. Fodder Conservation. Both fodder conservation as hay and silage are encouraged. Farmers are provided with technical and financial assistance for implementing these activities. Farmers of high altitude and far-western mid-hills regions have adopted hay making to some extent whereas both methods of conservation of fodder need to further be demonstrated for the other regions. Silage making is not yet in practice in farmer's level. Silage making in plastic bag is being piloted in few dairy pockets. Silage production is given due importance by forage mission programme.

ii. Fodder enrichment. In order to improve the utilization of crop residues, efforts have made to enhance their preservation and quality. Paddy straw, very common roughage in the Terai is improved by urea treatment of 1 to 2%. Urea mineral molasses block (UMMB) preparation training has been given in forage mission districts to support animal nutrition in winter season.

STRATEGIES FOR FODDER PRODUCTION

Despite a high average population per household, insufficient animal products are produced to meet the growing demand. The livestock consume nutrients below their maintenance requirement, which is the major reason for low livestock productivity. Different approaches have been adopted by Government organizations for fodder production in different zones:

High hill

Grazing land improvement: species introduced- Clover, Rye grass, Tall fescue and cocks foot. The introduction of small trails to virgin pastureland has been done. Rotational grazing has been done. In some areas, ponds for drinking water have been established for migratory herds.

Mid hill

Cultivation of forages: species introduced- stylo (Stylosanthes (guianensis and hamata), molasses (Melinisminutiflora), mulato (Hybrid brachiaria), setaria, joint vetch (Aeschynomene falcate), leucaena (Leucaenaspp), napier (Pennisetumpurpureum cv Mott), forage peanut (Arachispintoi), desmodium, climbing legumes such as fodder peas etc.

Terrace land utilization with forage species: stylo, molasses, aztec, broom grass etc.

Fodder establishment on bund & terrace risers: napier, leucaena, mulato, setaria, forage peanut, mulbery etc.

Community grazing land improvement: Community forest and Leasehold forest– stylo, mulato, joint vetch, Amriso (Thysanolaena maxima), molasses etc.

Establishment of fodder garden in each and every household has been emphasized in forage mission programme. But success rate varies depending upon districts.

Terai

Intensive cultivation of fodder crops: basically winter forages- oat, berseem, vetch. Berseem is very popular in Banke, Bardiya, Kailali and Kanchanpur districts.

CONCLUSIONS

Forage conservation is important in rural livestock farming. There are sufficient forages and grasses in monsoon period. The farmers can store grass in the form of silage and hay. There are good chances of cultivation of winter forages such as oat and vetch in mid hills and Terai region of the Nepal. In the Terai there is good scope of berseem. The balance of legumes and non legumes is very important for productive livestock farming. There is maximum utilization of back yard farm land for forage and one can use terraces raisers. Hedgerows of ipil ipil are doing well in mid hills of Nepal. Though cut and carry system is popular in hills and Terai of Nepal; due to lack of manpower automation of forage cultivation and harvesting is in increment. Rotational grazing is done in high mountains area. Hydroponics is the system in which plants can be grown in water without applying any fertilizers in the machine for 7 to 10 days. The grass along with roots can serve as fodder for livestock in urban and periurban areas of Nepal, where land is scare. Hydroponics may be beneficial for getting balanced feed and green matter to improved livestock. Forage resource centre has been established in different district which will provide seed materials to needy farmers. Vegetative propagation of seed materials shall be done in each and every district to cover the barren land and it may be helpful for controlling soil erosion and supplement dry matter need of the farms. Nepal has 34.7% deficit of TDN basis (Singh,2002) and forage mission is alleviating such condition in commercial farms with support for cultivation of winter, summer and perennial grasses. The commercial farms are now sustainable livestock keeping with forage based system of feeding.

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DIRECT SEEDED RICE CULTIVATION METHOD: A NEW TECHNOLOGY FOR CLIMATE CHANGE AND FOOD SECURITY

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ABSTRACT

Rice (Oryza sativa) is the major food crop in terms of production and economy and grown in all ecological regions of Nepal. Rice is cultivated traditionally through transplanting of 20-25 days old seedling in the country. Due to unavailability of suitable technology for rice cultivation, there is a huge yield gap in rice production of Nepal. Country has made target of self-sufficiency in rice production by 2020 AD. This target can be achieved through adoption of Direct seeded rice cultivation technology of rice cultivation which also helps to adapt in the climate change scenario of Nepal. Due to issues of water scarcity and expensive labour, direct seeded rice cultivation technology is adopting worldwide. Direct seeded rice is a resource conservation technology and reduces water and labor use by 50%. Productivity of DSR is 5-10% more than the yield of transplanted rice. It offers a very exhilarating opportunity to improve water and environmental sustainability. Methane gas emissions is lower in DSR than with conventionally tilled transplanted puddle rice. It involves sowing pre-germinated seeds into a puddled soil surface (wet seeding), standing water (water seeding) or dry seeding into a prepared seedbed (dry seeding). Precise water management, particularly during crop emergence phase (first 7-15 days after sowing), is crucial in direct seeded rice. Furthermore, weed infestation is the major problem, which can cause large yield losses in direct seeded rice. Weed management in DSR can be done through chemical, hand weeding or stale seed bed method.

Key words: Direct seeded rice, Green house gases, resource conservation, seed priming,weeds management

INTRODUCTION

Rice stands as the first crop in the Nepalese agriculture and its economy as it is grown in about 1.48 million ha producing 5.47 million tons of rough rice with an average productivity of 3.39 ton/ha (MOAD, 2015). Rice contributes 21% to the agriculture gross domestic product (GDP) and fulfills 50% of the calorie requirement of Nepalese people (MOAD, 2015). It is grown in all ecological regions and occupies 71% area in Terai where as hills and mountain occupies only about 25 and 4%, respectively (NARC, 2012). Of this about 7% is under double rice crop and 9% grown as broadcast sown rice (MOAC, 2003).

Productivity of rice is found highest in Egypt (8.56 t/ha) followed by Australia (8.2 t/ha) and South Korea (6.76 t/ha) which is almost three times greater than that of Nepal (FAO, 1997). The reasons for lower productivity of rice in Nepal may be due to unavailability of quality seed, inadequate weed management practices, little use of improved cultivation practices, lack of fertilizers, lack of irrigation facility, inappropriate government policy etc. There is a potentiality of getting higher productivity of rice in country through generating improved technology. This is essential because the country's target is to achieve over 5 million tones by the year 2020 to be self-sufficient in rice production (Joshi, 1997).

In Nepal, rice is cultivated in traditional way where 20-25 days old seedlings are transplanted in main field. This method of rice cultivation has deleterious effects on the soil environment and for the succeeding wheat and other upland crops and atmospheric environment through emission of

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methane gas (Dhakal *et al*., 2012). Therefore, it is suggested that alternate method of planting such as Direct-seeding should be adopted instead of the conventional transplanting to reduce the water and labor demand, which would ultimately decrease the cost of production (Mann *et al*., 2007). Based on the existing evidence, the present paper reviews the integrated package of technologies for DSR, potential advantages and problems associated with Direct Seeded Rice (DSR), and suggest likely future patterns of changes in rice cultivation.

METHODOLOGY

Systematic reviews of different published and unpublished papers, journal and books were done and their conclusions were drawn and summarized the evidence by use of explicit methodology. The results of the different articles were summarized in this manuscript.

RESULTS AND DISCUSSION

DIRECT SEEDED RICE (DSR)

Direct seeding refers to either wet or dry methods, depending on the manner of crop establishment. Wet-seeding involves sowing pre-germinated seed, either broadcast or drilled, on to puddled wet soil, and then gradually flooding the land. In dry-seeding, rice is broadcast or drilled into dry soil and the seed is then covered. There is also less land preparation. But, good weed control is essential (Suwankadniyom, 2004). In order to save water and labor and promote conservation agriculture (CA), with no/reduced tillage, it is absolutely essential to replace puddle transplanting with direct seeding. In South Asia, DSR is being practiced on terraced and sloppy lands of Bangladesh, along the coast and Western Himalayan region of India (Gupta *et al*., 2007). It is reported that productivity of DSR is 5-10% more than the yield of transplanted rice (Sun, 1990).

Table 1. Classification of direct-seeded rice (DSR) system

System of direct seeding	Seed bed condition and environment	Sowing method practiced	Suitable ecology/environment
Direct seeding in dry bed	Dry seeds are sown in dry and mostly aerobic soil	Broadcasting, Drilling or sowing in rows at depth of 2-3 cm	Mainly in rain fed area, some in irrigated areas with precise water control
Direct seeding in wet bed	Pre germinated seeds sown in puddled soil, may be aerobic or anaerobic	Various	Mostly in favorable rainfed lowlands and irrigated areas with good drainage facility
Direct seeding in Standing Water	Dry or Pre germinated seeds sown mostly in anaerobic condition in standing water	Broadcasting on standing water of 5-10 cm	In areas with red rice or weedy rice problem and in irrigated lowland areas with good land leveling

Source : (Joshi *et al*., 2013)

Table 2. Comparison of grain yield (t ha^{-1}) in direct seeded and transplanted rice under different ecosystems

Direct seeded rice	Transplanted rice	Rice ecology	Country	Reference
5.50	5.40	Shallow wetland-irrigated	Japan	(Harada *et al.*, 2007)
3.83	3.63	Rainfed lowlands	Thailand and Combodia	(Mitchell *et al.*, 2004)
2.93	3.95	Irrigated	Pakistan	(Farooq *et al.*, 2006a; Farooq *et al.*, 2009c)
5.40	5.30	Favourable irrigated	India and Nepal	(Hobbs *et al.*, 2002)
5.59	5.22	Favourable irrigated	India	(Sharma *et al.*, 2004)
5.38	5.32	Irrigated	South Korea	(Ko and Kang 2000)
3.15	2.99	Unfavourable rainfed lowland	India	(Sarkar *et al.*, 2003)
4.64	4.17	Rainfall lowland-hill	India	(Rath *et al.*, 2000)
6.09	6.35	Rainfall lowland-hill	India	(Tripathi *et al.*, 2005a)
2.56	3.34	Irrigated	Pakistan	(Farooq *et al.*, 2006b; Farooq *et al.*, 2007)
6.6	6.8	Rainfall lowland-hill	India	(Singh *et al.*, 2009a)

DIRECT SEEDING: PRESENT STATUS

In recent years, several countries of Southeast countries of Asia have been shifted from Transplanted Puddled Rice (TPR) to Direct Seeded Rice (DSR) cultivation (Pandey and Velasco, 2002). The shift in TPR to DSR is due to issues of water scarcity and expensive labour (Chan and Nor, 1993). DSR has several benefits to farmers and the environment over conventional practices of puddling and transplanting. Direct seeding helps reduce water consumption by about 30% (0.9 million liters acre-1) as it eliminates raising of seedlings in a nursery, puddling, transplanting under puddled soil and maintaining 4-5 inches of water at the base of the transplanted seedlings. Direct seeding (both wet and dry), on the other hand, avoids nursery raising, seedling uprooting, puddling and transplanting, and thus reduces the labor requirement (Pepsico International, 2011). Due to avoidance of transplant injury, DSR is established earlier than TPR without growth delays and hastens physiological maturity and reduces vulnerability to late-season drought (Tuong, 2008). The yield levels of DSR are comparable to the Conservation Tillage-TPR in many studies. Some reports claim similar or even higher yields of DSR with good management practices (Table 2). For instance, substantially higher grain yield was recorded in DSR (3.15 t ha-1) than TPR (2.99 t ha-1), which was attributed to the increased panicle number, higher 1000 kernel weight and lower sterility percentage (Sarkar *et al.*, 2003). In addition to higher economic returns, DSR crops are faster and easier to plant, having shorter duration, less labor intensive, consume less water (Bhushan et al., 2007), conducive to mechanization (Khade *et al.*, 1993), have less methane emissions (Wassmann *et al.*, 2004) and hence offer an opportunity for farmers to earn from carbon credits than TPR system (Balasubramanian and Hill, 2002; Pandey and Velasco, 1999).

EMISSION OF GREENHOUSE GASES (GHGS) UNDER DIFFERENT CROP ESTABLISHMENT PRACTICES

Flooded rice culture with puddling and transplanting is considered one of the major sources of methane (CH_4) emissions and accounts for 10-20% (50-100 Tg year-1) of total global annual CH4 emissions (Reiner and Aulakh, 2000). Amount of CH4 emission varies between different crop establishment techniques (Aulakh *et al.*, 2001). Most reports claim lower emission of methane gas under DSR compared to other traditional practices (Table 3). Studies comparing CH4 emissions from different tillage and crop establishment methods (CEM) under similar water management (continuous flooding/mid-season drainage/intermittent irrigation) in rice revealed that CH4 emissions were lower in DSR than with CT-TPR (Gupta *et al.*, 2002). Methane gas emission and global warming potential was maximum under conventional-TPR and emission of N_2O was maximum under DSR crop with conservation practice of brown manuring as the addition of organic matter to soil increased the decomposition rate, which resulted in higher emission of GHGs (Bhatia *et al.*, 2011).

Table 3. Comparison of Methane gas emission (kg methane ha-1) under direct-seeded and transplanted rice

SN	Location/Country	Year/Season	Tillage and crop establishment method	Water management	Seasonal total emission (kg CH_4/ha	% change from TPR or puddling	Yield (t/ha)	References
1	Pantanagar, India	2004	CT-TPR	-	315	0	6.8	(Singh *et al.*, 2009a)
			CT-dry DSR	-	220	-30	6.6	
2	Modipuram, India	2000-2005	CT-dry DSR	-	60	0	-	(Pathak *et al.*, 2009)
			CT-dry DSR	-	25	-58	-	
3	Beijing, China	1991	CT-TPR	Intermittent irrigation	299	0	4.5	(Wang *et al.*, 1999)
			CT-dry DSR	Intermittent irrigation	74	-75	3.6	
4	South Korea	1998-2000	CT-TPR (30 days old seedling)	Continuous flooding	403	0	5.4	(Ko and Kang, 2000)
			CT-dry DSR	Continuous flooding	424	5	5.4	
5	Jakenan, Indonesia	1993	CT-TPR	Continuous flooding	371	-8	5.3	(Setyanto *et al.*, 2000)
			CT-wet seeding	Continuous flooding	269	-33	-	
			CT-TPR	Continuous flooding	229	0	4.7	
			CT-dry seeding	Continuous flooding	256	12	7.1	
6	Suimon, Japan	1994-1997	CT-TPR	Continuous flooding	271	0	-	(Ishibashi *et al.*, 2007)
			ZT-dry seeding	Continuous flooding	129	-52	-	
7	Maligaya, Phillipines	1997	CT-TPR	Continuous flooding	89	0	7.9	(Corton *et al.*, 2000)
			CT-wet DSR	Continuous flooding	75	-16	6.7	
			CT-TPR	Continuous flooding	51	0	7.7	
			CT-wet-DSR	Continuous flooding	48	-6	6.4	

Source : (Joshi *et al.*, 2013)

CULTIVAR SELECTION

Direct dry seeded rice requires specially bred cultivars having good mechanical strength in the coleoptiles to facilitate early emergence of the seedlings under crust conditions (generally formed after light rains), early seedling vigor for weed competitiveness (Zhao *et al.*, 2006), efficient root system for anchorage and to tap soil moisture from lower layers in peak evaporative demands (Pantuwan *et al.*, 2002) and yield stability over planting times are desirable traits for DSR. Varieties suitable for DSR under Neplease context are;

SN	Geographical Region	Suitable varieties
1	Terai	Chaite-2, Ghaiya-2, Radha-4, Bindeshwori, Sukha Dhan-1, Sukha-2 and Sukha-3, Tarahara-1, Hardinath-2, Sona Masuli
2	Hill	Khumal-4, Khumal-8 and Khumal-10
3	High Hill	Chhomrong

Source : (Shah and Bhurer, 2005)

SEED PRIMING

One of the short term and the most pragmatic approaches to overcome the drought stress effects is seed priming (Farooq *et al.*, 2006). Seed priming tools have the potential to improve emergence and stand establishment under a wide range of field conditions (Phill 1995). These techniques can also enhance rice performance in DSR culture (Farooq *et al.*, 2006). It involves partial hydration to a point where germination-related metabolic processes begin but radical emergence does not occur (Farooq *et al.*, 2006a). Primed seeds usually exhibit increased germination rate, uniform and faster seedlings growth, greater germination uniformity, greater growth, dry matter accumulation, yield, harvest index and sometimes greater total germination percentage (Farooq *et al.*, 2006b; Kaya *et al.*, 2006).

For primed seed, treatment with fungicide or insecticide should be done post-soaking to control seed borne diseases/insects. Seed can also be soaked in solution having fungicide and antibiotics (Emisan and Streptomycin) for 15-20 hours (Gopal *et al.*, 2010; Gupta *et al.*, 2006). Priming with imidacloprid resulted in increased plant height, root weight, dry matter production, root length, increased yield by 2.1 t ha-1 compared to control (non-primed), which was attributed to higher panicle numbers and more filled grains per panicle (Farooq *et al.*, 2011). Use of biofertilizer like *Azospirillum* treatment had the highest shoot:root ratio during early vegetative growth and the maximum tillers (Farooq *et al.*, 2011). Seed priming also reduced the need for high seeding rates (Farooq *et al.*, 2011).

EFFECTIVE AND EFFICIENT MANAGEMENT OF WEEDS: A MAJOR CONSTRAINT

One of the major factors contributing to high yield of DSR is the weed management. Yield of rice is directly affected by weed. Weed reduces the economic yield (31.5%) by competing with crop plant for nutrients, moisture, space, light (Gupta, 1987). Weeds are mostly removed from the field manually in traditional method of rice cultivation. But high weed infestation is a major problem in direct-seeded rice (DSR) and causes grain yield losses up to 90 percent (Ghosh, 2002).

Gandhe (*Ageratum conyzoides*), Lunde (Amaranthus species), Kane (*Commelina diffusa*), Bhringraj (*Eclipta prostrate*), Jwane (*Fimbristylis miliace*) Dubo (*Cynodon dactylon*), Banso (*Digitaria adcendens*), Sawa (*Echinochloa colona*) Kade sawa (*Echinochloa crusgalli*), Madilo (*Ischaemum *rugosum*), Godhe dubo (*Paspalum distichum*), and Sedges (*Cyperus iria*, *Cyperus difformis*) are the major weeds of direct seeded rice (Gaire *et al.*, 2013).

For high productivity of a direct-seeded crop, good and effective weed management is essential. Weed can be managed through Integrated weed management practices which includes stale seed bed techniques in which weeds are allowed to germinate by giving irrigation and then killed by non-selective herbicides two days before seeding, using mulch and subsequently killed by 2,4-D at 30 DAS, and growing of rice varieties having greater ability to compete with weeds. However, 40-50 percent reduced weed densities are reported by mulching. Various mechanical methods are also available for weed control in direct- seeded rice such as manual weeding and using hand weeder. For chemical weed control, it is necessary to select the right herbicide depending upon the weed flora, and the herbicide should be applied with proper spray techniques. Glyphosate (systemic herbicide) or paraquat (contact herbicide) can be used as pre-plant herbicide. pendimethalin, pretilachlor, butachlor, thiobencarb, oxadiazon, oxyfluorfen, and nitrofen are used as pre-emergence herbicides, almix and fenoxaprop are the most effective post- emergence herbicide used to control the weeds of direct seeded rice. When the stale-bed technique is used to establish a direct dry-seeded rice crop, pre-plant application of glyphosate followed by the pre-emergence herbicide pendimethalin and post-emergence herbicide azimsulfuron/almix can eliminate weed problems in a DSR crop, including weedy rice (Dhakal *et al.*, 2012). However, the best result of weed control can only be seen in case of integrated weed management (Singh *et al.*, 2005).

PRECISE WATER MANAGEMENT

Precise water management, particularly during crop emergence phase (first 7-15 days after sowing), is crucial in direct seeded rice (Balasubramanian and Hill, 2002). From sowing to emergence, the soil should be kept moist but not saturated to avoid seed rotting. After sowing in dry soil, applying a flush irrigation to wet the soil if it is unlikely to rain followed by saturating the field at the three-leaf stage is essential (Bouman *et al.*, 2007).

There are few reports evaluating mulching for rice, apart from those from China, where 20–90% input water savings and weed suppression occurred with plastic and straw mulches in combination with DSR compared with continuously flooded TPR (Lin *et al.*, 2003). Bund management also plays an important role in maintaining uniform water depth and limiting water losses via seepage and leakage (Humphreys *et al.*, 2010). Some researchers (Gupta *et al.*, 2006) have recommended avoiding water stress and keeping the soil wet at the following stages: tillering, panicle initiation, and grain filling. Water stress at the time of anthesis results in maximum panicle sterility.

Table 4. Water management schedule in DSR at different phenological stages

SN	Phenological stages	Irrigation (times)
1	Pre-sowing	1 times
2	Emergence of seedling (7-10 days)	1 times
3	Tillering (30-45 DAS)	1 times
4	Panicle initiation to grain filling	1 times

Source : (Joshi et al., 2013)

Research showed that 33-53% irrigation water can be saved in Dry-DSR with AWD as compared with conventional tilled-transplanted puddled rice (CT-TPR) without compromising grain yield (Joshi *et al.*, 2013).

PEST AND DISEASE MANAGEMENT

In general, direct seeded rice is affected by similar pests and diseases as transplanted rice; however, under some conditions there may be greater chance of outbreak of insect-pests and diseases in DSR with high rice plant densities. In wet-seeded rice, rats are big problems to crop establishment and it is susceptible to various diseases, rice blast being one of the devastating diseases, in both aerobic and direct-seeded cultures (Bonman and Leung, 2004).

Water deficit and shift from transplanting to direct seeding favors neck blast spread (Kim, 1987). Sometimes the attack of arthropod insect pests is reduced in DSR compared with TPR (Oyediran and Heinrichs, 2001), but a higher frequency of sheath blight and dirty panicle have been observed in DSR (Pongprasert, 1995). For poor Asian farmers use of natural plant derived biocides, such as, those from neem (*Azadirachta indica*) as it is cheaper, indigenously available and eco-friendly product. Also pathogens cannot easily develop resistance against neem products because they have more than one molecule responsible for biocidal activity. Neem products have been reported to have fungicidal, insecticidal and nematicidal, and antiviral properties (Prasad, 2007). Cultivation of resistant crop varieties and summer ploughing is the pre requisite for efficient management of viral and other diseases/pests. Optimum rate of nitrogenous fertilizers avoid the incidence of brown plant hopper and blast attack. Fumigating the rat burrows with cow dung cake keeping the cow dung balls soaked in kerosene all over the field results in better control of rats and other borrowing animals.

CONCLUSION

DSR with suitable conservation practices has potential to produce slightly lower or comparable yields as that of TPR and appears to be a viable alternative to overcome the problem of labor and water shortage. Despite controversies, if properly managed, comparable yield may be obtained from DSR compared with TPR. If not managed efficiently, weeds may cause partial to complete failure of DSR crops. On the research front much needs to be done on the nutrient dynamics in soils under DSR. Also, research is needed on soil ecology in rice soils and weed management in DSR. Under different rice production zones need to develop a site-specific package of production technologies for different rice production systems. Varieties capable of synthesizing osmo-protectants and capable of synthesizing stress proteins may be introduced. Although methane emissions are substantially reduced in DSR, but, to combat increase in N_2O emission here is need to monitor GHG's emissions and develop strategies to reduce N losses vis-a-vis N_2O emissions under aerobic conditions for safer environment. Effective management strategies for pest and disease dynamics will help to resolve the issues of blast and insect infestation in DSR. Optimization of crop residue cover needs in systems' perspective.

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SELECTION OF MAIZE GENOTYPES RESISTANT TO GRAY LEAF SPOT (*Cercospora zeae-maydis*)

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ABSTRACT

*Gray leaf spot (GLS), caused by Cercospora zeae-maydis is an important and destructive foliar disease of maize (Zeae mays) mostly in the mid hills of Nepal. Considering its potential threat to maize production, a total of fourty two and thirty different maize genotypes were evaluated in the year 2012 and 2013 respectively with two replications in observation nursery at Kapurkot, Salyan (1480 masl) for resistance to GLS. Disease assessment was made using 1-5 scale at 15 days interval for three times starting from tasseling stage (65 days after sowing). The results showed that no immune and highly resistant genotypes were found in both the year. Response of 27 out of 42 genotypes of maize were identified as moderately resistant (2-2.5 score) and 15 genotypes showed moderately susceptible (3 score) to GLS during 2012. During 2013 out of 30 genotypes of maize 27 were identified as moderately resistant (1.75-2.5 score) and 3 moderately susceptible (2.75-3 score) to GLS. Among the tested genotypes, BGBYPOP, Rampur SO3FO4, Celaya OOHGYA*HGYB, O7SADVI, Manakamana-3, SO1SIYQ and local were found most promising and moderately resistant to GLS disease during 2012 and SYN312-SR and CML-395/CML-444 during 2013.*

Key words: *Cercospora zeae-maydis,* GLS screening, maize genotypes, Mid-hills, resistant

INTRODUCTION

Maize (*Zea mays* L) is third most important cereal crop in the world and second most important crop after rice in terms of area and production in Nepal. Maize contributed 24.93% of total edible cereal grain production and the total area under maize production is 928,761 ha in Nepal where mid hill, terai and high hill occupies 72.85, 17.36 and 9.79 percent respectively (MOAD, 2014). One of the main deterrents to high grain yield in maize is its susceptibility to several diseases among which gray leaf spot (GLS) caused by *Cercospora zeae maydis* Tehon & Daniels is an important and destructive foliage disease mostly in hills of Nepal. It is estimated to be spreading at a rate of 80-160 km each year (Rijal et.al 2015). Grain loss of 80% was estimated in farmer's field due to this disease (Manandhar et al., 2009). The disease was first identified from the state of Illinois, USA in 1925 (Tehon & Daniels, 1925).The occurrence of this disease was recorded for the first time in the Kavrepalanchowk district of Nepal in 2006 (Manandhar, G. 2007, Tiwari and Ferrara, 2007). It affects upper eight or nine leaves which contribute 75—90% of the photosynthesis for grain fill (Ward et al., 1999). The disease is significant since it rapidly destroys foliage when the plant is near at grain maturity. Since, the disease has been observed spreading over the years in 22 districts in the eastern, central and mid-western regions of the country (Manandhar et al., 2009) there is a prompt need of resistant maize varieties to combat the disease. Host resistance for this worldwide important disease of maize has been reported on several hybrids and inbred lines (Hilty et al., 1979; Ward et al., 1999). Choosing a variety/genotype resistant to gray leaf spot is utmost of the day in disease prone hilly areas of Nepal. With an objective to identify the source of resistance for gray leaf spot in maize genotypes for general cultivation for the resource poor farmers in the hills, GLS screening experiment was conducted in the western mid hill environment at Kapurkot, Salyan (1480masl) of Nepal.

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MATERIALS AND METHODS

STUDY SITE DESCRIPTION

A total of 42 and 30 different maize genotypes received from National Maize Research Program (NMRP) in the year 2012 and 2013 respectively with two replications were evaluated in the disease screening nursery at Ginger Research Program (GRP), Kapurkot, Salyan (1480 masl) for resistance to GLS in western mid hills condition of Nepal. The experiment was conducted during summer season and was raised under rainfed condition. Seeds of maize were sown @ 2 seeds/hill on 28th June during 2012 and 5th June during 2013. Thinning of plants was done on 30th day after sowing (DAS) in all the treatments and one plant/hill was maintained. Two times of manual weedings and hoeings were done throughout the maize growing period. First weeding was done at knee high stage followed by earthing up, i.e. 35 DAS, and 2nd before tasseling stage, i.e. 75 DAS.

EXPERIMENTAL DESIGN AND CROP HUSBANDRY

The experiment was laid out in randomized complete block design (RCBD) with two replications in a natural epidemic condition. Plant spacing was maintained 75 cm x 25 cm (row to row and plant to plant respectively) and the plot size was of 2 rows of 3 m length (4.5 m^2). Fertilizer was applied at the rate of 120:60:40 kg NPK/ha with half dose of nitrogen and full dose of phosphorus and potash as basal application and remaining half of nitrogen top dressed at knee height stage. Other agronomic practices to raise the crop were applied as per National Maize Research Program guidelines.

DISEASE SCORING

GLS severity was measured as percentage of leaf area infected on average plant of the plot visually at 15 days intervals. A total of 3 scorings were done from July to August in both the years.

Disease assessment was done by using 1-5 rating scales (Maroof et al., 1993) in all genotypes at 15 days interval for three times starting from the occurrence of lesions on leaves as,

1. (Resistant) = Plants with one or two to few scattered lesions on lower leaves,
2. (Moderately resistant) = Moderate number of lesions on leaves, affecting less than 25 per cent of the area,
3. (Moderately susceptible) = Abundant lesions on lower leaves, few on other leaves affecting 26-50% leaf area,
4. (Susceptible) = Lesions abundant on lower and mid leaves, extending to upper leaves affecting 51-75% leaf area and
5. (Highly susceptible) = Lesions abundant on almost all leaves, plant prematurely dried or killed with 76-100% of the leaf area affected.

HARVESTING, THRESHING AND YIELD

Harvesting was done manually from net plot area, i.e. 4.5 m^2 on 9th November during 2012 and 6th October during 2013. Yield/plot was taken by weighing all dehusked cobs and randomly taken cobs were shelled to calculate shelling percentage and the grains were used for moisture recording by a moisture meter, and grain yield (t/ha) was adjusted to 15% moisture level using the following formula,

$$\text{Yield (mt/ ha)} = \frac{\text{FW (kg)} \times (100 - \text{MC}\,\%) \times \text{SP} \times 10}{\text{Net harvested area (m2)} \times 85}$$

Where, FW = Fresh Weight; MC = Moisture Content and SP= Shelling Percentage

The shelled grains were cleaned by winnowing and sun dried so as to maintain 15% and grain yield per hectare was calculated by converting yield per plot into grain yield per hectare.

DATA ANALYSIS

The data on disease scoring and agronomic characters such as days to tasseling, silking, plant height and ear height along with the weight of ears and moisture content of kernels were recorded and analysis of variance for grain yield and other ancillary characters of maize were analyzed using the statistical package MSTAT-C (Russel and Eisensmith, 1983).

RESULTS

During 2012, response of 27 out of 42 genotypes of maize were identified as moderately resistant (2-2.5 score) and 15 genotypes showed moderately susceptible (3 score) to GLS. Among the tested genotypes BGBYPOP, Rampur SO3FO4, Celaya OOHGYA*HGYB, O7SADVI, Manakamana-3, SO1SIYQ and local were found most promising and moderately resistant to GLS disease (2-2.5 score). Highly significant difference on genotypes for the plant population, plant height and grain yield and only significant differences for ear height and GLS were observed, where as rest of the evaluated traits did not differ significantly. The highest plant height (219.90 cm) and ear height (106.00 cm) was recorded in Deuti variety followed by genotypes 07 SADVI (plant height 199.70 cm, ear height 88.10 cm) and Obatanpa (plant height 193.10 cm, ear height 102.80 cm). The genotypes Poshilo makai-1 and Celaya 00HGYA*HGYB were found to be GLS tolerant (2.50 and 2.00 GLS score respectively) with the highest yield potentiality of 4.39 and 4.00 mt/ha, respectively. The yield of the rest genotypes was found to be lower than the local genotypes (3.62 mt/ha).

Table 1: Evaluation of different maize genotypes against GLS at GRP, Kapurkot, Salyan (1480 masl), during summer season of 2012 and 2013

SN	Genotypes	Plant #/m^2	Tasseling days	Plant height, cm	Ear height,cm	GLS	ET	BLSB	Adjusted Grain yield mt/ha
1	Across 9942/ Across 9944	5.3	71.00	146.90	80.90	2.00	2.00	2.00	2.39
2	P501SRCO/ P502 SRCO	5.2	71.00	157.50	70.10	3.00	2.00	2.00	2.08
3	Rampur S03 F02	5.3	70.00	150.40	79.40	2.50	2.00	2.00	2.39
4	BGBYPOP	5.3	68.00	150.00	74.40	2.00	2.00	2.00	3.36
5	S99TLY-GH-B	5.3	72.00	158.70	87.90	3.00	2.00	2.00	3.40
6	S01SIWQ-3	5.3	66.00	165.20	80.90	3.00	2.50	2.00	2.65
7	S99TLYQ-B	5.3	70.00	159.30	88.30	2.50	2.00	2.00	2.12
8	S99TLYQ-A	5.2	67.00	150.50	79.70	3.00	2.50	2.00	2.66
9	S00TLY-1AB	5.3	66.50	173.50	85.60	3.00	2.50	2.00	2.92
10	Rampur S03 F08	5.3	69.00	166.50	90.00	3.00	2.00	1.50	1.90
11	Rampur S03 F04	5.2	68.00	163.00	82.90	2.00	2.50	2.00	3.23
12	Celaya00HGYA*HGYB	5.2	67.50	177.50	87.90	2.00	2.50	1.50	4.00
13	Poshilo makai-1	5.1	68.50	172.40	92.40	2.50	2.00	2.00	4.39
14	Cotaxla0024	5.3	70.00	148.30	76.50	3.00	2.50	2.50	1.51
15	TLBRS07F16	5.1	68.00	158.80	82.20	3.00	2.00	2.00	1.98
16	BLSBRS07F12	5.3	70.00	166.30	87.70	3.00	2.00	2.00	3.12
17	ZM-401	5.3	66.00	153.20	76.40	2.50	2.00	2.00	3.11
18	ZM-627	5.2	66.50	147.20	75.70	2.50	2.50	2.00	2.00
19	Heterotic Group A	4.3	66.00	146.80	68.20	3.00	2.00	2.00	1.33
20	Heterotic Group B	4.1	68.50	125.40	68.90	3.00	2.00	2.50	1.46
21	R Pop-2	4.8	68.00	156.70	83.40	3.00	2.00	2.00	1.66
22	BLSBRS07F10	5.2	66.00	141.60	63.30	3.00	2.00	2.00	1.90
23	TLBRS07F14	5.3	65.50	143.70	64.25	2.50	2.00	2.00	2.13
24	Rampur S10F18(A)	7.7	66.50	126.05	74.50	2.50	2.00	2.00	0.37
25	05SADVI	5.3	71.00	158.10	88.80	2.00	2.00	2.50	2.12
26	07SADVI	5.3	70.00	199.7	88.10	2.00	2.00	2.00	3.17
27	Manakamana-3	4.6	70.50	183.50	97.90	2.00	2.00	2.00	3.07

28	GLSYW	4.8	70.50	167.50	92.10	2.00	2.00	2.00	2.99
29	Obatanpa	5.1	67.50	193.10	102.80	2.50	2.00	2.00	2.74
30	S99TLYQ-HG-AB	5.1	68.50	151.00	80.80	2.50	2.00	2.00	1.83
31	S01SIWQ-2	5.3	70.50	146.30	69.00	2.50	2.00	2.00	2.63
32	S00TLYQ-B	1.1	70.00	134.15	59.45	2.00	2.00	2.00	0.22
33	S01SIYQ	5.3.	73.50	160.00	83.60	2.00	2.00	2.00	3.08
34	Rampur S03FQ-02	5.3	66.00	147.50	74.50	2.00	2.00	2.00	2.35
35	S99TLWQ-B	5.3	65.00	141.70	69.00	3.00	2.00	2.50	2.14
36	S00TLWQ-B	5.2	69.50	152.50	74.20	2.50	2.00	2.00	2.03
37	R Pop-3	5.3	69.00	159.20	94.20	3.00	2.00	2.00	2.77
38	Deuti	4.7	73.00	219.90	106.00	2.00	2.00	2.00	2.29
39	Manakamana-5	5.3	69.00	182.50	102.40	2.00	2.00	2.00	1.92
40	Manakamana-6	5.3	68.00	175.50	84.20	2.00	2.00	2.00	1.56
41	OEHPW	5.1	69.00	148.20	75.70	2.50	2.00	2.00	1.74
42	Local	5.3	70.00	169.10	91.00	2.00	2.00	2.00	3.62
CV %		5.07	3.66	10.06	14.05	17.46	14.82	13.26	33.70
P value		**	NS	**	*	*	NS	NS	**
LSD (p=0.01 and 0.05)		0.51		32.38	23.20	0.088			0.37

NS – Not significant * Significant ** – Highly significant

During 2013, Highly significant difference on genotypes for the tasseling days, silking days, ear height, grain yield was recorded and only significant differences for plant height was found where as plant stand and GLS score did not differ significantly. All the plants bear tassel between 73 to 86 days. The highest plant height (199.9 cm) and ear height (117.2 cm) was recorded in genotype JH-1203 followed by CZH 0923 (plant height 199 cm, ear height 113.6 cm). During 2013 out of 30 genotypes of maize 27 were identified as moderately resistant (1.75-2.5 score) and 3 moderately susceptible (2.75-3 score) to GLS. Genotype CZ 1108 produced highest grain yield (7.38 mt/ha) with lowest disease severity (2.25 score) followed by JH1203 (yield 7.01 mt/ha, GLS- 2 score). DTM # -38 was found inferior from GLS (3 score) and yield (2.26 mt/ha) point of view. Among the tested genotypes SYN312-SR and CML-395/CML-444 were found most promising having moderately resistant (1.75 GLS score) reaction to GLS with higher production of 5.9 mt/ha and 6.6 mt/ha respectively.

Table 2: Evaluation of different maize genotypes against GLS at GRP, Kapurkot, Salyan (1480 masl), during summer season of 2013 and 2014

SN	Genotypes	Plant #/m^2	Tasseling days	Silking Days	Plant height, cm	Ear height, cm	GLS	Grain yield mt/ha
1	J613-6	5.33	81.0	84.5	128	68.3	2.5	3.7
2	J586	4.77	73.5	77	163.7	77.4	2.5	4.4
3	ITS6C1F238	5.33	73.0	76	161	68.9	2.25	5.2
4	SYN312-SR-	5.11	80.50	83.5	171.7	94	2.5	5.1
5	CML-444/CML-489	5	80.50	84	173.5	92.1	2.25	4.8
6	SYN312-SR	4	77.50	81	192.7	91.5	1.75	5.9
7	CML-312/CML-444	5.12	80.50	84	196.4	105.4	2	6.1
8	CML-395/CML-444	5.11	84.50	87.5	191.6	100.8	1.75	6.6
9	JH-1203	5.33	86.50	90	199.9	117.2	2	7.0
10	CML144/SNSYN	5	77.50	82	189	105	2.5	4.24
11	CZH0837	5.11	73.0	76.5	159.4	69	2.5	3.52
12	CZH06623	5.22	76.0	80	189.5	86	2.5	5.65
13	CZH0923	5.33	81.0	84.5	199	113.6	2.25	6.75
14	CZH1012	5.22	74.50	78	185.6	90	2.25	6.52
15	CZH111	5.33	78	82	198.5	107.8	2.25	6.28
16	CZH0838	5.33	80	82.5	189.5	101.1	2.25	5.79
17	CZH1108	5.33	75.50	79	174.5	94.8	2.25	7.38
18	CZH1120	4.88	70.50	74	157.1	85	2.75	3.74
19	JH-1104	5.11	75.0	79.5	142.6	62.7	2.5	3.34

20	JH-1204	5.33	81	84.5	172.9	90.4	2.5	4.51
21	CZH0935	3.11	75	78	156	71.1	2.75	2.21
22	CZH0928	5.11	77	80.5	153.8	58.7	2.5	3.20
23	CML-305/CML-444/(CML-)	5.11	86	91	178.5	97	2	4.01
24	CML-444/CML-445	5.22	83	87	191	107.1	2	4.90
25	DMT#-35	4.77	82	85.5	135.7	67.7	2	2.47
26	DTM#-38	4.55	82.5	86	159.2	67.8	3	2.26
27	TLBRS07F16	5.33	80	82.5	158.6	80.5	2.25	4.32
28	BLSBRS07F12	5.11	79	81.5	148.1	75.8	2	2.89
29	TLBRS07F14	5.11	76	79	150.9	79.2	2.5	2.78
30	Local	5.11	84.5	88	163.1	77.3	2	2.88
CV %		10.12	4.01	4.09	11.21	14.02	15.50	27.14
P value		NS	**	**	*	**	NS	**
LSD (p=0.01 and 0.05)			6.46	6.88	39.21	24.98		2.56

NS – Not significant * Significant ** – Highly significant

The twenty maize genotypes could be categorized into four resistance levels, i.e. resistant, moderately resistant, susceptible and highly susceptible on the basis of disease severity. Among them, none of the genotypes were observed resistant, susceptible and highly susceptible reaction. Only 27 maize genotypes were observed moderately resistant during both the year 2012 and 2013 while 15 and 3 genotypes fell under moderately susceptible during 2012 and 2013 respectively.

Table 3: Classification of maize genotypes based on disease reaction and severity scale

Reaction	Maize Genotype	
	During 2012	**During 2013**
Resistant (1-1.5)	None	None
Moderately Resistant (1.75-2.5)	BGBYPOP, Rampur S03 F02 Across 9942/ Across 9944, S99TLYQ-B Rampur S03 F04, Celaya00HGYA*HGYB Poshilo makai-1, ZM-401, ZM-627, Rampur , TLBRS07F14, Rampur S03FQ-02, S01SIYQ, S00TLYQ-B, S01SIWQ-2 S99TLYQ-HG-AB, Obatanpa, GLSYW Manakamana-3, 05SADVI, 07SADVI S10F18(A), S00TLWQ-B, Deuti, Manakamana-5,Manakamana-6, OEHPW, local	SYN312-SR CML-395/CML-444, Local, TLBRS07F14 BLSBRS07F12, TLBRS07F16 DMT#-35, CML-444/CML-445 CML-305/CML-444/(CML-) CZH0928, JH-1204 JH-1104, CZH1108 CZH0838, CZH111, CZH1012 CZH0923, CZH06623, CZH0837, CML144/SNSYN, JH-1203 CML-312/CML-444, CML-444/CML-489, SYN312-SR, ITS6C1F238, J586, J613-6
Moderately Susceptible (2.75-3.5)	P501SRCO/ P502 SRCO, S99TLY-GH-B, S01SIWQ-3, S99TLYQ-A, S00TLY-1AB, Rampur S03 F08, Cotaxla0024, TLBRS07F16, BLSBRS07F12, Heterotic Group A, Heterotic Group B, R Pop-2, BLSBRS07F10, R Pop-3, S99TLWQ-B	DTM#-38, CZH1120, CZH0935
Susceptible (3.75-4.5)	None	None
Highly Susceptible (4.75-5)	None	None

DISCUSSION

In this research work, 42 and 30 maize genotypes were screened against GLS disease in naturally infested conditions during 2012 and 2013 respectively to identify the sources of resistance in mid hills condition of Nepal. Among the screened maize genotypes only 27 maize genotypes were observed moderately resistant during both the year while 15 and 3 genotypes showed moderately susceptible reaction during 2012 and 2013 respectively. The difference of genotypes in disease severity may be due to diversity in their genetic makeup. Among the moderately resistant genotypes, BGBYPOP, Rampur SO3FO4, Celaya OOHGYA*HGYB, O7 SADVI, Manakamana-3, SO1SIYQ and local were found most promising during 2012 while genotypes SYN312-SR and CML-395/CML-444 were found promising during 2013. Similar results were obtained in the GLS trial conducted at Pakhribas, Nepal which revealed that one genotype 07 SADVI was found highly resistant against GLS and produced 9.12 t/ha grain yield and other moderately resistant genotypes were S00TLWQ-B, Rampur S03FQ-02, Manakamana-6 and S01SIYQ (NMRP, 2013). Similar findings were also reported by Rijal et al. (2015) in the GLS disease screening trial conducted at Suping, Makwanpur and Dhungkharka, Kabre. The result of NMRP, 2014 also showed that at Rampur conditions the maize genotype 07 SADVI was found resistant against BLSB and CML-395/CML-444 was found moderately resistant to southern leaf blight on the disease screening trials.

