"Seven Billion Dreams. One Planet. Consume With Care."

"एउटै पृथ्वी सात अर्ब सपना: दिगो उपयोग हाम्रो चाहना"

The Journal of AGRICULTURE AND ENVIRONMENT

(This issue is published on the occasion of World Environment /Population Day, 2015)

Vol: 16 **June 2015**

Government of Nepal
Ministry of Agricultural Development
Food Security and Environment Division
Environment and Climate Change Section
Singh Durbar, Kathmandu

2015

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Published by:

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Food Security and Environment Division
Environment and Climate Change Section
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EDITORIAL

World Environment Day (WED) is an occasion for whole people of planet to encouraging awareness and action for the environment protection. It is a special day for positive environmental action doing something individually that converts into collective power which helps generate positive impact on or planet, the Earth.

The population of the planet is increasing day by day which raised the problem on shelter, food safety and security and resulting impact on the environment. The large volume of food required to both men and animals depends on plants and their products which are grown or found in the environment. Water is another major factor for living to animals and men as drinking, washing and bathing. Due to the daily activities done by humans for development work, cultivation, animal fodder, shelter, fire, power generation and other such activities, we are exploiting our environment.

The United Nations Environment Program fixed the theme for the World Environment Day, 2015 is "***Seven Billion Dreams. One Planet. Consume With Care".*** The theme really draws the attention to warning to consume foods without waste, produce without disturbing the environment to fulfill our dream. The theme is important for the environment and climate vulnerable countries like Nepal.

The day is being celebrated through several events in the world among them, Ministry of Agricultural Development, Food Security and Environment Division, publishing the ***Journal of Agriculture and Environment***, new issue, Vol. 16 in 2015.The journal includes technical and review articles related to climate change, organic agriculture, and agricultural product marketing and other cross cutting issues.

The Editor-in-Chief acknowledges for the valuable contribution from the authors, editors, reviewers and the management team and hopes that readers find some information from the articles useful to them. The Editorial Board always welcomes receiving valuable suggestions and feedback to improve the quality of articles published in the journal in days ahead.

Editor-in-Chief

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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 2071 (March 15, 2015).

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

GLOBAL EFFECT OF CLIMATE CHANGE AND FOOD SECURITY WITH RESPECT TO NEPAL

Mina Nath Paudel[1]

ABSTRACT

The effect of global climate change in Nepal could be observed by glacier retreat in the Himalaya region and change in the pattern of the south west monsoon which is the only reliable source of water for farming. Climate change has been occurred in Terai, hills and mountain of Nepal resulting change in agriculture systems leading to the emergence of new insect, pest and disease of crops and animals. There are frequent losses of lives, crops and, human settlements due to occurrence of flash floods, droughts, typhoon and hurricanes in the world mainly due to climate change. Global food production and trade have been affected by the negative consequences of climate change as a result countries like Nepal are also victimized due to the negative effect of climate change. Increase in $C0_2$concentration in the atmosphere and change in precipitation are being the main cause of floods, droughts, glacier retreat, and melting of snows, hence, change in the flora and fauna globally. To address such measures of climate change, Nepal has been trying to develop some adoptive ways such as development of climate resilient technology including crop varieties, animal breeds; agronomic practices that could address vagaries of climate change and sustain food and nutritional security. In Nepal, the effect of climate change is more pronounced in hills and mountains with respect to increase in temperature than that of Terai. This paper tries to address issue of global climate change with respect to food security of Nepal by applying some of the pragmatic adoptive measures to follow in agriculture for sustaining food security in Nepal.

KEY WORDS: Adaptation and mitigation, climate change, food security, global agriculture

MATERIALS AND METHODS

This is partly a review of the effect of global climate change with respect to the food security in Nepalese perspective. To make an analogy of climate change in Nepal two cross section study areas were selected to represent mountains and Terai region of Nepal encompassing Kakani (2030-m), central high hill and Dhangadhi (210-m), far western Terai, Nepal from where ten years' meteorological data (total rainfall, number of rainy days and temperature (max and min) were interpreted. Meteorological data of these two locations were correlated to judge impact of climate change in Nepal with respect to food security. Hence, effect on agriculture systems in Nepal.