During the year 2012 highly significant difference on genotypes for the plant population, plant height and grain yield and only significant differences for ear height and GLS were observed; whereas rest of the evaluated traits did not differ significantly however during 2013, highly significant difference on genotypes for the tasseling days, silking days, ear height, grain yield was recorded and only significant differences for plant height was found where as plant stand and GLS score did not differ significantly. The result is supported by Ali et al. (2011) that plant height is an important trait which affects the overall grain yield of the crop. These results showed differences in disease reaction along with other yield attributing character indicating that genetic variations exist among maize genotypes. There seems to be a good basis for introducing resistance against Grey leaf spot in breeding programs.

CONCLUSION

Since the maize genotypes varied highly in grey leaf spot severity, screening of genotypes seemed to be one of the important techniques for finding the sources of resistant and susceptible genotypes. In this respect use of resistance is an important part of the control strategy where different measures are combined to give an overall good disease control. Genotypes of maize resistant to moderately resistant to GLS have been identified. The open pollinated varieties like Manakamana-3 and Deuti which are already released and recommended for mid hills are still tolerant to GLS which can reduce yield loss in GLS prone environments of the hills. Several resistant genotypes of maize can be useful for source of disease resistance in the national maize breeding program. Genotypes of maize including BGBYPOP, Rampur SO3FO4, Celaya OOHGYA*HGYB, O7SADVI, SO1SIYQ, SYN312-SR and CML-395/CML-444 were identified as promising and resistant/moderately resistant to GLS and these genotypes should be used in breeding program of national maize research for further verification in agronomical and other yield attributing traits in the hills of Nepal.

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PARTICIPATORY F_1 HYBRID SEED PRODUCTION OF TOMATO AND ITS ECONOMIC BENEFIT

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ABSTRACT

Quality seeds play significant role in the agriculture production. This study was aimed to produce quality F_1 seed of tomato by involving farmers at reasonable price and increase the availability of F_1 hybrid 'Srijana' in commercial tomato growing areas of Nepal. The activities were carried out during three consecutive years from September 2009 to August 2012 in three sites i.e. Dhikurpokhari and Armala of Kaski district, and Mattikhan of Syangja district. Altogether 12 plastic houses were constructed for F_1 seed production. Twelve female farmers and technicians from Agricultural Research Station (ARS), Malepatan; District Agricultural Development Offices from Kaski and Syangja districts and I/NGO personnel and seed entrepreneurs participated in different seed production activities. Parental lines of Srijana tomato hybrid were maintained in ARS, Malepatan. Training was provided to farmers on F_1 hybrid seed production focusing on emasculation and pollination of tomato crop and crop protection. Farmers produced a total of 11.4 kg F_1 seeds and able to get NRs 10,01,730 by selling their produce. The gross profit margin from production of F_1 seed comprises 350 times more in comparison to maize seed production. The economic analysis showed that the net profit per kilogram of tomato F_1 seed is 92%. F_1 seed production has been carried out even by rural women farmers after getting good schooling of knowledge and skill through training. It indicates that F_1 hybrid technology should be extended to other crops so that more farmers could get benefit from producing F_1 hybrid seeds as well as by growing F_1 hybrid crops.

Key words: F_1 hybrid, income, seed, tomato, women farmers

INTRODUCTION

The tomato (*Solanum lycopersicum* L., 2n = 2X = 24) is a tropical vegetable used fresh and in processed products (Tiwari, 1986). It is the second in production among vegetables in the world after potato (http://faostat.fao.org) and it's grown in almost every region of the world. Tomato ranked fifth among vegetables in terms of growing area which is 18,415 ha (ABPSD, 2012/13) with the productivity of 14.5 t/ha and grown widely in Nepal. It covers about 7.5% area of total 246392 ha occupied by more than 54 types of vegetables in the country (ABPSD, 2012/13). Diversity relative to its use and production environments is high and many landraces have been reported in Nepal (Upadhyay and Joshi, 2003). Different types of tomato varieties e.g. inbred varieties, hybrids, GMOs, etc. have been developed using this diversity to meet the consumers as well growers' demands.

Improved crop varieties and quality seeds are the most viable ways of improving agricultural production and food security in a sustainable manner (SQCC, 2013). Due to the high potential in fruit production of F_1 hybrids, many growers have given due attention to grow F_1 hybrids for a number of crops. Due to easiness of emasculation and pollination of tomato flowers, hybrid technology is widely adopted and single pollination can produce many seeds in tomato. Developing F_1 hybrids is the best way to combine disease resistance and fruit quality and marketable fruit yield from breeding lines, although hybrid vigor is not reported in tomato. Resistance genes can also be

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incorporated to the parental lines which can be accelerated using marker linked to important diseases (Joshi et al., 2014). The quality of seed is an important factor for increasing yield per unit area (Ali, 2009). Several hybrids have been developed from different public and private tomato breeding programs and tomato hybrids can be selected that had high yield and stability across years over the locations (Joshi et al., 2011).

Phytopthera and *Ralstonia solancearum* are major setback for tomato production in Nepalese context and not many imported hybrids address these problems. Srijana is the first vegetable hybrid developed in Nepal which has good market quality and bacterial wilt resistance. This hybrid occupies almost 75% of the tomato area and is the most preferred variety of tomato in Nepal. The domestic demand for the tomato seeds is 4.1 t, of which 3.5 t are of open pollinated and 600 kg of F_1 seeds. About 100 kg seeds are of Srijana and rest F_1 seeds are imported varieties (SEAN, 2013). In addition, the demand for the hybrid tomato seed is rapidly expanding. Tomato is superlatively the leading vegetables in terms of number of hybrid varieties imported in the country. A lot of national currency is being spent every year to import hybrid seeds from India and aboard. Therefore, development F_1 seed production system is utmost necessary to increase the production, distribution and utilization of F_1 seed.

However, it is generally perceived that hybrid technology is costly and need high skill. If farmers could produce F_1 hybrid seeds, this technology will be rapidly increased in the country. This study was aimed to transfer the hybrid seed production technology to the farmers so that they can produce F_1 hybrid seeds of tomato in their environment and generate income adopting this technology as major agri-business. It was assumed that women farmers could adopt hybrid seed production technology as their long term agricultural business.

MATERIALS AND METHOD

This study was carried out in three consecutive years from September 2009 to August 2012 in three sites viz. Dhikurpokhari and Armala of Kaski district and Mattikhan of Syangja district. Altogether 12 plastic houses were constructed in these sites. Twelve women farmers were involved in the production of seeds of Srijana tomato.

GROWING PARENT LINES OF SRIJANA TOMATO HYBRID

Plastic houses were constructed using 120 GSM Silpaulin sheets for roofing. Sizes of the plastic houses were 15-x 5-m with the height of 4 m in the center and 3 m around the sides of plastic house. Under these plastic houses, 100-125 parent lines, of which around 20% were male parent lines, were transplanted in each location of Kaski and Syangja each year in April/May. After soil test 130 kg of agri-lime per 500 meter square was applied fifteen days prior to transplanting in first year. Well rotten farmyard manure @ 20 t/ha plus poultry manure @ 2 t/ha was incorporated in the soil ten days before transplanting. At the time of transplanting 3 kg of well decompose FYM plus 20 g DAP, 15 g urea, 10 g murate of potash and 0.5 g Carbofuran-3G per pit was applied. In addition, 1.5 g zinc and 1.5 g boron was used per plant. At the time of flower initiation, 5 g urea was top dressed and then 5 g urea was applied every 15 days interval up to crossing time. Multiplex @ 2.5 ml per liter of water was sprayed three times during the crop period for other essential micro nutrients

(ARS, 2011/12). It is very important to supply the pollen grains regularly during pollination, therefore, male parent was planted 7-10 days earlier than female parent and two times at 15 days interval after planting female parent (Jones et al., 2014).

CAPACITY ENHANCEMENT OF WOMEN FARMERS

Trainings were organized every year to five women farmers from Dhikurpokhari, Kaski, three farmers including Dalit Woman from Armala of Kaski district and four women farmers from Mattikan of Syangja district and got special technical knowledge on hybridization techniques in tomato and cultivation of tomato under plastic house condition for higher income. Similarly, the farmers at the vicinity area of seed production also got the information about tomato growing technology and various aspect of seed business. Technicians from ARS, Malepatan; DADO, Kaski and Syangja also upgraded their expertise in tomato growing/crossing technology. Manual/booklets were prepared and distributed in schooling process which definitely disseminated the generated information at wider scale. In addition to different trainings provided to the farmers, regular interaction among farmers and breeders helped farmers to develop confidence in production F_1 hybrid seeds of tomato.

EMASCULATION AND CROSSING

After initiation of flowering about 30-35 days after transplanting flowers were manually emasculated at the right stage (Figure 1A). For crossing, male flowers were collected in petri dish and kept in the warm sunny place for 10-15 minutes. Pollen grains were then poured in petri dish by opening upper tip of the male flower with the help of forceps. The stigmas of emasculated flowers were touched with pollen grains collected in the petri dish. The crossing was performed during between 8-11 am each day during this time.

SEED HARVESTING AND PROCESSING

Fruits were harvested 35-45 days after crossing. The selected full red ripe fruits were kept in plastic Carate overnight after harvesting as such for full maturation. Fruit were then cut with sharp knife and extracted pulp with seeds (Figure 1B) was kept one to two days for fermentation. The fermented pulps were washed 8-10 times with clean water and were sun dried for 3-4 days. These seeds were stored in the air tight container. Seed recovery was also measured based on the fruit weight.

SEED PACKING AND MARKETING

One-day interaction workshop was organized for marketing with stakeholders from government, farmers and seed entrepreneurs from Kaski, Syangja and Kathmandu. Marketing and production systems were discussed. Seed quality analysis especially seed viability was tested at Regional Seed Testing Laboratory, Bhairahawa. Truthfully labeled seeds of one and two gm packet were marketed in Kathmandu, Kaski, Syangja, Palpa and Gulmi districts.

ECONOMIC ANALYSIS

The economic analysis was conducted for tomato hybrid seed production at Kavre, Pani Tanki. Two plastic houses of 100 sq meters were constructed at two different farmer's fields. Total 155 plants transplanted, of which 128 plants were female and 27 plants male. Emasculation and pollination were carried out by trained female farmers. Seeds were extracted separately from 1 kg of fresh crossed fruits in 6 replications and the average seed per kg fresh fruit was estimated. The price of seed was estimated based on the existing wholesale price in the market. Similarly, maize was cultivated in one ropani for seed production for the comparison of cost –benefit analysis between maize grain and tomato seed.

For net profit calculation two plastic tunnels of 100 sq m were constructed on-farm. Total 160 plants of which 144 females and 16 males were planted in the plastic tunnel with the spacing of 100- x 60-cm. Crossing was done by skilled farmers and single skilled farmer crossed up to 1500-2000 buds per day during peak season. About 40-50 fruits per plant were maintained. Crossing was taken up for four and half months and seeds were extracted from red ripe tomatoes. The detail inputs required for the tomato hybrid seed production in 100 sq meter were listed and cost of each input calculated. The market wholesale price of 1 kg of seed was obtained and the net profit was calculated.

RESULTS

MEAN SEED RECOVERY

In the three years experiment conducted on station for mean seed recovery per kilogram crossed fruits, from the three samples taken in three consecutive years, the mean seed recovery yield per kg of fresh crossed fruits ranged from 4.0-4.4 g (Table 1).

Table 1. Seed recovery from fruit of female parent after crossing with male parent tomato during 2010-2012 in Malepatan

Sample	2010	2011	2012	2010	2011	2012	2010	2011	2012	Mean seed recovery (g)
	Fruit wt (g)			Seed obtained (g)			Seed recovery per kg of fruit (g)			
1	1120	1060	970	4.6	5.3	4.0	4.1	4.7	4.1	4.3 (2010)
2	3150	1240	975	13.8	5.9	3.8	4.4	4.8	3.9	4.4 (2011)
3	3510	1450	1260	15.0	6.4	5.4	4.3	4.4	4.3	4.1 (2012)

Figure 1. Emasculation of tomato flower by farmer (A) and seeds extraction from fruits pollinated manually (B).

ECONOMIC BENEFIT FROM F1 SEED PRODUCTION

F_1 cv Srijana is the product of hybridization between HRD-1 (female, indeterminate type) and HRD-17 (male, determinate type). Cross success in first, second and third year were 50%, 90% and 95% respectively. Eleven and half kg of quality F_1 seed has been produced with total income about NRs 10,00,000 (Table 2).

Table 2. F_1 seed production of Srijana tomato and income from the seeds during 2010-1012

SN	Farmer's name	Location	Seed produced (g)			Income (Rs)
			2010	2011	2012	
1	Hari KC	Dhikurpokhari, Kaski	219	159	200	51,560
2	Santu Subedi	Dhikurpokhari, Kaski	218	90	200	45,540
3	Aarati Subedi	Dhikurpokhari, Kaski	315	184	140	55,760
4	Sita Subedi	Dhikurpokhari, Kaski	230	38	40	29,820
5	Balika Subedi	Dhikurpokhari, Kaski	210	144	81	37,860
6	Laxmi Paudel	Mattikhan, Syangja	740	640	1470	2,63,800
7	Kausila Paudel	Mattikhan, Syangja	125	500	275	82,500
8	Dripa Chhetri	Mattikhan, Syangja	127	320	68	44,960
9	Khuma Paudel	Mattikhan, Syangja	73	584	109	16,740
10	Madhu M. BK	Armala, Kaski	489	596	900	1,87,650
11	Bishnu Basnet	Armala, Kaski	410	426	400	1,11,140
12	Jit B. Basnet	Armala, Kaski	406	268	190	75,600
		Total	**3562**	**3949**	**4073**	**10,01,730**

The comparative analysis of tomato hybrid seed and maize seed showed a huge difference in gross return from hybrid tomato seed and maize grain production. From one Ropani, maize grain production gives gross return of NRs 540 whereas tomato hybrid seed gives gross return of NRs 189000. The gross profit from production of F1 seed comprises 350 times more in comparison to maize seed. This indicates there is a large economic benefit in tomato hybrid seed production even in one Ropani of land (Table 3).

Table 3. Economic analysis of F_1 hybrid tomato seed production with comparison to maize grain production per kg per Ropani

SN	Description (in a Ropani i.e. 500 m^2)	Tomato	Maize
1	Mean seed yield (kg)	3.50	200.00
2	Seed price per kg (Rs)	90000.00	13.00
3	Gross income (Rs)	315000.00	2600.00
4	Total cost (Rs)	126000.00	2060.00
5	Net income (Rs)	189000.00	540.00

The comparative economic analysis of gross return from fresh fruit versus hybrid seed was carried out. The average market price of fresh fruit tomato was NRs 25 whereas the average seed obtained from 1 kg of crossed fruit was 5 g and the market price of 5 g of seed was NRs. 400. The average gross return from 1 kg of fruit was NRs. 355 which shows the difference of NRs. 355 rupees in terms of gross return between fresh fruit and hybrid seed (Table 4).

Table 4. Economic analysis of fresh fruit vs hybrid seed

Description	Plastic house 1	Plastic house 2
No. of fruit crossed within 3 months	40	35
No. of crossed fruits per kg	25	20
Mean seed production per kg fruit (g)	5	4.5
Economic return from 1 kg fresh fruit (NRs)	25	25
Economic return from 1 kg fruit after seed extracted (NRs)	5 x 80=400	4.5 x 80=360

The total number of fruit and total weight obtained from 100 sq m during 4.5 months crossing was 5760 and 288 kg respectively. On an average 4 g of seed was obtained from each kg of fruit sampled which totaled to 1000 g.

The detail breakdown on cost of hybrid seed production for one kg comes up to NRs. 51876 and from 100 sq meter, approximately is 1 kg of seeds can be obtained which depends upon the speed and skill of the crossing personnel. The minimum wholesale price of the seed is NRs 86400 which means there is a profit of NRs 34,524 per kg of fruit per 100 sq meter. In one Ropani, five plastic tunnels can be constructed and from where 5 kg of seed can be obtained. With the above finding, it can be extrapolated that around NRs 172,640 can be obtained as net profit from one Ropani (Table 5). The economic analysis showed that the net profit per kilogram of tomato F1 seed is 92%.

Table 5. Economic analysis (net profit from F_1 seed per kg)

SN	Description	Size/ capacity	Cost (NRs)	Total (NRs)
1.	Plastic house	100 m^2	9070	9,070
2.	Labour	2 x 4.5 months x 150 NRs	40,000	40,500
3.	Scissor	2	150	300
4.	Plastic rope	-	500	500
5.	Forceps	2	100	200
6.	Fertilizers (chemical + FYM)	-	700	700
7.	Pesticides	-	600	600
8.	Petri dishes	4	100	400
9.	Cost of inbred (male and female)	2 g	200	200
	Total			**51876**

MARKETING

There were two types of seed for marketing: packaged under ordinary plastic cover and packaged under private companies brand. The produced seeds were marketed by the private seed companies of Kathmandu and Pokhara.

A minimum support price (MSP) of NRs 90,000/kg was fixed by NARC. A half day workshop of seed producers and potential seed companies was organised. An effort was made to establish an appropriate linkage between the seed producers and companies. The private companies and seed producers had an informal contract and the seed produced were collected, tested, packed in their own brands and marketed.

The good linkage was established with the private seed companies and the seeds produced were collected by the companies, packed and marketed in their respective brands after the project phases out.

DISCUSSION

There were more than 7000 plastic houses in western development region only to grow tomato in rainy season (RAD 2012, personal communication). Cultivation in such environment requires high yielding, consumer preferred, and disease tolerant and indeterminate type of cultivars. Among many crops, tomato has been commercially grown in the mid hill regions and has further scope of its area expansion due to high market prices in the recent years. Farmers have been showing keen interest to produce F_1 seed of tomato under the proper guidance of research organization like NARC. All the activities of the project contributed to fulfill the demand of quality F_1 seed of tomato cv Srijana in some extent.

Use of quality seeds alone can significantly increase the crop yield (SAARC, 2011). For food security seed security is fundamental one. Seed sector has been identified as high value commodity and suitable for rural area even where no transportation facility was there. Hybrids can provide increased yield stronger resistant to disease, greater adaptability, uniformity in maturity and other fruit quality traits (Jones et al., 2014).

OCCURRENCE OF DISEASE AND PESTS

During the process of project implementation, the frequent problems encountered in Kaski sites were of bacterial disease, i.e. *Erwinia rot* which was managed by application of copper fungicides. In addition, two fungal diseases like late blight and septoria were pre dominant in the crossing tunnels which were managed by using contact and systematic fungicides. Occurrence of white fly and helicoverpa was observed in every year and in all locations throughout the project duration, which was managed by frequent spray of systematic insecticides. The prophylactic sprays for diseases (Late blights) and pests (aphids and whitefly) are strongly recommended for hybrid seed production.

INFRASTRUCTURE FOR HYBRID SEED PRODUCTION

Use of plastic in agriculture in Nepal was initiated by Japanese volunteer and Nepalese technicians in Dhading area since BS 2035/36 (1978 AD). In F_1 seed production there should not be moisture present around stigma at least four hours for better receptivity. In mid hill situation it may be quite difficult to produce F_1 seed in open field condition because of high rain fall in June to August, when crossing should be performed. Plastic house could be constructed using bamboo or other materials like mild steel rods, angle iron, GI or CI pipes, etc.

MAJOR CONSIDERATION AND ISSUE FOR F_1 SEED PRODUCTION

Acquisition of inbreds, skill enhancement and strong technical monitoring are three important aspects which need to go hand in hand for the successful hybrid seed production.

Formal process for hybrid seed production

The parental lines of Srijana hybrid were maintained by Horticulture Research Division (HRD). An official MoU was signed between the third party after obtaining the letter of recommendation from Seed Quality Control Laboratory. The inbreds were provided to these parties at minimal cost basis and the technical monitoring was done twice as mentioned in MoU. The inbreds were obtained annually from HRD and monthly progress was updated to HRD by the hybrid seed producers.

Production and maintenance of inbreds

Hybrid tomato seed production requires the planting of inbred breeding lines that have originated from single plants chosen for their special traits. In hybrid seed production the purity of parents is extremely importance. Therefore, every effort was made to avoid seed mixture during planting and transplanting. In addition, any off-type plants were removed by trained personnel. This activity was repeated two or three times prior to pollen extraction or pollination.

Optimum stages identification

Flower must be at late bud stage of development (i.e. closed and not turned yellow). Care must be taken to ensure that the receptive stigma is not damaged during the emasculation. Fruit without marked sepals are discarded prior to harvest to prevent accidental mixture of fruit from open flowers with hybridized fruits. To obtain the optimum viability, the seeds should be extracted from fully ripened fruits. The number of buds crossed and retained per plant should be 80-90 per plant and the number of buds per cluster should be 3-4 for the quality seed production.

Skill enhancement and monitoring and supervision

Hybridization is skilled based work and the skill and speed of the workers is very important factor for success of hybrid tomato seed production. The amount of seed obtained directly depends upon the number of buds pollinated by single worker in one day. At the initial stage the crossing speed of the skilled labors is slow so there might be huge amount of loss of mature buds and the business might be in loss. It is recommended that a single worker should cross at least 2500-3000 buds per day during prolific flowering.

Monitoring and supervision is equally important for the maintenance of quality seed. The supervision should focus on removal of the off-types and to identify the non crossed fruits. Minimum two supervisions from the technicians at the time of first crossed fruit setting and during the first harvest are mandatory.

Status and access of tomato hybrid seed

Availability of good quality seed is insufficient in Nepal and farmers have to depend on Indian and third country for tomato F_1 seed which is comparatively costlier and of uncertain quality. Timely availability, maintenance of quality and appropriate type for Nepalese market are major issues in hybrid seed production.

The seeds worth millions used for this cultivation is imported from different countries. The hybrid seeds obtained from abroad in some cases may not be suitable for our agro-ecological conditions. In addition, the imported hybrids are very expensive and in spite of paying high price, the reliability of the hybrids is questionable. The consistency in quality and supply is another major problem in imported seeds. More than 50% tomato cultivation was collapsed in Bharatpokhari area of Kaski district due to inadequate research and recommendations.

FARMER VIEWS

With the increasing demand of F_1 seeds in commercial pockets information flow was definitely very useful during project period so that the farmers could produce F_1 seeds of Srijana in their own socio-economic situation. However, proper and regular guidance of the expert is necessary. For the management of diseases and insects integrated pest management practice was adopted and got succeeded to overcome various problems. Training was found as an effective learning tool to change the knowledge and skill of the participants. Twelve seed producer farmers and technicians got expertise in tomato hybridization techniques. Being high profit oriented nature of work, some farmers are very much motivated to continue this. However, they want NARC's regular support to provide parent lines and technical guidance. The parental lines for Srijana is maintained and distributed by Horticulture Research Division, NARC at Khumaltar. The inbreds are provided by the Division to those parties, who have the MoU with HRD.

The twelve farmers trained by the project were the human assets in hybrid seed production of tomato. However, follow up is necessary to further empower them. District Agriculture Development Office should internalize this program in district seed production program with technical collaboration with NARC and need to extend to other districts. NARC should provide parental lines and technical assistance to such seed producing farmers.

CONCLUSION

Women farmers were able to produce 11.4 kg F_1 seeds of Srijana tomato. They could continue to produce F_1 hybrid seeds themselves and make available quality F_1 seeds of tomato in genuine price. Farmers have adopted F_1 seed production and tomato production as good income generating technology. Twelve seed producing farmers got expertise in tomato hybridization techniques and they produce F_1 hybrid seeds in their own socio-economic conditions. With the increasing demand of F_1 seed in the market, this business will continue in the future. This success story indicated that, if technicians and farmers are trained, such high level technical work could be done by themselves. Such strategy of training on commercial F_1 tomato seed production should be expanded to other areas for harvesting the potential benefit of hybrid.

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A CASE STUDY ON BOTANICAL PESTICIDES AND VERMICOMPOST FERTILIZER FOR ADOPTING NEW AGRICULTURAL PRACTICE BY FARMERS

Manoj Kaphle [1] Nagendra Bastakoti[2]

ABSTRACT

For last 3 years, vegetable growers from Devdaha and Kerawani VDC of Rupandehi and Daunnedevi and Rupaulia VDC of Nawalparasi districts Nepal are concerned to minimize the practices of using chemical pesticides exploring several options. Action research was carried out to dessiminate the effect of botanical pesticide and vermi-compost fertilizer with major aspects: perception and adaptation. Household surveys and focus group discussions (FGDs) were carried out which was analyzed measuring frequency; percentage; indexing; mean and standard deviation. Results show that the adoption rate of botanical-pesticides and vermi-compost was increased by 45% and 60% respectively. More than 80% farmers were motivated towards the use of vermi-compost and botanical pesticides. Vermi-compost was also found cost efficient comparing with Urea. More could have been done in transforming conventional farming into an organic one in studied area, where commercial olericulture has been seen as a booming business.

***Key words**: Botanical pesticide, Perception of farmers, Raw materials and Vermicompost*

INTRODUCTION

Rupandehi and Nawalparasi districts lie in western Terai parts in the western development region of Nepal covering 1360 and 2162 Sq. Km, respectively (DADO, 2014). Research area covers four Village Development Committees (VDCs), two in each district: Kerwani and Devdaha VDCs lie in Rupandehi district whereas Daunnedevi and Rupaulia VDCs in Nawalparasi district. A small survey before research provided scenario of people and their livelihoods in these four VDCs. Regarding the survey, education level of people was categorized into five levels, namely- Illiterate, literate (non-formal education), education level between class one to class five, class six to secondary level and above. Among them, only three levels were observed and majority of farmers found to be in between class 6 to secondary level. 17% farmers were illiterate and that of 30% were observed with education levels of class 1 to 5. In the other hand, land was found as main asset of people which determined their economic status in these VDCs. 47% house hold found with less than 0.5 hectare of land, 33% HH with 0.5 ha to 1 ha of land and reaming 20% HHs owned more than one ha of land. Same as about 80% farmers appeared with one hectare or less than that. The average land holding found 0.62 ha (±0.576). Same as livestock unit also considered as property of marginal people, larger the number, higher the status in society. 95% farmers were holding at least one cow or buffalo and/or few goats to feed their family as well as sell the product if found surplus. The average number of livestock per HH was 3.46 (±1.81) livestock unit (LU). The minimum and maximum numbers of livestock found to be 1 and 8.8 units, respectively (UMN, 2014).

Growing vegetables for their consumption was found as good practice initiated from last 6 years, however few people initiated (20 HH) vegetable as their business. 100 HH found growing vegetable to sell in market. Khaireni in Rupandehi and Bardaghat in Nawalparasi was the local market hub for this product. Only 5 % growers were able sell their product in big markets, Butwal and Parasi Bazzar, where they got more profit than other. Use of chemical pesticide by the commercial

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growers was common in the beginning days which was further controlled with introduction of alternative means such as urine, dung, herbs and plant debris (UMN 2013).

As several studies concluded that misuse of pesticides has caused soil degradation especially in the area of commercial agricultural production, it is essential to reduce the impact of chemical on both human and soil health by using alternatives means to control insect and pest in Nepal. Majority of the farmers are unaware of pesticide types, level of poisoning, safety precautions and potential hazards on health and environment. According to the latest estimate, the annual import of pesticides in Nepal is about 211 mt. a.i. with 29.19% insecticides, 61.38% fungicides, 7.43% herbicides and 2% others. The gross sale value accounts US $ 3.05 million per year. Average pesticides use in Nepal is 142 g a.i./ha, which is very low as compared to other Asian counties (Sharma et al 2012). Pesticidal misuse is a serious concern. Over use of these chemicals have severe effects on environment that may lead to an immediate and long term effects. Investigating farmers' awareness of agrochemicals residues and their behaviors regarding application is important in order to reduce human factors that negatively affect agricultural safety (Bhandari, 2014).

In this regard, various organizations are concerned to minimize the practices of using chemical pesticides by exploring several options while performing the interventions through different types of programme. Home gardeners in Nepal apply Zhol Mol, an organic liquid pesticide made of Neem leaves, Timur, garlic, livestock urine, and water, to their vegetables and fruits. Similarly, farmers in Nepal also found using Neem trees as a natural pesticide. Neem trees, which can also be found in the Sahara Desert and Florida, can repel pests such as spider mites and cutworms (Salinger, 2012). Similarly creating awareness through training, campaign, visit to organic farm and demonstration on organic pesticides (made from plant and animal debris) are major ways applied to minimize the effect of chemical pesticides in recent days. In addition, knowledge has been transferred on preparation of compost and vermi-compost in farmer's field of ten districts of Nepal including Nawalparasi and Rupandehi, which also minimized the practice of using chemical fertilizers beyond the recommended dose. Hence, the study was carried out to document the "Effect of botanical pesticide (BP) and vermi-compost (VC) fertilizer on three major aspects: perception and adaptation by the vegetable growers living in Rupandehi and Nawalparasi districts, where farmers started to adopt alternative means of pesticide and chemical fertilizer while cultivating vegetables.

METHODOLOGY

The methodology consists of conceptual framework, operational definition, location of the study, sampling techniques, procedure and sample size, research instruments, level of data collection and data analysis.

AREA OF ACTION RESEARCH

This study was conducted in Kerwani and Devdaha VDCs of Rupandehi district (1360 sq.km) and Daunnedevi and Rupaulia VDCs of Nawalparasi district (2162 sq.km). Both districts lie in western Terai parts in the western development region of Nepal (DADO Rupandehi, 2013 and DADO Nawalparasi, 2013).

SAMPLING TECHNIQUE, PROCEDURE AND SAMPLE SIZE

Farmer practicing at least one activity either vermi-compost and/or BP preparation of respective VDCs constituted the sampling population of this study. It has already been found from the preliminary key informant survey that the numbers of vermi-compost users and botanical pesticide users in VDCs were 100 HHs but only the sample of 30HHs were selected for individual interview along with four focal group discussion having 20 members in each discussion.

TECHNIQUES OF DATA COLLECTION

Face to face interview method was used to collect the information. The respondents were interviewed with the help of semi-structured questionnaire. Focus Group Discussions were also carried out to collect primary data.

DATA ANALYSIS

A number of descriptive and inferential statistical tools were employed to analyze the data such as frequency; percentage; indexing; mean and standard deviation etc. The statistical method used for inferential purpose was correlation coefficient (r). These were tested at 0.01 and 0.05 level of significance. Pearson Product moment correlation coefficient 'r' was used to predict the interdependencies of the independent variables.

RESULT AND DISCUSSION

CROP YIELD

On an average, one farmer was producing vegetables from 1332 to 1665 meter square of land. However, about 40% farmers found lacking to supply sufficient amount of FYM in their land. More than 65% farmers claimed that they are succeeding in reducing use of chemical pesticides in vegetables significantly (25%). According to them, all of them are using both chemical and organic means of inputs and only practices are not sufficient at the moment and it will not be sustainable. During FGD farmers could not deny that yield of organically produced either vegetables or crops in the first two years will decreased but it can be gradually recovered after 3 years. During this period small farmers cannot sustain because of investment and profits.

Majority of farmer assumed that yield would be decreased for the first and second year and they believe on the production increment after 3rd year, however, financial difficulties occurred to sustain the practice. So they were extremely reluctant to adopt complete organic crops and vegetable production. It is obvious that farmer may incur loss in two ways: firstly by losing productivity and secondly by investing higher cost of production. So, it would be difficult to sustain for small holders as majority of the farmers are holding less than 0.5 ha of land. It was revealed that yield of vegetable in the observed HH was not consistent. Some farmers claimed the decrease in the production of potato and cauliflower whereas some of them reported increase by 10-20 percent.

Overall, there still is maneuver to see the effect of vermi-compost and botanical pesticide on yield of crops. Yield recorded during research could not justify the consistence of yield; increase or decrease in yield might be due to vermin-compost and BPs or might not. For this in-depth analysis from larger area is required.

DIMINISHING USE OF CHEMICAL PESTICIDES AND FERTILIZERS

The survey identified that 45% of the respondents following botanical pesticide and 60% respondents adopting vermi-compost which was disappeared or not known before three years. In the mean time, the respondents showed their unhappiness with some specific pest and diseases (during FGD) hence, some of them had been using chemical pesticides as well. According to them, chemical fungicides required to control late blight of potato and tomato and that of soil dwelling insects like white grub, cutworms. Farmers could not find any registered organic pesticides to control these disease and pests. So, sometime they used Copper Sulphate to control some diseases in tomato which was too expensive to use in tomato.

The study identified that farmer's awareness about the hazard category of pesticides. So they reduced the application of chemical pesticides especially those which are extremely hazardous pesticides i.e. red category of insecticides (phorate (thimet), Methyl Parathion (Malathion) and Carbofuran (Furadan), however dichlorovous is being used by farmers. Similarly, chemical fertilizers, especially rampant use of urea, had been reduced by more than 75%. Its use has been reduced in vegetables and that of FYM application found increasing. According to vegetable growers use of chemical pesticides had been reduced by more than 60% and that of chemical fertilizer by more than 50%. On the other hand, use of FYM and vermi-compost was found increasing. More than 80% respondents showed their interest to produce and adopt vermi-compost, however, the raw materials like FYM could not be found easily in the villages, as a result, producing vermi-compost using different raw materials started to increase . It is due to decrease in density of livestock unit in the surveyed area. Tularam Pandey, a leading farmer said that previously about 34 kg of chemical fertilizer was used in 333 meter square of land. They were hardly using 300 kg of FYM in 333 meter square of land, which started to shift by more than 600 kg of FYM and less than 10 kg of chemical fertilizer in same piece of land (333 meter square)

COST OF VERMICOMPOST PRODUCTION

All variable cost and fixed cost were taken for the cost calculation. It was observed that average cost of one kg vermi-compost was found to be Rs. 13.3. Of the total cost casual labor cost was high which accounted about 36.6% of total cost followed by earthworm cost (21.6%), other raw materials (16%), FYM (11.8%) and annuity for fixed cost (14%). Farmers were using different materials to prepare vemi-compost and botanical pesticide. Commonly; they were using sand as base, banana leaf, paper, earthworm, farm yard manure to prepare vermi-compost. The proportion of raw materials varied among the farmers. It was observed that farmers started to use raw materials especially, degradable material available locally. Similarly, in case of botanical pesticide locally available Eupatorium leaf (*Eupatorium perfoliatum*), Melia leaf (Melia *azedarac*), Neem (*Azadirarchata indica*) , Asuro (*Adhatoda vasica*), Garlic, Onion, Tobacco, Chilli, urine, Sichuan pepper (*Zanthoxylum Spp*) Soya bean floor etc were found to be used.

Table 1.Raw material used to manufacture botanical pesticides and vermi-compost.

Vermicompost	Amount (kg)	Botanical pesticides	Amount
Eupatorium leaf (*Eupatorium perfoliatum*) – Banmara in Nepali	7	Urine of cow	7 lit
Malabar nut , (*Adhatoda vasica*)- Asuro in Nepali	20	Mugwort (*Artemisia vulgaris*)- Titepati in Nepali	3 kg
Mugwort (*Artemisia vulgaris*)- Titepati in Nepali	12	Malabar nut , (*Adhatoda vasica*)- Asuro in Nepali	3 kg
Neem leaf (*Azadirarchata indica*)	5	Neem(*Azadirarchata indica*)	5 kg
Melia leaf (*Melia azedarac*)	5	Chilly	60 gm
Earthworm	4	Tobacco	100 gm
		Garlic	100 gm
		Sichuan Peeper (*Zanthoxylum simulan*) – Timur in Nepali	50 gm
		Onion	150 gm

Attributes like cost, complexity, productivity, profitability, compatibility, efficiency, input available and manure sufficiency were selected and analyzed. Table 2 presented below shows the detail of attributes, while Table 3 shows their correlations. Significant contribution of compatibility to adoption behavior of farmers suggested that the preparation of vermi-compost and botanical pesticide seemed in line with the existing values, past experiences and present needs of the farmers. So, no more difficulties found to the farmers to switch-over to that practice.
Finding shows that cost of vermin-compost and botanical pesticide production is not stronger than previous parameters. So farmers ranked cost in 5th rank (Table 2), indicating other important factors to be considered. Cost is highly correlated and significant (0.01 level) with efficiency of vermin-compost production (Table 3). The practices which were perceived as costly by the farmers were likely to be adopted by them as much as the less costly practices. This finding was contrary to the general expectation and suggested that production cost of vermi-compost and BPs had no direct influence to its efficiency

It indicated that the practices, whether complex or simple, would be adopted equally by the farmers. It suggested that the simple and easily understood practices had faster rate of adoption than the more complex practices (Table 2).

More productive practices are always expected to be adopted by the farmers than the less productive innovations, but the present study was against this general expectation. It suggested that only production aspect could not predict the adoption behavior of farmers because more productive practices may not always be compatible.

Profitability, an important attribute of a farm practice, was found to be an important factor affecting the rate of adoption. Where farmer perceived high profits, adoption was high.

Though the finding reported no influence of efficiency on adoption of vermi-compot and botanical-pesticides, it might be partially responsible for the high correlation between compatibility and adoption as an efficient practice is always expected to have high level of adoption. (Table 2)

Table 2. Perceived attributes of vermi-compost use and botanical-pesticide use

Parameters	Mean	Std. Deviation	N
Manure Sufficiency	2.5667	0.97143	30
Complexity	3.0667	0.98027	30
Input availability	3.3333	1.21296	30
compatibility	3.6000	1.22051	30
Cost	3.7667	1.30472	30
Productivity	3.9667	0.55605	30
Efficiency	4.0333	0.96431	30
Profitability	4.3000	0.74971	30

Table 3. Correlation on perceived attributes of vermi-compost use and botanical-pesticide use

	Cost	Complexity	productivity	Profitability	compatibility	efficiency	Inputavailable	Manure Sufficiency
Cost	1							
Complexity	0.417*	1						
productivity	-0.059	0.067	1					
Profitability	0.004	-0.075	0.687**	1				
Compatibility	0.069	0.398*	0.640**	0.701**	1			
Efficiency	0.527**	0.472**	0.259	0.415*	0.627**	1		
Inputavailable	0.225	0.010	0.682**	0.720**	0.489**	0.344	1	
ManureSufficiency	0.380*	0.285	0.547**	0.658**	0.692**	0.679**	0.712**	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Input availability was ranked in fifth most important factor of adoption by farmers. For vermi-compost preparation and botanical-pesticide preparation input are not major problem in the adoption of those techniques. Manure availability was also asked to rank, but this was the last important factor of adoption as this is easily available in the villages, which also corroborates by the number of livestock holding by individual households.

ACCEPTABILITY OF BOTANICAL PESTICIDE AND VERMICOMPOST FERTILIZER

It was revealed that more than 70% of the farmers claimed to produce vermi-compost without further training, however, were looking for more technical help in different aspects like introducing novel ideas in villages. So, regarding reason of its adoptability farmers were asked to rank different parameters. The perceived reasons for the production of vermin-compost and botanical-pesticides are given in the Table 3. It was observed that healthy or no side effect from vegetables produced by using vermin-compost and botanical-pesticide ranked first position followed by maintenance of soil fertility and tasty and nutritious, Same as conservation of environment, longer storability and lower economic burden ranked 4th and 5th position, meanwhile, efficient use of local resources and high preferences by the consumers came at 6th and 7th positions respectively. Vegetables produced by using either vermi-compost and/or botanical-pesticides found to be used in household level for daily consumption but not for the market. They believed that vegetables produced without chemical means have no side effect on human health. However, market for those products not secured due to same market price between chemical used and chemical free products in market. They claimed that the use of organic manures in terms of vermi-compost and use of botanical-pesticides might increas the activities of microorganisms as an result they felt increasing status of soil fertility.

Table 3. Preference given to Botanical pesticide and Vermi-compost to produce vegetable

Reasons	Index	Rank
Maintenance of soil fertility	0.49	2
Vegetables- tasty and nutritious	0.52	3
Conservation of environment	0.53	4
Longer storage life	0.60	5
Lower economic burden	0.60	5
Efficient use of local resources	0.63	6
High preference by consumers	0.65	7

The above results show the high level of awareness on the farmers for the conservation of environment. In their own words, they started to reduce the use of chemical fertilizers and pesticides as they became familiar with hazardous effect of those chemical means. The chemical fertilizer and pesticides used in the fields get washed out of the soil into the source of water contaminating the drinking water. Further, the chemical pesticides sprayed on crops and vegetables made the environment more polluted causing many harmful effects on human and other living organisms. Farmers also experienced that vegetables produced using vermin-compost and botanical-pesticides have longer storability, more than 2-3 days. In other hand farmers found greatly lacking alternatives of chemical pesticides, due to which, they were bounded to use some pesticides for specific crops like late blight of tomato and potato.

Regarding the economic point of view, farmers thought that use of locally available resources like manure for vermicompost and like Eupatorium leaf (*Eupatorium perfoliatum*), Melia leaf (*Melia azedarac*), Neem (*Azadirarchata indica*), Asuro (*Adhatoda vasica*), Garlic, Onion, Tobacco, Chilli, urine for botanical-pesticides reduces the economic burden. However, they claimed that the voluminous production is a big challenge and side by side uniform quality of the botanical-pesticide was found to be a great problem. Farmers claimed that the consumers relatively prefer the products produced without chemical means but due to the lack of standardization of such products consumers had suspicion whether to buy or not. So, they are not ready to pay high prices in research area.

In an other hand, it was observed that the farmers faced many problems related to technical, production and consumption aspects of vermi-compost and botanical-pesticides. This study identified pest and disease attack as most serious problem in the field using vermi-compost and botanical-pesticides. Other problems, like, lack of enough knowledge on vermi-compost and botanical pesticide preparation, negligence of consumers, no price differentiation, lack of effective organic fertilizers and pesticides, lack of adequate biomass (raw materials), decrease in production, labor demanding and complexity in making procedure ranked 2nd, 3rd, 4th, 5th, 6th, 7th, 8th and 9th, respectively. Some of the problems were found interrelated. For example, lack of proper knowledge on vermin-compost and bio-pesticides preparation, lack of adequate biomass, lack of effective organic fertilizers and pesticides, were related to more pest and disease problem and low productivity of organic vegetables. Similarly, negligence of consumers was related to not satisfactory price difference between the organic and inorganic produce (Table 4).

Table. 4 Problems faced by the adopters of organic vegetable production

Problems	Index value	Rank
Complexity in making procedure	2.55	9
More labor demanding (collection and preparation)	1.98	8
Decrease in production	1.95	7
Lack of adequate biomass, raw materials	1.84	6
Negligence of consumers	1.55	3
No price difference on product	1.56	4
Lack of enough knowledge on preparation	1.49	2
More pest and disease attack	1.48	1
Lack of effective organic fertilizers and pesticides	1.58	5

Most of the farmers were facing the problem of pest and disease infestation in organically produced tomato and potato. The restricted use of chemical fertilizers and pesticides, lack of effective organic fertilizers and pesticides in the market and lack of knowledge on preparation of organic pesticides increased the problem of insects and pests.

The farmers claimed that a large number of consumers are not aware of IPM or organic products. They further added that even the aware consumers never ready to pay higher price for organic produce. As stated earlier, the restricted use of chemical fertilizers, complete avoidance of synthetic pesticides, insufficiency of organic manures and botanical-pesticides, lack of effective organic fertilizers and pesticides in the market and more pest and disease problem had decreased the yield of vegetables. In addition, farmers were also facing the scarcity of laborers; however vermi-compost and botanical-pesticide preparation needed more laborers which ultimately increase the cost of production.

During the FGD, it was revealed that lack of time management by farmers and poor management of earthworm, seemed major practical problems. According to them, application of BPs found time consuming with high frequency of application as compare to chemical pesticide.

ORGANIC AND INORGANIC MEANS OF INPUT SOURCES

It was observed that 100 percent of farmers were adopting Integrated Pest and Nutrient. Management (IPNM) practices (about 20 to 30% were using vermi-compost and botanical pesticide as fertilizer and pesticides, respectively) in producing vegetables and crops. Researcher asked to rank the reason behind to follow integrated pest and nutrient pest management to the participant farmers. Lack of confidence was observed the prior reason which was caused due to the lack of demo plots or trial experiments locally (Table 5).