INTRODUCTION

Nepal, noted for her majestic Himalayas, the roof of the world, *Sagarmatha,* Mount Everest (8848 m) in the north and the lowest point *Kechanakal*(60-m) in the south. The Himalayas, the water towers, which supply water to the Indo-gangetic plain of Indian subcontinent,

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are the proud of the mountainous and hilly country, Nepal. Nepal is about 650 kilometers long and about 200 kilometers wide, and comprises a total of 147,181 square kilometers area. Climate of Nepal varies from cool summers and severe winters in north to subtropical summers and mild winters in south. Nepal is rich in biodiversity and so is the case of climate that are prevailed almost all the climate available in the world, hence called the micro-museum of world climate. Climatic zones range from tropical to tundra with a narrow band of altitude. Climate varies from subtropical to arctic, all within a distance of approximately 180 kilometers. The broad differentiation in climate is that there is a great variety of micro climatic conditions, resulting in a diversity of land use and farming practices within the country.

In each of broad agroclimatic zone in Nepal there is variation of land type, vegetation and cropping patterns. In general, the climate of the Terai, Dun valleys, and part of the Siwaliks (300 to 1000-m) is subtropical while the climate of the middle mountains (1000 to 3000-m) ranges from warm temperature to cool temperate, and the high mountains (2600 to 4200-m) from cool temperate to sub-alpine. Mid hills or the mountain region is pleasant and amicable for many flora and fauna. As a result, this region is densely populated by many ethnicities. The Himalayas are above 4200-m to 8848m, the roof of the world and is represented by tundra and high alpine climate.

Merlon*et al* (2013) reported that 97% of climate scientists agree that global warming is because of human cause. They further noted that fewer than half of Americans believe in human caused global warming and 15% understand the degree of consensus in scientific community. Hence, global warming and climate change are very complex phenomena and it is difficult to come into consensus even globally how actually these phenomena are happening. Likewise, Cook *et al* (2013) analyzed 12000 peer-reviewed papers in climate science literature and found that 97% of the papers that stated apposition on the reality of human caused global warming are happening at least in part. They also noted by contrast that only 41% of Americans say global warming is happening and human caused. The impact of climate change in the world has occurred. It is accepted that developed countries are primarily responsible for enhancing factors of climate change and these have resources and ways to mitigate it whereas developing countries like Nepal have suffered heavily due to the negative impact of climate change. However, there are only ways for developing world to go for adaptation mechanisms to lessen the vagaries of climate change on food security, environment conservation and sustainability despite their low or no role in bringing climate change of present situation globally. Nevertheless, there are events of powerful typhoon in coastal areas of Philippines, India, USA and other parts of the globe. It has been forecasted that in the coming decades, global agriculture faces the prospect of a changing climate (International Panel on Climate Change (IPCC), 1990a, 1992). There lies a challenge to feed the world's population, projected to double its present level of five billion by about the year 2060 (International Bank for Reconstruction and Development/World Bank, 1990). Climate change could have far-reaching effects on patterns of trade among nations, development, and food security. Above all, climate change could make it more difficult to grow crops, raise animals, and catch fish in the same ways and same places as we have done in the past.

RESULT AND DISCUSSION

GLOBAL PERSPECTIVES OF CLIMATE CHANGE AND AGRICULTURE

Changes in the constituent of climatic factors have immense effect on agriculture such as increases in temperature and carbon dioxide (CO_2) can be beneficial for some crops in some places. Changes in the frequency and severity of climatic factors could lead droughts and floods which could pose challenges for farmers. Climate change has direct effect on other stresses such as population growth may magnify their effects. For example, in developing countries, adaptation options like changes in crop-management or ranching practices or improvements to irrigation are more limited than in the developed and other industrialized nations. Hence, it is imperative that there could be heavy burden of climate change to developing world compared to developed countries in coming days ahead with respect to agriculture and livelihood of rural poor is concerned.

Natural calamities have devastating effects on human civilization. In the Philippines, there are more than a dozen typhoons in a year and in December 2013 Typhoon *Haiyan* was so devastating that nearly 6,000 people are believed to have died, and some 3.6 million are displaced and there was massive land slide that destroyed many human settlements (http://www.worldvision.org/news-stories-videos/typhoon-haiyan-response-philippines). Similarly, hurricane *Katrina* was one of the deadliest hurricanes ever to hit the United States. An estimated 1,836 people died in the hurricane and the flooding that followed in late August 2005, and millions of others were left homeless along the Gulf Coast and in New Orleans, which experienced the highest death toll (http://www.livescience.com/22522-hurricane-katrina-facts.html). There are number of climate related such events that are experienced in the recent years. All of such natural calamities could be associated with negative impacts of climate change that have local and global impacts on human civilization affecting much on poor and agro-based countries in the world.

Impact of climate trends on global crop yields has been observed for important crops of maize, rice, wheat and soybean (Don Hofstrand, 2011). As a result, maize production would have been about six percent higher and wheat production about four percent higher had the climate trends since 1980 not existed whereas the effects on rice and soybeans were observed lower and not significant (Fig. 1). The implication of climate on agriculture explains that there is a need of finding ways of adapting to these changes of climatic scenarios. It was also noted that the impact of temperature on crop yields is a larger factor than the impact of precipitation. This would indicate that adaptation strategies should focus more on temperature changes than on precipitation changes. In developed countries, increase in agricultural production over the last century was mostly as a result of yield increases rather than agricultural land area expansion. However, due to the world's rapidly growing demand for food due to negative impact of climate change on food production, there will be elevated pressure to expand the world's agricultural land area. To cope up with these challenges on agriculture there needs an increased investment in agricultural research across the world to meet the challenge of world food production.

In Figure 1, estimated changes in yields for maize, rice, wheat, and soybeans for major producing countries are shown (Don Hofstrand, 2011). The country with the largest impact was wheat production in Russia with an estimated negative yield impact of almost 15 percent while for the U.S., yield changes due to temperature and precipitation trends are negligible for maize, wheat and soybeans. Yield impacts were smaller for rice than the other crops. The confidence intervals of the yield estimates were larger for soybeans than the other crops.

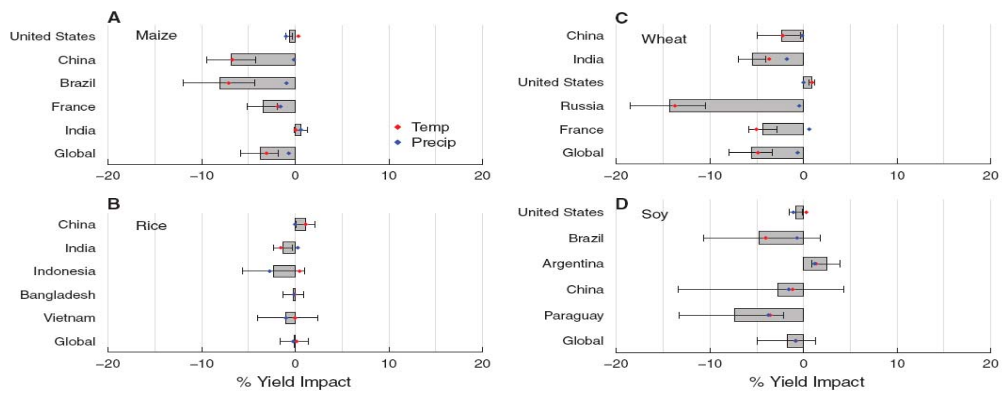

Figure 1. Estimated net impact of climate trends from 1980 to 2008 on crop yields for major producing countries and for global production (Source: Don Hofstrand, 2011)

A = Maize, B = Rice, C = Wheat, D = Soybeans *, Values are expressed as percent of average yields

*Gray bars show median estimate and error bars show 5 percent to 95 percent confidence internal from bootstrap resembling with 500 replicates. Red and blue dots show median estimate of impact for temperature trend and precipitation trend, respectively.