Table 5. Farmers preference on integrated farming

Reasons	Mean	Std. Deviation
Lack of trials/demo-plots	2.03	1.47
Decrease in productivity of organic vegetables	2.06	0.90
Ineffectiveness of organic pesticides	2.10	1.06
Lack of organic market	2.33	1.18
Lack of enough knowledge on organic vegetable production	3.80	1.60
Lack of adequate biomass	3.86	1.81

They strongly agreed to require trials and demo plots to motivate farmers towards botanical pesticide and vermin-compost which was absent in conventional farming practices in the village. Secondly, they believed that only organic production practices reduces yield of crops so they started to follow integrated pest and nutrient management practices. Ineffectiveness of organic pesticides for insects and diseases, lack of separate market channel for IPM products or organic products ranked in 3rd and 4th position, respectively. Lack of enough knowledge on vermin-compost production and BP preparation for organic production found another reason of adopting integrated farming. Lack of adequate biomass or inputs for vermi-compost ranked the last; indicating that this is not the major reason for adopting integrated pest and nutrient management.

FARMER'S CONCERN IN REPONSIBILITIES OF GOVERNMENT

Farmers were also asked to rank government's role on the promotion of vermi-compost and BPs on various parameters, namely; premium price on IPM products, awareness program to producer and consumer, technical knowledge to the producers, and support on input availability and subsidy on organic inputs (Table 6).

Table 6. Farmer's perception on the role of government in promoting vermi-compost and BPs

Options	Index	Rank
Provide premium price on products and market assurance	4.14	1
Awareness program to producers	4.07	2
Aware program to consumers	3.38	3
Provide technical knowledge to the farmers	2.93	4
Support on input availability	2.45	5
Provide subsidies on inputs	2.07	6

According to them, for the promotion and adoption of such technology government should focus primarily on premium price and market for the product. Other options like awareness program to producers, consumers, technical knowledge, input availability and subsidy on inputs kept in the orders of 2nd, 3rd, 4th, 5th and 6th respectively. Government support on providing subsidy appeared as the least important category. This reveals that farmers are more concerned about the market and premium price of the IPM/organic products.

CONCLUSION

There are many technologies and techniques such as: Integrated Pest and Nutrient (IPNS) which is near to organic farming. Among them vermi-compost and botanical pesticides have been found easy and adoptable means of chemical free farming while comparing the people's perception and practice from last three years in Rupandehi and Nawalparasi districts. This research measured the effect of both organic means; botanical pesticide and vermi-compost on perception of farmers and its adaptation concerning to yield, cost of production and raw material availability. The result indicated farmers changing practice in vegetable farming as 100 percent of farmers started to adopt Integrated Pest and Nutrient Management (IPNM) practices which further moved towards chemical free vegetable farming system. It was found that 45% and 60%, of people adopting botanical pesticide and vermi-compost respectively. About 83.3% of the farmers seemed to be motivated to the required level. In case of vermi-compost, farmers were found comparatively more motivated than that of botanical-pesticides. From the survey we can say that about 20% farmers felt high risk of losing crops if they followed only organic farming. This could be attributed to insecurities of farmers towards vermi-compost and botanical pesticides. From household survey, FGD and key informant interview we found that most of farmers were trained in different aspects of IPM or Organic farming locally followed by monitoring and supervision by District Agriculture Development Office. In the mean time, 65% farmers claimed that they became able to reduce application of chemical pesticides in vegetables significantly (25%). The usual pretense would be risk of insect predators like red ants or lack of reinforced structures for rearing earthworm. As survey claimed, majority of farmers seemed well convinced about the effectiveness of botanical-pesticides. While calculating all variable cost and fixed cost, it was observed that average cost of one kg vermi-compost is NRP 13.3, as compare to Urea fertilizer having NRP 25 per kg. Hence application of vermi-compost found more cost efficient than chemical fertilizer. Regarding the yield of vegetable, majority of farmer assumed that yield would be decreased for the first and second year and they believed on the production increment after 3rd year. To address the real issues of farmers, supporting hands from government and developing organization can only bring the sustainable change in the attitude of farmers towards conservation agriculture and against conventional chemical based agriculture. Above facts and figures show that there is still a huge space to work to achieve the goal of pesticide free agricultural practice in Rupandehi and Nawalparasi districts, where people are expecting much more from concerned organization.

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IMPACT OF CLIMATE VARIABLES TO MAJOR FOOD CROPS'YIELDIN MIDHILLS OF WESTERN DEVELOPMENT REGION, NEPAL

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ABSTRACT

Climate change is threatening the agriculture sector especially on present and future food security in low income countries. Primary and secondary data collected through household survey and collected from different secondary source were used to assess the effects of climate variables on crop yield and the uniformity of effects across crops and growing seasons in Kaski district considering six major food crops as paddy, maize, wheat, millet, Barley and potato. A multivariate regression analysis, based on the first difference time series of crop yield and climate variables, is employed to estimate the empirical relationships between crop yield and climate variables. The results are discussed at district level empirically. It showed that climate variables significantly influence the crop yield, but not uniformly on all crops and in all growing seasons.
Key words: *Climate change, crop yield, food crops, regression analysis*

INTRODUCTION

Climate change is a phenomenon due to emissions of greenhouse gases from fuel combustion, deforestation, urbanization and industrialization resulting variations in solar energy, temperature and precipitation. Climate change affects crop growth and development, due to changes in the mean and variability of rainfall and temperature (Challinora and Wheeler, 2008).Temperature rise and rainfall variation cause drought, flood, landslide, and soildegradation that lead to declining global agricultural productivity (IPCC, 2007). The year-to-year variability of rainfall and temperature is the primary source of agricultural production risk that causes uncertainty in crop yield (Cabas*et al.*, 2010). There is no uniformity in the directionand magnitude of effects of climate variable on crops (Granger, 1980).Higher variability intemperature (higher maximum and lower minimum) negatively affects the yieldof several crops (Mc Carl *et al.*, 2008). Though developing countries did not contribute much in increasing the level of GHGs they are highly affected by climate change and have low adapting capacity. Climate Change has serious impact on cereal crops and livelihood of farming community.). Effects of climate change on agriculture are particularly high as the agriculture produces food and provides the primary source of livelihood for large chunks of weaker sections of the society (Pant, 2012). Its impacts are severe in developing countries because they have rain-fed farming systems and weak capabilities in their technological adaptation (Ogallo*et al.*, 2000). Rain-fed agriculture is likely to be affectedadversely by climate change (Pant, 2009). Because of high dependence on theagricultural sector, loss of agricultural productivity due to climate change significantly affects the economy of many developing countries (Gebreegziabher*et al.*, 2011). The impacts of climate change have already been noticed in theagricultural sector in Nepal. Nepalese agriculture is rain-fed and relies mainly on weather patterns, so even small and short period weather extremities adversely affect the production.The agricultural sector dominates

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Nepalese economy; the contribution of agriculture and forestry sectors to total Gross Domestic Product (GDP) over 2001/02 to 2010/11 is 34.2% on average (MoAD, 2012). Agricultural dependence makes the economy sensitive to climate variability (World Bank, 2002). Intensive rain concentrated in a particular month has a devastating effect on crop production (McCarl*et al.*, 2001). 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.

Previous studies by Welch *et al.*, 2010; Sheehy *et al.*, 2006; Chen *et al.*, 2004 suggest that there are heterogeneous effects of climate variables on crop yield that depend on crop types, growing seasons, and regions. The existing studies do not cover the assessments of the intra-regional site-specific variations of the impacts of climate change on crop yield. Spatial patterns of climate and their effects on crop yield are essential to identify vulnerability and determine the suitable regional agricultural adaptive strategies to climate change (Tao *et al.*, 2008). A betterunderstanding of the empirical relationships between crop yield and climate variables is essential for implementing adaptation to climate change inagriculture (OECD, 2012). There are few studies in Nepal (Poudel and Kotani, 2012; Pant, 2012; Joshi *et al.*,2011; Malla, 2008) that empirically evaluate the effects of climate variables oncrop yield. Malla (2008) analyzes the relationships between climate scenariosand agriculture, which is based on datagenerated in a controlled experimental condition. Joshi *et al.* (2011) assess the relationships between crop yield and climate variables by using time series analysis, but their study does not cover the heterogeneity of climate change impacts on crop yield across spatial dimensions within Nepal and has limitations in capturing the effects of the intra-seasonal variations of climate variables on crop yield. Poudel and Kotani (2012) assess the relationships between crop yield and climate variables and the heterogeneity of impacts across growing seasonsand altitudes in the central region of Nepal, but do not assess the heterogeneity ofclimate change impacts on crop yield within geographic regions and their study has limitations in capturing the effects of day versus night temperature on crop yield.

This study evaluates the empirical relationships between crop yield and the corresponding growing seasonal climate variables in different sites within Kaski district of Nepal. The study assesses the impacts of growing seasonal climate variables on the yield of the major food crops (paddy, maize, wheat, millet, barley and potato) across crop types, growing seasons, and adds information and insight to the existing literature of climate change impacts on Nepalese agriculture. The findings are useful for estimating climate variable effects on crop yield and identifying the most vulnerable crops for prioritizing strategies for adapting to climate change. An understanding of the impacts of recent climate trends on major food-crops would help to anticipate impacts of future climate changes on food self-sufficiency of the country.

Both maximum and minimum air temperatures are considered to assess the effects (direction and magnitude) of the day and night temperature on crop yield, assuming difference in the influence of day versus night temperature on crop. Maximum and minimum temperature can impact differently indifferent crops and on different regions; temperature increase during the day can have different effects on the crop than temperature increase during the night. The understanding of the effects of temperature during the day and night on crop yield is necessary because warming trend during the day and night differs; minimum temperature has been rising faster than the maximum temperature in some Asian countries (Welch *et al.*, 2010). In most regions, maximum temperature increase is more harmful to crop yield than minimum temperature increase (Lobell, 2007).

METHODOLOGY

Precipitation and temperature are the most widely used climate variables to assess the impact of climate change. Rainfall is the most important form of precipitation in terms of meeting water requirement of agricultural crops. Daily mean air temperature is the widely used temperature variable to assess the effects of global warming on grain yield. The use of mean air temperature assumes no difference in the influence of day versus night temperature. However, the inclusion of minimum and maximum temperature in the assessment will capture differential effects of day and night temperature as well as climate extremities to some extent.The study is based on primary (household survey)and secondary data.Literatures relating to the climate change and food security are reviewed in addition to the national policies relating to the food security directly and indirectly.

Regression models are useful to predict crop yield changes due to changes in climate variables, based on historical data on crop yield and climate variables, is common (Poudel and Kotani, 2012; Joshi *et al.*, 2011; Lobell and Burke, 2010; Kim and Pang, 2009; McCarl*et al.*, 2008 and Lobell and Field, 2007). The regression model using observed data of crop yield and climate variables is based on time series. In this study, a multivariate time series regression model, a common approach (Joshi *et al.*, 2011and Tao *et al.*, 2008) based on the first difference time series (difference in values from one year to the next) for yield and climate variables is used. It is assumed that crop yield responds to year-to-year changes of climate variables, and use of the first difference time series of the crop yield helps to remove the non-climatic influences such as adoption of new varieties and changes in crop management practices (Lobell and Field, 2007).

Crop specific growing seasonal averages are used to make the regression results realistic. Consideration of the growing seasonal average for each climate variable for each crop produces the best-fit model R^2 (Lobell and Field, 2007). This study considers the total growing seasonal rainfall, average growing seasonal maximum and minimum temperatures, and standard deviations of monthly rainfall and temperature within the growing season. The standard deviations of rainfall and temperature are included in the regression model to assess the intra-seasonal effects of climate variables on crop yield. The standard deviations of monthly rainfall and temperature within a growing season are considered on the basis that sub-seasonal variations are critical to crop growth.

Analysis is done for estimating the effects of rainfall and temperature on food production in Kaski district using multivariate regression analysis. The ordinary least square method is used to estimate the contribution of climate variables to crop yield. The STATA tool is used to run the regression model. The multiple regression function estimated in the study is expressed as (Joshi *et al.,* 2011):

$\Delta Yield = m+r_y\Delta Climate + \varepsilon$……………………………………………………………………………………………………(1)

Here, ΔYield is the observed trend in yield, m is the average yield change due to management and other non-climatic factors or intercept, ΔClimate is the observed trend in temperature and rainfall, $r_y$is the yield response to this trend, and ε is the residual error. Detrending of the yield and climate variables and using the residuals to calculate quantitative relationships between variation in climate and yield can remove non-climatic influences such as adoption of new cultivars and changes in crop management practices (Lobell*et al.*, 2005). Due to consistency in the availability of climate data from the Kaski district, the period from 1977 to 2012 collected from Department of Hydrology and Meteorology, Nepal. A period of more than 30 years is qualified for study of the impact of climate variables on yield of the food crops as response to climate change (IPCC, 2007). District average yields of the food-crops from 1980 to 2015 were collected from different publications of the Ministry of Agriculture Development.

Change in crops yields due to climate variables is calculated using coefficient of theclimate variables for the respective crops and observed change in the climate variablesduring the study period i.e., $\Delta Y_i=(\beta_{1i}*\Delta R)+(\beta_{2i}*\Delta T_{min})+(\beta_{3i}+\Delta T_{max})$. Here, ΔY_i is observed change in yield of i^{th} crop due to climate variable, and β_{1i}, β_{2i}, and β_{3i}, are coefficient of rainfall, maximum summer temperature, and minimum summer temperature respectively for i^{th} crop. Similarly, ΔR, ΔT_{min}, and

ΔT_{max} are observed changes in rainfall, summer minimum temperature, and summer maximum temperature, respectively, during the study period.

RESULTS AND DISCUSSIONS

CROPS' YIELD TREND

The yield trend of the food-crops based on the regression coefficient against time shows that time has significant (P-value <0.00) effect on yield of all the food-crops. However, the yield trend shows very different patterns (Figure 1). Potato has the highest regression coefficient against time variable. Potato yield has increased from 7.5 to 14.9 ton/ha from 1980 to 2015 contributing the yield growth rate of 2.16%. Except for the year 1985, during which the yield of potato declined, potato yield has been continuously increasing. Wheat also shows better performance in terms of yield growth. With the regression coefficient of 0.029 against time variable, yield growth rate of wheat is 1.91%. Yield growth rate of paddy is 2.37% during 1980-2015. Yield growth rate of only these three crops is higher compared to population growth rate (1.35%) of the country. Maize yield is also increasing but the growth rate is well below the population growth rate. Sharp decline in the yield of paddy and maize in 1982 and 2006 can be linked to sharp decline in summer rain in the same year (Figure 1 and 2). Yield growth of barley and millet, which are also a minor crops are relatively stagnant, growing at the rate of less than 1%.

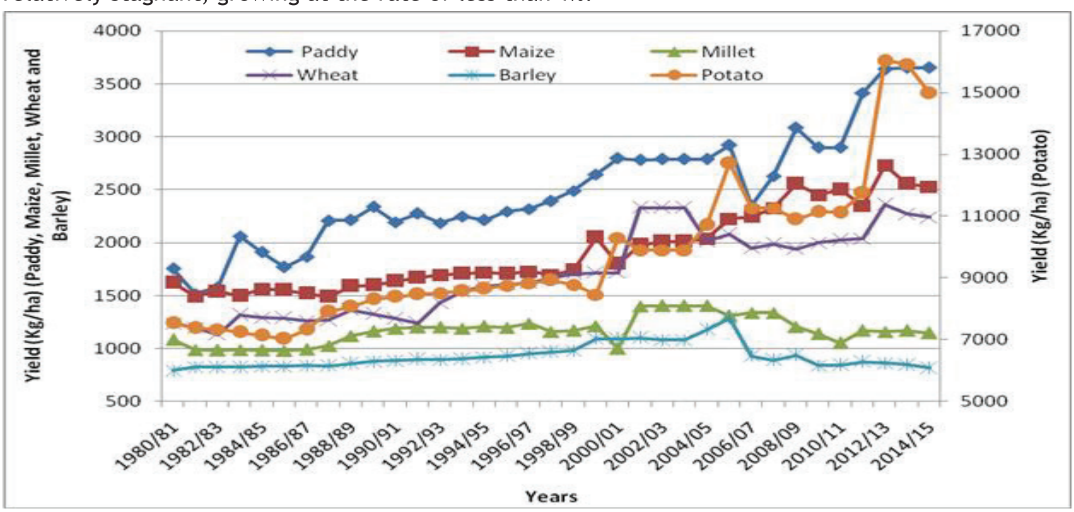

Figure 1 : Yield trend of major food crops in Kaski district

Source : Ministry of Agriculture Development, 2014

1.1 TREND OF CLIMATE VARIABLES

Trend of minimum temperature, maximum temperature,and rainfall for summer and winter is presented in Figure 2 and 3, respectively. Only maximum temperature for winter and summer season shows significant (P-value <0.00) increase over time, whereas minimum temperature and rainfall for both seasons show non-significant association with time variable.

Rainfall fluctuates over the years with less degree of predictability. However, it is inincreasing trend in summer season, but in decreasing for winter. The coefficients suggest that summer rainfall trend is increasing by 2.32 mm every year whereas winter rainfall is in decreasing trend by 0.59 mm every year. Rainfall in Nepal is concentrated during summer (around 75%) season. The positive coefficient for summer rainfall and negative coefficient for winter rainfall indicates that rain in summer is becoming more intense, which could hamper yield of summer food-crops due to water borne disaster like flood and landslides. However, still the relationship between rainfall and yield show positive correlation, i.e. yield will grow with increased rainfall and decrease with decreased rainfall. There was no rain during winter and the lowest during summer in 2008 which coincides with the low crop yield.

Coefficients of temperature for both seasons are positive except for winter minimum temperature. Winter maximum temperature is increasing at higher rate compared to summer maximum temperature. Summer and winter maximum temperature trend is increasing at the rate of 0.028^{0}C and 0.045^{0}C each year between 1977 and 2012, respectively. Summer minimum temperature is also in increasing trend every year by 0.01^{0}C. However, winter minimum temperature is decreasing trend each year but at very low rate 0.001^{0}C. Increase intemperature up to 2^{0}C will increase the food-crops yield in Nepal (Malla, 2008).

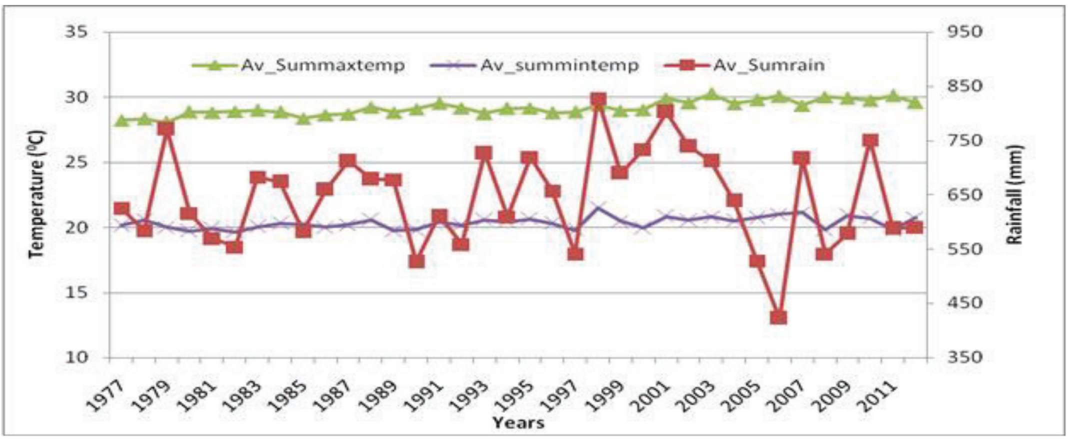

Figure 2 : Trend of average summer rainfall, summer maximum and minimum temperature of Kaski

Source : Department of Hydrology and Meteorology, Nepal

Therefore, the increase in temperature during the period i.e. below 20^{0}C would be favorable for growth in yield of food-crops. However, decline in minimum winter temperature could hamper the yield of winter crops as frost frequency caused by decline in minimum winter temperature which influence wheat yield adversely (Nicholls, 1997).

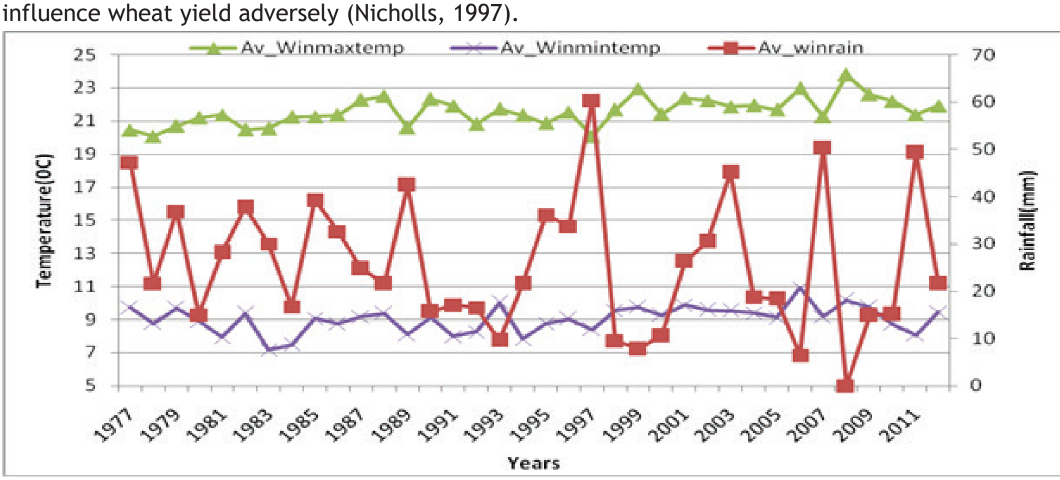

Figure 3 : Trend of average winter rainfall, maximum and minimum temperature of Kaski district

1.2 CLIMATE VARIABLES AND CROP YIELD RELATIONSHIP

The results from multivariate regression analysis are presented separately for both summer and winter crops in Table 1, and 2, respectively.

Table 1 : Relationship of summer food crops and summer climate variables

Variable	Paddy		Maize		Millet		Potato	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
Sumrain	0.012*** (0.004)	0.01	-0.002	0.43	-0.001 (0.001)	0.56	0.003 (0.013)	0.79
Summintemp	-0.15(0.12)	0.25	0.07(0.006)	0.32	0.02(0.03)	0.55	0.21(0.38)	0.58
Summaxtemp	0.06(0.11)	0.61	-0.13**	0.04	-0.04(0.03)	0.19	-0.02(0.35)	0.95
R^2	0.24		0.12		0.03		0.11	

Note *** Significant at the 0.01 level, and ** significant at the 0.05 level, Sumrain-Summer rainfall, Summintemp-Summer minimum temperature, Summaxtemp-Summer maximum temperature, figures in parentheses indicates standard error

The results suggest that the model is able to describe a variation in food-crops yield rangingfrom 25% in paddy to only 1% in the case of barley. Though, the regression results show very few significant relationships between yield and climate variables, such coefficient can be used to assess real effect of climate variables in change of yield of food-crops (Nicholls, 1997). In addition, sign of coefficients give direction of movement of yield against change in climate variable. Climate variables show significant relations with paddy and maize only. The coefficient indicates that paddy yield increase significantly with increase in summer rainfall. Maize yield shows negative relation with summer maximum temperature, i.e., if summer maximum temperature increases yield of maize will decline sharply.

Table 2 : Relationship between winter food crops and winter climate variables

Variable	**Wheat**		**Barley**	
	Coefficient	P-Value	Coefficient	P-value
Winrain	0.003(0.004)	0.52	0.001(0.002)	0.69
Winmintemp	0.04(0.03)	0.15	-0.002(0.02)	0.87
Winmaxtemp	0.008(0.03)	0.78	0.01(0.02)	0.54
R^2	0.13		0.01	

Note :Winrain-Winter rainfall, Winmintemp-Winter minimum temperature, Winmaxtemp-Winter maximum temperature

The current trend in climate variables has contributed positively to yield of both wintercrops namely wheat and barley. In the case of wheat, there is 581 kg increase of yieldduring the study period, out of which 28.1 kg is contributed by the current climate trend. Decreasing winter rain and winter minimum temperature offset the positive effect ofincreased winter maximum temperature. For barley, the current climate trend contributed around 28% of the yield increase. Such increase can be attributed to increased winter maximum temperature and decreased winter minimum temperature. In the case of summer crops, only paddy is favored by the current climate trend. It has contributed 34 kg increase in paddy yield. An increase in summer rain and summer maximum temperature has contributed highly in such increase in paddy yield. Other crops especially maize is adversely affected by the current climate trend in Kaski. The adverse impact of increased summer maximum temperature and summer rain are the main factors which caused suppression of yield by 69 and 23 kg/ha for maize and millet, respectively. In the case of potato, the adverse impact caused by increase in summer maximum temperature offsets positive impact of increased summer rain and summer minimum temperature. The current climate trend suppress the yield of potato by 72 kg/ha.

CONCLUSION

This paper analyzed the impact of current trend of climate variables on yield of six main food-crops of summer and winter season crops. Yield of potato, wheat, paddy, and maize is in growing trend, but fluctuates over the years, whereas yield of millet and barley, two minorcereal crops, is growing very steadily. In summer, each of the climate variables is in increasing trend, whereas in winter, rainfall and minimum temperature is in decreasing trend. Insummer, increase in rain and maximum temperature has contributed positively to yield growth of paddy. Similarly, increase in wheat and barley yield is contributed by current climate trends. However, increased summer rain and maximum temperature suppressed the yield growth of maize and millet, whereas negative impact of increase in summer maximum temperature outweighed positive impact of increased summer rain and summer minimum temperature in case of potato.

The indicated that food-crops grown in summer are adversely affected by the current trend of climate variables in Kaski district except for paddy Maize and millet crops are adversely affected by increase in rainfalland maximum temperature. On the other hand, though rainfall is at declining trend in winter, increase in temperature has positively contributed to the yield growth of both wintercrops. With this, it can be recommend that any program dealing with minimizing adverse impact of climate change on food-crops production should first consider the crops like maize and potato, which are being affected at higher degree compared to other food-crops. Moreover, these two crops are important staple food in case of Nepal, especially in mountain and hills that are also exposed to higher degree of vulnerability to climate change. The main short coming of this study is treating the mid hills of western development region as one basket despite the huge diversity existing within. Therefore, it is also recommended to conduct similar studies considering the variation caused by ecological and administrative division of the country. The empirical analysis does not capture the details of crop physiology, but it does capture the net effect of the processes by which climate variables affect yield. Besides climate variables, other factors such as crop management practices also play a significant role in determining crop yield and coping the adverse impact of climate change. The estimates of rainfall and temperature, therefore, donot represent the correct determinants of crop yield. The findings are useful for estimating climate change impacts on crop yield and determining the most vulnerable crops for prioritizing adaptation strategies for climate change.

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FFICACY OF TWO ENTOMOPATHOGENIC NEMATODES STRAINS *STEINERNEMA SIAMKAYAI* AND *S. ABBASI* AGAINST THE 3RD INSTAR LARVAE OF *CHILOLOBA ACUTA*

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ABSTRACT

Larvae of scarabaeid beetle Chiloloba acuta (Coleoptera: Cetoninae) was found high densities in Khulekhani VDC, Makawanpur district. These insects are major pest of flower. The efficacy of two species of entomopathogenic nematodes, Steinernema siamkayai (CD1) and S. abbasi (CS1) was tested against third instar of Chiloloba acuta. In a dose response experiments, 0, 125, 250, 500, 1000, 2000 and 4000 infective juveniles (IJs) were inoculated in 50 ml plastic vial containing 40g silt loam soil (45.3%sand, 33.5% silt, 12.2% clay 4.913 organic matter and 5.5pH) and a single C. acuta larva. Mortality of C. acuta exposed to series of increase dose of two nematodes strains was analysed two days intervals upto 14th days after the inoculation by time dose mortality regression .Between these strains, S. abbasi found more effective (LD_{50} 44.9IJs/ml) as compared to S. siamkayai (LD_{50} 98.1IJ/ml) after 14th days. At initial days both strains had high LD_{50} value and it was gradually decreased with increase time.

Key words: Entomopathogenic nematodes, scarabaeid beetle, *Steinernema siamkayai, Steinernema abbasi, Chiloloba acuta*

INTRODUCTION

White grubs are the soil inhabiting root feeding larvae of scarab beetles. They cause significant damage to many agricultural, horticultural and plantation crops, and also to ornamentals, lawns, turfs, pastures and forest trees in different parts of the world (Jackson, 1992; Potter *et al.*, 1992; Koppenhofer and Fuzy, 2003a). *Chiloloba acuta* (Coleoptera: Cetoninae) is one of the major white grubs species found in Makawanpur district. They are called Green rose chafers; larvae move ventrally and dorsoventrally and have well developed hairs on the body. They are major pest of flower.

Due to the unavailability of successful biologic control agents to manage these pests, Nepalese farmers mainly rely on chemical pesticides. However it poses a risk of environmental pollution and is a threat to human health. Application of insecticides to control soil dwelling pests like white grubs is even more harmful to soil health. The most effective and persistent insecticides used to control soil dwelling insects are banned. There is an increased desire for safer and more environmentally sound methods of control.

Entomopathogenic nematodes (EPNs) from families Steinernematidae and Heterorhabditidae are important natural enemies of insects (Kaya, 1990). They are soil organisms, which live in mutualistic relationship with bacteria from the genera Xenorhabdus and Photorhabdus (Burnell and Stock, 2000). Once inside the infected insect, symbiotic bacteria are released from the bodies of infective juveniles (third larval stage of EPNs) to the host hemocoel system. And with the excretion of several toxins they cause its death within 24 to 72 hours (Forst and Clarke, 2002). Entomopathogenic nematodes are an attractive biological control alternative for white grubs, often providing suppression comparable to that achieved with chemical pesticides (Klein, 1993).

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These nematodes may offer an environmentally safe and IPM compatible option for curative white grub control (Grewal *et al.,* 2005). The development of techniques of in-vitro mass production involving solid substrates (Bedding, 1984) and liquid media (Ehlers, 2001), and formulation (Grewal, 2002) led to important progress for the use of these nematodes as biologic control agents. Many qualities make them excellent biocontrol agents: they have a broad host range, possess the ability to search for hosts actively, present no hazard to mammals, and were made exempt from registration and regulation requirements by the US Environmental Protection Agency (EPA) (Gaugler, 1988; Georgis and Manweiler, 1994). At present, they are used commercially against soil-inhabiting pests (Georgis and Manweiler, 1994).

The aims of our research was to study the efficacy of indigenous strain, *S. siamkayai* (CD1), in a comparison to other strain *S. abbasi*(CS1) when controlling third stage-larvae of Green rose chafers *C. acuta* and on the other hand to determine concentration of suspension on the activity of studied biological agents.

MATERIALS AND METHODS

NEMATODES PRODUCTION

A survey of entomopathogenic nematodes (EPN) was conducted for the first time in Nepal during June–December 2007 (Khatri-Chhetri *et. al.*, 2010) and identified. Those identified strains used in this study were as follows.

1. *Steinernema siamkayai* (CD1)
2. *Steinernema abbasi* (CS1)

These two nematodes species were produced in-vivo by using the *Galleria* larvae. *Galleria* larvae killed by nematodes were placed in modified White traps (White, 1927) to allow the emergence of infective juveniles (IJ). Harvested nematodes were stored in incubator at 12-15 °C (Woodring and Kaya, 1988). In all experiments, fresh nematodes(less than two weeks older) were used.

MAINTENANCE OF WHITE GRUB HOST INSECTS
The grubs were collected from damaged maize field from different locations of Makawanpur district during June 2010 *Chiloloba acuta* were mainly collected from field. Naturally infected larvae were discarded and only non infected larvae were used in bioassay experiments.

EXPERIMENT DESIGN AND BIOASSAY PROCESSES
The experiments were carried out at laboratory of Entomology Division, NARC, Khumaltar. Two bioassays were conducted at different dates. 1st bioassay was done at 8 July 2010. In 1st bioassay *Steinernema siamkayai* was used for 350 white grub larvae. Seven treatments were used in this bioassay (125IJs, 250IJs, 500IJs, 1000IJs, 2000IJs, 4000IJs and 1 control used dichloranated water (0IJs) per larvae of white grub). In each treatment 50 white grub larvae were used.

Second bioassay was conducted at 9 July 2010. In this bioassay *Steinernema abbasi* was used for 350 white grub larvae. Seven treatments were used in this bioassay as mentioned as bioassay 1st. In each treatment 50 white grub larvae were used. The bioassay was carried out using EPNs in a complete randomized design (CRD).

BIOASSAY
Separate bioassays were conducted for each nematodes species. Two bioassays were conducted at room temperature (23.96 °C to 29.75 °C) in aerated plastic vials filled with 40 g sterilized soil. Initially, soil contained the moisture 21 g by volume. Soil was found a silt loam (45.3% sand, 42.5% silt, 12.2% clay, 4.913% organic matter and 5.5pH) for 1st and 2nd bioassays. Individual larvae that had been maintained for bioassay were released into the aerated plastic vials. Larvae that did not

enter into the soil with in half hour were replaced. Treatments were prepared and applied in each vials with required number of nematodes in 1ml dechlorinated tap water. Control treatment received the same amount of dechlorinated tap water only. To maintain the moisture in nematodes treated vials, two ml of dechlorinated tap water added in each vials. Potato slice also added in vials for food. Larval mortality was monitored at 2 days interval after treatments up to 14 days for survival. Dead larvae were removed from the experiment and dissected two days after death for checking nematode infections using the microscope at 10x magnitude. Individuals were recorded during each evaluation as “survived”, “death due to EPN infection”, “death due to other reasons”. For surviving larvae a potato slice (about 1 g) was provided as food after each observation.

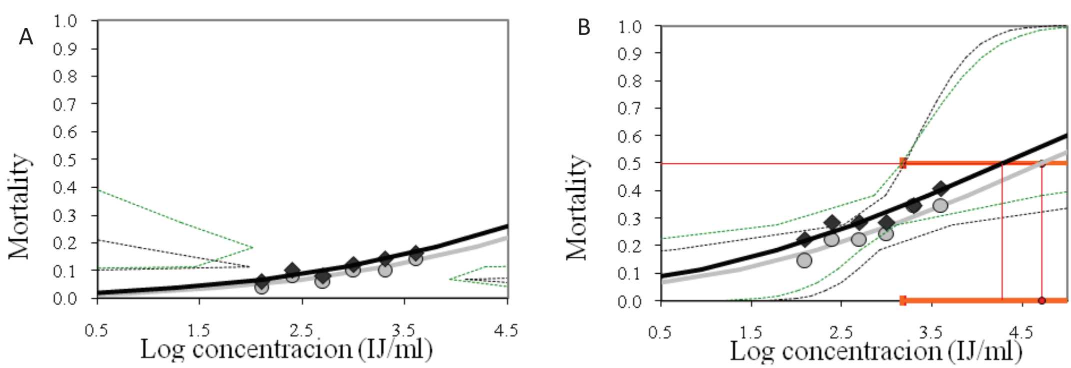
STATISTICAL ANALYSIS

The data were further analyzed to assess the dose-time mortality curves for each EPN strain tested. First, survival data from each evaluation date were submitted to Probit analysis according to Finney (1977) to determine the dose-mortality relationship for each date individually. LD_{50}-values and the slope of the regression were determined for each date individually with their corresponding standard errors and confidence bands. Parallelism was evaluated using a Likelihood Chi^2-test (G-test).For calculating EPN-caused mortality observed mortalities were adjusted using Abbott’s formula (Abbott, 1925). Established functions were used to establish an overall dose-time-mortality model that predict LT_{50} -values for a given EPN dose.

RESULTS

VIRULENCE OF THE TWO STRAINS OF EPNS AGAINST *Chiloloba acuta*

Regression based on the Probit model resulted always P-values above 0.97 (according to Chi^2) indicating high acceptability of model fit over all evaluation dates (Table 1). Individual regression lines for each evaluation interval are presented in Figure 1(A-G).



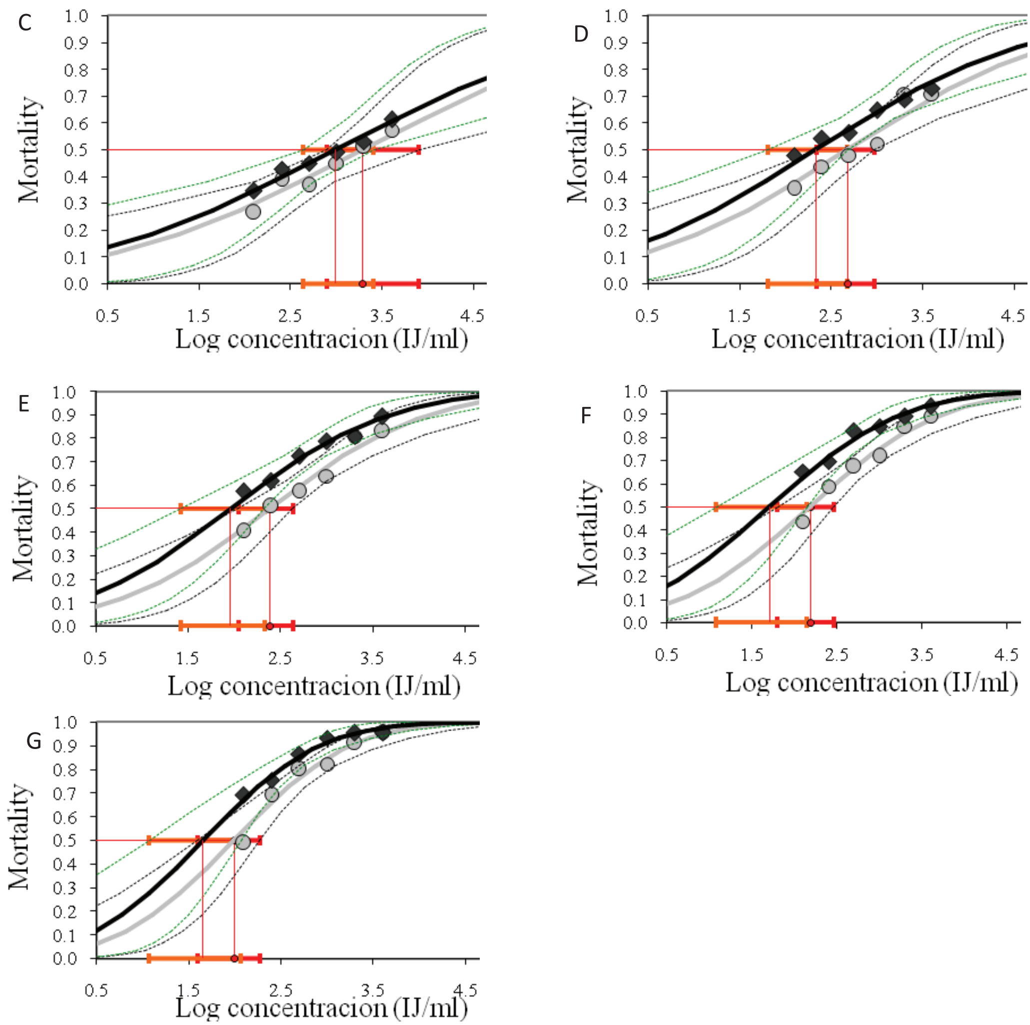


Figure 1. Comparing the regression line between the *S. siamkayai* and *S. abbasi* treated third instar larvae of white grub (*Chiloloba acuta*) showing the LD_{50} values at 2 (A), 4 (B), 6 (C), 8 (D), 10 (E), 12 (F) and 14 (G) days after inoculation.

Filled diamonds: observed mortality in *S. abbasi* Black line: resulting probit model for *S. abbasi*, filled circle: observed mortality in *S. siamkayai*, gray line: probit mod for *S. siamkayai*, scatter lines indicate 95% confidence bands for the probit models; bars: confidence band (95%) for LD_{50}-values.

Table 1. Details of the probit statistics resulting from 1st experiment.

DAI	Strain	Intercept	Slope	Heterogeneity		Parallelisms		LD_{50}	CL95		Potency	CL95	
				chi^2	P	chi^2	P		Lower limit	Upper limit		Lower limit	Upper limit
2	*S.s.*	-2.38	0.35	0.93	0.99	0.01	0.92	$5.28x10^6$	$7.68x10^{-4}$	$2.79x10^{53}$	1		

		(±0.115)											
	S. a.	-2.24 (±0.105)						$2.16x10^6$	$6.05x10^{-1}$	$1.31x10^{46}$	2.44	0.18	∞
4	S.s.	-1.69 (±0.082)	0.35	1.35	0.99	0.31	0.58	$5.19x10^4$	$1.56x10^3$	$2.86x10^8$	1		
	S. a.	-1.53 (±0.079)						$1.92x10^4$	$1.46x10^3$	$1.28x10^7$	2.70	0.62	37.3
6	S.s.	-1.46 (±0.075)	0.44	1.03	0.99	0.16	0.68	$1.92x10^3$	$7.76x10^2$	$7.93x10^3$	1		
	S. a.	-1.33 (±0.075)						$9.70x10^2$	$4.33x10^2$	$2.54x10^3$	1.98	0.66	8.37
8	S.s.	-1.46 (±0.076)	0.54	1.54	0.992	0.90	0.35	$4.79x10^2$	$2.16x10^2$	$9.27x10^2$	1		
	S. a.	-1.27 (±0.077)						$2.15x10^2$	$6.43x10^1$	$4.80x10^2$	2.23	0.90	7.13
10	S.s.	-1.78 (±0.080)	0.75	1.51	0.993	0.37	0.541	$2.40x10^2$	$1.10x10^2$	$4.27x10^2$	1		
	S. a.	-1.47 (±0.084)						$9.08x10^2$	$2.66x10^1$	$2.12x10^2$	2.64	1.31	6.30
12	S.s.	-1.816 (±0.084)	0.83	1.14	0.997	0.37	0.545	$1.54x10^2$	$6.28x10^1$	$2.88x10^2$	1		
	S. a.	-1.421 (±0.091)						$5.14x10^1$	$1.20x10^1$	$1.41x10^2$	2.98	1.51	7.05
14	S.s.	-2.028 (±0.092)	1.01	2.22	0.974	0.21	0.643	$9.81x10^1$	$3.91x10^1$	$1.86x10^2$	1		
	S. a.	-1.682 (±0.102)						$4.49x10^1$	$1.18x10^1$	$1.16x10^2$	2.18	1.187	4.45

DAI Days after treatment, *S. a. Steinernema abbasi*, S. s. *Steinernema siamkayai*

Between the two nematode species tested against the third instar of white grub (C. acuta), S. abbasi was more effective (LD50, 44.9 IJs/ml/40g soil) as compared to S. siamkayai (LD50, 98.1 IJs/ml/40g soil) after 14 days of inoculation. LD50 values obtained from each observations of both nematodes strain clearly indicated S. abbasi had low LD50 value than S. siamkayai. At initial days, both strains had high LD50 value and gradually decreased with increased time.

NATURAL MORTALITY

Natural mortality within the experiment increased from 2% at 2 DAT to 10% at 14 DAI. The estimated for natural mortalities from the Probit model resulted quite similar from 1.99% (±0.019) for 2 DAI and 9.88% (±0.038) for 14 DAI. The increase in natural mortality over time could be well described by a linear regression model (R^2 = 0.971) with a daily increase rate of 0.62% (SE 0.044%) which is significantly different from zero (F=201, df = 6, p <0.0001) (Figure 2).

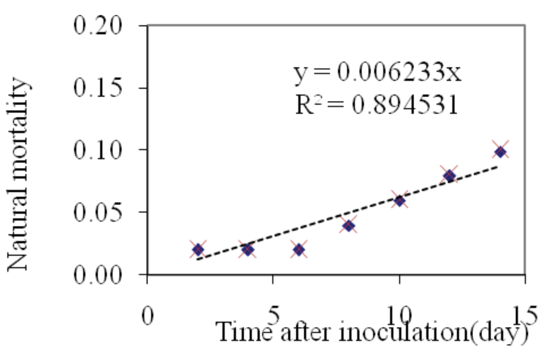


Figure 2. .Control mortality in *Chilolobaacuta* observed during experiment

Crosses indicate observed mortality, blue symbols indicate the estimated mortality by the probit model, and line represents the linear model fitted to the data.