Note: the sum of the temperature (red dots) and precipitation (blue dots) estimates equals the total estimate shown by the gray bars.

The effects of climate change also need to be considered along with other evolving factors that affect agricultural production, such as changes in farming practices and technology. It has been keenly observed that sensitivity studies of world agriculture to potential climate changes have indicated that the effect of moderate climate change on world and domestic economies may be small, as reduced production in some areas is balanced by gains in others (Kane *et al*., 1991; Tobey *et al*., 1992). Agriculture is an important sector of the

U.S. economy. In addition to providing U.S. with much of food, crops, livestock, and seafood that are grown, raised, and caught in the United States contribute at least $200 billion to the economy each year (USGCRP, 2009). U.S. exports more than 30% of all wheat, corn, and rice on the global market (U.S. Census Bureau, 2011). Any change in climate parameters such as temperature, amount of carbon dioxide (CO_2), and the frequency and intensity of extreme rainfall and other weather condition could have significant impacts on crop yields (Fig. 2). Warmer temperatures may make many crops grow more quickly, but this could reduce crop yields for crops tend to grow faster in warmer conditions and this could have negative impact on yield from a given area of land (USGCRP, 2009).

For a particular crop, the effect of increased temperature will depend on the crop's optimal temperature for growth and productivity. In some areas, warming may benefit the types of crops that are typically planted. Nevertheless, if temperature exceeds a particular crop's optimum temperature, yields can be declined. It has been established that higher CO_2 levels can increase crop yields. The yields for some crops, like wheat and soybeans, could increase by 30% or more under a doubling of CO_2 concentrations. The yields for other crops, such as corn, exhibit a much smaller response less than 10% increase in CO_2 concentrations (CCSP, 2008).

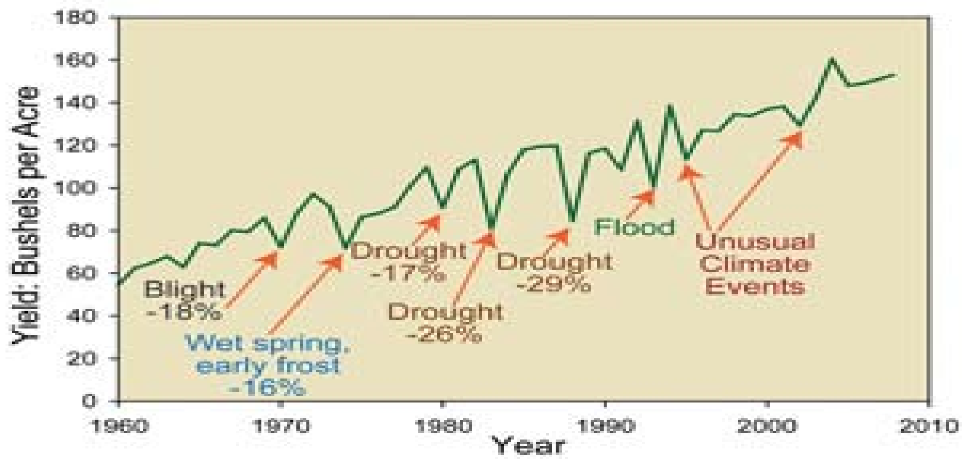

Figure 2. Impact of climate change in USA on corn yield in 2009
(Source: United States Global Change Research Program (USGCRP, 2009)

However, some factors may counteract these potential increases in yield. For example, if temperature exceeds a crop's optimal level or if sufficient water and nutrients are not available, yield increases may be reduced or reversed. In USA, there are reports that more extreme temperature and precipitation can prevent crops from growing such as extreme events, especially floods and droughts, can harm crops and reduce yields. For example, in 2008, the Mississippi River flooded just before the harvest period for many crops, causing an estimated loss of $8 billion for farmers (USGCRP, 2009). Many weeds, pests and fungi thrive under warmer temperatures, wetter climates, and increased CO_2 levels and farmers spend more than $11 billion per year to fight weeds in the United States (USGCRP, 2009). The result of these consequences is that the ranges of weeds and pests are likely to expand northward. This would cause new problems for farmers' crops previously unexposed to these species. Moreover, increased use of pesticides and fungicides may negatively affect human health (USGCRP, 2009).

In Nepal also, infestation of new insects, pests and weeds have recently been observed as problem on crops, animals and even in humans as the consequence of climate change. Noxious weeds such as *Parthenium hysterophorus* (White top Weed/ Congress Weed), *Pistiastratiotes* (water lettuce/Pani Banda) and *Mikaniamicrantha* (Bitter Vine or American Rope) have invaded crop and national reserve. The former two are becoming menace to crop production whereas the later one is so rapidly invading national reserve of Chitwan in central Terai and Bardiya in western Terai in such a way that endangered wild life one horned rhino and other herbivores could face forage and pasture limitation if these weeds are not brought under control immediately. Similarly, trans-boundary disease of bird flu in poultry, swine flu in humans, Ug-99 of wheat stem rust, brown plant hopper (BPH) in rice, and so on and so forth are causing heavy economic losses to developing countries including Nepal. These are becoming potential threats to human civilization. Recently Ebola virus in Africa has become a new threat to human beings across the globe threatening to food security in Africa (UN Report, Sep, 16, 2014). Who know these might have been critically favored by climate change?

Global agriculture has been facing prospect of a changing climate (IPCC, 1990a, 1992) to feed the world's population, projected to double its present level of five billion by about the year 2060 (International Bank for Reconstruction and Development/World Bank, 1990). There appears to be closely linked between agriculture and climate, the international nature of food trade and food security, and the need to consider the impacts of climate change in a global context. In areas with increased rainfall, moisture-reliant pathogens could thrive (USGCRP, 2009). Increases in atmospheric CO_2 can increase the productivity of plants on which livestock feed. Many fisheries have already been experiencing multiple stresses, including overfishing and water pollution. Climate change could enhance these stresses particularly temperature changes could lead to significant impacts. The ranges of many fish and shellfish species may change. Many marine species have certain temperature ranges at which they can survive. Many aquatic species can find colder areas of streams and lakes or move northward along the coast or in the ocean as result of ecosystem impact due to climate change (Fig. 3).

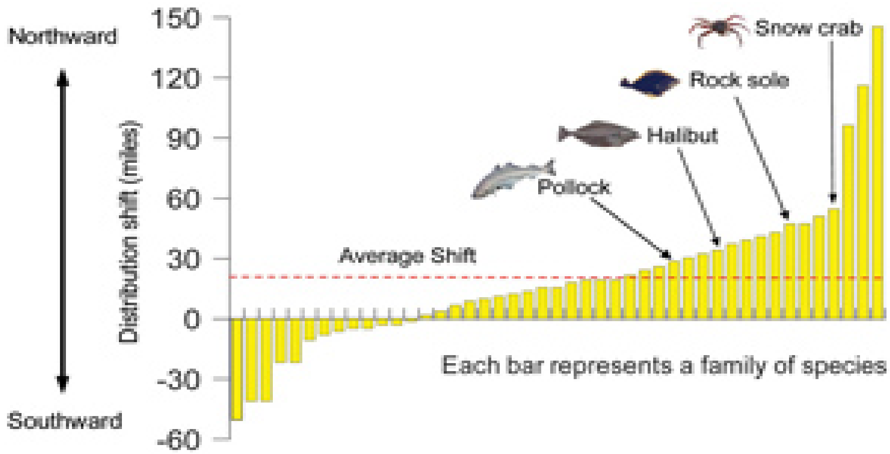

Figure3- The range of marine species shifted northward as water warmed

(Source: United States Global Change Research Program (USGCRP, 2009)