Probit regression lines for each evaluation date were fitted in a parallel assay. The slope of regression lines for the two strains were not significantly different between the two stains of nematodes (*S. siamkayai and S. abbasi*) throughout the evaluation period (see chi^2 values for parallelism in Table 1) Common slopes obtained for each evaluation was increased but it was lower than 0.5 at 2, 4 and 6 DAI and higher than 0.5 at 8, 10, 12 and 14 DAI. Slope obtained at 14 days after treatment was higher than 1, which indicates that the variability in insect response to the nematodes reduces with incubation time. The increase in slope over time could be well described by an exponential model; i.e. $y = a \times \exp(b \times x)$, where "y" is the Slope and "x" is the incubation period in days after treatment, and "a" and "b" are fitted parameters. The model explained 97.3% of the variation in slopes by DAI (Figure 3).

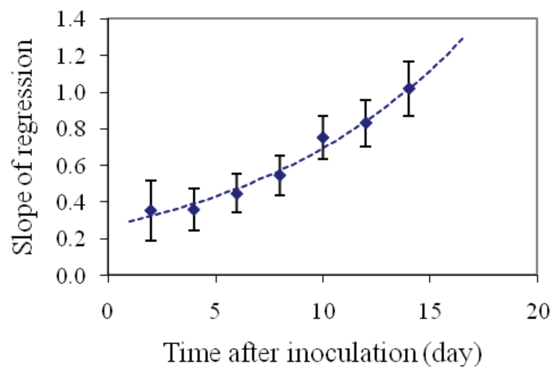


Figure 3. Common slopes of the probit regression lines for the two nematodes (*S. siamkayai* and *S. abbasi*) against *C. acuta* at different days after inoculation.

Blue symbols indicate observed slope, Bar: confidence bands for the slope scattered line: linear model fitted to the data.

Between the two nematode species/strains tested against the third instar of white grub (*Chilolobaacuta*), *S. abbasi* found more effective (LD_{50}, 44.9 IJs/ml/40g soil) as compared to *S. siamkayai* (LD_{50}, 98.1IJs/ml/40g soil) after 14 days of treatment. LD_{50} values obtained from each observations of both nematodes strain clearly indicated *S. abbasi* had low LD_{50} value than *S. siamkayai*. At initial days both strains had high LD_{50} value and it was gradually decreased with increased time (Table 1).

DIFFERENCES IN BIOLOGICAL ACTIVITY BETWEEN STRAINS

Relative potencies of LD_{50}-values with their 95% confidence limits were used to compare the virulence between *S. siamkayai* and *S. abbasi* of nematode strains using *S. siamkayai* as reference (activity = 1). Relative potencies, which were in the range between 1.981 and 2.989 values (Table 1), did not change for different evaluation dates. This was verified by linear regression,where the regression coefficient resulted not significantly different from zero ($F = 0.047$, $df = 5$, $P = 0.83$). Due to the low activities of pathogens at the beginning of the evaluation period obtained potencies were more variable than at the end of the experiment and accordingly confidence interval for the relative potencies resulted much wider than at the end of the experiment. Therefore, the relative potency for *S. abbasi* resulted not significantly different compared to *S. siamkayai* after 2, 4, 6 and 8 days of incubation; however, from 10 to 14 days the potency became significantly different; i.e. higher, due to more precise estimates of the LD_{50}-values (Table 1).

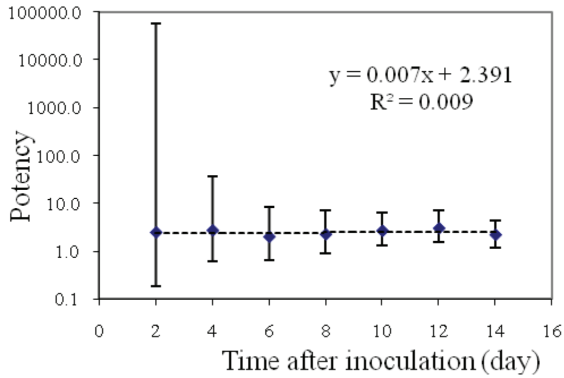


Figure 4. Relative potencies obtained for comparing *S.siamkai* against *S. abbasi* throughout the course of experiment. Symbols: calculated potencies obtained form probit analysis. Bar: confidence bands for the relative potencies Scattered line: linear model fitted to the data.

DISCUSSION

White grub need to be controlled because of their negative impact on agricultural crops and ornamental plants. The present results as well as those of Gharty Chhetry (2006) indicate the important role of biological control agents. Insect pathogenic fungi (*M. anisoplia* and *B. bassiana*) and insect pathogenic nematodes Steinernematidae and Heterorhabditidae are the major microbial pesticides to control the white grub. Entomopathogenic nematodes are the most extensively studied parasites of white grub (Klein, 1993; Georgis *et al.*, 2006). So, different nematode strains *S. siamkayai* and *S. abbasi* were assessed against third instar white grub (*C. acuta*) to determine the biological activity of these pathogens. These nematodes were first recovered and described from Asia: *S. abbsi* from Oman (Elawad *et al.*, 1997) and *S. siamkayai* from Thailand (Stock *et al.*, 1998). In Nepal these nematodes were isolated and identified first time from inner terai region (silt loam soil) 160 and 145 masl respectively (Khatri-Chhetri, 2010).

Our study established the mortality of *C. acuta* treated with entomopathogenic nematodes *S. siamkayai* and *S. abbasi* at different days with the various concentration levels. Mortality of *C. acuta* treated with *S. siamkayai* ranges from 26.5-%57% and 49 -95% at 6 and 14 days after treatment treated with 125 and 4000 IJs/grub/40gm soil respectively. In case of *S. abbasi* treated *C. acuta* mortality became higher ranged from 34.7-61.2% and 68.9-95% at same dose and days. Several researchers demonstrated that most effective strains which controls white grub were *H. bacteriophora* GPS11 (83-96%), *H. zealandica* X`1 (96-98%) and *S. scarabaei* (100%)(Cappaert and Koppenhofer, 2003; Koppenhofer and Fuzy, 2003; Grewal *et al.*, 2004). This study shows that the entomopathogenic nematode *S. siamkayai* and *S. abbasi* can provide effective curative control of third instar white grub *C. acuta*.

The dose response bioassay has been used many times previously (Morris *et al.*, 1990; Mannion and Jansson, 1992) and probit analysis has been used to analyze the data to calculate LD_{50} values. In the assays conducted in 50 ml plastic vial, nematodes and insects were kept in close contact and the influence of foraging strategies was limited. High mortality was received by treating the nematodes strains.

The efficacy of entomopathogenic nematodes depend upon various factor. Soil texture, soil pH, soil moisture are the major factor. Soil used in bioassay is silt loam having the pH 6.4 which is favorable for nematodes. Observations of other studies suggest that *S. scarabaei, H. bacteriophora*, and *H. zealandica* becomes less effective in acidic soils than in more pH-neutral soils Koppenhofer and Fuzy (2006).Grewal *et al.*, (2004) reported that optimum soil moisture has vital role in nematodes movement and efficacy, the grub control provided by the two strains always exceeded 80% (83–97% for H.b.-GPS11 and 96–98% for H.z.-X1 strain). Entomopathogenic nematodes require moisture film to prevent desiccation and in which to move, they are more typically used in soil environments. Interestingly, our results also indicate that optimum soil condition may have positive effect on nematode efficacy.

Luan *et al.*, (1996) computed the LD_{50} values as 417 IJs of *Steinernema glaseri* NC 34 for the second instar larvae of *Holotrichia parallela*. In our study, a positive correlation between the inoculation dose and the host mortality was observed in the case of all the test nematode species/strains evaluated with the soil inoculation method. Between the two nematode species/strains tested against the third instar of white grub (*C. acuta*), *S. abbasi* was more effective (LD_{50}, 44.9 IJs/ml/40g soil) as compared to *S. siamkayai* (LD_{50}, 98.1 IJs/ml/40g soil) after 14 days of inoculation. LD_{50} values obtained from each observations of both nematodes strain clearly indicated *S. abbasi* had low LD_{50} value than *S. siamkayai*. At initial days, both strains had high LD_{50} value and gradually decreased with increased time.

CONCLUSION

In bioassay experiment, mortality of *C. acuta* exposed to series of increase dose of two nematodes strains was analyzed at two days intervals up to 14 days after the treatment by time- dose mortality regression. Between the two nematode species/strains tested against the third instar of white grub (*C. acuta*), *S. abbasi* was more effective (LD_{50}, 44.9 IJs/ml/40g soil) as compared to *S. siamkayai* (LD_{50}, 98.1 IJs/ml/40g soil) after 14 days of inoculation. LD_{50} values obtained from each observations of both nematodes strain clearly indicated *S. abbasi* had low LD_{50} value than *S. siamkayai*. At initial days, both strains had high LD_{50} value and gradually decreased with increased time. It was found that both entomopathogenic nematodes were effective in lab conditions so it is suggested to test them in field for the management of white grub.

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ACTIVITY OF STRAINS OF METARHIZIUM ANISOPLIAE (METSCH) SOROKIN AGAINST WHITE GRUB (CHILOLOBA ACUTA, SCARABAEIDAE, COLEOPTERA) UNDER LABORATORY CONDITION IN NEPAL

Dipak Khanal[1]

ABSTRACT

Soil insect pests are the major productivity constrains of different crops among which white grubs (Coleoptera: Scarabaeidae), both adult and larval stages, are extremely destructive in nature. Laboratory studies were conducted to evaluate the virulence of an indigenous and a commercial strain of the entomopathogenic fungi, Metarhizium anisopliae (Metsch.) Sorokin, against white grubs species Chiloloba acuta by applying the dipping method at Entomology Division, NARC, Nepal. Third instars larvae of C. acuta were dipped in suspensions of indigenous and commercial strains (Pacer) of M. anisopliae at different concentrations ranging from 3.33×10^4 to 1.04×10^8 spores/ml for 3-5 seconds which resulted in 97.8% and 89% mortalities with the highest dose of 1.04×10^8 spores/ml 40 days after inoculation (DAI), respectively. The LC_{50} values for indigenous and commercial strain were 3.5×10^5 and 1.88×10^6 spores/ml, respectively, with the potency of 1:0.28 at 40 DAI. Bioassays were conducted in completely randomized design. From results it is concluded that the tested strains of entomopathogenic fungi have potential as microbial control agents in managing white grubs in laboratory and it is suggested to be tested under farmers field condition.

Key words: Bioassay, coleoptera, Entomopathogenic fungi, LC_{50} ,irulence, white grubs

INTRODUCTION

Insect pests are the major limiting factor to crop production systems, which cause about 12-15% crop losses worldwide (Upadhyaya, 2003) and 15- 20% in Nepal (Joshi *et al*., 1991; Palikhe *et al*., 2003). Among them soil insect pests are becoming major biological constraints to the productivity of different upland crops (Oya, 1996; Guppy and Harcourt, 1970; Potter *et al*., 1992). The extent of damage caused by white grubs solely depends upon the species involved, the number present and the host crops. The damage caused by scarab larvae is estimated to reduce the crop yield by about 40-80% (Prasad and Thakur, 1959; Raodeo, 1974), and in a more recent study by about 12-60% (Pokhrel, 2004). However, insecticides have been found ineffective in controlling scarab larvae (NMRP, 1997) because the larvae present in the soil do not come into direct contact with the insecticides, which is generally applied during the growing season (Oya, 1995) and have even shown resistance to organochlorine (Pokhrel, 2004). Scheduled chemical methods are ineffective (Schweigkofler and Zelger, 2002) and farmers are not considering economic thresholds of these pests, but applying pesticides at higher dosages than it is required (Maharjan *et al*., 2004).

The entomopathogenic fungus (EPF) *Metarhizium anisopliae* (Metschn.) Sorokin is one of the most reviewed, studied and applied species amongst fungal bio-control agents, and several commercial products have been developed and registered for the control of different insect pests (Butt *et al*., 2001; Ferron, 1985; Upadhyay, 2003). *M. anisopliae*, as being environmentally friendly and also likely to be self-perpetuating (Mazodze *et al*., 1999) and has no mammalian toxicity.

Microbial control has evolved worldwide as an important component of integrated pest management (IPM), with success in Asia and South America (Fuxa, 1987) although it is still in developing stages in Nepal (G.C, 2006). The evaluation of the efficacy of *M. anisopliae* in the field and in the laboratory with both indigenous as well as commercial isolates is of prime importance to answer the growing debate on the use of indigenous ones (Gurung, 1985; Katuwal, 1998; Khanal *et al*., 2014). Hence *M. anisopliae* has been used as a biological control agent in this study for possible integration in the IPM program in order to replace synthetic insecticides with their negative effects.

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MATERIALS AND METHODS

FUNGUS STRAINS

Two strains of *M. anisopliae*, an indigenous and a commercial one, were used in this experiment. The indigenous strain was obtained from the Insect Pathology Unit, Entomology Department, Institute of Agriculture and Animal Science. The commercial product, named "Pacer" manufactured by Agri Life Medak, India, obtained from a non-governmental organization, the International Development Enterprises (IDE) based in Kathmandu. This wettable powder (WP) formulation contains 1.15% of *M. anisopliae* corresponding to 10^8 conidia forming units (CFU) per g dry weight of the product.

For conidia production of the indigenous strain, the selective medium Sabouraud Dextrose Agar (SDA) adopted from Strasser *et al.* (1997) with the following composition was used: 20 g dextrose, 10 g peptone, 18 g agar-agar, 0.6 g streptomycine, 0.05 g tetracycline, and 0.05 g cyclohexamide and 1000 ml of distilled water. Autoclaved (at 1.5 bar, 121°C, for 40 min) medium was poured in Petri dishes and allowed to solidify under laminar air flow. Then *M. anisopliae* was inoculated on solid media using loops and the Petri dishes incubated at 24°C and 75% RH for growth and sporulation of the fungus in an aseptic condition. After 16 days, they were used in bioassay.

INSECT COLLECTION

For the bioassays, white grubs were collected from Kulekhani VDC, Ward-7 of the Makawanpur district (85°18'605 N, 27°59'900 E, 1530 masl). The collected white grubs were placed individually in 100 ml vials (5 cm × 5.5 cm, d × h) containing soil and covered with a perforated lid. In the laboratory of the Entomology Division NARC, Lalitpur, white grubs were transferred into rearing vials (5 cm × 5.5 cm, d × h) filled with soil obtained from the field where the grubs were collected. The rearing vials were kept under ambient room temperature (25±5^{0}C; 75±5% RH) for 10 days. Any larva that showed symptoms of a disease during this quarantine period was discarded. After a week, the soil and feeding material were changed. Only non-infected and morphologically identical larvae were used in the bioassays.

SOIL ANALYSIS

To study physio-chemical properties of the soil, samples were taken from the collected soil and analyzed at the Soil Division, NARC, Khumaltar. The soil texture was determined by the hydrometer method and pH by a digital pH meter. Soil pH was 5.5. The soil was composed of sand 61.3%, silt 28.5%, clay 20.2 % and consequently classified as silty loam.

BIOASSAY

The bioassays were conducted at Entomology Division, NARC, Khumaltar. Soil, from the insect collected area, was carried, sieved and then sterilized (autoclaved at 15 bar, 121°C for 1 h) and kept sealed at room temperature until one day before use. The vials (100 ml, 6 × 5.5 cm, h×d) with perforated lids for better aeration were filled 3/4 with this sterilized soil.

The concentration (conidia per ml) was determined by using a Thoma Haemocytometer (Sigma). The conidia of the indigenous strain of *M. anisopliae* were harvested by scraping off the contents from each Petri dish with a sterile metal spatula into a beaker containing 120 ml distilled water. Two drops of Tween 20 (0.1%) were added as dispersing agents. In another beaker the commercial strain of *M. anisopliae* was mixed in 120 ml water along with 2 drops of Tween 20 (0.1%) which were kept for fifteen minutes to allow talcum residue settle down. From the prepared solutions, 1 ml solution was taken and the conidia counted using haemocytometer and microscope (at 40 $\times$ magnification, stereomicroscope, Model SZX ILLD200, No. at FO 4725, Olympus, Japan). Conidia were added to the suspension and the counting repeated until the required concentration of 1.04×10^8 conidia per ml were obtained which was further diluted to obtain the different concentration levels (1.04×10^8, 2.08×10^7, 4.16×10^6, 8.32×10^5, 1.66×10^5, 3.32×10^4) using five as dilution factor. The titer of the suspensions was calculated using the formula "C1V1 = C2V2", where C1, V1 are initial concentration and initial volume and C2, V2 are final concentration and final volume, respectively.

The experiments were completely randomized. Each treatment (strain and concentration level) was tested with n = 50 larvae of *C. acuta*; i.e. a total number of $N = (2\times6\times50) + (50 \text{ control}) = 650$ were used in the bioassay. Each test insect was dipped into 100 ml of the required suspensions (concentration level) of the respective *M. anisopliae* strain (either indigenous or commercial) for about 5 seconds. An additional number of 50 larvae were dipped into distilled water mixed with Tween 20 only, which served as control. The excess water was removed by placing the wet larvae on tissue paper before transferring individually to 100 ml plastic vials containing 40 g of sterilized soil and a slice of potato as food source. Larvae that had not entered the soil within 15 minutes were considered injured and replaced.

OBSERVATIONS

Mortality was assessed through direct observation of larvae in one-day interval from 10 days after inoculation (DAI) to 40 DAI. During evaluation dead larvae without visible fungal symptoms were removed from the plastic vial, placed individually in a Petri dish with filter paper (9 cm diameter) and incubated at 25^0C and 85% RH for 7-10 days to allow mycelia growth. The cause of death was confirmed by microscopic examination of the outgrowing fungus.

Daily room temperature was recorded up to 40 days from the beginning of the experiment. The maximum and minimum temperatures recorded were 29.7^0C and 24.0^0C on July 7 and July 13, respectively.

DATA ANALYSIS

The data from the bioassays were analyzed to assess the dose-time mortality curves for each of the *M. anisopliae* strain tested. First, survival data from each evaluation date were submitted to Probit analysis according to Finney (1971) to determine the dose-mortality relationship for each DAI. LC_{50}-values and the slope of regression lines with their corresponding standard errors and confidence bands were determined for each DAI. Data from the same experiments were analyzed in a parallel assay. Parallelism was evaluated using a Likelihood Chi^2-test (G-test). If the regression lines were acceptably parallel ($p > 0.05$) a common slope was used for all Probit lines. Observed mortalities were adjusted for control mortality (dead test insects without signs of fungal disease) using Abbott's formula (Abbott 1925). Estimation of the natural mortality rate was included into the Probit model (Finney, 1971):

RESULTS

Biological activity of *M. anisopliae* against *C. acuta*

Two experiments were conducted with indigenous and commercial *M. anisopliae*. The Probit model adequately describes the relationship between the fungus concentration and the mortality response in *C. acuta* for all evaluation dates after fungus application (Figure 1).(Table 2).

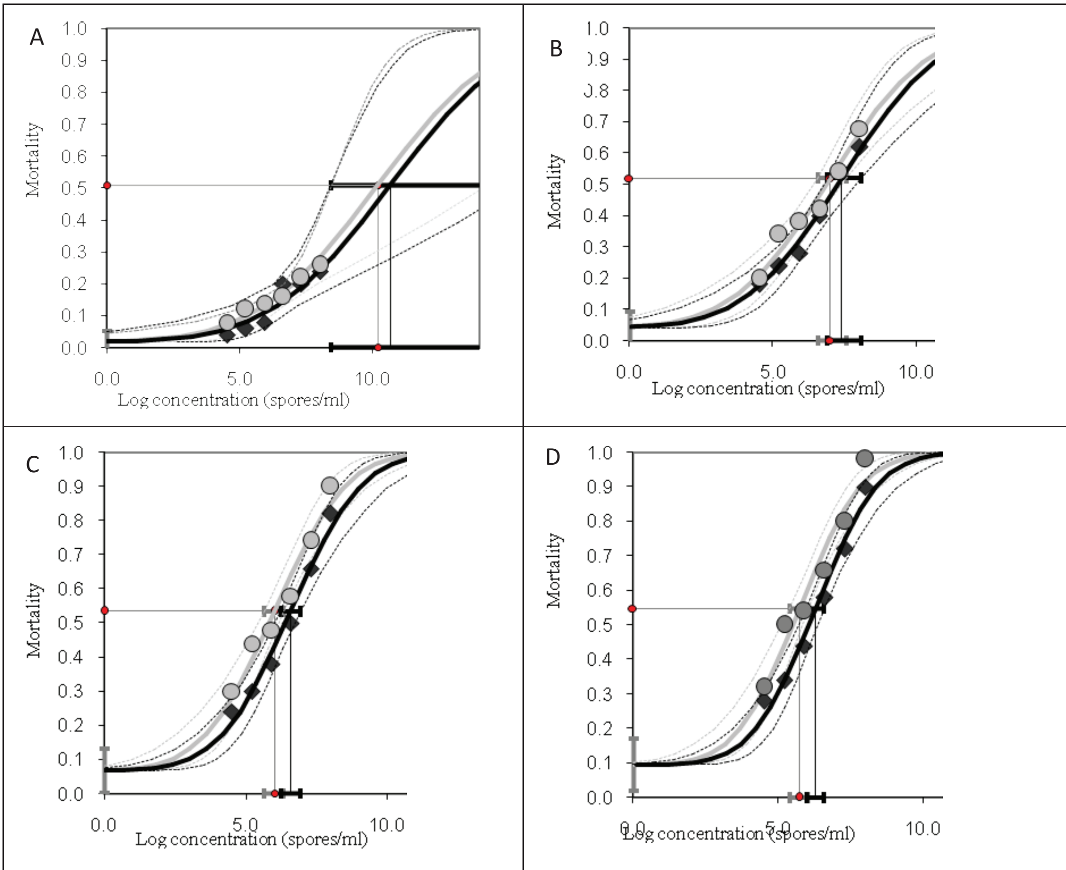

Figure 1. Probit regression line retransformed into percentage mortality obtained for *M. anisopliae* against third instar larvae of *Chiloloba acuta* 10 DAI to 40 DAI (A, B, C and D are mortality concentration curve at 10, 20, 30 and 40 DAI with *M. anisopliae*. Gray lines and gray vertical bars indicate the probit regression line of the indigenous strain and their LC_{50}, respectively. Black lines and black vertical bars indicate probit regression line of the commercial strain and their LC_{50}. Scatter lines indicate 95% confidence bands for the probit model)

The intercepts of the probit regression lines changed with increasing incubation time (Figure 2). At the beginning of the experiment, intercepts increased from 10 to 14 DAI, thereafter values decreased gradually up to 40 DAI (Table 2).

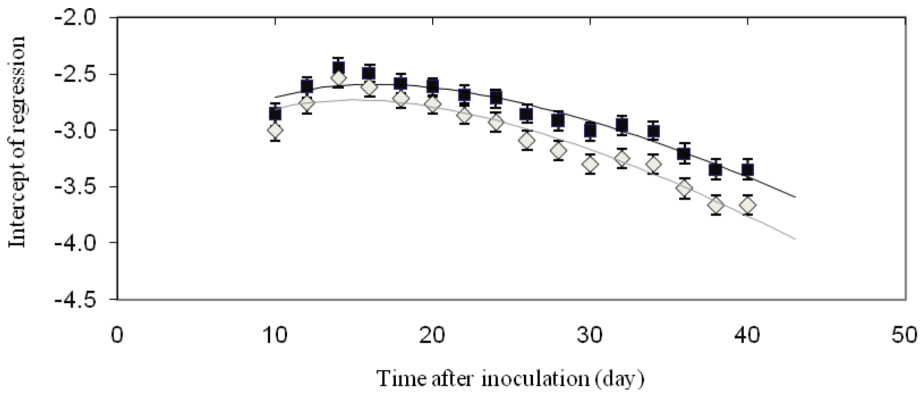

Figure 2. Intercepts of probit regression lines obtained during testing of the indigenous strain (black line) and commercial strain (gray line) strain of *M. anisopliae* against *C. acuta* at different DAI

The following non-linear model was successfully fitted to describe the relationship between time after inoculation and the intercept for both stains.

$$intercept = a + bx + c\sqrt{x}$$

In which, x is DAI. The model explained 92% and 93% of the variation in intercept over time for indigenous and commercial strains of *M. anisopliae* respectively (Figure 3), see model parameters and statistical details in Table 1.

Table 1. Resulting parameters in regression statistics for describing the relationship between intercept resulting from the probit analysis and DAI for the commercial and indigenous strains of *M. anisopliae* against *C. acuta*

Strain	Parameters			R^2	F	df	P
	a	b	C				
Indigenous	-5.139 (0.589)	-0.157 (0.026)	1.263 (0.252)	0.917	71.4	13	<0.001
Commercial	-5.275 (0.708)	-0.170 (0.032)	1.316 (0.303)	0.925	80.0	13	<0.001

a, b and c are model parameters, number in parentnesis indicate standard error. p=probability. F=Fisher test, R^2= Coeffecient of determination, df= degree of freedom

The slopes of the regression lines were not significantly different between the two stains of *M. anisopliae* throughout the evaluation period as indicated by Chi^2 values for parallelism (Table 2). Slope increased from 0.2811 at 10 DAI to 0.5820 at 40 DAI almost linearly (Figure 3). Linear regression explained 99% of the variability of the common slope by DAI. The slope increased by a value of 0.011 (SE 0.0003) per day (F= 1490, df= 14, p<0.001).

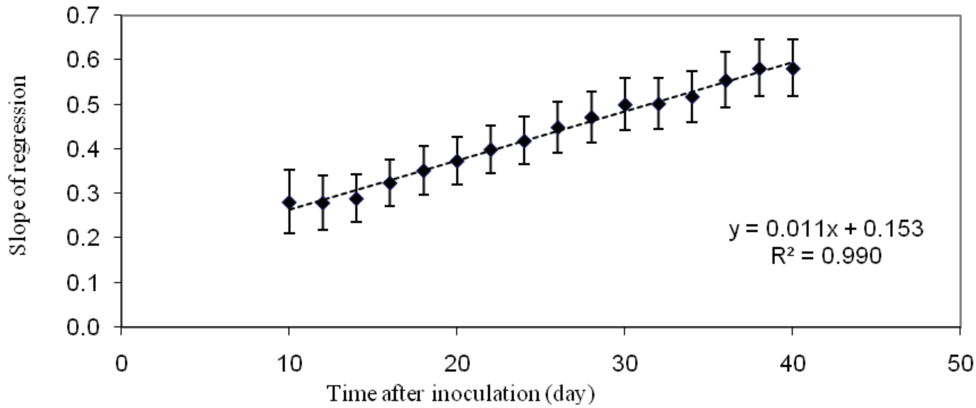

Figure 3. Regression line obtained from common slope of probit regression line during the comparison of the indigenous and the commercial strain of *M. anisopliae* against third instars of *C. acuta* (Black points indicate the common slope and the dotted line shows the regression line fitted between the common slope of the probit models and time after fungus application)

Lethal time was inversely propotional to the concentration of *M. anisopliae*. With the increase in the concentration level of *M. anisopliae* the lethal time of both strains (indigenous and commercial) decreased. Lethal time required for the indigenous strain was less than commercial strain with same concentration (Table 2, Figure 4).

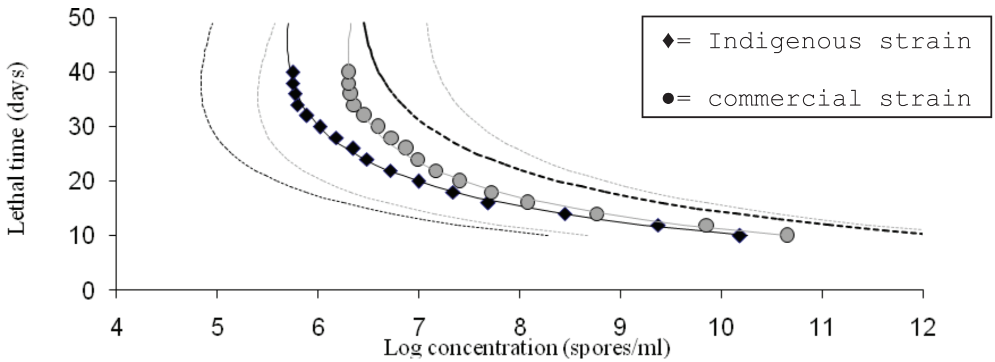

Figure 4. LC_{30}, LC_{50}, LC_{70} value of indigenous (black line) and commercial (gray line) strain of *M. anisopliae* obtained in bioassay

Table 2. Detail of the probit statistics resulting from the bioassay

					Heterogenity		Parallelism		LC_{50}	CL95%			CL95%	
DAI	Strains	Intercept	Slope	SE	chi ^{2}	P	chi ^{2}	p	Spores/ml	Lower	Higher	Potency	Lower	Higher
10	I	-2.863	0.2811	0.071	2.00	0.981	0.92	0.337	$1.52x10^{10}$	$2.66 x10^8$	$1.87 x^{14}$	1		
	C	-2.995							$4.51x10^{10}$	$2.75x10^8$	$2.97 x^{15}$	0.34	0.018	3.85
12	I	-2.621	0.2796	0.060	0.47	1.000	1.50	0.220	$2.36x10^9$	$1.05x10^8$	$9.25 x^{11}$	1		
	C	-2.757							$7.24x10^9$	$1.54x10^8$	$9.20 x^{12}$	0.33	0.026	2.80
14	I	-2.443	0.2891	0.053	1.11	0.997	0.47	0.491	$2.82x10^8$	$3.21x10^7$	$9.70 x^{09}$	1		
	C	-2.534							$5.79x10^8$	$4.82x10^7$	$3.31 x^{10}$	0.49	0.061	3.26
16	I	-2.496	0.3246	0.051	1.42	0.994	0.25	0.620	$4.9x10^7$	$1.15x10^7$	$3.85 x10^8$	1		
	C	-2.622							$1.19x10^8$	$2.16x10^7$	$1.43 x10^9$	0.41	0.071	2.06
18	I	-2.586	0.3524	0.054	1.82	0.986	0.20	0.653	$2.18x10^7$	$6.61x10^6$	$1.09 x10^8$	1		
	C	-2.720							$5.22x10^7$	$1.30x10^7$	$3.68 x10^8$	0.42	0.080	1.90
20	I	-2.619	0.3743	0.053	1.89	0.984	0.19	0.662	$9.93x10^6$	$3.57x10^6$	$3.47 x10^7$	1		
	C	-2.770							$2.51x10^7$	$7.84x10^6$	$1.15 x10^8$	0.40	0.087	1.61
22	I	-2.684	0.3996	0.053	2.26	0.972	0.13	0.723	$5.20x10^6$	$2.07x10^6$	$1.46 x10^7$	1		
	C	-2.864							$1.47x10^7$	$5.32x10^6$	$5.12 x10^7$	0.35	0.086	1.30
24	I	-2.719	0.4192	0.053	2.00	0.981	0.13	0.720	$3.07x10^6$	$1.28x10^6$	$7.64 x10^6$	1		
	C	-2.928							$9.69x10^6$	$3.84x10^6$	$2.87 x10^7$	0.32	0.083	1.09
26	I	-2.856	0.4496	0.057	2.13	0.977	0.07	0.786	$2.25x10^6$	$9.60x10^5$	$5.27 x10^6$	1		
	C	-3.093							$7.59x10^6$	$3.18x10^6$	$2.04 x10^7$	0.30	0.082	0.98
28	I	-2.921	0.4726	0.057	3.06	0.931	0.07	0.791	$1.51x10^6$	$6.55x10^5$	$3.37 x10^6$	1		
	C	-3.182							$5.41x10^6$	$2.39x10^6$	$1.32 x10^7$	0.28	0.082	0.87
30	I	-3.013	0.5008	0.058	4.12	0.846	0.07	0.787	$1.04x10^6$	$4.57x10^5$	$2.22 x10^6$	1		
	C	-3.300							$3.90x10^6$	$1.80x10^6$	$8.74 x10^6$	0.27	0.084	0.78
32	I	-2.960	0.5026	0.057	4.89	0.770	0.06	0.807	$7.77x10^5$	$3.33x10^5$	$1.67 x10^6$	1		
	C	-3.249							$2.91x10^6$	$1.35x10^6$	$6.37 x10^6$	0.27	0.084	0.78
34	I	-3.004	0.5185	0.057	5.70	0.681	0.07	0.787	$6.22x10^5$	$2.67x10^5$	$1.32 x10^6$	1		
	C	-3.298							$2.29x10^6$	$1.08x10^6$	$4.85 x10^6$	0.27	0.089	0.77
36	I	-3.206	0.5555	0.062	5.97	0.651	0.10	0.749	$5.90x10^5$	$2.57x10^5$	$1.22 x10^6$	1		
	C	-3.516							$2.14x10^6$	$1.02x10^6$	$4.39 x10^6$	0.28	0.095	0.76
38	I	-3.347	0.5820	0.063	7.42	0.492	0.15	0.694	$5.63x10^5$	$2.52x10^5$	$1.14 x10^6$	1		
	C	-3.665							$1.98x10^6$	$9.67x10^5$	$3.97 x10^6$	0.28	0.101	0.75
40	I	-3.347	0.5820	0.063	7.42	0.492	0.15	0.694	$5.63x10^5$	$2.52x10^5$	$1.14 x10^6$	1		
	C	-3.665							$1.98x10^6$	$9.67x10^5$	$3.97 x10^6$	0.28	0.101	0.75

DISCUSSIONS

An indigenous and a commercial strain of *M. anisopliae* were assessed to determine the biological activities of these strains using the dipping method. Both strains were significantly effective to cause mortality to the test insects. The common slope for the microbial agents rarely exceeds above 2. It was believed that the pathogens which caused infectivity without producing toxins produced slopes predominantly below 2 (Burges and Thomson, 1971). The value of slopes exceeding 2, might be expected with pathogens like Bt (that produce toxin), but this also depends on the strain used and the host treated (Meynell and Meynell, 1965).

The present study was performed to evaluate the virulence of two strains of *M. ansiopliae* for controlling white grubs under laboratory conditions. The result revealed that both strains were effective to control white grubs. The mortality rates increased significantly with the increasing concentrations of the conidial suspension. The results also showed that both strains of *M. anisopliae* had a pathogenic effect on the white grubs. Among different concentration of indigenous strain, the concentration of 1.04×10^8 and 2.08×10^7 spores/ml caused mortality of 97.8% and 78.1%, respectively. This result is somehow similar with the result of G.C. (2006), where he calculated 73% mortality with the concentration of 1×10^7 spores/ml and a mortality of 82.5% was reported by Dhital (2008) for the same concentration. Higher mortalities (up to 100%) of larvae, pupae and adults of *Brontispa longissima (*Chrysomelidae, Coleoptera) were observed by Liu *et al*. (1989) with local isolates of *M. anisopliae* which might be due to the sophisticated bioassay technique and the lab facility. He also reported an average mortality of 86.7% of same insect with a range of 25%-98%. Likewise, indigenous isolates of *M. anisopliae* caused mortalities of 64.3-77.7% under laboratory conditions with forth instar larvae of silkworm (Acharya, 2005). Similarly, an *M. anisopliae* suspension containing $4\text{x}10^9$ conidia/ml caused 96% mortality of *Ixodes scapularis* (Acari: Ixodidae) under laboratory conditions (Benjamin *et al.*, 2002). In the same way, there was 94% adult mortality of *Anopheles stephensi* (Diptera: Culicidae), a vector of Malaria, at 10^6 conidia/ml (Kannan *et al.,* 2008). Strains of *M. anisopliae* showed good potential to control adult banana weevils with mortalities up to 60% (Gold *et al*, 2002).

The LC_{50} values resulting from an indigenous and a commercial strain were 5.5×10^5 spores/ml and 1.89×10^6 spores/ml, respectively. Similar finding was observed by Rodriguez *et al*. (2004) with the LC_{50} value of 5×10^4 conidia/ml for the isolate Qu-M270 against the white grub *Hylamorpha elegans* Burm (Coleoptera: Scarabaeidae). In the same way, Caston (2008) found an LC_{50} of 3.1×10^4 conidia/ml for *M. anisopliae* isolate IMI098378 when tested against adults of the black maize beetle (*Heteronychus ficas* Coleoptera: Scarabaeidae). When using oil suspensions, the same author obtained LC_{50} ranging from $1.4 \text{x}10^4$ to 1.4×10^8 conidia/ml under laboratory condition at 28^0C, Further, the author observed variable LC_{50} at different temperatures during the experiments. Vanninen *et al*. (1999) found *M. anisopliae* isolates, applied at 1×10^7 spores/larvae to be superior to *B. bassiana* in infecting *Delia radicum* Anthomyiidae, Diptera larvae.

In the laboratory, the indigenous fungus and the commercial product of *M. anisopliae* showed efficacy to control white grubs. Although statistically not significant, the native fungus showed a better performance and a higher virulence against white grubs in the laboratory than the commercial product based on a non-native isolate. This is probably due to the use of freshly produced material and the better adaptation of the native fungus to the local conditions like soil properties, host species and temperatures. Since both fungi were found effective under laboratory conditions, field studies are necessary to evaluate the field efficacy of the fungi against white grubs.

CONCLUSION

From these results it is concluded that the tested entomopathogenic fungi have potential as microbial control agents in managing white grubs. Research should be continued to obtain more virulent strains of the fungus. As indigenous and commercial strains of *M. anisopliae* were effective against of *C. acuta* it is imperative to test against other important insect pests of Nepal. As laboratory work was encouraging it should be tested under farmers field condition. If it proves that entomopathogenic fungi are an effective tool in controlling pest insects, they should be integrated in pest management programs and replace synthetic insecticides.

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PROSPECTS OF BIOCHAR AS SOIL AMENDMENT IN NEPAL HILL FARMING SYSTEMS

Ngamindra Dahal[1], Roshan Man Bajracharya[1] and Juerg Merz[2].

ABSTRACT

Burning of biomass under controlled temperature and oxygen limited environment produces biochar along with syn-gases and bio-oil. A significant volume of literatures portray biochar as a remedial option to meet growing needs of amending agricultural soils for global food security and carbon sequestration to curb climate change. Biochar has generated huge interests among agro-practitioners mainly for its two sets of benefits. The first set of benefits is about desirable changes in soil function that includes enhanced soil microbial activity, retention of nutrients and moisture, alkaline effect for treating acidic soils and, increased porosity on soil structure. The second set includes enhanced adaptive capacity of agricultural systems to climate change impacts, and, carbon sequestration due to its recalcitrant nature that remain in soil for a very long period. These acclaimed effects of biochar on soils are among the much sought-after remedies to heal a number of soil health ailments that millions of farmers and policy planners are looking for. However, effectiveness of biochar has yet to be examined carefully in different soil types over diverse topography corresponding with local cropping patterns. Matching properties of soils with those of biochar is a prerequisite for any interventions aimed at soil amendment. Properties of biochar generally depend on feedstock types, and temperatures during pyrolysis. This review analyses major published works on different aspects of biochar with the key question of whether promotion of biochar could be a viable solution to address some of the critical concerns of soil productivity in the Nepal mid hills and concludes with a note that there are serious knowledge gaps in two fronts – systematic practice of biochar production and application in agricultural farms is yet to take off, and, documented evidences of effectiveness of biochar on various soil types and cropping patterns are insignificant.

***Key words**: Application,biochar,climate change,farm yard manure, fertilizer,organic matter, sustainable soil management*

INTRODUCTION

Traditionally, Nepali hill farmers practiced subsistence agriculture and relied mostly on farm yard manure (FYM) and some compost to replenish plant nutrients in soils. In recent decades, majority of farmers increasingly depend on industrial fertilizers with limited inputs of locally produced manure (Bajracharya & Sherchan, 2009). Growing crop intensification is a prevalent practice among the hill farmers of Nepal from one or two crops per annual cropping cycle to intense farming of cash crops (3 to 4 crops/year). This has spurred on by increasing food and cash-crop demands along with the ready availability of agro-chemicals (Dahal & Bajracharya, 2011). This has added pressure on lands where low organic matters and high acidity are evident that eventually lead to reduce productivity of lands (Bajracharya 2002). The main reasons for low yields are believed to be the lack of replenishment of soil organic matter and inadequate or inappropriate use of fertilizers (Sherchan & Karki 2005). In hill agricultures, fertilizer retention capacity of lands, till the crop roots uptake it, is limited due to shallow layer of soil, low to high degree of slope and frequent runoffs after stormy rains. It's like a vicious cycle of low organic matter leading to increased susceptibility of soil erosion, thus, lower retention of fertilizers and less production of crops and further depletion of soil organic matter (SOM). Lal (2009) depicted two major causes for depleting soil organic matter (SOM). The first cause is the long-term use of extractive farming practices and, the second is the conversion of natural ecosystems such as forest land, prairie lands and steppes into croplands and grazing lands in Nepal where SOM stocks suffer losses due to a number of factors like less input of biomass, tillage practices, crop harvesting, excessive inputs of chemical fertilizers, and soil erosion.

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Hill farmers traditionally use farm-yard manure (FYM) as a significant source of organic matters based on local knowledge and techniques (Bajracharya and Sherchan, 2009). They prepare FYM out of locally available forest litters, crop residues as well as animal manures to replenish farmlands. With the advent of changing agricultural practices from low intensity (subsistence oriented) to more intensive cropping (commercial), farmers depend more on chemical fertilizers rather than FYM. Nevertheless, a significant number of hill farmers continue to use FYM particularly those who have adopted an improvised practice called 'sustainable soil management or SSM' as this helped them making FYM more effective and sustainable (Dahal & Bajracharya, 2012). Given the diminishing trend of FYM inputs throughout the country, some urgent measures to tackle the issue are imperative. Locally produced biochar could be a potential answer to this solution.

EVOLUTION OF BIOCHAR AS A SOIL AMENDMENT

The history of reporting effects of biochar goes back to 1960s, when Sombroek (1966), for the first time, published a description of 'tera preta' from Amazon soil. Contemporary studies on biochar largely deal with testing of promises or limitations of its effects to amend field soils, developing device for pyrolyzing various types of biomass, and weighing options for biomass management. More recently, the growing climate change concerns have fueled interests on biochar as a promising tool to sequester carbon, enhance climate adoptability of agricultural soil and increase agronomic yield. This is spectacularly reflected in growing publications and rising portfolios of biochar in agricultural extension programs.

Traditionally, local farmers from various parts of world follow numerous techniques to prepare and use biochar based on their indigenous knowledge and practices. For example, in parts of Japan, China, India, Nepal and many other countries, farmers have long traditions of using pyrolysed biomass in their farmlands (Amonette & Joseph, 2009). In Nepal, high mountain farmers have a tradition of producing on-farm biochar (Bajracharya et al, 2013), which they called 'bukma' in local language but their applications are limited to nursery beds of finger millet, potato and other vegetables. The modern biochar technologies are based on trials through cycles of research, development and field verifications undertaken by diverse groups of agencies and individuals. With the growing interests on biochar, there is a rapidly evolving knowledge on practices in various fronts of its production and application in response to diverse agricultural challenges such as climate change, rehabilitation of degraded farmlands, and, building more efficient and sustainable farming systems.

BIOCHAR FUNCTIONS

Properties of biochar determine the way how biochar functions within soil and its potential to act as a route to sequester atmospheric carbon dioxide (Downie et al. 2009). Nature of biochar-soil interactions largely depend on characteristics of biochar, which in turn, are determined by types of feedstock and pyrolyzing mechanisms (moderation of temperatures and oxygen). Biochar applications bring a change in soil structures, texture, porosity, particle size distribution and density, thereby potentially altering air oxygen content, water storage capacity and microbial and nutritional status of the soil within the plant rooting zone (Amonette and Joseph 2009). The suction effects of pores in biochar are attributed to create favorable environment for enhanced microbial activity due to holding of rich moistures and nutrients (Josheph et al, 2012). Biochar particles when applied in soils do not get decomposed like any other biomass, and exhibit enhanced sorption and cat-ion exchange capacities and alkaline properties that profoundly support healing a number of soil ailments such as acidity, nutrient leaching and poor rates of microbial activity.