CLIMATE CHANGE AND GLOBAL FOOD SECURITY

Agricultural scientists of 18 countries have simulated potential changes in grain yields using compatible crop models (IBSNAT, 1989). The crops modeled were used for wheat, rice, maize, and soybeans. The crop models were run for current climate conditions, for arbitrary changes in climate (+2^{0}C and +4^{0}C increase in temperature and +/-20% precipitation), and for climate conditions predicted by general circulation models (GCMs) for doubled atmospheric CO_2 levels. The study consisted with the direct effects of CO_2, and precipitation held at current levels, average crop yields weighted by national production show a positive response to +2 ^{0}C warming and a negative response to +4 ^{0}C. The output showed that wheat and soybean yields increased 10-15% whereas maize and rice yields increased about 8% with a +2 ^{0}C temperature rise. Yields of all four crops turned negative at +4 ^{0}C, indicating a threshold of the compensation of direct CO_2 effects for temperature increases between 2 and 4 ^{0}C, as simulated in the IBSNAT crop models. Rice and soybean are most negatively affected at +4 ^{0}C. For example, the effects of latitude are such that in Canada, a +2 ^{0}C temperature increase with no precipitation change results in wheat yield increases (with direct effects of CO_2 taken into account), while the same changes in Pakistan result in average wheat yield decreases of about 12%. In general, 20% increase in precipitation improved the simulated yields of the crops tested, and 20% decrease lowered yields of all crops. Climate changes without the direct physiological effects of CO_2 cause decreases in simulated wheat yields in all cases, while the direct effects of CO_2 mitigate the negative effects primarily in mid- and high-latitudes (Rosenzweig, *et al*, 1993).

Climate change scenario with the use of compatible model predicted the greatest warming (5.25^{0}C global surface air temperature increase), causes average national crop yields to decline almost everywhere up to -50% in Pakistan (Rosenzweig, *et al,* 1993). In the model, assuming that full agricultural trade liberalization and no climate change by 2020 provides for more efficient resource use. The prediction leads to a 3.2% higher value added in agriculture globally and 5.2% higher agricultural GDP in developing countries (excluding China) by 2060 compared to the original reference scenario. This policy change results in almost 20% fewer people at risk from hunger. If this scenario continues global cereal production increases by 70 million metric tons with most of the production increases occurring in developing countries (Rosenzweig, *et al*, 1993). Under such circumstances losses in production are greater in developing countries and at the same time, price increases are reduced slightly from what would occur without full trade liberalization, and the number of people at risk from hunger is reduced by about 100 million. The effect of climate change on these trends is generally to reduce production, increase prices, and increase the number of people at risk from hunger. However, it is observed in the model that developed countries increase cereal production in these scenarios even with the projected lower economic growth rates, but developing countries decrease production under all climate change scenarios.

Key factors in agricultural productivity are technological advances such as improved crop varieties and irrigation systems, and weather. Among these entities climate possess prime impact on agriculture systems. For example, weak monsoon rains in 1987 caused largely reduced crop production in India, Bangladesh, and Pakistan, contributing to reversion to wheat importation by India and Pakistan (World Food Institute, 1988). So was the case in 1980s which also saw the continuing deterioration of food production in Africa due to persistent drought and low production potential of crops due to negative impact of climatic factors in agriculture production. As a result international relief efforts were implied to prevent widespread famine in Africa. Repercussion of climate change in agricultural trade has grown dramatically in recent decades and now provides significant increments of national food supplies to major importing nations and substantial income for major exporting nations.

The effect of temperature and precipitation trends on the yields of maize, rice, wheat and soybeans is shown in Table 1 (Don Hofstrand, 2011). The impact on yields is greater for temperature than for precipitation. The greatest yield impact of temperature was on wheat followed by maize. When the three percent yield gain from elevated CO_2 levels is added to wheat, soybeans and rice, the yield response for rice and soybeans become positive but remained negative for maize and wheat. It is the explicit evidence that climate change has negative effect on global food production.