The feedstock material, levels of oxygen supplied to the feedstock chamber and temperatures during pyrolysis determine the variability in physical and chemical properties of biochar (Lua et al

2004; Gundale & DeLuca 2006; Amonette & Joseph 2009). Properties of biochar fluctuate depending on temperature and air control mechanisms while pyrolysing the biomass (feedstock). Biochar properties, mainly porosity and ash-content, are reportedly varied in slow and fast pyrolysis of feedstock with same composition. In general, slow pyrolysis (low temperature, often between 300 and 600 degree Celsius) biochar is preferred against fast pyrolysis (high temperature often above 600 degree Celsius) to avoid complete burning into ashes and increasing porosity of the charred particles. A variety of agricultural crop residues and by-products including coffee pulps and husk, invasive species of shrub or weeds, forest litters, organic wastes, chicken manures, sawdust, waste-wood or a combination of these types of materials are commonly used as feedstock (Dahal & Bajracharya, 2014, Brown et al., 2006; Abdullah & Wu, 2009; Lucchini et al. 2014, Feng et al., 2012, Chun et al., 2004, Peng et al., 2011, Yao et al., 2011b). However, biochar practitioners often go for fast pyrolysis to meet their quantitative target of biochar volume.

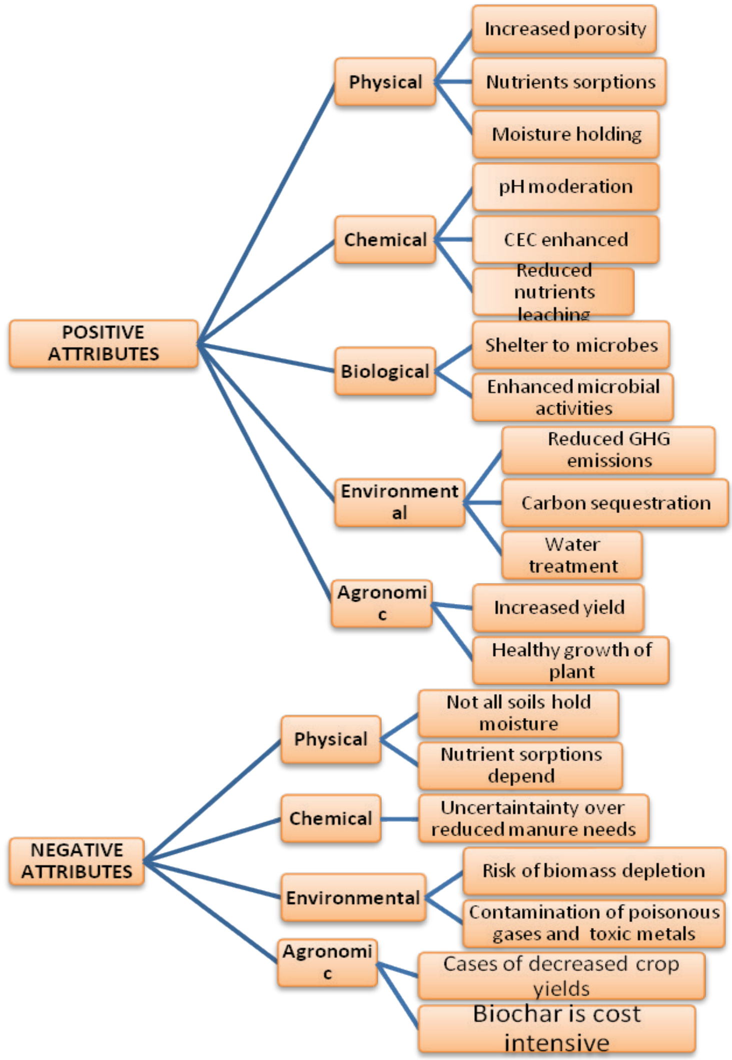
O'Neill et al. (2009) report that biochar contributes to improve soil health by enhancing processes like soil nitrification, with the added benefits of catalyzing nitrous oxide reduction that lead to reduce GHG emissions and to some extent improving plant productivity. Biochar particles are non-decomposable hence, remains immobilized in soils for decades or longer. According to a review by Gurwick et al (2013), stability of biochar in soil depends on ecosystems, source and application methods among others and vary between 300 years to over 1000 years. The decomposition rate slows over time and stay longer. According to Angin and Sensoz, (2014), the processes of biochar formation from various types of biomass are complex and remain unexplained. The feedstock types and pyrolyzing process profoundly affect shaping of biochar characteristics. For example, biochar made out of animal manures tend to have higher pH than biochars pyrolysed from plant species (Novak et al. 2009; Singh et al. 2010; Spokas et al. 2011) although farmers rarely prefer such feedstock for various reasons. Animal manures are either applied directly in the field as major source of fertilizers or making compost or farmyard manure (FYM)

BIOCHAR ATTRIBUTES

The biochar literatures depict various scenarios of its effectiveness as a means of soil amendment. Majorities of studies based on field experimentations highlight positive effects but come with precautionary notes as they also mention of various limitations in terms of geographical coverage, duration, types of biochar and feedstock among others. Positive attributes of biochar include effectiveness for improving soil quality, increasing agricultural productivity, and addressing environmental and agronomic issues (e.g., climate change, soil degradation, low agronomic yield, eutrophication of surface and groundwater), and reducing GHG emissions through carbon sequestration. Recently, some studies (see Mukharjee & Lal, 2013) have also emphasized on the need of critical review of results from biochar trials for building a more balanced explanation (without exaggerations) of its effects as a soil amendment. Comprehensive experiments on real field situations, not limited to the laboratory or greenhouse, are emphasized.

An overview on findings of biochar studies often raises ones expectations for the promising results of its incorporations in soils. The number of positive attributes exceeds the negative. The negative attributes are about uncertainties associated with beneficial effects that may require further testing for clarity. This also underlines the need of a systematic field research program that studies effectiveness of biochars representing a range of feedstock varieties and production methods, across climate and soil gradients. Lack of confidence of farmers and investors on promises of biochar adequately depicts the needs of boosting comprehensive plan of testing biochar in the areas where land degradation and productivity decline is more spectacular. This should also involve up-scaling across the diverse farming systems.

Figure 1: Positive and negative attributes of biochar applications (Source: A summary chart based on authors' review of biochar literatures listed in the references)



Manya (2012) reported that the immense variability among biochars and site-specific interactions with the soil and vegetation create a challenge in establishing clear relationships between physico-chemical properties of soil and right composition of biochar. This implies to the need of refining current knowledge on relative influences of conversion technology and feedstock on biochar properties for greater efficiency on large-scale biochar production. Seasonal and spatial limitations of feedstock sources from agricultural fields and natural forests pose challenges for regular operation of biochar plants (Yuan et al. 2012). This also refers to the knowledge gap to be filled through innovations in pyrolysis mechanisms tied with field trials to ascertain the standard biochar productions with respect to the types of feedstock and conditions of soils.

According to Xie et al (2015) once biomass is pyrolyzed, labile organic matter (i.e., biomass) in the sample is effectively destroyed, while the mineralized (fixed) carbon remains intact, which highlight the fact that the temperatures applied in the pyrolysis process dictate the loss of labile C leaving behind the fixed organic C content in the resultant char. The authors further reported that concentrations of volatile matter and C content in biochar from agricultural residues are relatively lower than that from wood due to the limited content of lignocellulosic biomass in herbaceous species than in wood.

Acknowledging a range of published works on various aspects of biochar, Gurwick et al (2013) concluded on the need of a systematic field research program that investigates stability of biochars representing a range of feedstock and production methods, across climate and soil gradients. Therefore biochar is likely to bring a win–win strategy by building organic matters in soils, enhancing soil quality, improving agronomic productivity and thereby advancing food security marginalized and degraded lands.

MIXED SCENARIOS OF BIOCHAR APPLICATION RESULTS

Generally, studies acknowledge positive effects of biochar to enhance soil quality thereby increasing agricultural productivity, and mitigating environmental and agronomic problems (e.g. climate change, soil degradation, low agronomic yield, eutrophication of surface and groundwater) to reducing GHG emissions through carbon sequestration. They report that applications of biochar enhances soil chemical properties by (i) reduction in soil acidity and increase in availability of plant nutrients and cation exchange capacity (CEC) (Lehmann et al. 2003; Cheng et al. 2006; Liang et al. 2006; Lee et al. 2010); (ii) sorption of heavy metals (Freddo et al. 2012); (iii) immobilisation of toxic organic and inorganic compounds in soil (Beesley et al.2011; Ogbonnaya & Semple 2013) and iv) liming effect of biochar in soil (Jeffery et al. 2011). Interactive effects of biochar on soils are commonly acknowledged in five aspects, namely, physical, chemical, biological, environmental and agronomic. Glaser et al. (2002) reported desirable effects of biochar on soil chemistry, Mukherjee and Lal (2013) on physical properties, (Lehmann et al. 2011) microbial communities and biota; and, Lehmann et al. (2006); Fowles (2007) on greenhouse gas (GHG) emissions. However, Gurwick (2013) cautions that optimistic claims about biochar's benefits to the soil environment contrast sharply with the limited amount of research on biochar's behavior and effects due to insufficient empirical evidence to support assertions of mitigating climate change significantly.

Biochar, an organic additive for soil amendment, improves soil health, thereby, increasing crop yields and productivity through reduced soil acidity, and minimizing the needs of some chemical and fertilizer inputs (Glaser *et al* 2002 and Lehmann and Rondon 2006). Lehmann *et al* (2003), and Steiner *et al* (undated) further informed of rich moisture after the use of biochar as a soil amendment probably due to sorption property of biochar that retains more water, nutrients and agrochemicals in soils for utilization of crop thus reducing leaching and run-off to ground and surface waters. Although, biochar particles resemble with charcoal, the process of preparing this differs from the formers; and, widely used as a useful ingredient with beneficial effect on soil fertility. Several studies (Inyang et al., 2010, Abdullah and Wu, 2009; Yu et al., 2009, Rondon et al., 2007) reported that as every feedstock material has different composition and proportions of cellulose, hemicelluloses and lignin with differential thermal degradation, quantity and characteristics of biochar vary depending on the contents of lignin and recalcitrant carbon. These findings are further analysed and summarized in table 2 to depict some prospects biochar applications at variety of agricultural soils and its corresponding remedial effects.

Table 2: Common problems with agricultural soils presented against corresponding remedial effects of biochar as reported in some studies

S.N.	Common problems in agricultural soils	Favorable effects of biochar applications	References
1	Growing acidity in agricultural lands limiting growth of microorganisms	In most cases biochar exhibits liming effects, thus, contributes to neutralize soil acidity thus helping enhanced microbial activity in soil.	Jeffery et al. 2011, Glaser *et al* 2002 Lehmann et al. 2011; Cheng et al. 2006; Liang et al. 2006; Lee et al. 2010
2	Losses of nutrients from slopes and terraced farms in hilly regions	Biochar amended soils show higher rate of sorption capacity leading to reduced nutrient losses	Glaser *et al* 2002
3	Low moisture holding capacity (shallow soil)	Longer/higher moisture holding	Lehmann *et al* (2003)
4	Low uptake of nutrients by plants/poor microbial functions	Higher CEC is an inherent characteristic of biochar that boosts microbial functions and increased nutrient uptake by plants.	Glaser *et al* 2002 Lehmann et al. 2003; Cheng et al. 2006; Liang et al. 2006; Lee et al. 2010
5	Depleting organic matters/ low SOM and spread out of toxic compounds	Biochar remains locked in soils, holds nutrients leading to increased organic matter and immobilize toxic compounds	Lehmann and Rondon 2006, Beesley et al.2011; Ogbonnaya and Semple 2013
6	Unmet demands of fertilizers and other inputs to the soil	Reduced needs of fertilizers and other agro-inputs in biochar amended soil	Lehmann and Rondon 2006, Glaser *et al* 2002
7	GHG emissions from agricultural activities	Reduced GHG emissions to net sequestration as biochar is locked into soils (stability of biochar)	Gurwick et al, 2013, Lehmann et al. (2006); Fowles (2007), Jeffery et al. 2011
8	Low crop productivity	Increased productivity of crops such as on pumpkin that reportedly increased up to four-fold.	Lehmann and Rondon 2006, Glaser *et al* 2002, Schmidt et al, 2015.

NEW INITIATIVES AND ISSUES FOR MAINSTREAMING BIOCHAR APPLICATIONS IN NEPAL

Biochar continues to gain global attention as a potential cure for a range of problems associated with soil productivity and crop yields even though uncertainties remain with its effectiveness on soil amendment (Kim et al. 2012). Whether biochar would serve as a meaningful remedy to improve agricultural soils in mid hills still remains as a research question due to lack of sufficient trials and validation in the diverse eco-agricultural contexts of the regions. For sustained productivity against a range of natural (e.g. soil erosion, climate change) and anthropogenic factors (e.g. inadequate organic inputs to maintain fertility) have been attributed to the diminishing productivity of the mountain agricultural soils requiring remedial research and policy actions to address the issue. Dahal (1997) reported that core issues of reforming the agriculture sector remained largely unchanged since 1950s when needs of crop intensification, expanding irrigation facilities, and, switching to mechanized agriculture, as well as, industrial fertilizers were emphasized to address the low productivity and declining soil fertility. More recently, Sunam, et al (2015) pointed out labor migration as a contributing factor to accelerate impoverishment of soils due to increased costs of agricultural inputs and labor.

Against this background, Bishwakarma et al (2014) reported a success story from mid hill region where over 100,000 farmers reaped benefits of increased productivity after 10 years of interventions under sustainable soil management (SSM) practices. This approach has been effective to enhance soil organic matters in the lands that reflect on the improved physical, chemical and biological characteristics of soil. Retaining soil nutrients and moistures, however, remains a critical challenge in cultivated lands with relatively shallow soil layer and high degree of slopes. Here, the biochar, which is yet to be tested and adopted as a viable tool, can play a role due to its sorption property that helps retain nutrients and moistures to make available for plants. Beyond the scope of traditional practices, major initiatives towards mainstreaming biochar applications are discussed here.

Piloting activities of biochar production and application have recently been launched in Nepal. For example, Nepal Agriculture Council (NARC) is experimenting with biochar in its research pocket zones for possible use to enhance soil productivity in degraded lands. A collaboration of Nordik Development Fund (NDF), Asian Development Bank (ADB) and NARC is piloting biochar in three agro-ecological zones of Nepal, namely, mountain, mid hills and plain. Quality of biochar and its effective applications are the key priorities (NDF, 2013)[1]. Some non-governmental agencies, namely, Helvetas Intercooperation and Nepal Agroforestry Foundation (NAF) are also undertaking field trials (Table 3). These actions are directed towards generating more evidences on effectiveness of biochar in various soils types and vegetation conditions. However, the question remains whether the trials performed in limited conditions produce sufficient evidences to making policy decisions in favor of spending the public funds provisioned for supporting agriculture development.

Table 3: Agencies undertaking biochar programs in Nepal

Agency	**Types of activity**	**Funding source, program areas, years and key interventions**
ADB in collaboration with Nepal Agriculture Research Council and Nepal Academy of Sciences and Technology	Action research, piloting	Nordic Development Fund, 3 eco-regions – high mountains, mid hills and Tarai, 2014 -16, production tests, trials on soil amendment, carbon sequestration, and energy saving stoves.
Department of Environment Science and Engineering, Kathmandu University	Action research	Helvetas Intercooperation, Sindhupalchok, Kavre and Lalitpur of Nepal, 2013-15,
Multi-stakeholders Forestry Programme	Community support	Jointly funded by Swiss, UK and Finland, 2013-14, support to communities of small holding farmers for livelihood improvements
Nepal Agroforestry Foundation	Scientific research	Norwegian Geotechnical Institute and the Norwegian University of Life Sciences, 2012 onwards. Nepal is one of the 4 countries where the project has been launched.
Local Initiative for Biodiversity Research and Development	Action research, piloting	DanChurchAid, 2014-2016, support for livelihood improvement among low income households

Limited tested knowledge of biochar applications in the Himalayas: We found hardly any peer reviewed journal articles that are based on comprehensive experimentations of biochar in Nepali soils. Nepali farmers traditionally practice open-burning of agricultural wastes prior to the cropping season with a belief that ashes of biomass help enriching soils. Majority of studies are based on experiments in the soils of temperate climates, namely, Asia, Europe, Australia, US and South America. Among Asian countries, biochar researches are picking up in recent years in China,

[1] http://www.ndf.fi/project/pilot-project-test-climate-change-benefits-biochar-ndf-c55 as access on Jul 30, 2015

Indonesia, and Japan. Nepali researchers have also published some papers on biochar but they are not based on Nepali soils and climates.

Uncertainties persist on results of biochar experimentations: Uncertainty persists on the expected benefits of biochar despite of the growing volumes of research findings in favor of its positive impacts. Some critical views on biochar highlight two major gaps: first, the present research findings are coming from the limited field experiments that cannot represent the world's vast and diverse conditions of soils and climates. Second, the results are not consistent, leaving a number of questions unanswered. According to Mukherjee and Lal (2014), biochar advocacy is growing worldwide without adequate scientific knowledge on basic soil processes and cost–benefit analysis of biochar application to soil. Likewise, Gurwick et al (2013) emphasize on more research needs on biochar despite its beneficial effects on soil environment particularly to assess its effectiveness in different soil profiles, climatic conditions and crop varieties. This is true in Nepal where biochar has not been tested beyond exception. This leaves a huge knowledge gap and opportunity for fresh researches and field experimentations in the region. Scores of prominent reviews of biochar studies (for example Mukherjee & Lal, 2014,) indicate the needs of comprehensive field testing before moving on policy reform in favour of using biochar, which has significant cost implications.

Maintaining production quality of biochar: The actors determining quality of biochar are feedstock types, temperature and oxygen level. Majority of studies indicate that biochar produced in low temperature, preferably below 500 degree Celsius, is more effective (Dahal and Bajracharya, 2014). Information regarding availability of minerals in biochar is particularly relevant to raise confidence on potential biochar benefits to plant growth (e.g. see Gundale & DeLuca 2007). In developing societies, biochar is produced mostly from locally designed and assembled retorts or stoves. These stoves are run manually, for filling with feedstock, firing and adjusting temperatures. Thus, the quality of biochar often varies from one batch to other that highlights the need of testing properties of each lot before field applications. This becomes a critical issue particularly for studying effects of biochar when one needs to know its physical and chemical properties including the microscopic structures. This involves significant costs and time, thus, has been a major constraint for ascertaining the effects of biochar on soil properties and plant growth. Types of feedstock and burning rates shape the properties of biochar in terms of its taste, odor, color and other chemical and physical characteristics.

Sources of feedstock: Availability of sufficient volumes of renewable feedstock sources is critical for promoting biochar. Usually the preferred feedstock type is the underutilized biomass available at the farm fields sites, households, market places or agro-processing mills. Feedstock varies depending on preferences of farmers, availability and accessibility of biomasses, season (rainy season not a preferred time) and biochar-making devices. For example, majority of hill farmers prefer locally available forest litters and invasive species of grass and shrubs, while in suburban areas the preferences shift to bio-wastages such as rice husks, coffee pulps and wooden dust from mills. Others include wastes from vegetables, fruits and crops. Some prefer mix others prefer single type feedstock. Nevertheless, varieties of feedstock are available in limited volumes depending on seasons and ecological conditions. For example, Dahal and Bajracharya (2013) found forest litter and weeds, coarse rice husks, coffee pulps and sawdust as possible sources of feedstock in parts of mid hill Nepal, which are available in specific seasons and limited quantity as a source of biochar feedstock.

Types of stoves for making biochar: A perception survey by these authors among 100 farmers who attended training programs on 'how to make and apply biochar' in seven hill districts of Nepal between Jan and June 2015, revealed that majority of them are interested to adopt biochar making and applications as an integral part of their improved agricultural practices. Majority of them pointed out that accessing an appropriate design of retort or stove for making biochar is the top constraint. The existing designs are not so appropriate for their dual needs of making biochar and daily cooking or preparing cattle feed. They also found the stoves expensive and time-taking as they spend nearly 4 hours for producing about 3 kilograms of biochar in a session. They also emphasized on a robust design so that the stoves need no maintenance at least for a year.

In summary, the aforementioned discussions depict a scenario that biochar is increasingly getting attentions of farmers and researchers alike to restore soil fertility. Its properties of nutrient sorption against leaching, alkalinity for neutralizing acidic soils, retention of moistures, enhanced microbial activities near the cavities of biochar particles and reduced compactness of soil structures are the key properties. It is also emphasized that biochar should be taken as a catalizer, not a fertilizer, and, can show its effects more clearly in degraded soils with low moisture holding capacity where it helps enhancing retention of nutrients and moistures. In this ground, biochar offers an alternative technique for enhancing not only productivity of agricultural lands but also for carbon sequestration through added organic matter in the soil which is locked for centuries. These benefits, however, come with costs and uncertainties.

CONCLUSIONS AND FUTURE PROSPECTS

Although biochar offers a promising opportunity to reduce climate change impacts and enhance adaptability of agricultural sector, a significant knowledge gap exists about its costs and benefits. Fertility losses are linked to several factors including depletion of soil organic matters as a result of lower agricultural inputs, leaching of nutrients, crop intensification and excessive use of chemical fertilizers (Dahal & Bajracharya, 2012), for which biochar offers a viable alternative to minimize these effects.

Although studies generally agree on beneficial effects of biochar to enhance soil productivity, they also call for taking precautions to carefully match biochar properties with those of soils with active participations of local farmers. Of the reviewed literatures on biochar, we broadly identified three types of findings. The first type demonstrates significant effects of biochar that is capable enough to treat several soil health problems with little or no negative effects, the second type presents mix or inconclusive results, and the third types present insignificant or no beneficial effects, and offer critical view on promoting biochar. Nevertheless, the limited studies conducted in Nepal's diverse soil and climate conditions, clearly indicate very positive effects of biochar in improving soil qualities and crop productivity. Thus, Nepal's agriculture sector offers a huge potential for reducing emissions from soil and enhancing sustainable productivity of the land through biochar enrichment. In this context, there is a potential of reducing organic soil carbon losses that can be produced into carbon emission reduction credits and traded like any other farm produce.

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PERCEPTION ANALYSIS OF CLIMATE CHANGE AND ADAPTATIONS BY SMALLHOLDER FARMERS IN NEPAL

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ABSTRACT

Climate change is posturing warning on present and future food security in low income countries. But, the actual effect of the climate change is still unknown. This study examined the farmer's perception on climate change and strategies employed to adapt using primary and secondary data collected through household survey and reported by government. Statistical analysis is used for exploring the adaptations by farmers for the negative impact of climate change on domestic production of major cereals crops. The results are discussed at district level empirically and major variables are found statistically significant. This study conclude that there is a need for adaptations strategy by government authority in environmental management and agricultural sustainability in Nepal to come to terms with negative impacts of climate change and likely positive and beneficial response strategies to global warming. The paper suggests some policy measures for improving adaptations and food security situation in the country and open up some areas for further research.

Key words: Adaptations, cereal crops, climate change, crop yield, perceptions

INTRODUCTION

The relationship between climate change and agriculture is two-way; agriculture contributes to it in several ways and climate change in general adversely affects agriculture. Agricultural production and productivity are primarily dependent on climatic factors, and the favorable climatic conditions are crucial in generating optimal yield. So, economy of the country is more sensitive to agriculture and climate change (Alam and Regmi, 2004). Though Least Developed Countries (LDCs) did not contribute much in increasing the level of GHGs they are highly affected by climate change and have low adapting capacity (Orindi and Eriksen, 2005 and Glieck, 1989). Climate Change has serious impact on cereal crops and livelihood of farming community through increasing uncertainties in agricultural production due to the disturbances in the natural system such as climate change, environmental degradation and rising competition for land and water.

The agricultural sector with low productivity growth is facing high rate of population growth coupled with the effects of climate change leading to serious consequences for sustainability. Intensive rain concentrated in a particular month has a devastating effect on crop production (McCarl, *et al.*, 2001). The majority of the farmers in Nepal hills depend on the monsoon rain for crop cultivation. In the recent years, intensity, amount and distribution of rainfall are changing in unpredictable manner. So, the changes in the rainfall pattern may be fatal for them. Once the climate is disturbed, the whole agriculture system is affected. Climate change affects food, feed, fiber and fuel (4"F") causing food insecurity. Out of 26 million populations, more than 2 million faced food insecurity in Nepal (IAASTD, 2008). If the increase in temperature exceeds by 1.5 to 2.5^{0}c, there will be the risk of extinction of plant and animal species by 20-30% (IPCC, 2007).

Climate change affects green sectors more than other sectors of the economy. Agricultural production is the outcome of the freshwater irrigation supplies from rivers and spring and rainfall, fertile soil terraced and maintained by the farmers for generations. Agriculture production depends on nature and gets affected by the change in the climatic parameters such as expected changes in frequency, duration, intensity and geographic distribution of rainfall and snowfall and increased frequency, duration and intensity of droughts (FAO/NRCB, 2008). Effects of climate change on agriculture are particularly high as the agriculture produces food and provides the primary source of livelihood for large chunks of weaker sections of the society (Pant, 2012).. 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.

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Due to unscientific cropping systems, inappropriate infrastructure and poor technology, Nepalese agriculture is equally sensitive to the long dry spell and high temperature during spring season. As Nepal is an agricultural country practicing mostly conventional system of farming with inadequate infrastructures, the effects of global climate change are expected to be very serious (Maharjan *et al.*, 2011). In fact, a series of regular and extreme weather events in Nepal have caused a significant decline in the country's crop yield.

Under such circumstances, most of the works have been done on changes in temperature and rainfall as proxy indicators for climate change and tried to show that alteration to these variables affect the 'mean' annual crop yield. To approach the issue appropriately, accounting local communities is essential, since they perceive climate as having a strong spiritual, emotional, and physical dimension. Community response is critical to understand & estimate effects of climate change on production & food supply for adaptation. Thus, it is vital to seek adaptation strategies to cope its effects on crop yield. The effect of climate change on crop yield and adaptation strategies are the predominant interest in recent time.

The study analyzes the perception about climate change and its impact on agriculture in Nepal particularly small holders and farmers adaptations based on household survey data. The scope of the paper is limited to the analysis of perception and adaptations against climate change by the farmers.

Recent research has focused on regional and national assessments of the potential effects of climate change on agriculture (Lobell, *et al*, 2008; Hassan and Nhemachem, 2008; Fischer *et al*, 2002). These efforts have, for the most part, treated each region or nation in isolation and do not integrate (i.e. combined biophysical and economic) assessment of the potential effects of climate change on proletariat agriculture focusing mostly on world agriculture (ODI, 2007; Segerson and Dixon, 1998). Therefore, this research also intends to investigate the effects of climate change on small holders at community level and their perception and adaptation to changing in climate. This will helps to synthesize a better understanding of the communities' perception of climate change and existing adaptation strategies in Nepal.

METHODOLOGY

AREA OF STUDY

Area of study is Rupandehi district of western development region and is known for its arable food crop production. Purposive sampling was used to select district and two Village Development Committees namely Manmateria and Hatti Bangai based on primary information. Random sampling was used to select sample households within the e communities and the communities that are prone to climate change impact.

MATERIALS AND METHODS

The study administered questionnaire and held Focus Group Discussions to elicit information, where 70 valid responses from household survey were used for further analysis. Both structured questionnaire and interviews were held with indigent and local government officials and all other stakeholders on climate change knowledge and adaptation. The study uses logit regression analysis to examine the characteristics that best explain variation in the measures of attitudes of the indigent perception and adaptation level to climate change and factors that influences such decisions. The study decomposes various measures of climate change adaptation. In addition, the study also uses Focus Group Discussions (FGDs) to find out the level of understanding of climate change at community level and their perception and level of preparedness. Panel data were collected during the late rain of September–October and early rain of March-April, 2014 to understand the variation of climatic conditions and its effect on agricultural outputs and other form of activities of food crop farmers.

ANALYTICAL APPROACHES

Logit model was adopted and used to analyze the determinants of the perception and adaptation level of climate change. The choice of the explanatory variables in the model was based on literature review (Ghazouani and Goaied 2001; Rodriquez and Smiths, 1994; Mendels *et al.*, 1994). The estimating logarithmic equation is

$$Ii = \beta_0 + \beta_1 In_1 X_1 + \beta_2 In_2 X_2 +, \ldots, + \beta_{19} In_{19} X_{19} \quad (1)$$

The dependent variable Ii is a dichotomous variable, which is one when a respondent perceive any of the climate change variations and adapt to the changes and zero otherwise.
The explanatory variables used in the Logit Models and hypothesized as determinants of respondents poor in the level of perception and adaptation to climate change (that is specialized in only mono cropping*)* are:, 1 for mono and 0 otherwise. Increased temperature (X_1), decreased temperature (X_2), altered climate range (X_3), changed timing of rains (X_4), frequency of droughts (X_5), noticed climate change (X_6), cereal/legume intercropping (X_7), mulching (X_8), practiced zero tillage (X_9), making ridges across farms (X_{10}), farm size (X_{11}), own heavy machines (X_{12}), household size (X_{13}), farming experience (X_{14}), education (X_{15}), age of farmers (X_{16}) access to extension facilities (ACEXT) (X_{17}) Dummy, if access 1, otherwise 0, access to credit facilities (ACCRE) (X_{18}) and Sex (X_{19})

RESULTS AND DISCUSSIONS

Figure 1 and 2 present farmers' perception about temperature change and precipitation in Rupandehi district in 2014. Majority of the respondents (46%) expressed that they perceived the increased temperature in 2014. Majority of the respondents (30%) perceived the decreased rainfall and 33% perceived the change in timing of rains in Rupandehi district (Figure 2).

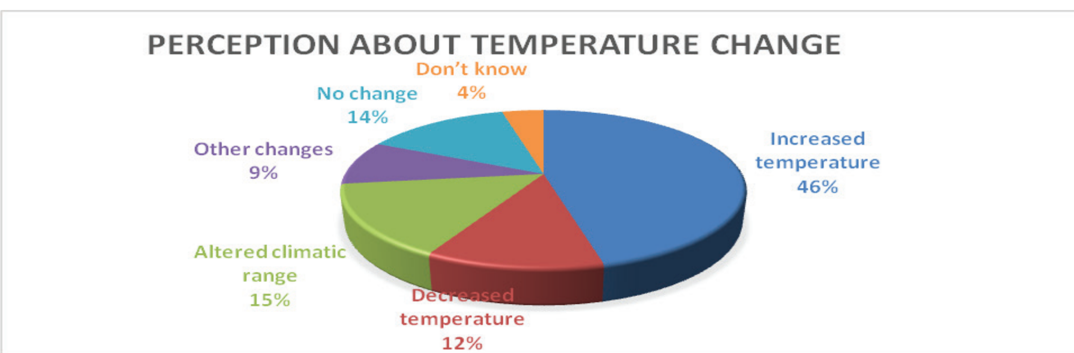

Figure 1 : Farmers' perception about temperature change in Rupandehi district, 2014

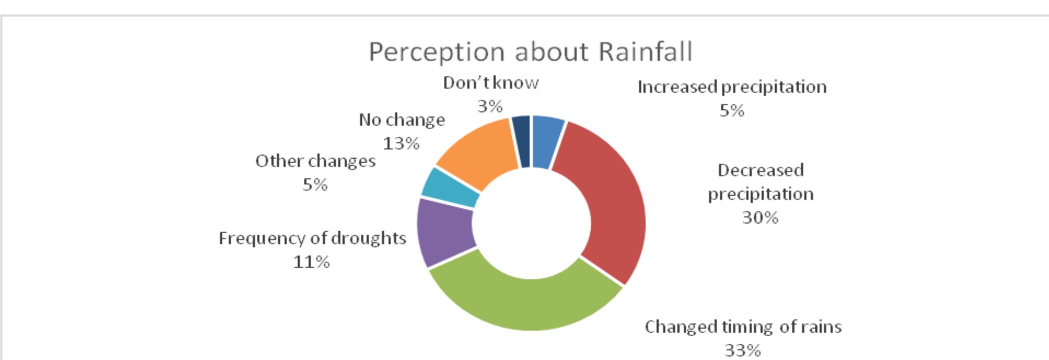

Figure 2 : Farmers' perception about precipitation in Rupandehi district, 2014

Table 1 presents farmers' *actual* adaptation measures and practices actually followed, thus, grouped into different categories (Table 2). These strategies, however, are mostly followed in combination with other strategies and grouped into the following adaptation options: diversifying into multiple and mixed crop-livestock systems, and switching from crops to livestock and from upland to irrigation, practicing zero tillage, making ridges across farms and cereal/legume intercropping.

Table 2 reveals that multiple cropping mixed with livestock rearing under upland conditions is the dominant system (27.75%). Cereal/legume intercropping is the second most common strategy (21.28%), and multiple cropping without livestock under dry land (13.1%) comes third.

Diversification from farming to non-farm the most common adaptation practice (23%) (Table 2). The implication is farmers are gradually moving away from farming to non-farm activities. The main adaptation strategic measures was followed as per Food and Agriculture Organization (FAO) classification (Dixon et al., 2001) and were used to classify the strategic measures into thirteen.

Table 1 : Farmers' perceived adaptations

SN	Variable	% of Respondents
1	Planting different crops	3
2	Planting different varieties	5
3	Practicing crop diversification	4
4	Different planting dates	7
5	Shorten length of growing period	6
6	Move to different site	2
7	Change amount of land	1
8	Changes from crops to livestock	2
9	Changes from livestock to crops	1
10	Adjust livestock management practices	1
11	Farming to non-farming	23
12	Non-farming to farming	2
13	Increase irrigation	3
14	Change use of chemicals, fertilizers and pesticides	5
15	Increase water conservation	8
16	Soil conservation	5
17	Shading and shelter	8
18	Use insurance	2
19	Prayer	3
20	Other adaptations	2
21	No adaptation	7

Table 2 : Actual adaptation measures used by farmers

SN	Adaptation measures	% of Respondents
1	Specialized crop under upland	2.21
2	Specialized crop under irrigation	1.03
3	Specialized livestock under upland	1.02
4	Specialized livestock under irrigation	0
5	Multiple crops under upland	13.1
6	Multiple crops under irrigation	0.27
7	Mixed mono-crop/livestock under upland	4.95
8	Mixed mono-crop/livestock under irrigation	2.04
9	Mixed multiple crops/livestock under upland	27.75
10	Mixed multiple crops/livestock under irrigation	4.24

11	Practiced zero Tillage	9.73
12	Making ridges across farms	12.38
13	Cereal/legume intercropping	21.28

Table 3 : Results of the Logit Regression Model

SN	Variables	Coefficient	t-Values
1	Increased Temperature (X_1)	0.090E-02	4.24***
2	Fall in Temperature (X_2)	-0.298E-01	-2.923**
3	Altered Climate Range (X_3)	0.3911	1.321
4	Changed timing of rains (X_4)	-0.161E-01	-3.3561***
5	Frequency of Droughts (X_5)	-0.8751	-0.2783
6	Noticed Climate Change (X_6)	0.6172	1.6061
7	Cereal/legume Intercropping (X_7)	0.5883	2.5412**
8	Mulching (X_8)	0.22E-05	2.1271*
9	Zero Tillage (X_9)	913E-06	3.112***
10	Making Ridges across Farms (X_{10})	0.719	2.752**
11	Farm size (X_{11})	0.797E-07	2.1242*
12	Owned heavy machines (X_{12})	-0.893E-01	- 4.4272***
13	Household size (X_{13})	-0.133E+11	-4.4252***
14	Farming experience (X_{14})	0.5197E-04	2.5731*
15	Educational status (X_{15})	0.1152	4.12***
16	Age (X_{16})	0.2117	0.2847
17	Access to extension facilities (X_{17})	0.368	2.73**
18	Access to credit facilities (ACCRE) (X_{18})	0.2605	1.962*
19	Sex (X_{19})	-0.4688	-0.918

***Sig. at P<.01, **Sig. at P<.005, * Sig at P<.001, Sig level P<.00001 and constant 0.62, Most of the explanatory variables are statistically significant at 10%.

Table 3 presents the estimated marginal effects and t-levels from the logit model. The results show that most of the explanatory variables considered are statistically significant at 10%. This study uses specialized (mono) cropping as the base category for no adaptation and evaluates the other choices as alternatives. The results show that altered climate change, noticed climate change frequency of droughts, age and sex had no significance effect on adaptation. While the increased temperature, intercropping of cereal/legume, mulching, zero tillage making ridges, farm size, farming experience, educational status access to extension and credit facilities are factors influencing adaptation positively (Table 3). However, fall in temperature, change timing of rains, own heavy machines and household size are also significant factors but influence adaptation negatively. This result suggests that the larger the occurrence of these variables, the poorer the adaptation.

The results revealed that fall in temperature influences the probability of switching away from mono-cropping more than changes in increased temperature. Similarly, the magnitudes of the marginal coefficients suggest that low outputs farming is a strong factor influencing the probability of switching to other systems that are better adapted to changes in temperature. Better accesses to extension and credit services seem to have a strong positive influence on adaptation.

In addition, access to other farm assets such as heavy machinery is found to promote the use of large –scale farming. These results suggest that capital, land and labor serve as important factors for coping with adaptation. The choice of the suitable adaptation measure depends on factor endowments (i.e. family size, land area and capital resources). The more experienced farmers are, the more likely to adapt. Sex of the farmer did not seem to be significance in influencing adaptation, as the marginal effect coefficient was statistically insignificant and signs do not suggest any particular pattern. These results suggest that it is the experience rather than sex that matters for adapting to climate change.

FOCUS GROUP DISCUSSIONS (FGDs)

The events of higher temperature, faster water evaporation, increased incidence of pests and weeds, violent rainfall and hailstorms, delayed rainfall and less clearly defined seasons were responded by 89, 72, 71 68 65 and 65 % of respondents on the issues of environment change for farming.

The costs associated with crops damaging weather events double each decade as the people (85%) indicated that their crops were damaged by unpredicted rains and a series of freak hailstorm. Downpours (Rainfall) were more intense in the past years that always leave a trail of destruction on the farms (76%). On the other hand, lack of water or delayed rainfall threatened crop production activities and 68% have switched their crop farming activities to other sectors due to low outputs. Many of the communities/farmers (82%) do not attribute these changes to climate change but the soil productive.

There is need of agricultural insurance (54%), weather alert (Radio and Television for daily weather forecast and relevance to agricultural activities) service (71%) to help for effective adaptation. Weather forecasting services will further help them to facilitate in farming operations. The extension agents needs knowledge enhancement in some of the adaptation technologies as zero tillage, organic agriculture, and better land management techniques.

CONCLUSION AND RECOMMENDATIONS

Farmers in the area of study rely on rainfed agriculture with mono-cropping practicing upland condition. Due to low outputs from farms, as a result of low rainfall and increased temperature, farmers are diverting from mono-cropping to mixed cropping and mixed crop-livestock systems.. Educating the farmers were found to promote adaptation which implies that raising awareness of potential benefits of adaptation is an important policy measure through education and trainings.

Focus Group Discussions revealed lack of effective access to information on climate change. Thus, there is need for effective and reliable access to information on changing climate to dissuade farmers' attitude from spiritual angle. In addition, empowerment (credit or grant facilities) is crucial in enhancing farmers' awareness. This is vital for decision making and planning process for adaptation. Combining access to extension and credit ensures that farmers have the information for decision making and the means to take up relevant adaptation measures. Some of the recommendations are :

- Policies must aim at promoting farm-level adaptation through emphasis on the early warning systems and disaster risk management and also, effective participation of farmers in adopting better agricultural and land use practices.
- There is an urgent need for agro-meteorological information and services and alerts to be made accessible (when necessary) to farmers in an understandable forms.
- Massive field level on-the-spot campaign on the reality of climate change and its serious consequences on farming and food production is highly recommended so as to persuade against farmers' believe from spiritual angle.
- Need of readily availability emerging technologies and land management practices that could greatly reduce agriculture's negative impacts on the environment and enhancement of its positive impacts.

The farmers and the communities are experiencing change in climate. Therefore policy of reliable and effective measures of adaptation need to be implemented and must be accessible to the end users. Looking at the issue of climate change adaptation, the role of agricultural extension is significant to raise both the consciousness of the need to climate change adaptation and possible methods of mitigating the impact to both the end users and policy makers. There is also need to design strategies that could help the farmers/rural communities adapt effectively against global warming. Early warming alerts and their interpretations in local language is required for preparedness against any damages in farming due to agro-metrological disasters.

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RICE SEED PRODUCTION AND MARKETING PRACTICES IN NEPAL

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ABSTRACT

Production and marketing of rice seed involves diverse activities and actors in seed value chain. This study aims to investigate practices and pattern of rice seed production and marketing in Nepal employing survey of 270 seed producers and 240 seed dealers and retailers covering most of the Terai and market accessible hills. The finding showed that seed business activities are concentrated on later generation seeds produced by diverse actors but marketed mainly through seed dealers and retailers. The most popular varieties with highest seed sales are Radha-4, Sabitri and US 312 (hybrid) respectively. Seed dealers selling hybrids receive higher benefits due to their higher market margins. The major constraints faced by seed actors are low profit margins in seed marketing of domestic varieties as compared to exotic hybrids. Improving rice seed business requires strengthening seed production and marketing of domestically developed varieties through entrepreneurship development, networking and policy support.

Key words: Actors in seed business, domestic varieties, market margin, policy support, rice seed, seed system

INTRODUCTION

Seed system is one of the most vital components of agricultural system that involves activities associated with seed production, multiplication, processing and marketing to ultimate seed use by farmers. An efficient and effective seed system is expected to provide seed of adapted varieties at proper quantity, quality, time and place at an affordable price to farmers. Timely supply of sufficient quantity of quality seeds of high yielding varieties increases crop yields by 15-25% (Thompson, 1979) and it can be further raised up to 45% with timely applications and efficient management of other inputs such as fertilizer, irrigation water and pesticides. An estimated 50% of the global increase in yields over the past 50 years has been derived from genetic progress and seed quality, in addition to agronomic improvement and phytosanitary product uses (FAO, 2011). Fresh replacement of quality seed of improved varieties increases not only yields but also reduces cost of production due to lower seed rate requirement and disease free status of the good quality vigorous seeds. Use of quality seeds also enhances efficiency and productivity of other key inputs such as fertilizers, irrigation and human labour.

The growth of production and marketing of quality seeds of rice in the country has increased in recent years with the advent of liberal economic policies particularly on seed sector and growth of private and community sector in seed business. For instance, the trend of seed replacement rate (SRR) in rice has increased from less than 3% in the year 2000 to about 12% in 2014, indicating a gradual rise of formal supply of quality seeds in the country (SQCC, 2014; Gauchan et al., 2014). The major objective of any seed sector strategy and policy is to enhance timely access and availability of sufficient quantity of quality seeds of choice varieties to farmers in affordable price. However, the current SRR as an indicator of availability and access in major food staples including rice is very low (less than 12%) as compared to desired level of 25% SRR (MoAD, 2013). As a result, the productivity of rice in Nepal is still low (3.3 t/ha) as compared to global average of 4 t/ha (FAOSTAT, 2014). Therefore, there is a need to study current status, prospects and constraints in existing production and marketing of rice seed system to improve SRR for increased productivity and income of farmers. Furthermore, most of the past studies in rice are focused on technical aspects of seed production and marketing of grains or products without due consideration given for seed system; a vital input in agriculture and the means of delivery of new technologies. In addition, seed production and marketing has also not been a prioritized activity in overall agricultural system. As a result, there are limited information and scant studies on rice seed production and marketing in Nepal.

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METHODOLOGY

This study involved a nationally representative sample survey of 270 seed producers and 240 seed dealers and retailers (Agrovets) located in key seed producing and marketing locations of Terai (east of Jhapa to far west in Kailali) and accessible regions of central and western hills and mountains. In addition, the survey was supplemented by institutional survey of selected seed companies, cooperatives and community based seed producer (CBSP) groups from selected seed producing and marketing centers. The survey covered 10 key seed producing districts of Terai (Morang, Siraha, Rautahat, Chitwan, Rupendehi, Dang, Bardiya) and hills (Kavre, Tanahun, Syangja) in 2011/12 and 2012/13 for collecting information about rice seed production, while it covered 30 districts (20 Terai and 9 hills and 1 mountain districts) for seed dealers-retailers (Agrovets) to collect marketing information. Seed marketing survey covered hilly districts mainly from central and western region and one mountainous district (Jumla) from mid-western region. The seed producing districts were chosen based on the dominance of seed production activities of the seed actors (presence of CBSP groups, Cooperatives, contract seed production activity of seed companies). For the selection of seed producers, first 2 dominant seed producing villages from each district were selected from where 25-35 seed producer farmers affiliated with CBSP groups, cooperatives or seed companies were randomly interviewed. For seed marketing related information, we selected Agrovets randomly from market centers of 20 Terai and 10 Hills and mountain districts where they were engaged in rice seed marketing. The sample size ranged 5-10 Agrovets in the Hills (where presence of Agrovets were limited) and 10-20 Agrovets in the Terai districts (where their presence was higher). The actual sample size represented about 20-30% of the total sample size of producers and traders and covered representation of different ecology (hills, Terai), production systems (main season and spring rice) and market centers (urban, rural) and seed actor types (producer cum dealer, traders only). The survey information covered institutional profile, business operations and practices of seed actors, general features of seed producers, entrepreneurs and institutional actors, existing marketing systems and market networks, type of rice varieties and hybrids produced, sold and marketed and their market price including major bottlenecks and gaps in seed production, marketing and supply.

RESULTS AND DISCUSSION

SEED ACTORS AND THEIR SOCIOECONOMIC FEATURES

Broadly three types of seed actors were common in Nepal in terms of their real involvement with seed enterprise and production led seed business motives. These include Seed companies, Cooperatives and CBSP groups who had a practice of contracting or engaging farmers for rice seed production. The unique feature and similarity of all of these three actors was that they all were involving individual farmers in producing seeds whether by bringing them to group or cooperative members or in contractual mode of seed production with seed companies, thus providing smallholder farmers an opportunity to earn cash income and livelihood by growing seed crops. There are no seed companies or cooperatives owning separate seed producing farms for producing large scale commercial seed production in Nepal. The key socioeconomic and seed producing features of sample farmers associated with CBSP groups, Cooperatives and Seed Company from key seed producing districts are presented in Table 1.

Table 1: Characteristics of seed producers that are associated with key seed actors

Characteristics	CBSP Groups (N=94)	Cooperative (N=92)	Seed Company (N=84)	All (N=270)
Age (years)	46	44	46	45
Education (years)	7	6	8	7
Family size (no)	6.52	6.51	7.05	6.68
Farm size (ha)	1.03	1.29	1.76	1.34
Rice cultivated area (ha)	0.83	0.93	1.58	1.10
No of rice varieties grown	1.84	1.36	1.69	1.63
Average rice seed area (ha)	0.48	0.69	1.50	0.85
Average rice seed produced (t)	1.2	2.5	4.1	2.5
Rice seed yield (t/ha)	2.50	3.62	2.73	2.94
Rice seed sold (t)	1.0	1.8	3.7	2.2
Rice seed sold (%)	83.3	72.0	90.2	88.0

Source: Field Survey (2012, 2013).

The data showed that demographic features (age, education) of the sample seed producers were of similar type and nationally representative across the seed actors, whether they engaged with Seed Company, Cooperative or CBSP groups. However, average farm size (1.34 ha) and family size (6.68) of seed producing farmers were larger than that of national average farm size (0.70 ha) and five family members obtained from national census survey (CBS, 2013). This indicates that farmers with better resource endowments (land, labor) are engaged in seed production. Farmers generally grew 2-3 varieties of rice in their field but actual number of varieties in seed production was average of 1.63 varieties. Rice seed area owned and used in seed production by farm households was smaller in CBSP groups (0.48 ha) followed by Cooperative (0.69 ha), while seed producers affiliated with seed company had largest farm size and area under rice seed production (1.5 ha).

Average seed yield obtained by seed producers was 2.94 t/ha and it ranged from 2.50 to 3.62 t/ha among the seed producers. The share of marketed seeds from the total produced seed was highest in seed producers associated with seed companies as compared to those associated with CBSP groups and Cooperatives. On average 88% of the produced seed was sold and the rest 12% was locally consumed.

PRODUCTION SHARE AND MODE OF PRODUCTION

Seed business activities in rice during survey were led by three key actors mainly CBSP, Cooperatives or Seed Company and they were involved in membership or contractual mode of seed production with farmers. The seed types, production shares by seed actors for rice seed production is presented in Table 2. The findings showed that seed actors are mainly concentrated on commercial or later generation (certified or improved) of seeds. These include: (i) Certified seed (CS), (ii) Truthfully labeled (TL) seed, and (ii) improved seeds.

Table 2: Seed production share (%) by class of seeds and contractual modes of production

SN	Seed types and contract mode	Seed types and share (%)	Seed producers and their affiliation with actors			
			CBSP (N=94)	**Cooperative (N=92)**	**Seed Company (N=84)**	**All (N=270)**
1	Type of seed produced	Certified /Truthful Labeled Seed (%)	81	95	95	90
		Improved seed (%)	19	5	5	10
2	Contractual seed production	Seed producers (%)	60	47	83	63
	If contract followed	Verbal (%)	88	64	47	67
		Written (%)	12	36	54	33

Source: Field survey (2012, 2013). Note: The sample survey was not able to clearly separate CS and TL seeds.

A large proportion (90%) of seed business by sample seed producers involved quality assured seeds, either certified or truthfully labeled (CS/TL), and the rest 10% accounted for improved seeds (IS) which were not quality assured (CS/TL) seeds. Contractual mode of seed production among seed producers varied with the type of seed actors. More than three-fourth of the seed producer farmers associated with CBSP groups and two-third of Cooperatives had adopted verbal mode of contract, while about half of the seed producers associated with seed company adopted written contractual mode for producing quality seeds. The contract mechanism for seed production was mainly done for the period of one year or one crop season.

Seed testing, certification, seed tagging and bagging are essential functions of seed actors for maintaining quality and marketing of seeds. Such quality assurance builds trust to help avoid fraudulent sale in the private seed sector (Tripp, 2001). About one-third of total quality assured seed produced by these seed actors during survey year were certified, while two-thirds were truthfully labeled. Truthful labeling was the most common practice adopted by seed actors since they have flexibility not to depend on seed certification agencies for quality assurance (Khanal, 2015). Among the three types of seed actors, the extent of performing quality assurance services was lower in CBSP groups as compared to cooperatives and private companies since quality assurance (certification or truthful labeling) adds to the costs and technical requirements, and demands contacts with the formal certification agencies (e.g. Regional Seed Testing Laboratories (RSTL) that are mostly located in regional centers of Terai and Kathmandu. Moreover, many public certifying agencies had limited technical staff and slim budget to provide certification services for CBSP groups that were located far away from their offices in the remote hills and mountains.

SEED MARKETING CHANNELS AND PRACTICES

Seed marketing is one of the most vital components of seed system that involves activities associated with seed collection, storage, distribution, and market intermediaries to ultimate seed user farmers. The various market channels through which seed is marketed vary greatly according to the needs of a seed enterprise. There were two major seed market channels prevalent in Nepal. These included (i) sales of seeds by seed entrepreneurs through seed dealers and retailers often referred to as Agrovets (Agriculture and veterinary shops) and (ii) direct marketing (sale) by seed entrepreneurs to seed users from their own seed stores/sales points, which involved no intermediaries in the marketing. A case study of rice marketing indicated that most of the seed companies market their major bulk of their seeds (90%) through first channel or private dealers (Agrovets), while some cooperatives and many of the CBSP groups market their seeds directly through their own stores/outlets (Gauchan et al., 2014). The seeds that were marketed through market and non-market channels were either produced with contract growers or it may be purchased from farmers groups (e.g. CBSP) and cooperatives. Seed dealers preferred to market imported hybrid seeds as compared to domestic inbred varieties as there was high price margins and benefits in selling hybrids. Rice seed marketing was more efficient in directly marketed seeds from seed producers to grain producers and other users of seeds.

MARKET SALES AND MARGINS

Seed dealers cum retailers (Agrovets) sell different rice varieties covering inbred varieties (domestic released and non-notified ones) and hybrids (both registered and non-registered ones). The larger share (90%) of seed was sold to Agrovets by the seed companies, some to cooperatives, CBSP groups, and individual farmers and limited quantity also to District Agriculture Development Offices (DADOs). Most of them provided 7-10% commission to buyers buying in bulk. The seeds were sold mostly on credit (70-90%) while remaining about 10-30% of the seeds was sold on cash. The price of seed in some districts was determined at the district level (e.g. Chitwan, Rupandehi) by district seed coordination committee, where presence of private seed companies and cooperatives had greater influence in seed sector in the districts. Seed dealers often used to sell rice varieties and hybrids in different names that may be formally released/registered or not in Nepal with varied market margins (Table 3). The market sale margins (benefits) was lower for domestic inbred varieties (Rs 4-5/kg), while for imported hybrid varieties, margin was relatively high with average of Rs 18-42/kg. More than one-fourth of the total sales in survey year (2013) made by Agrovets accounted for hybrid seeds. The sale price of hybrids was very high with high variation among them that ranged from NRs 150/kg to maximum of NRs 600/kg, with an average sale price of Rs 345/kg. The survey estimated that about 1,000 t of hybrid seeds were marketed across Nepal in 2013 which constituted about 30% of the total Agrovet sales and about 10% of total formally supplied seeds in the country. Nearly one-third of hybrids and one-fifth of all inbred varieties marketed by Agrovets in 2013 were not officially registered and notified in the country.

Table 3: Sale of rice varieties and hybrids by dealers and retailers (N=240) in Nepal 2013

Variety types	**Sale (t)**	**Average buying price (NRs/kg)**	**Average market sale price (NRs/kg)**	**Sale margins (NRs/kg)**
Nepali released varieties	1874 (60)	45	50	5
Non released inbred varieties	339 (11)	47	51	4
Registered hybrids marketed	582 (19)	345	387	42
Un-registered hybrids and uknown varieties	301 (10)	315	333	18

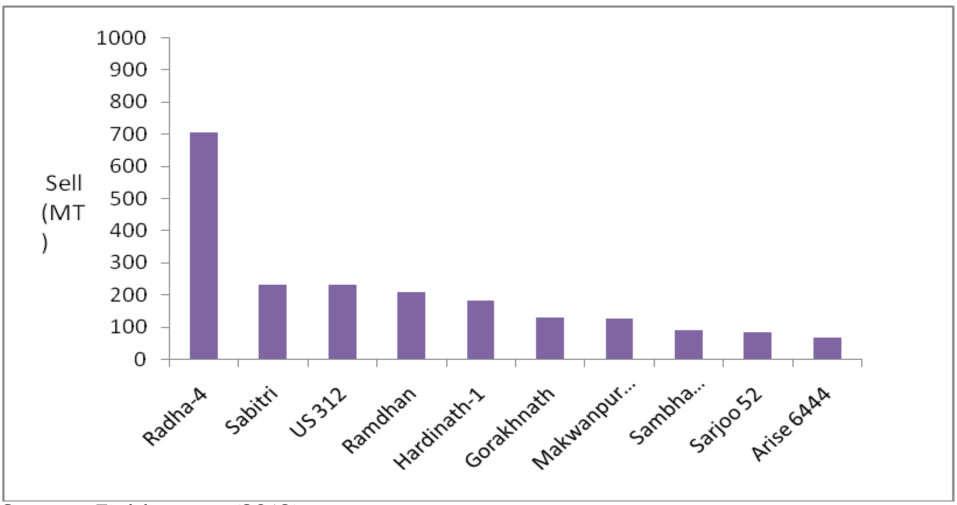
Total	**3,104 (100)**

Source: Seed dealers (Agrovets) survey, 2013. Figures in parenthesis indicate percent market share

MOST POPULAR MARKETED VARIETIES

Seed dealers cum retailers (Agrovets) marketed more than 100 rice varieties and hybrids across Terai and market accessible favourable regions of lower hills of Nepal in 2013. About half of them were only officially notified, which included half of the released inbred varieties (35 out of 69 inbred varietes in 2013) and 17 hybrids that were registered in Nepal until 2014. The ten most popular varieties with highest seed sales in 2013/14 is presented in Figure 1.

Figure 1: Dominant varieties marketed by seed dealers in 2013



Source: Field survey (2013).

Radha-4 variety had the largest seed sales followed by Sabitri and then US 312, which is registered hybrid. Ramdhan and Hardinath-1 ranked fourth and fifth, Gorakhanath hybrid sixth and Makawanpur-1 in seventh postion. Shamba Mahsuri Sub1 ranked eighth which has been gaining popularit from the year 2013 due to its good grain quality, higher market price and its higher demand in the market. Among 10 important ranked varieties, three were hybrids rencently registered in Nepal. In addition, data showed that varieties such as Radha-12 was popular in the eastern region, Masuli in the Terai and lower altitudes of hills and Khumal-4 in the mid hills across Nepal. Estimates showed that one-third of the total estimated share of formal sector seed in 2013 was marketed through dealers cum retailers (Agrovets).

VALUE OF SEED MARKET

The value of rice seed market in Nepal accounted for over NRs.600 million in 2013 by combining total seed marketed and distributed through formal sector only. The total formal rice seed marketed and distributed in 2012-2013 is estimated about 10,000 t with 9,000 t of improved inbred varieties and about 1,000 t of hybrids contributing about 12% seed replacement rate (SRR). The value of improved inbred varieties formally marketed in Nepal was estimated to be NRs.320 million with 2013 seed sale price (NRs. 35/kg). The value of hybrid rice seeds with average price of NRs. 300/kg accounts for NRs.300 million in the current price. The total value combining improved inbred and hybrids accounted for NRs. 620 million (US$ 6.2 million). This value of seed market accounts only for formal sector supply but does not include seeds supplied informally through farmers own savings and exchanges. Estimates showed that there is a higher demand of formal rice seed market to the amount of 20,000 t annually in the country as estimated recently by Nepal Seed

Producer Association of Nepal (SPAN, 2014). This indicates that the formal system currently supplies only half of the total actual quality seed demand for rice crop in Nepal. This assessment showed that the potential formal seed market value of quality improved rice seed in Nepal in 2013 was of about NRs 1 billion (US $ 10 million).

GAPS AND ISSUES IN PRODUCTION AND MARKETING

The field survey observations and assessments showed that rice seed production and marketing was not a prioritized activity in overall rice seed system in Nepal. Production and marketing of rice seed face several constraints and bottlenecks for efficient supply and farm level deployment of choice varieties. The major gaps and issues in current seed production and marketing system obtained from survey were: (i) low profit margin for marketing of domestic inbred varieties (ii) slow multiplication of quality seeds of farmers preferred varieties in seed chains with limited policy support and seed networking (iii) mis-match in demand and supply of source seeds as a result of poor integration of variety development, seed multiplication and marketing chains, (iv) inadequate training, networking and capacity building of seed actors in quality seed production and marketing of domestically developed inbred varieties, (v) inadequate seed storage, processing and marketing infrastructure and (vi) problems in seed marketing and market networks with dominance of unregulated market supply. Furthermore, marketing of good quality seeds of domestic improved inbred varieties were constrained by poor market information and absence of proper packaging, labelling, branding and seed marketing campaigns. Seed dealers also lacked proper public sector support, awareness level, training and networking in promotion and marketing of domestically developed varieties. Hence, at the farm level, farmers had limited choice of seeds of improved varieties and constraints in timely access of quality seeds.

CONCLUSIONS

Seed business is emerging as a viable and sustainable enterprise in Nepal. The main actors in seed production are individual seed producers, CBSP groups, Cooperatives and Seed companies. Seed production was done either through contractual mode or membership based production by the groups or cooperatives. However, seed marketing was done by a range of seed actors such as Agrovets (dealers-cum retailers), seed companies, cooperatives and CBSP groups. Seed business activities were mainly concentrated on commercial or later generation of seeds focusing on certified, truthful labeled or improved of seeds. Marketing of seeds are done mainly through seed dealers and retailers (Agrovets) and to some extent directly to users. About one-third of the total estimated share of formal sector seed is marketed through dealers cum retailers (Agrovets). Non-market channels are also prominent among CBSP groups and cooperatives selling their seeds through own informal channels and District Agricultural Development Offices. Agrovets market more than 100 rice varieties and hybrids, out of which about half of them are only officially notified. The most popular varieties with highest seed sales in order of rank are Radha-4, Sabitri and US 312 (hybrid), respectively. More than one fourth of the total sales made by Agrovets accounted for hybrid seeds. Recently flow of hybrid rice seeds is expanding with higher profit margin for Agrovets and increasing trend for market oriented production in favourable rice producing domains of Terai and the hills. Seed dealers selling hybrids receive higher benefits due to higher sale price and profit margins for hybrids as compared to inbred rice varieties.

Presently, seed marketing is not a prioritized activity in overall rice seed system in Nepal. Moreover, seed production and marketing system face several constraints and bottlenecks for efficient supply and farm level deployment of choice varieties. Furthermore, marketing of good quality seeds of domestic improved inbred varieties are constrained by low profit margins and absence of proper packaging, labelling, branding and seed marketing campaigns. Seed dealers also lack proper public sector support, training and networking in promotion and marketing domestically developed varieties. Strengthening production and marketing system of quality rice seed for enhanced access and availability at farm level will require development of efficient production and marketing mechanisms including entrepreneurship skills among the seed actors. This can be made through (i) improving information flow of the quality assurance of domestic improved varieties in the market (ii) proper linkage of varietal development and seed multiplication chains with marketing to reduce mis-match in demand and supply, (iii) strengthening market and seed infrastructure facilities for production, processing, packaging, labeling and branding with adequate market campaigns and monitoring, (iv) enhancing capacity of seed producer farmers and private seed suppliers in marketing and business skills by diversifying their linkages and networking (v) price incentives for quality assured domestic varieties and their seed production and sales, and (vi) effective implementation and harmonization of seed policy and legislation for diversifying farmers' choices for quality seeds of preferred domestically developed varieties. Policy measures should support, promote and strengthen commercial seed networks in rural areas, not only for marketing seeds but also for quality assurance services as well as related inputs such as fertilizers, registered pesticides and small-scale tools and equipment. Future in-depth research will be required to focus on measuring efficiency of seed production and marketing channels for identification of appropriate measures to strengthen overall production and marketing of rice seed system in Nepal.

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PERFORMANCE OF MICRONUTRIENT DENSE POTATO GENOTYPES

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ABSTRACT

Mother Trial on micronutrient dense potato genotypes received from International Potato Centre (CIP), Lima, Peru was carried out for two consecutive years 2013 and 2014 to evaluate potato genotypes suitable for the Karnali region of Nepal. Eighteen different micronutrient dense potato genotypes with three checks in first year and nine selected micronutrient dense potato genotypes with same three checks in second year were tested on Randomized Complete Block Design (RCBD). Tested genotypes differed significantly for vegetative as well as yield parameters. During 2013, the highest tuber yield (27.2 t/ha) was recorded from CIP395112.32 followed by CIP394611.112 (20.7 t/ha), CIP393079.179 (18.6 t/ha) and the lowest (5 t/ha) from CIP399092.116 among the micronutrient dense potato genotypes. Similarly, during 2014, the highest tuber yield was obtained from CIP390478.9 (24.3 t/ha) followed by CIP395112.32 (22 t/ha), CIP394611.112 (20.8 t/ha) and the lowest from CIP399078.11 (7.8 t/ha). Based on the average result of both year, CIP395112.32, CIP394611.112, CIP390478.9, CIP393079.179, CIP397060.19, CIP395017.229 and CIP395017.242 gave the better productivity ranging from 15.9 t/ha to 24.6 t/ha.

Key words: Genotypes, micronutrient dense, mother trial, parameters,yield

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important tuber crops of Nepal. It is utilized as a major vegetable in terai and mid hills and used as a vegetable and staple food in high hills. Potato serves as staple food supplying in lean period thus fills food gap. It occupies the 5th position in area and 2nd in total production and 1st in productivity among the food crops (rice, wheat, maize, millet and potato) grown in Nepal. Area under potato is 197234 ha and total production 2690421 mt with an average productivity of 13.6 t/ha (ABPSD, 2012/13). The area under potato in Jumla district is about 2,650 ha (1.3 % of the total cultivated area), total production is 26,000 mt with average productivity of 9.81 mt/ha (DADO, Jumla, 2012/13). This indicates that the average productivity of potato in Jumla is less (9.81t/ha) than the national average (13.64 t/ha) productivity (MOAD, 2012/13). Out of total area under potato, around 19% is in the high hills and mountains, 44% in the mid hills and 37% in terai (NPRP, 2014). In the recent years food security has become one of the biggest challenges in Nepal. Similar to other developing countries, food security situation has been affected in the country by the increasing population, changes in food habits and impacts of climate changes (Bista et al. 2013). Low productivity of potato in Nepal is lack of quality planting materials, prevalence of insect pest and diseases, inadequate research on varieties for different locations (NDPP, 2011) and adoption of new varieties of potato is relatively less in many parts of Nepal (Kafle and Shah, 2012).

Similarly, low productivity of potatoes in the Karnali region has been identified as core problem resulting from several limiting factors such as inadequate quantity of disease free, drought tolerant basic seed of recommended varieties to flush out the degenerated seed potatoes, inadequate knowledge regarding the new varieties and inadequate availability of quality seed potatoes of recommended varieties.

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Though area, production and productivity are increasing over the periods, the national productivity is still low in comparison to its potential yield (Sharma, 2011). Demand of high yielding varieties with resistance to major disease and pest has remained always very high since long in Nepal (Khatri et al. 2010). To overcome these problems and evaluate suitable micronutrient dense potato genotypes, mother trial on potato genotypes was conducted at the station.

MATERIALS AND METHODS

Eighteen different micronutrient dense genotypes of potato introduced from CIP, Lima, Peru that are rich in micronutrient were evaluated and compared in RCBD with three replications during 2013 and 9 different micronutrient dense clones of potato with three replication during 2014 at Agriculture Research Station (Horticulture), Rajikot Jumla. In addition to micronutrient dense potato clones, Kufri Jyoti, Desiree and Jumla Local varieties were used as check during both years. The plot size was 5.4 m^2 (3m x 1.8m) and was fertilized with compost @ 20 ton/ha, $N_2P_2O_5K_2O$ @ 100:100:60 kg/ha. Tubers were planted at 60 cm x 25 cm spacing. Planting and harvesting was done on the Chaitra (mid March) and Bhadra (mid August) respectively. All the management practices were followed as per National Potato Research Program (NPRP) recommendation. The necessary data for growth, yield and yield parameters were recorded and statistically analyzed with MSTATC.

RESULT AND DISCUSSION

During 2013, almost all the vegetative as well as yield parameters were found significant among the tested potato genotypes. Emergence was found highly significant at 30 days after planting. The highest (30.6%) emergence was recorded in Jumla Local followed by Kufri Jyoti (23.2%) and the least (0.9%) in CIP394611.112, CIP392820.1, CIP393079.179. Similarly, emergence after 45 days of planting was also highly significant. The highest emergence (78.7%) was found in Jumla Local and Kufri Jyoti whereas the lowest (8.3%) in CIP397060.19. Highly uniform plants (5) were found in genotypes CIP393536.13, CIP392740.4, CIP393382.44, CIP394611.112, CIP390478.9, CIP393617.1, CIP395017.229, CIP394613.139 and the least uniform (3.7) in CIP399079.22. Maximum ground coverage (76.7%) was observed in Jumla Local followed by Kufri Jyoti (73.3%) and minimum (8.3%) in CIP397060.19. Number of main stem (4.6) was counted highest in Kufri Jyoti followed by Jumla Local (3.5) and the lowest (1.4) in CIP394004.19. The tallest plants (102.1cm) were measured in CIP394004.19 which was statistically at par with CIP395112.32 (101.8 cm) and the dwarfest plants (47.6 cm) were measured in Desiree.

Maximum number of tubers (243210) were counted in CIP394611.112 whereas CIP394613.139 produced the least number of tubers (110493.7) per ha. Maximum marketable tuber yield (17.8 t/ha) was recorded in Kufri Jyoti followed by CIP395112.32 (15.9 t/ha) and the lowest (2.2 t/ha) in CIP390478.9. Number of non marketable tuber per ha was counted maximum (242592.7) in Kufri Jyoti followed by Jumla Local (216666.7) whereas CIP399079.22 produced the lowest number of non marketable tubers (69913.7) per ha. Kufri Jyoti produced the maximum total number of tubers per ha (440740.7) followed by CIP394611.112 (419135.7) where as CIP393536.13 produced the minimum total number of tubers per ha (217284). Yield of non marketable tuber was found the highest (11.3 t/ha) in potato genotype CIP395112.32 followed by Jumla Local (11.1 t/ha) and the lowest (1.9 t/ha) in CIP394004.19. Total tuber yield was recorded the highest (27.2 t/ha) from Kufri Jyoti followed by CIP395112.32 (27.2 t/ha), Jumla Local (25.7 t/ha) where as the lowest yield (5 t/ha) was recorded from CIP399092.116. Genotypes CIP394611.112, CIP393079.179, CIP395017.229, CIP395017.242 and CIP397060.19 were also among the highest yielder (Table 1 and 2).

During 2014, all the vegetative character was found highly significant among the potato genotypes. Maximum emergence (26.9%) was found from Jumla Local followed by Desiree (23.2%) and the lowest (1.9%) from CIP394611.112 at 30 days after planting. Similarly, at 45 days after transplanting, Kufri Jyoti showed the maximum emergence (88.9%) followed by Jumla Local and Desiree (85.2% each) and the lowest (29.6%) emergence was found in CIP397060.19. Highly uniform (5) plants were observed in potato genotypes CIP395112.32, CIP394611.112, CIP393617.1, Kufri

Jyoti followed by CIP395017.229, CIP390478.9, CIP395017.242, Desiree and Jumla Local where as the least uniform (3) plants in CIP393079.179. The highest ground coverage (73.3%) was recorded in Kufri Jyoti followed by CIP390478.9 (65%) and the lowest (23.3%) in CIP397060.19. Number of main stem was recorded maximum (4.1) from genotype CIP394611.112 followed by CIP393617.1 (4.1) whereas the minimum number from CIP395112.32 and CIP397060.19 (2). The tallest plants (80.9 cm) were measured from potato genotype CIP399078.11 followed by CIP395112.32 (78.4 cm) and the dwarfest (35.5 cm) plants were measured from Desiree.

All the yield parameters were statistically significant among the potato genotypes except weight of non marketable tuber per ha. Number of marketable tuber per ha was counted maximum (520987.7) from Jumla Local followed by Kufri Jyoti (456790.1) whereas the lowest number of marketable tuber (135802.5) was counted from CIP399078.11. Potato genotype CIP390478.9 produced maximum marketable tuber yield (22.6 t/ha) followed by CIP395112.32 (20.2 t/ha) and the lowest (6.5 t/ha) marketable tuber yield was recorded in CIP399078.11. Number of non marketable tuber was counted the highest (261111.1) from Jumla Local followed by Kufri Jyoti (141358) and the lowest (43209.9) in CIP395017.242. Maximum total number of potato tubers (782098.8) was counted from Jumla Local followed by Kufri Jyoti whereas the lowest (179629.6) from CIP399078.11.Yield of non marketable tuber was recorded the highest (2.5 t/ha) in Jumla Local followed by Kufri Jyoti, CIP393079.179 (2.5) and the lowest (1 t/ha) in CIP394611.112. Total tuber yield was recorded the highest (24.3 t/ha) from potato genotype CIP390478.9 followed by CIP395112.32 (22 t/ha) and the lowest (7.8 t/ha) from CIP399078.11 (Table 3 and 4).

Significant differences for almost all the vegetative as well as yield parameters show the wider genetic variability among the tested micronutrient dense potato genotypes (Chapagain et al. 2014). Significantly more tuber yield from CIP395112.32 (27.2 t/ha) during 2013 among the micronutrient dense potato genotypes and the highest tuber yield from CIP390478.9 (24.3 t/ha) during 2013 were obtained. In addition to these, CIP394611.112, CIP393079.179, CIP397060.19, CIP395017.229 and CIP395017.242 were also high yielders among the tested micronutrient dense potato genotypes. This result clearly showed these genotypes performed better under high hill conditions.

Table 1: Vegetative parameters of potato genotypes under mother trial at ARS, Rajikot, Jumla during 2013

SN	Treatments	Emergence at 30 DAP	Emergence at 45 DAP	Uniformity	GC at 6 weeks	No. of main stem	Plant ht (cm)
1	CIP395112.32	6.5	38.9	4.3	40	1.5	101.8
2	CIP393536.13	5.6	53.7	5	50	1.6	91.1
3	CIP392740.4	16.7	65.7	5	65	2.5	80.5
4	CIP393079.179	0.9	23.2	4	25	1.5	89.1
5	CIP399092.116	2.8	25	3.7	21.7	1.9	83.9
6	CIP393382.44	1.9	50	5	43.3	1.9	96.3
7	CIP394611.112	0.9	40.7	5	38.3	1.9	94.8
8	CIP390478.9	9.3	55.6	5	51.7	2.3	94.1
9	CIP393617.1	14.8	60.2	5	55	2.6	85.6
10	CIP399078.11	1.9	25	4.7	25	1.6	97.7
11	CIP397060.19	1.9	8.3	3.7	8.3	1.9	101.6
12	CIP395017.242	3.7	49.1	4.3	46.7	2.1	95.7
13	CIP395017.229	2.8	50	5	46.7	2.3	96.1
14	CIP394613.139	1.8	54.6	5	53.3	1.9	91.3
15	CIP399067.22	5.6	50.9	4.7	51.7	1.9	96.5
16	CIP392820.1	0.9	25.9	4.3	25	1.5	91.5
17	CIP399079.22	2.8	27.8	3.7	26.7	1.5	90.7
18	CIP394004.19	6.5	45.4	4.3	41.7	1.4	102.1
19	Jumla Local	30.6	78.7	5	76.7	3.5	74.1
20	Kufri Jyoti	23.2	78.7	4.7	73.3	4.6	73.7
21	Desire	11.1	70.4	5	70	2.9	47.6
	Mean	7.2	46.6	4.6	44.5	2.1	89.3
	F Test	***	***	***	***	***	***
	LSD (0.05)	11.2	24	0.7	24.8	0.7	15.4
	CV (%)	94	31.2	9.6	33.8	19.9	10.5

Note: DAP=Days After Planting GC: Ground Coverage *= Significant at p<0.05
***=Significant at p<0.001

Table 2: Yield parameters of potato genotypes under mother trial at ARS, Rajikot, Jumla during 2013

SN	Treatments	No. of marketable tuber per ha	Wt.of marketable tuber per ha (ton)	No. of non marketable tuber per ha	Total no. of tuber per ha	Wt.of non marketable tuber per ha (ton)	Total wt of tuber per ha(ton)
1	CIP395112.32	167284	15.9	126543.3	29827.3	11.3	27.2
2	CIP393536.13	112962.7	4.9	104321	217284	3.5	8.4
3	CIP392740.4	219135.7	7.9	152469	371605	4.8	12.7
4	CIP393079.179	174074.3	12.7	100617.3	274691.3	5.9	18.6
5	CIP399092.116	152469.3	2.2	103703.7	256173	2.8	5
6	CIP393382.44	211728.7	8	174074	385802.3	2.6	10.7
7	CIP394611.112	243210	13.9	175926	419135.7	6.8	20.7
8	CIP390478.9	141975.7	10.1	138889	280864	5.1	15.1
9	CIP393617.1	175926	3.8	145679	321605	2.4	6.2
10	CIP399078.11	120987.7	6.5	115432	236419.7	5.7	12.1
11	CIP397060.19	176543.3	11.1	146296.3	322839.3	5.8	16.9
12	CIP395017.242	204938.3	10.7	125925.7	330864.3	6.9	17.1
13	CIP395017.229	210493.7	12.2	153703.7	364198	5.7	17.4
14	CIP394613.139	110493.7	2.6	170370.3	280864.3	3.4	6
15	CIP399067.22	186419.7	6.5	156469.3	338888.7	3.8	10.1
16	CIP392820.1	137654.3	5.3	109259.3	246913.7	2.9	8.1
17	CIP399079.22	128394.7	3.7	69913.7	225308.3	2.8	6.5
18	CIP394004.19	240741	6.1	132716.3	373456.7	1.9	8
19	Jumla Local	201852	14.7	216666.7	418518.3	11.1	25.7
20	Kufri Jyoti	198148.3	17.8	242592.7	440740.7	9.4	27.2
21	Desire	159876.3	14.8	183333.3	343209.7	4.5	19.4
	Mean	175014.7	9.1	146090.6	321105.2	5.1	14.2
	F Test	NS	***	*	*	***	***
	LSD (0.05)		3.7	7197	14080	3	5
	CV (%)	31.4	25.1	29.9	26.6	35.2	20.4

Note: NS=Non Significant *= Significant at p<0.05 ***=Significant at p<0.001

Table 3: Vegetative parameters of potato genotypes under mother trial at ARS, Rajkot, Jumla during 2014

SN	Treatments	Emergence at 30 DAP	Emergence at 45 DAP	Uniformity	GC at 6 weeks	No. of main stem	Plant ht (cm)
1	CIP395017.229	5.6	54.6	4.7	63.3	3.3	70.4
2	CIP395112.32	3.7	67.6	5.0	56.7	2.0	78.4
3	CIP394611.112	1.9	68.5	5.0	46.7	4.1	66
4	CIP393079.179	4.6	38.9	3.0	30.0	1.3	63.3
5	CIP390478.9	9.3	45.4	4.7	65.0	2.4	50.4
6	CIP395017.242	9.6	61.1	4.7	50.0	2.6	64.3
7	CIP399078.11	3.7	37	3.3	31.7	2.1	84.9
8	CIP393617.1	9.3	67.6	5.0	60.0	4.1	66
9	CIP397060.19	2.8	29.6	3.7	23.3	2.0	66.3
10	Kufri Jyoti	22.2	88.9	5.0	73.3	3.2	65.7
11	Desire	23.2	85.2	4.7	43.3	3.1	35.5
12	Jumla Local	26.9	85.2	4.7	48.3	2.4	51.2
	Mean	9.9	60.8	4.4	49.3	2.7	63.5
	F Test	***	***	***	***	***	***
	LSD (0.05)	10.7	13.2	0.8	13.1	0.8	10.5
	CV (%)	64.1	12.9	10.1	15.6	17.5	9.8

Note: DAP=Days After Planting GC: Ground Coverage ***=Significant at p<0.001

Table 4: Yield parameters of potato genotypes under mother trial at ARS, Rajikot, Jumla in 2014

SN	Treatments	No. of marketable tuber per ha	Wt. of marketable tuber per ha (ton)	No. of non marketable tuber per ha	Total no. of tuber per ha	Wt. of non marketable tuber per ha (ton)	Total wt of tuber per ha(ton)
1	CIP395017.229	208024.7	15.2	57407.4	265432.1	1.5	16.7
2	CIP395112.32	278787.8	20.2	55555.6	333333.3	1.8	22
3	CIP394611.112	323456.8	19.9	63580.3	387037	1	20.8
4	CIP393079.179	156790.1	17	30864.2	187654.3	2.5	19.5
5	CIP390478.9	259259.3	22.6	51851.9	311111.1	1.8	24.3
6	CIP395017.242	217284	13.5	43209.9	260493.8	1.2	14.7
7	CIP399078.11	135802.5	6.5	43827.2	179629.6	1.3	7.8
8	CIP393617.1	278395.1	14.4	52459.1	330864.1	1.4	15.7
9	CIP397060.19	225925.9	16.3	72839.5	298765.4	1.8	18.1
10	Kufri Jyoti	456790.1	17	141358	598148.2	2.5	19.5
11	Desire	284567.9	15.5	101851.9	386419.8	1.5	16.9
12	Jumla Local	520987.7	16.6	261111.1	782098.8	2.5	19.1
	Mean	278755.1	16.2	81327.2	360082.3	1.7	17.9
	F Test	***	*	***	***	NS	*
	LSD (0.05)	8191	7.9	7048	9496		7.3
	CV (%)	17.4	28.9	51.2	15.6	51.8	24

Note: NS=Non Significant *= Significant at p<0.05 ***=Significant at p<0.001

CONCLUSION AND RECOMMENDATION

Based on the results of 2013, only 9 micronutrient dense potato genotypes: CIP395017.229, CIP395112.32, CIP394611.112, CIP393079.179, CIP390478.9, CIP395017.242, CIP399078.11, CIP393617.1, and CIP397060.19 were selected and tested under mother trial in 2014. During 2014, performance of all the potato genotypes was good except CIP399078.11 (7.8 t/ha). Productivity of remaining eight genotypes ranged from 14.7 t/ha to 24.3 t/ha whereas the national productivity of potato is 13.6 t/ha. As per the results of both years, genotypes CIP395112.32, CIP394611.112, CIP390478.9, CIP393079.179, CIP397060.19, CIP395017.229 and CIP395017.242 are the promising micronutrient dense potato genotypes for the Karnali region of Nepal.

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INFLUENCE OF SOME AGRONOMIC MANIPULATIONS ON THE MANAGEMENT OF LENTIL STEMPHYLIUM BLIGHT IN RAMPUR, CHITWAN, NEPAL

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ABSTRACT

Stemphylium blight of lentil (*Lens culinaris* Medik) caused due to *Stemphylium botryosum* Walr is becoming widespread throughout major lentil growing areas of Nepal. The management of this disease is now most necessary for increasing lentil yield and checked out its spread. Series of experiments were organized where lentil was sown with different agronomic practices following Randomized Complete Block Design with four replications during two winter seasons of 2012-2013 and 2013-2014 at GLRP, Rampur, Chitwan. The trends of disease control and lentil yield were found similar in both experimental periods. During 2012-2013, the lower disease index (39.15%) along with higher crop yield (1167 kg/ha) and hundred seed weight (1.86 gm) and for the experimental period of 2013-2014 also higher percent disease control (52.77%) along with higher lentil yield increase (125.75%) were recorded from the plot practiced with recommended seed rate (30 kg/ha) with hydro priming (8 hour) of seed and fertilizer doze of (20:40:20 NPK Kg/ha plus 1 kg/ha Boron as a basal doze) as compared to farmers practice (Higher seed rate 90 kg/ha only).

Keywords: Agronomic practices, Lentil, Stemphylium Blight

INTRODUCTION

Stemphylium blight caused by *Stemphylium botryosum* Walr was first reported during 1993 in Nepal and has become widespread throughout major lentil growing areas of the country (Bayaa *et al.*, 1998). It is the most important disease of lentil in Nepal (Joshi, 2006; Gharti *et al.*, 2008) and estimated yield losses of about 60-90% and sometime total crop collapsed have been reported (GLRP, 2012). This disease has been also reported in Bangladesh, Egypt, Syria and the USA (Bayaa and Erskine, 1998). *Stemphylium botryosum* causes leaf blight on lentil that can result in large scale defoliation of plants. Since the end of the Second World War, there was a great boom in the use of fungicides throughout the world. An urgent need for alternative method of plant disease control was felt after great justified alarm in the early sixties about dangerous consequences to man and environment in the area of phyto-toxicity. This scenario necessitates the search for and the development of ecologically sustainable disease control methods which should be effective against the target species but create minimal adversity for non-target species. Because of the adverse environmental effects of fungicide application, there is a need to explore the potential alternative strategies including the manipulation of agronomic practices for disease control (Jacobsen and Backman, 1993). Control of plant disease becomes successful and economical when management approach involving several methods are employed including chemical means (Bakr and Ahmed, 1992), biological (Hosen, 2011), cultural practices (Howlider *et al.*, 1989) , use of resistant varieties (Ahmed, 1986) and shifting of sowing time (Sud and Singh, 1984; Hedge and Anahosur, 1994). The management techniques of lentil stemphylium blight with different environment and farmer friendly agronomic practices were scanty in Nepal. Hence the present study was organized to know the effect of different agronomic practices on stemphylium blight severity and yield performance of lentil.

MATERIALS AND METHODS

The experiments were conducted under field condition following Randomized Complete Block Design with four replications during two winter seasons of 2012-2013 and 2013-2014 at GLRP, Rampur, Chitwan. A susceptible lentil variety Shital was sown on November 9th of 2012 and 2013 in a unit plot size of 4m x 2m with 25cm row to row spacing. There were altogether six treatments of the experiment comprising different agronomic practices viz., recommended seed rate (SR) (30kg/ha)

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only, recommended SR + seed priming (8 hour), Recommended SR + Priming + Fertilizer doze (20:40:20 NPK Kg/ha + 1 kg/ha B basal doze), Lower SR (15 Kg/ha) + Priming + Fertilizer doze (10:20:10 NPK Kg/ha only), Higher SR (60kg/ha) + Priming + Fertilizer doze (40:60:40 NPK Kg/ha) and Farmers practice (Higher SR 90 Kg/ha) only. After completion of the sowing, the experiment was kept under constant watch from sowing up to harvest. Disease severity data was recorded using 1-9 scoring scale from 25 randomly tagged plants/plot (Morrall and Mckenzie, 1974).

1= No lesion visible (Highly resistant)
3= Few scattered lesions, usually visible after careful searching (Resistant)
5= Lesions common on plants and easily observed but defoliation and/ or damage not great, or in only one or two patches in plot (Moderately resistant)
7= Lesions very common and damaging (Susceptible)
9= Lesions extensive on all plants, defoliation and drying branches, and killing of some plants (Highly susceptible)

Percent Disease Index (PDI) was computed on the basis of recorded data according to the formula (Wheeler, 1969) and Percent Disease Control (PDC) was calculated on the basis of the formula developed by Shivankar and Wangikar, 1993.

$$PDI = \frac{\text{Sum of numerical values}}{\text{No of plant parts observed}} \times \frac{100}{\text{Maximum diseases rating}}$$

$$PDC = \frac{\text{Disease in control plot} - \text{Disease in treated plot}}{\text{Disease in control plot}} \times 100$$

Early Plant Stand (EPS) and Final Plant Stand (FPS) were recorded by the scale developed by International Centre for Agricultural Research in the Dry Areas, Aleppo, Syria.

90% or more = very good
80-89% = good
70-79% = acceptable
60-69% = poor
Less than 60% = very poor

Data were recorded on yield and yield attributes. Yield increase over the control was calculated.

All data were analyzed statistically using MSTAT-C computer package program. Treatment means were compared using and Duncan's Multiple Range Test (DMRT) at 5% levels of significance. The correlation among percent yield increased over control and percent disease control was calculated.

RESULTS

EXPERIMENT YEAR 2012-2013

The Early Plant Stand (EPS), Area Under Disease Progress Curve (AUDPC), Percent Disease Index (PDI), Final Plant Stand (FPS), grain yield and Hundred Seed Weight (HSWT) were significantly ($P \le 0.05$) varied among different agronomic practices at Rampur, Chitwan during research period 2012-2013. The higher EPS (94.65%) and FPS (88.25%), lower PDI (39.15%) and AUDPC (48.38) along with higher grain yield (1167 kg/ha) and HSWT (1.86 gm) were recorded in the plot practiced with recommended seed rate (30 kg/ha) + priming (8 hr) + fertilizer doze (20:40:20 NPK Kg/ha + 1 kg/ha Boron as a basal doze) followed by the plot practiced with higher seed rate (60kg/ha) + Priming (8 hour) + Fertilizer doze (40:60:40 NPK Kg/ha). The lower yield (503.10 kg/ha) and HSWT (1.07 gm) along with higher AUDPC (130.10) and PDI (84.60%) was recorded in the plot treated with farmers practice (Higher seed rate 90 kg/ha only) (Table 1). The higher percent disease control (53.72%)

along with yield increase (131.96%) were recorded from the plot practiced with recommended seed rate (30 kg/ha) + priming (8 hr) + fertilizer doze (20:40:20 NPK Kg/ha + 1 kg/ha Boron as a basal doze) as compared to farmers practice (Higher seed rate 90 kg/ha only) (Table 2).

Table 1: Effect of agronomic practices on stemphylium blight disease severity and yield performance of lentil during 2012-13

Agronomic practices	EPS %	AUDPC	PDI %	FPS %	Yield (Kg/ha)	HSWT (gm)
Recommended SR (30 Kg/ha) only	$68.38^{e\dagger}$	121.00^{b}	82.57^{a}	50.60^{f}	592.20^{e}	1.12^{de}
Recommended SR + seed priming (8 hr)	82.63^{c}	103.00^{c}	74.25^{b}	74.97^{c}	725.00^{d}	1.19^{d}
Recommended SR + Priming + Fert. doze (20:40:20 NPK Kg/ha + 1 kg/ha B basal doze)	94.65^{a}	48.38^{f}	39.15^{e}	88.25^{a}	1167.00^{a}	1.86^{a}
Lower SR (15 Kg/ha) + Priming + Fert. doze (10:20:10 NPK Kg/ha only)	75.50^{d}	91.63^{d}	63.45^{c}	60.88^{e}	871.90^{c}	1.31^{c}
Higher SR (60kg/ha) + Priming + Fert. doze (40:60:40 NPK Kg/ha)	89.97^{b}	84.06^{e}	54.22^{d}	82.32^{b}	1003.00^{b}	1.62^{b}
Farmers practice (Higher SR 90 Kg/ha) only	82.38^{c}	130.10^{a}	84.60^{a}	67.63^{d}	503.10^{f}	1.07^{e}
F-test	**	**	**	**	**	**
LSD (≤0.05)	3.87	7.29	3.71	2.23	45.29	0.10
CV%	3.12	5.02	3.70	2.09	3.71	4.87

† Means of 4 replication. Means in column with same superscript is not significantly different by DMRT ($P<0.05$). SR-Seed rate, EPS-early plant stand, AUDPC- Area under disease progress curve, PDI-percent disease index, FPS-final plant stand, HSWT-hundred seed weight, Kg/ha- Kilogram per hectare, gm- gram, %- percent, Fert-fertilizer, NPK- nitrogen, Phosphorus, potash, B- boron, hr-hour

Table 2: Effect of agronomic practices on stemphylium blight disease control and yield increase percent of lentil at Rampur, Chitwan during 2012-13

Agronomic practices	PDC%	YI%
Recommended SR (30 Kg/ha) only	2.40	17.71
Recommended SR + seed priming (8 hr)	12.23	44.11
Recommended SR + Priming + Fert. doze (20:40:20 NPK Kg/ha + 1 kg/ha B basal doze)	53.72	131.96
Lower SR (15 Kg/ha) + Priming + Fert. doze (10:20:10 NPK Kg/ha)	25.00	73.31
Higher SR (60kg/ha) + Priming + Fert. doze (40:60:40 NPK Kg/ha)	35.91	99.36
Farmers practice (Higher SR 90 Kg/ha) only		

SR-Seed rate, PDC-percent disease control, YI- yield increase, Kg/ha- Kilogram per hectare, %- percent, Fert-fertilizer, NPK- nitrogen, Phosphorus, potash, B- boron

RELATIONSHIP BETWEEN DISEASE CONTROL AND YIELD INCREASE

During experimental year 2012-2013, the yield increase again was found to had significantly positive correlation ($r = 0.99$) with the lentil stemphylium blight disease control due to different agronomic practices. The predicted linear regression line was i.e. $y = 2.229X + 15.65$, with regression coefficient $R^2 = 0.99$, where 'y' denoted predicted yield increase of lentil and 'x' stood for disease control with different agronomic practices (Figure 1). The estimated regression line indicated that the unit rise in the percent disease control of lentil stemphylium blight (within 1-9 scale) due to different agronomic practices, there existed possibilities of yield increase by 2.23 percent.

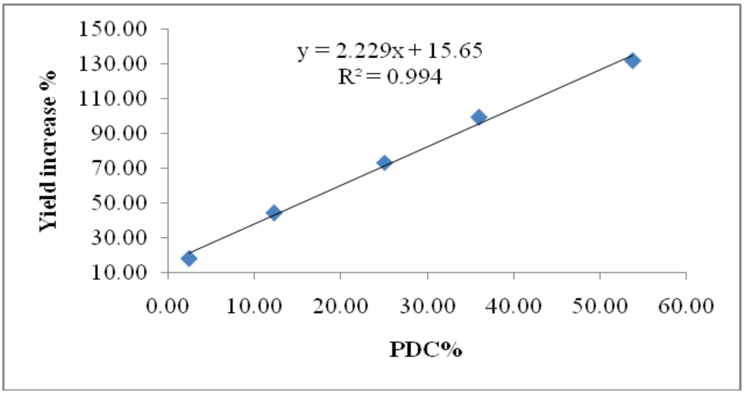

Figure 1: Relationship between disease control and yield increase through different agronomic practices at Rampur, Chitwan during 2012/13

EXPERIMENT YEAR 2013-2014

During second year of experiment also, different agronomic practices were significantly ($P \leq 0.05$) effective to control lentil stemphylium blight disease control and yield increase. The plot treated with recommended seed rate (30 kg/ha) with 8 hour priming and fertilizer doze (20:40:20 NPK Kg/ha + 1 kg/ha Boron as a basal doze) become significantly effective again to lower the percent disease index (40.73%) and increase crop yield by 125.75% (Table 3 & 4). The plot treated with farmers practice (higher seed rate 90 kg/ha only) again become significantly less effective than other practices against lentil stemphylium blight having higher disease index (86.24%) and lower crop yield (526.70 kg/ha).

RELATIONSHIP BETWEEN DISEASE INDEX AND CROP YIELD

A linear negative correlation between yield and PDI was observed during 2013/014. The lentil yield was found to had significantly negative correlation (r = -0.99) with the percent disease index of stemphylium blight disease due to different agronomic practices. The equation Y= -14.11X + 1791 and R^2 = 0.98 gave the best fit (Figure 2). The predicted linear regression line was displayed downward slope where 'y' denoted predicted crop yield of lentil and 'x' stood for PDI of stemphylium blight of crop. The estimated regression line indicated that the unit rise in the PDI of stemphylium blight disease due to different agronomic practices (within 1-9 scale), there existed possibilities of yield reduction by 14.11 kg/ha.

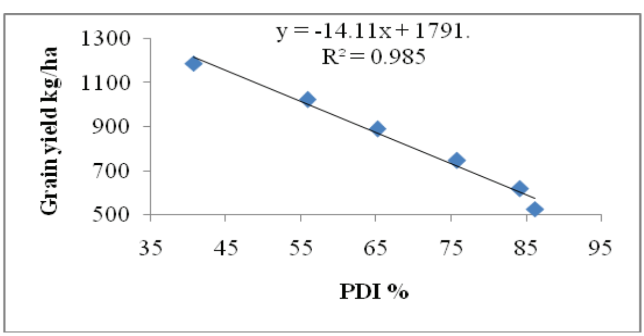

Figure 2: Relationship between PDI and crop yield in different agronomic practices to control lentil stemphylium blight disease at Rampur, Chitwan during 2013/14

Table 3: Effect of agronomic practices on stemphylium blight disease severity and yield performance of lentil during 2013-14

Agronomic practices	EPS %	AUDPC	PDI	FPS %	Yield (Kg/ha)	HSWT (gm)
Recommended SR (30kg/ha) only	70.05^{e†}	125.50^{b}	84.15^{a}	52.23^{f}	617.10^{e}	1.28^{de}
Recommended SR + seed priming (8 hr)	84.10^{c}	108.50^{c}	75.83^{b}	76.52^{c}	746.30^{d}	1.36^{d}
Recommended SR + Priming + Fert. doze (20:40:20 NPK Kg/ha + 1 kg/ha B basal doze)	96.20^{a}	53.31^{f}	40.73^{e}	90.01^{a}	1189.00^{a}	2.02^{a}
Lower SR (15kg/ha) + Priming + Fert. doze (10:20:10 NPK Kg/ha only)	76.95^{d}	97.39^{d}	65.19^{c}	62.53^{e}	890.70^{c}	1.49^{c}
Higher SR (60kg/ha) + Priming + Fert. doze (40:60:40 NPK Kg/ha)	91.50^{b}	89.16^{e}	55.86^{d}	83.87^{b}	1023.00^{b}	1.77^{b}
Farmers practice (Higher SR 90kg/ha) only	84.08^{c}	135.30^{a}	86.24^{a}	69.26^{d}	526.70^{f}	1.23^{e}
F-test	**	**	**	**	**	**
LSD (≤0.05)	3.72	7.46	3.70	2.22	47.25	0.09
CV%	2.94	4.88	3.61	2.04	3.77	4.14

† Means of 4 replication. Means in column with same superscript is not significantly different by DMRT ($P<0.05$). SR-Seed rate, EPS-early plant stand, AUDPC- Area under disease progress curve, PDI-percent disease index, FPS-final plant stand, HSWT-hundred seed weight, Kg/ha- Kilogram per hectare, gm- gram, %- percent, Fert- fertilizer, NPK-nitrogen, Phosphorus, potash, B- boron

Table 4: Effect of agronomic practices on stemphylium blight disease control and yield increase percent of lentil at Rampur, Chitwan during 2013-2014

Agronomic practices	PDC%	YI%
Recommended SR (30 Kg/ha) only	2.42	17.16
Recommended SR + seed priming	12.07	41.69
Recommended SR + Priming + Fert. doze (20:40:20 NPK Kg/ha + 1 kg/ha B basal doze)	52.77	125.75
Lower SR (15 Kg/ha) + Priming + Fert. doze (10:20:10 NPK Kg/ha)	24.41	69.11
Higher SR (60kg/ha) + Priming + Fert. doze (40:60:40 NPK Kg/ha)	35.23	94.23
Farmers practice (Higher SR 90 Kg/ha) only		

SR-Seed rate, PDC-percent disease control, YI- yield increase, Kg/ha- Kilogram per hectare, %- percent, Fert-fertilizer, NPK- nitrogen, Phosphorus, potash, B- boron

DISCUSSION

Agronomic practices can exert a profound effect on disease development, with fertilizer application increasing or decreasing development of diseases caused by different pathogens. The finding of present study is agreed with the view of Huber and Wilhelm (1988) that mineral nutrition has long been recognized as an important component of disease control practices although limited understanding of the mechanisms underlying nutrient-induced changes in disease development means that mineral nutrition has not been exploited fully in disease control. Balanced nutrition does not only help to achieve better yield in crop production but also allows plants to protect themselves from new infection (Agrios, 2005). Intensive cropping of high yielding cultivars and mismanagement of fertilizer application has resulted in nutrients imbalance which further cause severe fungal infestation and greatly reduce the production. Marschner (1995) agreed that boron is reported to be involved in keeping cell wall structure and maintaining membrane fraction. Boron is believed to improve the strength of the membrane and cell wall with the cross-linked polymer and strengthen the plants vascular bundles which hold back the invasion of pathogens (Stangoulis and Graham, 2007). Boron is very important in cell division and in pod and seed formation. According to Noppakoonwong *et al*. (1997) the reproductive growth, especially flowering fruit and seed set is more sensitive to boron deficiency than vegetative growth. Boron influences the absorption of Nitrogen, Phosphorous, Potassium and its deficiency changed the equilibrium of optimum of those three macronutrients. The nitrogen and boron concentrations of grain for lentil were markedly influenced by boron treatment indicating that the boron had a positive role on protein synthesis. Iqtidar and Rahman (1984) also found that essential aminoacid increased with increasing boron supply. The priming of lentil seed helped to provide the moisture security for seed required for the germination and also created favorable micro-environment in lentil sown field for its better growth and development during early stage of lentil. The result showed that primed lentil seed gave more yield than non-primed seed. This finding is completely agreed with Gharti *et al*. (2014) who mentioned that lentil seed primed with water up to 12 hour followed by 2 hours air drying prior to sowing gave more yield, one week earlier in maturity and robust seed over non priming. The mean yield increment of primed seed was 26% over the non-primed seed in the farmers field (GLRP, 2012). The finding of ways to overcome the environmental stresses such as inadequate moisture during seed germination was important for an economic crop production. Seed priming may be enhanced metabolic and physiological activity in seed and have a positive effect on seed ling growth. According to Ali *et al*. (2005) germination and seedling stages were critical for crop production, rapid and uniform plant stands resulted in early maturity and reduced disease attack. Although there was no direct evidence of low disease severity in crop sown after hydro-priming over non primed seed but priming may enhanced the physiological and metabolic process which promoted the germination process and minimized the inadequate moisture stress of seed. It reduced the time period required for crop growth and development and helped crop for early maturity which may be supportive for the reduction of disease severity and incidence appeared in later stage of crop. Hydro-priming also supportive to created strong base for the plant since from its germination and chances of prone to many diseases were less during its growth period. Seed priming is an old technology but many farmers were unaware of its benefit and do not practice it. Sarker *et al*. (2004) mentioned that seed priming where by seed is soaked in water usually overnight before being surface dried and then sown improves plant stands, enhances early vigor and results in earlier maturity, reduced disease and increased yield. Research with improved varieties Barimasur-2 and Barimasur-4 had shown yield increase of 29-38% from priming.

CONCLUSION

The findings of two consecutive years (2012-2014) showed almost similar trends regarding yield and disease severity with the agronomic practices. Thus from this study it is clear that the plot practiced with recommended seed rate (30 kg/ha) with hydro priming (8 hour) and fertilizer doze (20:40:20 NPK Kg/ha plus 1 kg/ha Boron as a basal doze) was effective against the lentil *Stemphylium* blight severity and also increased the crop yield significantly.

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DEVELOPMENT OF THE PULSE BEETLE (*Callosobruchus chinensis* L) AND OVIPOSITIONAL PREFERENCE ON DIFFERENT LEGUMES UNDER STORAGE

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ABSTRACT

Under storage, to study ovipositional preference of *C. chinensis*, a pair of freshly emerged adults of *C. chinensis* was released in 15 g seeds of each of selected grain legumes, namely soybean (*Glycine max* L.), mungbean (*Vigna radiata* L), pigeonpea (*Cajanus cajan* L.), cowpea (*Vigna unguiculata* L.), chickpea (*Cicer arietinum* L.) and lentil (*Lens culinaris* Medik.) replicated four times in Completely Randomized Design (CRD) under laboratory conditions of minimum (25±1 °C) and maximum (35±1°C) temperatures and 72 ± 2 % RH. Empty jar was kept to determine whether the female was capable of laying eggs without food materials inside. The number of eggs was found significantly higher on (211.09 /15g seed) and mungbean (103.15 /15g seed) seeds, while female were unable to lay more eggs on lentil (45.67/15 g seed). Both male and female adults died in the empty jar in three days. Adult female preferred eggs laying on soybean followed by mungbean, pigeonpea, cowpea, chickpea and lentil seeds. Mungbean, cowpea and pigeonpea also had the highest percentage of adult emergence, with the shortest developmental period, highest susceptibility index (SI) and maximum seed weight loss. Lentil, chickpea and soybean seeds were the least preferred hosts of *C. chinensis*. Though the adult female beetles highly preferred to egg laying, larvae did not develop on soybean seeds.

Key words: Development, pulse beetle, ovipositional preference, legumes, storage

INTRODUCTION

Pulse beetle *Callosobruchus chinensis* L. is reported to be the major pest infesting all types of pulses both in the field and in storage. Due to invasion of the beetle, deterioration in quality and quantity of stored pulse is high in terai and foot hill region of Nepal (Paneru and Shivakoti, 2001). The differential rate of damage infected by *C. chinensis* in different pulses was reported to be 68, 56, 49 and 52 percent in cowpea, bengal gram, red gram and green gram, respectively over a storage period of 6 months (Sharma, 1984). The grain damage was as high as 69.93% under storage condition (Singh *et al.*, 2001). This pest is a serious problem at small farmers' level, village traders and households where storage conditions are poor and inadequate. Gujar and Yadav (1978) reported 55-60% loss in seed weight and 45.50 - 66.30% loss in protein content due to its damage and pulse seed became unfit for human consumption as well as for planting. To control the pulse beetle in storage, a number of synthetic organic insecticides, such as malathion and dichlorvos as well as neem based and other botanicals have been recommended (Kumari and Singh, 1998). The admixture synthetic insecticide with food grains has more recently been banned in many countries. There are also reports that the pulse beetle is developing resistance to malathion (Singh and Srivastava, 1983). Because of the economic importance and cosmopolitan distribution, the development of suitable control measures for this pest is essential. As it is difficult to find suitable, cheap methods of control, emphasis should be placed on developing host (seed) resistance mechanisms to bruchids as well as high yield (Giga and Smith, 1987). The knowledge on pest resistance characteristics of seeds and the biology of the pest is therefore very important to achieve this goal. Most species of the genus *Callosobruchus* are capable of breeding on a wide variety of pulses. The process of host selection and oviposition is mainly influenced by physical, environmental and biochemical factors. The degree of resistance and susceptibility of different pulses

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to bruchid attack vary with their different characteristics (Bellows, 1982; Howe and Currie, 1964; Nwanze, 1975; Nwanze and Hober, 1976). The present investigation was accomplished with a view to study the fecundity behavior of adult female *C. chinensis* on different legumes seeds and their suitability for subsequent development.

MATERIALS AND METHODS

The grain legumes seeds were obtained from Grain Legumes Research Programme (GLRP), Rampur, Chitwan, which included- soybean (*Glycine max* L.), cowpea (*Vigna unguiculuata* L.), pigeonpea (*Cajanus cajan* L.), chickpea (*Cicer arietinum* L.), mungbean (*Vigna radiata* L.), and lentil (*Lens culinaris* Medik). Seeds were disinfested by keeping them in a hot oven maintained at a temperature of 50 °C for 48 hours and conditioned to a room temperature before being used for experimental purposes. The moisture percent of seeds were maintained at 12% before the initiation of the experiment. The culture of test insects (*C. chinensis*) was also obtained from the Laboratory of GLRP, Rampur, Chitwan and reared under laboratory conditions. Four glass jars each with 1 kg green gram seeds were used to rear *C. chinensis*. The reared culture was daily cleaned collecting newly emerged adult beetles for the experiments. The test insects (*C. chinensis*) were identified properly with the help of available literature and comparing with reference specimens. To study ovipositional preference of *C. chinensis*, one pair of freshly emerged adults of *C. chinensis* was released in 15 gram of each legume seeds sample in a jar. There were six above mentioned legume commodities and one empty jar with a pair of test insect. Empty jar (without legume seeds) was kept for the purpose to determine whether the female was capable of laying eggs without food in the jars. Each treatment was replicated four times in a Complete Randomized Design (CRD). The legumes along with the released *C. chinensis* were kept under laboratory conditions (33±1ºC) and R.H. (72±2%) for the whole experimental period (April 10, 2013 to April 22, 2013) till the death of male and female *C. chinensis*. Seeds for the released pair were changed daily to facilitate the data recording. Eggs were counted in each replicate at an interval of 24 hours just before the death of female. The observation continued until all the released pairs of *C. chinensis* died. This was studied under free and no-choice conditions.

For free choice experiment, seeds of six earlier mentioned legume species were used as treatments in a completely randomised design (CRD) with four replications. The other materials- jars, muslin cloth, plastic bags etc were purchased from the local market. Adults were obtained from the mass reared culture in the laboratory. 20 gm seed of each variety was used for the test. Weighted seed was placed in petridish of 9 mm diameter. A round bucket of diameter 60 cm was used to place the open petridish in round order. In the central portion, a petridish was kept to place the 6 pair of adult for each replication (on an average a pair of adult for each treatment). After transferring adults, each bucket was covered with fine muslin cloth and tied with rubber band. Each day data was taken for the number of eggs laying, which was recorded up to 10 consecutive days. Hundred seeds were randomly selected and the number of eggs in each seed was counted. Seeds with eggs were again reared in petridish. Initial weight, egg per grain, egg per twenty gram, adult per twenty gram seed, final weight, mean development period, mean damage, susceptibility index, weight loss percent and germination percent were recorded.

MEAN GERMINATION LOSS

Three samples each of 100 mungbean grains were taken randomly from each experimental plastic jar and placed in petridish lined with blotting paper. Three such sets were prepared for germination test after 30 days. These petridishes were kept at room temperature for seven days to allow sufficient time for all the grains to germinate. Water was poured regularly to prevent drying. The number of germinated grains was counted and the mean percent germination loss was calculated by following formula:

$$\text{Mean germination loss (\%)} = \frac{\text{Number of not germinated grains}}{\text{Total no. of seeds kept for germination}} \times 100$$

SUSCEPTIBILITY INDEX

The susceptibility index (SI) was calculated by the following formula developed by Dobie (1974).

$$SI = \frac{\log_e F_1}{D} \times 100$$

Where,
F_1= Total number of emerging adults
D = Median developmental period (estimated as the time from the middle of oviposition to the emergence of 50% of the F_1 generation).

In a choice experiment, the bruchids were removed after 24 h and the number of eggs laid on different pulses was counted and a total count in a mixture recorded before the means were calculated.

MEAN WEIGHT LOSS

After removing the beetles from each jar, the weight of grains were taken separately on an electric balance from each replicate after 30 days of release. The mean percent loss in weight was calculated by the following formula:

$$\text{Mean weight loss} = \frac{I - F}{I} \times 100$$

Where, I = Initial weight of grains in gram
F= Final weight of grains in gram

NO-CHOICE TEST

All procedures were same as free choice experiments. A pair of adult was transferred in each petridish. Petridish were covered with cover lid and kept in laboratory. The design was CRD with six treatments and four replications. Average laboratory temperature was (32±2ºC). Adult emergence was recorded daily after their emergence was seen and finally removed from each petridish. Observations were recorded as in free choice experiments.

All data were analyzed statistically using MSTAT-C computer package program. Treatment means were compared using Duncan's Multiple Range Test (DMRT) at 5% levels of significance. In all cases, a significance level of $P < 0.05$ was used unless otherwise stated.

RESULTS AND DISCUSSIONS

OVIPOSITIONAL PREFERENCE OF *C. chinensis*

Statistically, there was no difference between total number of eggs laid on mungbean and pigeonpea seeds. The female was capable of egg-laying till the death of male bruchid, which found dead after 9th day. The result showed that the ovipositional response of the female adults significantly varied with different pulses (Table 1). All the pulses were utilized by the females for egg laying. The highest total number of eggs per 15 g seeds during 8th days of egg laying period was observed on soybean (211.09 eggs/15 g seed) followed by mungbean (103.15 eggs /15 g seed), pigeonpea (98.97 eggs /15 g seed) and cowpea (90.90 eggs/15 g seed). The lower numbers of eggs were deposited on lentil (45.67 eggs/15 g seed) and chickpea (79.35 eggs/15 g seed) (Figure 1). Oviposition was not observed on empty jar at all. It was also observed that adults died after 2-3 days during experimental periods in empty jar (control). Soybean followed by mungbean, pigeonpea, cowpea, chickpea and lentil were preferred by female adult for egg laying. The findings of this study is in line with Applebaum *et al*. (1970) who reported that bruchids are known to prefer to feed and develop on legume seeds as their main hosts. Yadav and Pant (1974) observed that

Callosobruchus spp. oviposited on any seed even though the seed may not be suitable for the development of these insects. The finding is also partially supported by Seifelnasr (1991) who reported that, on different legumes studied, the highest total oviposition by *Callosobruchus* spp was recorded on cowpea seed followed by garden pea and soybean while the lowest was on chickpea and lentil seed. Smooth well-fitted seeds of soybean and mungbean appear to increase the tendency of *C. chineneis* to lay more eggs on them. Though the seed coat of the lentil was smooth, size and weight of the seed may have been responsible for the reduction of oviposition. Chickpea was also less preferred by the female for oviposition and this may be due to its considerably rough seed coat. According to the observations, the texture of the seed coat appears to play a major role in the selection of oviposition sites by pulse beetle.

The female preferred seeds with a smooth coat to a rough coat. Schalk (1973) noticed that the resistance in chickpea for the oviposition by *C. maculatus* was related to the roughness of the seed coat. Further Girrish (1974) observed that *C. maculatus* was guided in its oviposition where preferences had been shown towards the smoothness of the seed coat and the size of the grain. However, the smoothness of the seed coat may not be the only factor responsible for high oviposition by the pulse beetle. A combination of several factors, such as seed texture, seed size and shape, weight and volume of the seed and the seed color have been suggested to be responsible for the ovipositional preference of bruchids to different pulses (Nwanze, 1975; Mitchel, 1975; Satya vir and Jindal, 1981; Manohar and Yadava, 1990). Howe and Curie (1964) reported that odor of seeds may also provide a stimulus for oviposition which could come from the chemical composition of the seed.

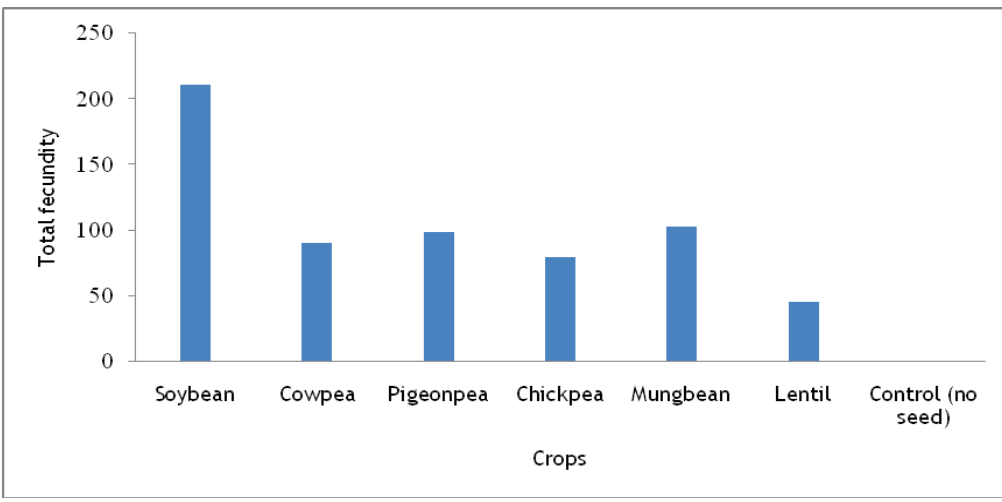

Figure 1. Total fecundity of adult female *C. chinensis* on different legumes during her life span, at GLRP, Rampur, Chitwan, 2013

FREE CHOICE TEST

The mean number of eggs deposited by bruchid in grain and number of adults emerged with initial and final germination percent of grain under free choice condition are presented in Table 2. Initial and final germination percent of seed was highly significant among the different types of pulses used in the study. Soybean seeds showed both higher initial and final germination percent, i.e. 100 and 98.33 %, respectively followed by cowpea seeds, i.e. 96.80 and 81.85 %. The highest mean number of egg was deposited on soybean seed (52.95 egg/seed) followed by mungbean seed (32.33 egg/seed). The mean number of eggs deposited per twenty gram seeds was also highly significant among different type of legume seeds. The highest mean number of eggs deposited per twenty gram seeds was in soybean (1372 egg/20g seed) followed by cowpea (1016 egg/20g seed). The number of adults of *C. chinensis* emerged from twenty gram seeds was recorded higher in cowpea seed (636.60 adults/20g seed) followed by mungbean (538.80 adults/20 g seed). There was no emergence of adult of *C. chinensis* from soybean seed (Table 2).

Table 1. Ovipositional preference of adult female *C. chinensis* on different legumes at GLRP, Rampur, Chitwan, 2013

Crops	1D	2D	3D	4D	5D	6D	7D	8D	TF
Soybean	†33.64[ab]	29.57[b]	27.10[a]	12.00[a]	28.25[a]	24.52[a]	23.00[a]	33.00[a]	211.09[a]
(*G. max*)	(5.84)	(5.48)	(5.25)	(3.53)	(5.36)	(5.00)	(4.84)	(5.78)	(14.55)
Cowpea	15.22[d]	14.80[d]	13.15[d]	12.27[a]	7.32[b]	5.30[bc]	13.02[b]	9.80[b]	90.90[c]
(*V. unguiculata*)	(3.96)	(3.91)	(3.69)	(3.57)	(2.79)	(2.40)	(3.67)	(3.19)	(9.56)
Pigeonpea	36.20[a]	18.05[c]	16.40 [c]	12.90[a]	7.57 [b]	4.77[c]	2.20[d]	0.87[d]	98.97[b]
(*C. cajan*)	(6.05)	(4.30)	(4.11)	(3.65)	(2.83)	(2.29)	(1.64)	(1.17)	(9.97)
Chickpea	23.72[c]	17.60[c]	11.82[e]	9.73[b]	8.57[b]	4.82[c]	3.07[cd]	0.00[e]	79.35[d]
(*C. arietinum*)	(4.91)	(4.25)	(3.50)	(3.19)	(3.01)	(2.29)	(1.87)	(0.71)	(8.93)
Mungbean	32.37[b]	33.25[a]	20.57[b]	9.07[b]	2.72[d]	2.07[d]	3.07[cd]	0.00[e]	103.15[b]
(*V. radiata*)	(5.73)	(5.80)	(4.59)	(3.09)	(1.79)	(1.59)	(1.87)	(0.71)	(10.18)
Lentil	7.17[e]	5.75[e]	4.37[f]	8.92[b]	4.22[c]	6.50[b]	3.97[c]	4.75[c]	45.67[e]
(*L. culinaris*)	(2.76)	(2.50)	(2.20)	(3.07)	(2.15)	(2.63)	(2.10)	(2.28)	(6.78)
Control	0.00[f]	0.00[f]	0.00[g]	0.00[c]	0.00[e]	0.00[e]	0.00[e]	0.00[e]	0.00 [f]
(no seed)	(0.71)	(0.71)	(0.71)	(0.71)	(0.71)	(0.71)	(0.71)	(0.71)	(0.71)
F-Test	**	**	**	**	**	**	**	**	**
LSD(≤0.05)	0.27	0.25	0.17	0.29	0.29	0.31	0.29	0.25	0.29
CV%	4.29	4.34	3.39	6.64	7.47	8.70	8.15	8.05	2.31

† Means of four replications. Mean values in column with the same superscript are not significantly different by DMRT (P<0.05). Figure in the paremthesis indicate the square root transformed value.D-Day, TF- Total fecundity, LSD- Least Significant Difference, CV- Coefficient of Variation, **- Highly significant (p>0.001)

Final weight of the grain also significantly differed with the types of legumes under free choice condition. Soybean seeds significantly retained higher final grain weight (19.89g) followed by lentil (18.55g). The median development period of insect was noticed longer in lentil seed (28.33 days) followed by chickpea (28.06 days), while it took shorter development period in mungbean (23.31 days) and there was no development at all in soybean seeds. The mean damage was recorded higher in mungbean seeds (4.04%) followed by pigeonpea (2.39%).

Table 2. Initial and final seed germination, number of eggs and adults of *C. chinensis* emerged under free choice condition at GLRP, Rampur, Chitwan, 2013

Legume seeds	Initial Ger (%)	Egg/grain	Egg/20 gm grain	Adult/20 gm grain	Final Ger (%)
Pigeonpea	†90.00[b]	19.89[c]	293.70[e]	175.40[b]	84.80[b]
(*C. cajan*)	(9.51)	(4.49)	(17.11)	(13.25)	(9.23)
Soybean	100.00[a]	52.95[a]	1372.00[a]	0.00[d]	98.33[a]
(*G. max*)	(10.02)	(7.29)	(36.97)	(0.71)	(9.94)
Mungbean	91.05[b]	32.33[b]	733.60 [c]	538.80[a]	81.77 [b]
(*V. radiata*)	(9.56)	(5.68)	(27.07)	(23.18)	(9.07)
Cowpea	96.80[a]	17.55[c]	1016.00[b]	636.60[a]	81.85 [b]
(*V. unguiculata*)	(9.86)	(4.22)	(31.84)	(25.05)	(9.07)
Chickpea	90.70[b]	19.08[c]	489.10[d]	155.30[b]	84.50[b]
(*C. arietinum*)	(9.55)	(4.39)	(22.09)	(12.46)	(9.22)
Lentil	92.00[b]	10.00[c]	282.20[e]	132.90[b]	85.47[b]
(*L. culinaris*)	(9.62)	(3.22)	(16.77)	(11.36)	(9.27)
F-Test	**	**	**	**	**
LSD (≤0.05)	0.21	0.87	2.69	2.87	0.19
CV%	1.50	12.08	7.16	13.48	1.45

† Means of four replications. Mean values in column with the same superscript are not significantly different by DMRT (P<0.05). . Figures in the parenthesis indicate the square root transformed value. Ger – Germination, LSD- Least significant difference, CV- coefficient of variation, **- Highly significant (p>0.001)

There were significant differences among the treatments on their SIs, indicating differences in their suitability as hosts for oviposition, development and feeding by *C. chinensis*. Mungbean and cowpea seeds had significantly the highest SIs of 11.81 days and 11.34 days, respectively. Yadav and Pant (1974) observed that *Callosobruchus* spp. oviposited on any seed even though the seed may not be suitable for the development of these insects. The results are in accordance with similar studies which found that *C. chinensis, C. maculatus* and *Acanthoscelides obtectus*, there was no correlation between host preference and previous conditioning of the bruchids on their hosts (Wasserman, 1981; Zaazon, 1951).

Soybean, pigeonpea, chickpea and lentil had the lowest SIs of 0 days, 7.44 days, 7.54 days and 6.87 days, respectively (Table 3). Mungbean seeds suffered the highest weight loss (20.23%) followed by cowpea (12.53%). The lowest weight loss was recorded on lentil (7.27%) and soybean (0.55%) seeds.

RELATIONSHIP BETWEEN NUMBER OF PULSE BEETLES AND SEED DAMAGE

A positive linear correlation between number of adult per 20 gm grain and mean damage percentage of six different legume seeds was observed with a Equation Y= 0.004X + 1.004 and R^2= 0.602 showing the best fit (Figure 2) and indicating higher damage with the increase in number of *C. chinensis* adults per grain.

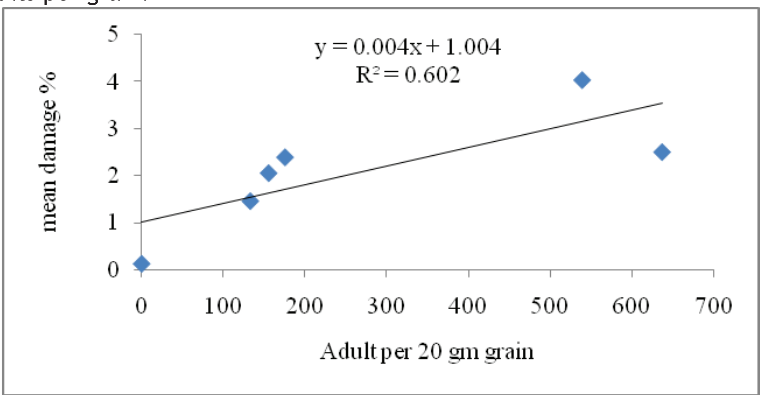

Figure 2. Relationship between number of adults and damage of six different legumes under free choice condition at GLRP, Rampur, Chitwan, 2013

Table 3. Initial and final seed weight, median development period, mean damage and susceptibility index of *C. chinensis* under free choice condition at GLRP, Rampur, Chitwan, 2013

Legume seeds	Initial wt (g)	Final wt (g)	Med. D.P. (days)	Mean damage (%)	SIs (days)	Wt. loss (%)
Pigeonpea	20.00	†17.60[bc]	26.80[a]	2.39[b]	7.44[b]	11.89[b]
(*C. cajan*)		(4.25)	(5.22)	(1.69)	(2.81)	(3.52)
Soybean	20.00	19.89[a]	0.00[c]	0.11[c]	0.00[c]	0.55[c]
(*G. max*)		(4.52)	(0.71)	(0.78)	(0.71)	(1.02)
Mungbean	20.00	15.95[d]	23.31[b]	4.04[a]	11.81[a]	20.23[a]
(*V. radiata*)		(4.05)	(4.88)	(2.13)	(3.51)	(4.54)
Cowpea	20.00	17.49[c]	23.73[b]	2.50[b]	11.34[a]	12.53[b]
(*V. unguiculata*)		(4.24)	(4.92)	(1.70)	(3.44)	(3.50)
Chickpea	20.00	17.95[bc]	28.06[a]	2.05[b]	7.54[b]	10.25[b]
(*C. arietinum*)		(4.29)	(5.34)	(1.59)	(2.81)	(3.27)
Lentil	20.00	18.55[b]	28.33[a]	1.45[b]	6.87[b]	7.27[b]
(*L. culinaris*)		(4.36)	(5.37)	(1.39)	(2.71)	(2.77)
F-Test		**	**	**	**	**
LSD (≤0.05)		0.11	0.17	0.29	0.31	0.70
CV%		1.85	2.68	12.62	7.86	15.26

† Means of four replications. Mean values in column with thesame superscript are not significantly different by DMRT $_{(P<0.05)}$. Figures in the parenthesis indicate the square root transformed value. Wt- Weight, g-gram, Med. D.P.-Median Development Period, SI- Susceptibility Index, LSD- Least significant difference, CV- coefficient of variation, **- Highly significant (p>0.001)

RELATIONSHIP BETWEEN SUSCEPTIBILITY INDICES AND SEED WEIGHT LOSS

A linear correlation was observed between susceptibility indices and percent seed weight loss of six different legume seeds with Equation Y= 1.403X – 0.074 and R^2= 0.843 showing the best fit, which indicated a positive correlation resulting in higher susceptibility and higher loss of seed weight (Figure 3).

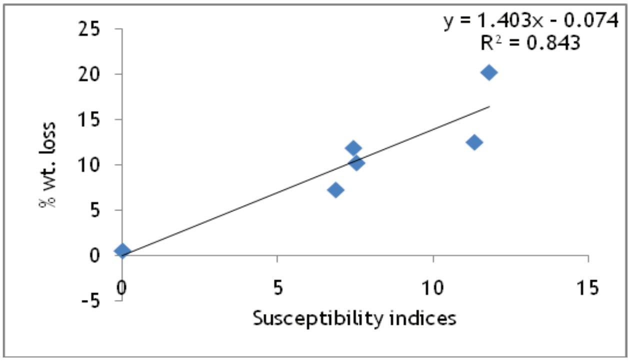

Figure 3. Relationship between susceptibility indices and percent seed weight loss of six different legumes under free choice condition at GLRP, Rampur, Chitwan, 2013

NO CHOICE TEST

Initial and final germination percent of seed was highly significant among the different types of legumes. Soybean seeds showed both higher initial and final germination percent, i.e. 100 and 98.61% followed by cowpea seeds 96.80 and 85.10%, respectively (Table 4). The highest mean number of eggs was deposited by bruchid on mungbean (24.45 eggs) followed by cowpea seeds (21.53 eggs). Similarly, the mean number of eggs deposited per twenty gram seeds was also higher in mungbean (2225 egg/20g seed) followed by cowpea seeds (1612 egg/20g seed). Eventually, higher number of adults of *C. chinensis* emerged from twenty gram mungbean seeds (645.70 adult/20g seed) followed by cowpea (474.90 adult/20g seed) and lentil (464.10 adult/20g seed) seeds. There was no emergence of adult of *C. chinensis* from soybean seeds (Table 4). Final weight of the grain also differed significantly with the types of legumes under no choice condition. Soybean seed significantly retained higher final grain weight (19.60 g) followed by chickpea (17.95g). The median development period of insect was noticed longer in lentil seed (29.08 days) followed by chickpea (28.81 days) while it was significantly shorter in mungbean (23.56 days) and no development in soybean seeds. The mean damage was recorded higher in mungbean seeds (5.06%) followed by pigeonpea (2.94%). Therefore, there existed significant differences among the treatments on their SIs, which indicated their suitability as hosts for adult oviposition, larval feeding and development of *C. chinensis*. Mungbean and cowpea seeds had significantly the highest SIs of 11.93 and 11.14 days, while soybean, chickpea, lentil and pigeonpea had the lowest SIs of 0, 8.68, 9.06 and 9.10 days, respectively (Table 5). Hence, mungbean seeds suffered the highest weight loss (25.34%) followed by pigeonpea (14.75%) and chickpea (10.25%), and the lowest weight loss was recorded on soybean seeds (2.00%). Development responses of the pulse beetle varied among different pulses. A number of physical and chemical factors of seeds appear to be responsible for the reduction of the development of the pulse beetle in some pulses. The ability of the larvae to penetrate the seed coat appears to be influenced by the physical properties of the seed coat, such as thickness, hardness and roughness (Manohar and Yadava, 1990). Loose testa may also provide difficulties for the larva to enter successfully in to the cotyledon. In addition, factors, such as poor nutrition, presents of growth deterents or toxic substances may have been responsible for the death of all or most of the larvae after penetration into the cotyledons of soybean. Also compactness of the seed cotyledon may cause difficulties for the larvae to feed resulting in their death due to starvation. According to Nwanze and Hober (1976), larval survival during penetration of the seed coat is also affected by surface texture and structure and larval development within seeds depends on quality and compactness of seed as well as the amount of food available.

The present study clearly indicates that the preference for oviposition by females is not an indication of suitability for the development of pulse beetle. The highest larval mortality was recorded from one of the most preferred oviposition sites, i.e. soybean. Considerably high adult emergence was recorded from chickpea although it was less preferred by the female as an oviposition site. Therefore, it is evident that the female *C. chinensis* is not able to determine the most suitable oviposition site for the development of its larvae. This is in accordance with the findings of Satyavir and Jindal (1981) for *C. maculatus*. Seilfelnasr (1991) observed a similar trend in haricot bean where maximum numbers of eggs were deposited which was higher than the number deposited on chickpea but none of the larvae survived to adulthood. Microscopic examinations revealed that the newly hatched larvae had died before bring the seed coats or cotyledons of haricot bean. Soybean seed significantly retained higher final grain weight followed by chickpea. This finding is in agreement with Applebaum *et al.* (1969) who discussed the inability of *Callosobruchus* spp. to develop on soybean seed, which can be attributed mainly to the high protein-carbohydrate ratio of the seed and in part to its saponin content. Mphure (1981) also supported the evidence that this bruchid is known for not being capable of attacking seeds with a high fat content like soybean. The developmental period is appreciably prolonged in non-host seeds reaching a maximum number of days. The development and survival of *Callosobruchus* spp is affected by certain nutritive and digestive factors (Applebaum and Birk, 1972; Mphuru, 1981).

Table 4. Initial and final seed germination, number of eggs and adults of *C. chinensis* emerged under no choice condition at GLRP, Rampur, Chitwan, 2013

Legume seeds	Initial Ger (%)	Egg/grain	Egg/20 gm grain	Adult/20 gm grain	Final Ger (%)
Pigeonpea	†90.00^{b}	18.49^{bc}	526.70^{c}	272.50^{c}	85.35 ^{bc}
(*C. cajan*)	(9.51)	(4.34)	(22.95)	(16.41)	(9.27)
Soybean	100.00^{a}	17.89^{bc}	1522.00^{b}	0.00^{d}	98.61^{a}
(*G. max*)	(10.02)	(4.28)	(38.75)	(0.71)	(9.95)
Mungbean	91.05^{b}	24.45^{a}	2225.00 ^{a}	645.70 ^{a}	83.55^{d}
(*V. radiata*)	(9.56)	(4.99)	(47.13)	(25.42)	(9.16)
Cowpea	96.80^{a}	21.53^{ab}	1612.00^{b}	474.90^{ab}	85.10^{c}
(*V. unguiculata*)	(9.86)	(4.68)	(39.96)	(21.65)	(9.25)
Chickpea	90.70^{b}	15.98^{c}	450.50^{c}	331.00^{bc}	85.07^{c}
(*C. arietinum*)	(9.55)	(4.05)	(21.20)	(17.99)	(9.25)
Lentil	92.00^{b}	3.78^{d}	1316.00^{b}	464.10^{ab}	86.45^{b}
(*L. culinaris*)	(9.62)	(2.05)	(36.26)	(21.16)	(9.32)
F-Test	**	**	**	**	**
LSD (≤0.05)	0.21	0.49	4.65	4.15	0.07
CV%	1.50	8.15	9.10	16.20	0.51

† Means of four replications. Mean values in column with the same superscript are not significantly different by DMRT $_{(P<0.05)}$. Figures in the parenthesis indicate square root transformed values. Ger – Germination, LSD- Least significant difference, CV- coefficient of variation, **- Highly significant (p>0.001)

RELATIONSHIP BETWEEN SUSCEPTIBILITY INDICES AND SEED WEIGHT LOSS

A positive linear correlation between susceptibility indices and percent seed weight loss of six different legume seeds was observed under no-choice condition, which resulted in the equation Y= 1.497X + 0.371 and R^2= 0.710 giving the best fit (Figure 4). As the susceptibility indices increased, percent seed weight loss also increased.

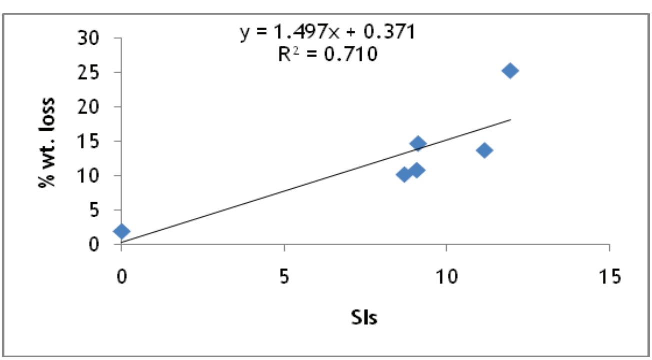

Figure 4. Relationship between susceptibility indices and percent seed weight loss of six different legumes under no-choice condition at GLRP, Rampur, Chitwan, 2013

Table 5. Initial and final seed weight, median development period, mean damage and susceptibility index of *C. chinensis* under no-choice condition at GLRP, Rampur, Chitwan, 2013

Legume seeds	Initial wt (g)	Final wt (g)	Med. D.P. (days)	Mean damage (%)	SI (days)	Wt. loss (%)
Pigeonpea	20.00	†17.05[b]	26.63[b]	2.94[b]	9.10[c]	14.75[b]
(*C. cajan*)		(4.18)	(5.21)	(1.83)	(3.09)	(3.83)
Soybean	20.00	19.60[a]	0.00[d]	0.40[c]	0.00[d]	2.00[c]
(*G. max*)		(4.48)	(0.71)	(0.93)	(0.71)	(1.47)
Mungbean	20.00	14.93[c]	23.56[c]	5.06[a]	11.93[a]	25.34[a]
(*V. radiata*)		(3.93)	(4.90)	(2.35)	(3.53)	(5.05)
Cowpea	20.00	17.24[b]	23.91[c]	2.75[a]	11.14[b]	13.77[b]
(*V. unguiculata*)		(4.21)	(4.94)	(1.79)	(3.41)	(3.75)
Chickpea	20.00	17.95[b]	28.81[a]	2.05[b]	8.68[c]	10.25[b]
(*C. arietinum*)		(4.29)	(5.41)	(1.59)	(3.03)	(3.27)
Lentil	20.00	17.83[b]	29.08[a]	2.17[b]	9.06[c]	10.88[b]
(*L. culinaris*)		(4.28)	(5.44)	(1.61)	(3.09)	(3.31)
F-Test		**	**	**	**	**
LSD (≤0.05)		0.16	0.08	0.38	0.10	0.94
CV%		2.56	1.25	15.11	2.51	18.36

† Means of four replications. Mean values in column with the same superscript are not significantly different by DMRT $_{(P<0.05)}$. Figures in the parenthesis indicate square root transformed values. Wt- Weight, g-gram, Med. D.P.–Median Development Period, SI- Susceptibility Index, LSD- Least significant difference, CV- coefficient of variation, **- Highly significant (p>0.001)

Yadav and Pant (1974) reported that *C. chinensis* to breed successfully on many legumes seeds and except on blackgram and lentil. This supports our findings in the present study on lentil, which has a longer developmental period compared to other legumes. Those legume seeds with a low SIs could be regarded as being poor or non-host, where as mungbean and cowpea seed with a high SIs could be regarded as being suitable host for *C. chinensis*. The finding is in association with the findings of Applebaum and Guez (1972) who reported that the resistance of legumes to *Callosobruchus* infestation is attributed to the presence of saponins which comprised 3.2% of the lipid-free bean meal or to the hetero-polysaccahrides. Since the factors rendering inherent resistance are not yet known, it might be important to investigate the factors contributing to resistance of the seeds of certain legume species.

CONCLUSION AND RECOMMENDATION

The female was capable of egg-laying till the death of male bruchid. The last male was found dead after 9th day. It was also observed that both adults found dead after 2-3 days during experimental periods in empty jar. Seeds of mungbean, cowpea and pigeonpea were the most susceptible legume seeds and thus the most suitable host for *C. chinensis*. These hosts had the highest number of eggs oviposited and percent adult emergence, the shortest developmental period, highest susceptibility index and highest weight loss. Conversely, lentil, chickpea and soybean seeds were found to be lowly susceptible. Soybean was the most resistant for larval development although it was highly preferred by the females for oviposition. In the choice experiment, soybean, mungbean and cowpea seeds respectively had a maximum number of eggs deposited and adult emergence was highest in cowpea and mungbean rather than soybean. The order for ovipositional preference for all legumes seeds remained the same irrespective of the host on which *C. chinensis* has been reared. Thus farmers have to be advised not to store cowpea, mungbean and pigeonpea seeds in the same place and or at the same time to avoid cross infestation because of their high susceptibility to *C. chinensis*.

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ECONOMIC ANALYSIS OF COST OF PRODUCTION OF APPLE IN MUSTANG DISTRICT OF NEPAL

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ABSTRACT

Apple is an important fruit grown in Nepal. But apple yield per hectare in Nepal is very low resulting perhaps from inefficient use of inputs at farmer's level. To investigate into the fact, the study was conducted at farmer's level in Mustang district of Nepal in 2012 with a sample of 80 apple growers (40 from each Kobang and Tukuche VDCs) applying multiple regression function model. The overall B/C ratio was found to be 2.94 and it was higher in Tukuche VDC (3.15). The labour cost incurred in production was found to be 31.17 percent in both VDCs. The functional analysis revealed that number of productive plants and labour were found significant that affect the production in both VDCs while in Tukuche, area under apple production was also significant factor affecting production.

Key words: Apple, B/C ratio, cost, inputs, multiple regression

INTRODUCTION

Apple is a prominent and one of the important prioritized high value cash crops (APP, 1995). Apple is a main temperate fruit of Nepal, which is cultivated on 5,674 hectares productive area with production of 48,946 mt and productivity 8.63 mt/ha in hilly topography lying from east to west. It contributes about 4.75% of the total fruit production and occupies 5.6% of the total fruit area in Nepal (MoAD, 2011/12). Largest productive area under apple is found in Jumla (2,472 ha), Mugu (818), Kalikot (1,084 ha) followed by Mustang (708 ha) and Solukhumbu (414 ha) (MoAD, 2011/12). Most of the apple growing districts are not linked with roadways. They are not easily accessible to the national and export marketing channels, although air transport service has contributed a great extent to transport these apples at the urban market centers of Nepal. The construction of agricultural roads to these commercial production pockets, envisaged by APP, will link these districts to roadways and develop opportunities for exporting Nepalese delicious apples to our neighboring countries (MDD, 2000).

Moreover, due to continuous increase in the cost of production, harvesting, carrying and freight charges, the small producers are not getting a fair return from the marketed fruits. All these difficulties in the process of production, harvesting and marketing of fruits affect farm income as well as limit the expansion of agricultural enterprises. The government has formulated many programs and policies for the improvement of agricultural sector but most of these seem to have limited only to policy and not able to leave real impact on farmers level. So, most of the farmers have been following less profitable, traditional production and harvesting practices which are characterized by high cost of production, low productivity and low profitability. The agriculture needs diversification and commercialization to raise the income and employment opportunities of the farmers by identifying high value low volume crops, which have comparative advantage, such as fruits and vegetables, and by optimally utilizing the available resources for production and marketing operations for sustainable development (Gautam and Saraf, 1995). This study was mainly focused on the major apple growing VDCs such as Kobang and Tukuche concerning different aspect

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of production of the commodity. Thus, realizing its importance to increase farm income, this study was conducted to dig out the real cost of production and different factors affecting apple production. So this study is expected to be helpful for the formulation and implementation of plans and programs for the concerned stakeholders within the district.

METHODOLOGY

SOURCES OF DATA

Mustang district was purposively selected for the purpose of the study based on the relatively higher area coverage by apple. The required data for this study were collected through survey method from a sample of 80 farmers from two areas namely Kobang and Tukuche village development committees (VDCs) of Mustang district. However, apple has been growing extensively in several VDCs of this district. Due to limited resources, complete listing and enumeration of apple farmers in study areas was not possible. Eighty farmers were randomly selected taking 40 from each study VDC. The secondary data were collected from the various publications of related organizations like Fruit Development Directorate (FDD), Market Development Directorate (MDD), Ministry of Agricultural Development (MoAD), Agro-Enterprise Center (AEC), Central Bureau of Statistics (CBS), District Agriculture Development Office (DADO), Mustang.

METHODS OF DATA ANALYSIS

COST OF PRODUCTION

Variable cost items were included for analyzing cost of production. The variable cost included manure cost, irrigation cost, labor cost, training–pruning cost, and pesticide cost for different production activities. Total cost was calculated by summing all the variable cost items.

BENEFIT COST RATIO ANALYSIS OF APPLE PRODUCTION

Benefit cost ratio simply gives an idea about recovery of cost incurred during the production by return from products. This analysis was done after calculating the total cost and gross return from apple production. Total variable cost was treated as total cost of production and fixed cost was not included in the total cost. The benefit-cost analysis was carried out by using following formula.

$$B/C\ ratio = \frac{\text{Gross return}}{\text{Total cost}}$$

ANALYSIS OF FACTORS AFFECTING APPLE PRODUCTION

It was assumed that there exist linear relationship between yield of apple and others factor affecting the yield of apple such as number of productive plants, area under apple production, labour and manure used. The theoretical multiple regression model under study was as follows;

Y = f (number of productive plant, area under the apple production, labour and manure used)

The mathematical specification of model was;

$$Y_i = \alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4$$

where,

Y_i = yield of apple (ton/*ropani*)

X_1 = number of productive plant (no./*ropani*)

X_2 = area under the apple production (*ropani*/household)

X_3 = total labour used per *ropani*

X_4 = manure used per *ropani*

a, $\beta_1 ....\beta_4$ = *coefficient to be estimated*

RESULT AND DISCUSSION

COST OF PRODUCTION AND RETURN

Cost of production refers to the outlay of funds for the procurement of necessary inputs and labor employed. The production of apple depends on the levels of inputs used like labor, manure, pesticide application, number of productive plants per unit area and training and pruning practices. Fixed costs were not included in the analysis of cost of production. The study showed the average cost of production and return per *ropani* was Rs 6,145.90±23.87 and Rs 17,997.04±144.62 respectively and benefit cost ratio was 2.94 indicating that apple cultivation was profitable enterprise in Mustang district (Table 1).

Table 1. Average cost and return of apple cultivation (Rs/*ropani*) (2012)

VDC	Cost	Return	B/C ratio
	Mean ± SE	Mean ± SE	
Kobang (n=40)	6139.60±36.94	16699.71±219.10	2.72
Tukuche (n=40)	6152.20±30.68	19294.38±158.14	3.15
Total (N=80)	6145.90±23.87	17997.04±144.62	2.94

SE = Standard Error.

The cost of production was somewhat similar in both VDCs as presented in Table 1. The benefit cost ratio analysis showed that the apple cultivation was profitable enterprise in both VDCs as the B/C ratio was greater than one i.e. 2.72 for Kobang and 3.15 for Tukuche VDC. The higher return in Tukuche VDC might be due to the higher density of apple trees per *ropani* and higher quality of apple produced in Tukuche VDC as compared with Kobang.

COMPARATIVE ANALYSIS OF COST OF PRODUCTION

Per unit cost of production was found somewhat similar in both VDCs. The benefit cost ratio was higher in Tukuche VDC indicating profitability of the enterprise. The detail comparative analyses of cost of production on different items are presented in Table 2.

Table 2. Average variable cost of production of apple (Rs/*ropani*) (2012)

Variable cost of production	Kobang	Tukuche	Total	*Share*
	Mean ± SE	Mean ± SE	Mean ± SE	*%*
Labour cost	1955.46±13.79	1876.04±17.41	1915.67±11.12	*31.17*
Manure cost	920.79±8.64	1035.04±7.28	978.42±6.07	*15.92*
Pesticides cost	1349.15±7.50	1226.86±9.02	1288.18±6.26	*20.96*
Training and pruning cost	1725.29±19.19	1805.26±12.08	1765.10±11.39	*28.72*
Irrigation cost	188.29±6.22	208.3±6.26	198.51±4.40	*3.23*
Total cost	6139.60±36.94	6152.20±30.68	6145.90±23.87	*100.00*

SE = Standard Error Note: Share of the each variable cost to the total cost in percent.

The analysis of cost of production showed that the average production cost incurred in labour, manure, pesticides, training-pruning and irrigation were 31.17, 15.92, 20.96, 28.72 and 3.23 percent of the total cost respectively. The studies revealed that higher amount of cost were incurred for labour, training-pruning practices and for pesticides spray across the study sites. The expenditure in manure cost per *ropani* was higher in Tukuche (Rs 1,035.04±7.28), as the farming system of this area was livestock based compared to Rs 920.79±8.64 in Kobang whereas expenditure in pesticides application for checking diseases and insect-pests was found higher in Kobang (Rs 1,349.15±7.50) compared to Tukuche (Rs 1,226.86±9.02) per *ropani*.

FACTORS AFFECTING PRODUCTION OF APPLE

Multiple regression model was used for the analysis of factors affecting the production of apple. In this model, number of productive plants, area under apple cultivation, labour and manure were taken as explanatory variables whereas the production of apple was taken as explained variable. The coefficients of factors affecting production of apple are given in Tables 3 and 4.

Table 3. Factors affecting production of apple in Kobang VDC (2012)

Variables	Unstandardized coefficients		Standardized coefficients	t	P value
	B	SE	Beta		
Constant	5.580	4.218	-	1.323	0.194
Number of productive plants (X_1)	0.722	0.120	0.880	5.379	0.000**
Area under apple production (X_2)	-0.239	0.589	-0.092	-0.568	0.573
Labour (X_3)	0.304	0.185	0.176	2.191	0.035*
Manure (X_4)	0.151	0.197	0.050	0.769	0.447

Dependent Variable: Yield of apple, SE = Standard Error.

$R = 0.864$, $R^2 = 0.746$, Adjusted $R^2 = 0.717$ and Stand error of estimate = 12.69514,

Darwin watson = 2.171 and F statistics = 25.763**

Note: ** and * refers to the significant at 0.01 and 0.05 level of significance, respectively.

The result of regression model showed that number of productive plants and labour were the significant factors that affect yield of apple. Based on regression analysis an econometric model (first order polynomial equation) for factors affecting apple production has been developed as:

$Y = 5.580 + 0.722X_1 - 0.239X_2 + 0.304X_3 + 0.151X_4$ …....... (iii)

where,

Y = yield of apple (ton/ropani)

X_1 = number of productive plant per *ropani*

X_2 = area under apple production (*ropani*/HH)

X_3 = total labour force used per *ropani*

X_4 = manure used per *ropani* (*pathi*/*ropani*)

The equation (iii) is a least-squares multiple regression equation which is used to isolate the separate effects of the independent variables and to predict scores on the dependent variable. However, in many situations, using this equation (iii) to determine the relative importance of the various independent variables will be awkward especially when the independent variables differ in terms of units of measurement. In situation where the units of measurement differ, we will not necessarily be able to tell from the partial slope which independent variable has the strongest effect on the dependent variable and is thus the most important of the independent variables (Healey, 1999). The independent variables can be made more nearly comparable by converting all of the variables in the equation to a common scale and thereby eliminating variations in the values often partial slopes that are solely a function of differences of units of measurement (Healey, 1999). We can standardize all distribution by converting all scores into 'Z' scores. These standardized partial slopes are called beta-weights. The beta-weights will show the amount of change in the standardized scores of dependent variable for a one-unit change in the standardized scores of the independent variables while controlling for the effects of other independents variables. The standardized regression equation can be further simplified by dropping the term for the intercept, since this term will always be zero when scores have been standardized (Healey, 1999). Thus, the standardized regression equation, with beta-weights noted would be:

$Z_{y} = 0.880Z_1 - 0.092Z_2 + 0.176Z_3 + 0.050Z_4$ ………..…... (iv)

where,

Z_{y} = yield of apple (ton/ropani)

Z_1 = number of productive plant per *ropani*

Z_2 = area under apple production (*ropani*/HH)

Z_3 = total labour force used per *ropani*

Z_4 = manure used per *ropani* (*pathi*/*ropani*)

Number of productive plants and labors were found to be significant factors affecting production of apple. The output elasticities of number of productive plants and labor were found to be 0.722 and 0.304 indicating that holding the other explanatory variables constant one percent change in respective plant and labor input caused 0.722 and 0.304 percent increase in output from the respective variables. Similarly, area under apple and manure used were found to be non-significant. The summation of all the values of the parameters was found to be 0.938, which indicated decreasing returns to scale. The value of multiple correlation coefficient (R=0.864) indicates the strong correlation between dependent and independent variables in the analysis. Likewise, the value of coefficient of multiple determination (R^2=0.746) indicates that 74.6 percent variation in dependent variable was explained by all independent variables.

Table 4. Factors affecting production of apple in Tukuche VDC (2012)

Variables	Unstandardized coefficients		Standardized coefficients	t	P value
	B	SE	Beta		
Constant	4.563	3.710	-	1.230	0.227
Number of productive plants (X_1)	1.177	0.624	0.283	2.045	0.009**
Area under apple production (X_2)	0.219	0.064	0.503	2.782	0.038*
Labour (X_3)	0.316	0.280	0.334	2.089	0.044*
Manure (X_4)	-0.579	0.572	-0.158	-1.097	0.280

Dependent Variable: Yield of apple, SE = Standard Error.

R = 0.874, R^2 = 0.765, Adjusted R^2 = 0.738 and Stand error of estimate = 10.72834,

Darwin watson = 2.505 and F statistics = 28.422**

Note: ** and * refers to the significant at 0.01 and 0.05 level of significance, respectively.

Result of the regression suggest that number of productive plants, area under apple production and labour were the significant factors that affect yield of apple. Based on regression analysis an econometric model for factors affecting apple production has been developed as:

$Y = 4.563 + 1.177X_1 + 0.279X_2 + 0.386X_3 - 0.579X_4$ …....... (v)

where,

Y = yield of apple (ton/ropani)

X_1 = number of productive plant per *ropani*

X_2 = area under apple production (*ropani*/HH)

X_3 = total labour force used per *ropani*

X_4 = manure used per *ropani* (*pathi*/*ropani*)

Similarly, the standardized regression equation, with beta-weights noted would be:

$Z_y = 0.283Z_1 + 0.503Z_2 + 0.334Z_3 - 0.158Z_4$ ……….….... (vi)

where,

Z_{y} = yield of apple (ton/ropani)

Z_1 = number of productive plant per *ropani*

Z_2 = area under apple production (*ropani*/HH)

Z_3 = total labour force used per *ropani*

Z_4 = manure used per *ropani* (*pathi*/*ropani*)

Number of productive plants was found highly significant factors affecting the production of apple whereas the area under apple was also found to be significant. The output elasticity of number of productive plant was found to be 1.177 indicating that holding the other explanatory variables constant one percent change in respective plant number caused 1.177 percent increase in output. Similarly, labour used was found to be significant i.e. one unit change in labour force resulted the 0.316 percent change in yield of apple whereas manure used was found to be non-significant. The summation of all the values of the parameters was found to be 1.113, which indicated increasing returns to scale. The value of multiple correlation coefficient (R=0.874) indicates the strong correlation between dependent and independent variables in the analysis. Likewise, the value of coefficient of multiple determination (R^2=0.765) indicates about 76.5 percent variation in dependent variable was explained by all independent variables.

CONCLUSION

Apple cultivation is one of the prioritized fruit by the APP and different Governmental plans and policies for the high-hill farming system. Though the area is increased significantly in the present years but the production and productivity is still below the target. Kobang and Tukuche are the potential production area of apple due to climatic and edaphic suitability. Apple cultivation was profitable, which was also supported by high B/C ratio in both of the VDCs. The average cost of production was Rs 6,145.90±23.87 and average return was Rs 17,997.04±144.62 per *ropani*. The studies revealed that higher cost per *ropani* was incurred for labour across the study sites. Multiple linear regression model was used to analyze the factor affecting production of apple in surveyed VDCs. In Kobang VDC, number of productive plants and labor were found significant factors affecting production while in Tukuche VDC number of productive plants, area under the apple and labour were found significant factors affecting production. Uneconomic utilization of inputs on apple field resulted in decreasing return to scale.

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PERFORMANCE OF RICE VARIETIES UNDER CONVENTIONAL AND SRI PRACTICES IN FAR WESTERN TARAI OF NEPAL

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ABSTRACT

An experiment was conducted in Farmers' Field Schools (FFS) in Kailali district, Nepal during the rainy season (June - November) of 2010 to compare the System of Rice Intensification (SRI) with conventional (recommended) transplanting practice (21 days old 3-4 seedlings/per hill planted with continuous flooding), and to evaluate the performance of six rice varieties under SRI. Rice varieties; Sabitri, Mithila, Sarju#52, Sunaulo Sugandha, Radha#4 and Jaya were included in the experiment. The experiment was laid out in a factorial Randomized Complete Block design and replicated in four FFSs. Results showed that 472 % more tillers/hill, 241% more number of effective tillers/m^2 and 2.71 % higher thousand grain weight (TGW) were produced in SRI than in conventional practice. Result further revealed that on an average 92.42% more yield (7.58/ha) was obtained in SRI as compared to that (4.01 t/ha) in conventional practice under similar condition of fertilizer management. Likewise, significantly higher net return (NRs.68.65 thousands/ha) and B:C ratio (1.52) were observed in SRI practice than that (2.97 thousands/ha and 0.76) obtained in conventional method. Result also showed that variety Sabitri cultivated using SRI produced the highest number of tillers/hills (41.25) and effective tillers/m^2 (383), highest yield (8.35t/ha), highest net return (NRs 80.15 thousands/ha) and B:C ratio (1.77). From the experiment, it can be concluded that SRI practice could be one of the potential ways of increasing rice production in Nepal even with existing varieties. Further refinement of the technology depending upon prevailing microclimatic conditions is[1] suggested.

Key words: SRI, rice varieties, grain yield, B:C ratio, western tarai Nepal

INTRODUCTION

Rice is the most important cereal crop in agriculture and economy of Nepal. It occupies more than 50% of the agricultural area, shares 20% in the agricultural gross domestic product (AGDP) and accounts for 53% of the total food grain production (NARC, 2007). Cultivation of rice stretches throughout the country; *Tarai* and inner-*Tarai* (71%) Hills (24.9%) and Mountains (4.1%) (MOAC, 2008). Total area under rice in Nepal is about 1.55 million ha with the annual production of 4.30 million ton and productivity of 2.9 t/ha (FAOSTAT, 2010). The food grain production of the country was deficit by 329,972 ton in fiscal year 2009/2010 as compared to her requirement (ABPSD, 2010) and the food deficiency is chronic in recent years with some exceptions. Increasing rice production can solve this problem and save millions of rupees now spent by the Government every year in importing food grains. One of the main reasons for the deficiency of food grain is the low productivity (2.9 t/ha) of rice crop in Nepal as compared to the neighboring country India (3.1t/ha) and world (4.1t/ha) (FAOSTAT, 2010).

Recently, a new approach, widely known as system of rice intensification (SRI), has attracted the attention of farmers as well as of scientists because of its success in increasing rice grain yield. The performance of SRI technology raises the hope among policy makers, development workers and farmers for solving problem of low productivity of rice even in highly marginal lands. SRI was not invented in laboratory or field experimentation but it is a civil society innovation which occurred in the farmers' fields in Madagascar, and was first developed accidentally by Father Henri de

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Laulanié, who combined field observations of rice plant performance with a series of experiments over a decade (Laulanié, 1993). The new set of practices greatly improved the growing environment for rice plants, evoking more productive phenotypes from all rice genotypes on which the practices were used. The five major components of the SRI that make it different from other rice cultivation practices are: (1) the use of young (8–15 days old/two-leaf stage) single seedling per hill), (2) wide plant spacing of 25 cm x 25 cm to as much as 50 cm x 50 cm, (3) use of rotator weeder, (4) the addition of organic matter (manure and/or compost) to supply adequate nutrients and (5) intermittent wetting and drying of the field for soil aeration during the vegetative stage (Stoop *et al.*, 2002). Claims have been made that with SRI methods rice yields can exceed even 15–20 t/ha (Uphoff, 2002). However, these claims have been questioned in general by some of the scientist (Dobermann, 2003; Sheehy *et al.*, 2004). Practice of SRI in Nepal is not common and there is dire need for the research work to make this technology popular among the farmers. Therefore, present research was conducted at 4 farmers' field schools in Kailali district during the rainy season of 2010 with the aim compare SRI with conventional transplanting practice and to assess the performance of rice varieties of under SRI practice in far western *Tarai* of Nepal.

MATERIALS AND METHODS

Series of experiments consisting of six rice varieties grown under SRI management were conducted at different farmers' field schools in Kailali district, during the rice season (June–November) of 2010. The single experiment was tested in 4 farmers' field school in different VDCs (Table 1).

Table 1: Details of the treatment combinations in the experiment in farmer's field school during June to November, 2010 in Kailali, Nepal.

SN	Name of the Varieties tested	Methods of cultivation	Replication sites	Parameter taken
1	Sabitri, Mithila, Sarju#52, Sunaulo sugandha, Radha#4, Jaya	SRI and conventional	Ramsikhrajhala, Lalbojhi, Khailad, Pahalmanpur	Number of tillers/hill, number of effective tillers/m^2, thousand grain weight (TGW), grain yield
2	Financial analysis of the cultivation practices		Ramsikhrajhala, Lalbojhi, Khailad, Pahalmanpur	Cost of cultivation, yield, returns, net returns and B:C ratio

The soils of the experimental fields were clay loam having pH 6.4. the most popular varieties; Sabitri, Mithila, Sarju 52 (not a recommended variety in Nepal but popular in far-western *Tarai*), Sunaulo Sugandha, Radha 4 and Jaya were tested using both SRI and conventional practices. All the experiments were conducted using Factorial Randomized Complete Block Design where method of cultivation was taken as a factor "a" and varieties as factor "b". Individual farmer's field school was taken as replication. Each individual plot had the size of 4 m x 3 m^2. The practices prescribed by SRI methodology: (a) 8–10 days old seedlings; (b) single seedlings per hill; (c) intermittent wetting and drying during the vegetative phase (limited to 3 cm irrigations after surface drying to keep the soil moist) and 2–3 cm of standing water during the reproductive phase; (d) plant spacing of 25 x 25 cm; and (e) three weedings by rotatory weeder at 15, 30 and 45 days after transplanting were used in all the SRI treatments. In the plots with recommended transplanting practice 21day-old seedlings with three seedlings per hill were transplanted into a puddled field at the depth of 2–5 cm deep spaced 15 cm × 10 cm^2, with 5–6 cm of pounded water. The water level was maintained during the entire vegetative and reproductive stages and was drained 15 days before harvest. Single hand weeding was done at 25 DAT.

Nutrient management was similar in both of the systems of planting. Farm yard manure at the rate of 1.5 ton/ha along with chemical fertilizer at the rate of 60: 40: 40: 8 kg N, P, K and Zn/ha through urea, Diamonium Pospahte (DAP), muriate of potash (MOP), and zinc sulfate, respectively, were applied. All the P, K and Zn fertilizers were applied at the time of final land preparation whereas N was applied in three equal splits at 15, 45 and 55 days after transplanting. Observation on number of tillers per hill, number of effective tillers per m^2 and thousand grain weight (TGW) was made from ten hills randomly collected from each plot. For the measurement of yield, crop was harvested excluding the boarder lines, sun dried for five days, threshed by stick and grain was separated. Grain was weighed and yield was adjusted to 14% moisture level. All inputs and their costs were recorded throughout the crop growing season based on which overall net income was calculated. Cost–benefit analysis was done for each treatment. Data were analyzed using MSTATC prescribed for Factorial RCBD and mean separation was done by Dunkan's Multiple Range (DMR) test.

RESULTS AND DISCUSSIONS

EFFECT OF METHOD OF CULTIVATION ON THE YIELD AND YIELD ATTRIBUTES OF RICE

Methods of cultivation and management practice greatly alter the productivity of rice by influencing the yield and yield attributing characters (Sheehy *et al.*, 2004; McDonald *et al.*, 2006). The data from the experiment conducted in farmers' field school in Kailali also followed this phenomenon and showed that method of cultivation had significant effect on yield and yield attributing characters like numbers of tillers/ hill, effective tillers/m^2, thousand grin weight (TGW) and grain yield (table 2).

Table 2: Effect of methods of cultivation of rice on the number of tillers/hill, number of effective tillers/ m^2, TGW and grain yield at farmers' field schools, Kailali, Nepal, during June- November, 2010.

Methods of cultivation	Tillers/hill	Effective tillers/m^2	TGW(g)	Yield (t/ha)
SRI	35.46[a]	340.50[a]	21.55[a]	7.58[a]
Conventional	6.20[b]	146.1[b]	20.98[b]	4.012[b]
LSD	1.44**	7.23**	0.28*	0.14**
SEM±	0.50	2.51	0.10	0.05

Mean separated columns represented with same letters are not significantly different at 5% level of significance.

SRI practice produced significantly higher number of tillers/hill (35.46) and effective tillers/m^2 (340.50) in comparison with that (6.20) and (146.1), respectively produced from conventional method. Similarly, thousand grain weight (21.55g) and grain yield (7.5ton/ha) produced from SRI method were significantly higher than that (20.98g) and (4.01), respectively produced from conventional practice. The positive effect of SRI method of cultivation on yield and yield attributing characters are also reported by many previous researchers; Uphoff (2006) and Chapagain and Yamaji (2010) who found that SRI management promoted better root growth, greater number of effective tillers/hill, longer panicles, and greater number of filled grains per panicle over conventional management. The effects of SRI on enhanced tillering and earlier flowering were also reported by Vijayakumar *et al*. (2006) and Krishna *et al*. (2008), who achieved greater yields and better quality grain in SRI management as compared to conventional methods. The favorable effect of SRI might be due to more efficient utilization of resources as a result of less inter and intra-space competition.

VARIETIES AND CULTIVATION PRACTICES

Number of effective tillers per meter square: Grain yield of cereals is highly dependent upon the number of effective tillers/m^2 produced by each plant (Power&Alessi, 1978; Nerson, 1980). Data from the experiment (table 3) showed that an average number of effective tillers/m^2 across all the treatments was 243.3 and was ranged from 109.4 to 383.3 depending on cultivation practices and variety used. In general, the number of effective tillers/m^2 was significantly influenced by both the cultivation practice and variety. There was significant difference in this parameter among the varieties, when grown with the same methods or set of practices. Variety Sabitri produced 287.5 effective tillers/m^2, which differed significantly from the rest followed by Mithila (254.9), Sarju 52 (249.67), Jaya (242.90). However, Radha 4 (212.60) and Sunaulo Sugandha (212.20) did not differ significantly regarding this parameter. The data also showed that the grain yield is highly depended on the number of effective tillers/ m^2. The analysis showed a close relationship between these two parameters (fig 1); grain yield was positively correlated with the number of effective tillers/m^2 (r=0.913) and the relationship was significant.

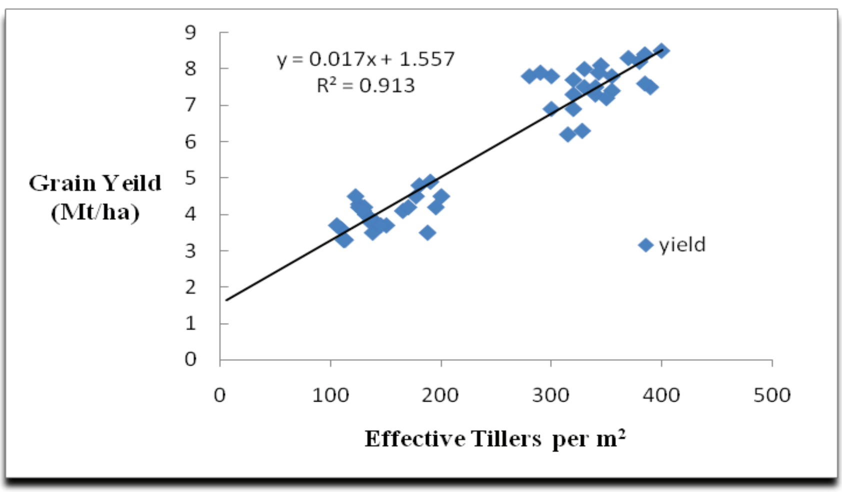

Fig: 1. Effect of effective tillers per m^2 on grain yield of rice in farmer's field school during June-Sept. 2010.

The number of effective tillers/m^2 differed significantly among the varieties as well. However, all varieties produced comparatively higher number of effective tillers/m^2 under SRI practice than that in conventional practice. Varied response of rice varieties to SRI and conventional methods in terms of effective tillers/m^2 have also been reported by Avasthe *et al*. (2012).

Table 3: Interaction effect of methods of cultivation and variety of on yield and yield attributing characters of rice at farmers' field school, Kailali, Nepal, during June - November, 2010.

Interaction effects	Number of tillers/hill		Number of effective tillers/ m^2		TGW (g)		Grain yield (t/ha)	
Varieties/methods	SRI	CON.	SRI	CON.	SRI	CON.	SRI	CON.

Sarju 52	36.00^{bc}	5.25^{e}	367.5^{a}	131.9^{f}	26.08^{a}	24.83^{b}	7.45^{cd}	3.94^{gh}
Sunaulo Sugandha	29.75^{d}	5.25^{e}	297.5^{d}	126.8^{fg}	19.01^{ef}	18.51^{fg}	7.80^{bc}	4.20^{g}
Radha 4	33.00^{cd}	4.75^{e}	315.8^{c}	109.4^{g}	24.80^{b}	24.30^{b}	6.57^{e}	3.47^{i}
Jaya	35.00^{bc}	6.25^{e}	343.3^{b}	142.5^{f}	21.14^{c}	20.89^{c}	7.95^{b}	3.77^{h}
Mithila	37.75^{ab}	7.75^{e}	335.0^{b}	174.9^{e}	18.25^{gh}	17.75^{h}	7.37^{d}	4.07^{gh}
Sabitri	41.25^{a}	8.00^{e}	383.8^{a}	191.3^{e}	20.00^{d}	19.63^{de}	8.35^{a}	4.60^{f}
LSD	3.54 *		17.71*		0.70*		0.35*	
SEM	1.23		6.155		0.24		0.12	
CV	11.84%		5.06%		2.30%		4.28%	

Mean separated by columns represented with same letters are not significantly different at 5% level of significance

Thousand Grain weights (TGW): The TGW is a stable varietal character because the grain size is rigidly controlled by the size of the hull (Yoshida, 1981). The average test weight (TWG) was 21.26g in the experiment, ranging from 17.75 to 26.08 g depending upon the combination of methods of cultivations and variety. Data (table 3) showed that TGW was significantly influenced by method of cultivation and variety and there was an interaction effect between them. Average TGW (21.55g) was found to be significantly higher in SRI practice as compared to that (20.98g) produced in conventional practice. Sarju 52 produced the highest TWG (25.45 g) which was significantly different than the rest of the varieties, except Radha 4 (24.55). Significantly lower TGW was obtained in Mithila (18.00) which was at par with Sunaulo Sugandha (18.76). There was significant interaction effect between methods of cultivations and variety on TGW (table 3). Methods of cultivations produced no significant effect on TGW for Sunaulo Suganda, Radha 4, Jaya, Sabitri and Mithila varieties. The analysis of data showed that TGW was found to be significantly higher with SRI methods in Sarju 52 as compared to other varieties and it was lowest in conventional method produced by variety Mithila.

Over all response of rice varieties to SRI practice: Rice varieties have varied potential regarding vegetative growth, yield and yield attributing characters depending upon the management practices. In this experiment there was significantly different response of varieties to SRI practice. The analyzed data (table 4) showed that the number of tillers/hill was found significantly higher in Sabitri, which was at par with Mithila and was significantly different from the rest of the varieties. The lowest value of this parameter was found in Sunaulo Sugandha, which was at par with Radha 4 and was significantly different from the rest. Sabitri also produced significantly higher number of effective tillers/m^2, differing from the rest of the varieties. The performance of the Sarju 52 produced thousand grain weight which was significantly higher from rest of the varieties.

Table 4: : Effect of methods of cultivation of rice on yield and yield attributes at farmers' field school, Kailali, Nepal, during June- November, 2010.

Varieties	Tiller per hill	Effective tiller per m^2	TGW	Yield
Sarju 52	20.63^{bc}	249.7^{b}	25.45^{a}	5.69^{c}
Sunaulo sugadha	17.50^{d}	212.20^{c}	18.76^{e}	6.00^{b}
Radha 4	18.88^{cd}	212.60^{c}	24.55^{b}	5.025^{d}

Jaya	20.63^{bc}	242.90^{b}	21.01^{c}	5.86^{bc}
Mithila	22.75^{ab}	254.90^{b}	18.00^{f}	5.72^{c}
Sabitri	24.63^{a}	287.5^{a}	19.81^{d}	6.47^{a}
LSD	2.510*	12.52*	0.49*	0.25*
SEM	0.87	4.35	0.17	0.08

Mean separated by columns represented with same letters are not significantly different at 5% level of significance.

Analyzed data (table 4) showed that variety Sabitri produced significantly higher number of tillers/hill and number of effective tillers/m^2 and grain yield in SRI method whereas significantly lower yield was produced by Radha 4 when cultivated with recommended practice. The results corroborate with the NARC findings (Khatiwada & Upreri, 2008) in which 5t/ha grain yield of Sabitri as compared to 3.5 t/ha of Radha 4 under similar condition has been reported.

ECONOMIC ANALYSIS

The economical analysis of various treatments under study was worked out to evaluate the most beneficial and economical treatment for rice cultivation.

Table 5: Economic analyses for SRI and conventional rice cultivation in farmers' field school, Kailali, Nepal, during June-November, 2010.

Methods of cultivation	Cost of cultivation	Gross return	Net Return	B:C ratio
SRI	45.10	113.8^{a}	68.65^{a}	1.52^{a}
Conventional	34.20	60.17^{b}	25.97^{b}	0.76^{b}
LSD		2.18 **	2.18 **	0.05**
SEM±		0.75	0.75	0.02

Mean separated by columns represented with same letters are not significantly different at 5% level of significance.

COST OF CULTIVATION

The data (Table 5, 6 and 7) showed that, in general, SRI practice required higher cost (Rs 45.10 thousand/ha) of cultivation per hectare as compared to that (Rs 34.20 thousand/ha) needed for conventional method. At the same time, no significant difference in cost of cultivation among the varieties was observed.

GROSS RETURN

The data (table (5, 6, 7) showed that average gross return in the experiment was Rs. 86.98 thousand/ha which ranged from Rs. 52.12 to 125.25 thousand/ha depending upon the cultivation practices and variety. Significantly higher gross return was observed in SRI practice (113.8 Thousand/ha) than conventional (60.17 thousand/ha). There was significantly higher gross return (Rs. 97.12 thousand/ha) in Sabtri whereas lower value (Rs. 75.37 thousand/ha) of this parameter was in Radha 4. There was no significant difference in gross return among Jaya, Sunaulo sugandha, and Mithila. Significantly higher gross return in Sabitri variety is due to significantly higher grain yield. Thus, the highest gross return was obtained from Sabitri variety when cultivated through SRI practices indicating that SRI method of cultivation can be used for better economic return in rice production.

Table 6: Economic analysis for rice varieties under SRI practices at farmers' field school in Kailali, Nepal during June to November, 2010.

Varieties	Cost of cultivation	Gross return	Return	B:C ratio
Sarju#52	39.65	85.46	45.81 [c]	1.10[c]
Sunaulo sugadha	39.65	90.00	50.35 [b]	1.21[b]
Radha#4	39.65	75.37	35.72 [d]	0.85[d]
Jaya	39.65	87.93	48.28 [bc]	1.15[bc]
Mithila	39.65	85.87	46.22 [bc]	1.12[bc]
Sabitri	39.65	97.12	57.47 [a]	1.39[a]
LSD	ns	ns		0.10*
SEM				0.03

Mean separated by columns represented with same letters are not significantly different at 5% level of significance.

NET PROFIT

The analyzed data (table 5, 6, 7) indicated that the average net profit was Rs. 47.31thousand/ha, which ranged from Rs. 17.92 to 80.15 thousand/ha depending upon the methods of cultivation and variety. There was significantly higher net return (Rs. 57.47 thousand/ha) in Sabitri and lower (Rs. 35.72 thousand/ha) in Radha 4. However, no significant difference in this parameter was found among Jaya, Sunaulo sugandha, and Mithila. Significantly higher net return was observed in SRI practice (68.65 thousand/ha) than conventional (2.97 thousand/ha). The highest net return was obtained from Sabitri variety when cultivated through SRI practices indicating that variety Sabitri, if cultivated with SRI method, would ensure better net return in rice cultivation. Similar result was also found by Avasthe *et al.* (2012) who found significantly higher net return in SRI methods over the conventional whereas no significant difference among the varieties with the same method of cultivation.

BENEFIT COST RATIO

Benefit cost ratio is the ratio of gross return to cost of cultivation which can also be expressed as returns per rupee invested. Any value greater than 2 is considered safe as the farmer get Rs. 2.00 for every rupee invested (Reddy and Reddi, 2002). On the other hand, minimum benefit cost ratio of 1.5 has been fixed for an enterprise in the agricultural sector to be economically viable (Bhandari, 1993).

Table 7: Economic analysis for methods of cultivation and varieties of rice at farmers' field school in Kailali, Nepal during June to November, 2010

Interaction effects	Cost of cultivation		Gross Return		Net returns		B:C ratio	
Varieties/methods	SRI	CON.	SRI	CON.	SRI	CON.	SRI	CON.
Sarju 52	45.100	34.200	111.75	59.17	66.65[c]	24.97[gh]	1.47[c]	0.73[fg]
Sunaulo sugadha	45.100	34.200	117.00	63.00	71.90[bc]	28.80 [g]	1.59[bc]	0.84[f]
Radha 4	45.100	34.200	98.62	52.12	53.52[d]	17.92 [i]	1.18[d]	0.52[h]
Jaya	45.100	34.200	119.25	56.62	74.15[ab]	22.42 [h]	1.64[ab]	0.65[gh]
Mithila	45.100	34.200	110.62	61.12	65.52 [c]	26.92 [gh]	1.45[c]	0.78[fg]
Sabitri	45.100	34.200	125.25	69.00	80.15 [a]	34.80 [f]	1.77[a]	1.01[e]
LSD	Ns		Ns				0.14 *	
SEM							0.05	

Mean separated by columns represented with same letters are not significantly different at 5% level of significance

Data showed that there was significantly higher B:C ratio (1.77) in Sabtri and lower (0.52) in Radha 4. However, no significant difference in B:C ratio among Jaya, Sunaulo sugandha, and Mithila was found. Significantly higher B:C ratio was observed in SRI practice (1.52) than conventional (0.76). The highest B:C ratio was obtained from Sabitri variety when cultivated through SRI practices. Hence, it can be mentioned that SRI and the variety Sabitri can be used for better net return for rice cultivation in western Terai of Nepal. The data showed that, SRI can greatly increase net benefits as it saves approximately 25%–50% water over conventional production (Randriamiharisoa and Uphoff, 2002; Chapagain and Yamaji, 2010), thereby reducing production costs under water-scarce conditions. As SRI farmers spend less money on inputs, they reduce their financial risk on crop production, and the negative impact of agro-chemicals on the environments. Evaluations done by Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ) and IWMI have shown that financial risk of farmers are reduced with SRI (Anthofer, 2004; Namara *et al*, 2004), and have concluded SRI as a valuable system with respect to a farmers' enterprise budget.

SUMMARY AND CONCLUSION

One season experiments conducted in the farmers' field school showed some notable benefits of SRI practices as compared to conventional method like increased number of tillers/hill, number of effective tillers/m^2, thousand grain weights and grain yield with less water and with the same set of fertilizer management. In addition, there was a significant difference among the varieties regarding the number of tillers/m^2 and grain yield showing supremacy of SRI practices over recommended practice. The gross return, net return and cost benefit ratio were greatly influenced by methods of cultivation and variety. Significantly higher gross returns, net returns and B:C ratio was observed in Sabitri variety cultivated with SRI practice. Therefore, the SRI practice would be the better choice for the farmers for increasing yield of rice with reduced seed and water requirements and thereby reduced production costs in western Nepal.

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