Table1. Estimates of global impacts of temperature and precipitation trends on yields of four major crops, 1980-2008 (Source: Don Hofstrand, 2011)

Crop	Global production (1998-2002 avg. mil. metric tons)	Global yield impact of temperatures trends	Global yield impact of precipitation trends	Subtotal	Global yield impact of CO_2 trends	Total change
Maize	607	-3.1% (-4.9%, -1.4%)	-0.7% (-1.2%, 0.2%)	-3.8% (-5.8%, -1.9%)	0.0%	-3.8%
Rice	591	0.1 (-0.9, 1.2)	-0.2 (-1.0, 0.5)	-0.1 (-1.6, 1.4)	3.0	2.9
Wheat	586	-4.9 (-7.2, -2.8)	-0.6 (-1.3, 0.1)	-5.5 (-8.0, -3.3)	3.0	-2.5
Soybeans	168	-0.8 (-3.8, 1.9)	-0.9 (-1.5, -0.2)	-1.7 (-4.9, 1.2)	3.0	1.3

GLIMPSE OF CLIMATE CHANGE IN NEPAL

Climate change has been observed in Nepal in varying level of climates that are prevalent in diversified topography and vegetation (Paudel, 2010, 2012). There are impacts of climate changes in Terai (almost tropical region), mid-hills and valley (subtropical region), and mountains and the Himalaya (temperate and tundra regions) of Nepal. It was reported that the pioneer mountaineer Mr. Apa Sherpa, the Goodwill Ambassador to Climate Change (Sherpa 2010) scaled Mount Everest for the 21st time on 11 May 2011 and observed that there was no snow on the Everest trail and he waited snow fall for days at the base camps to scale Mt. Everest. Apa on 23 May 2010 noticed stream flowing on top of the Everest by melting ice (Shrestha, 2009). A country like Nepal could not explain more than this as the impact of climate changes in the Himalayan region – the experience of Apa! Because of climate change it is reported untimely start of monsoonal rainfall that resulted rain deficit in the eastern Terai lowlands in 2005/06, reducing crop production by 12.5% nationwide (Malla, 2008). In agriculture, about 10% of agricultural land was left fallow due to rain deficit on the one hand, while on the other hand in the mid- western Terai faced heavy rain with floods, which reduced crop production by 30% (Regmi, 2007). Adverse effect of climate change could lead to the extinction of some indigenous crop varieties such as many aromatic rice varieties including Basmati rice, some local wheat, maize, and other agricultural crops as well (Paudel, 2012). It was also observed that a severe winter cold wave in Nepal in 1998 had negative impacts on agricultural productivity and showed a high percentage of yield reduction for potato (27.8%), leaf mustard (36.5%), mustard seed (11.2%), lentil (37.6%), and chickpea (38%) (NARC 1987/88 to 1997/98). In Nepal, negative impacts of climate change are observed for food crops which are already infected by diseases and pests such as club root of *crucifiers*, blight of *solaneceous*, rust of wheat, blast of rice and leaf spot of maize and red ants which have become menace leading to decreasing crop productivity.

Until and unless such issues are tackled timely, there are less likely chances of coping climate change with respect to food security and poverty reduction to meet the MDGs set by the UN for 2015 for developing countries (Paudel, 2010). Almost in every year, Nepal has been facing vagaries of climate change in the form of flood, landslide, drought, untimely onset and exhaust of monsoon as a result there has been heavy toll of human (Figure 4): The Sunkoshi River land slide on August 2, 2014. Causality and losses of agriculture land and human settlements in the the Sunkoshi river land slide on August 2, 2014 in the central hills, Nepal was severe.

The August2, 2014 land slide in the Sunkoshi river killed 33 people and 122 were reported missing. Experts say this event, one of the deadliest in the country's recent history, is a wake-up call for hazard mapping, early warning, and disaster managementhttp://www.irinnews.org/country/npa/nepal). There are other cases of such devastation in the Hindu Kush mountain regions and similar other mountain regions across the world which justify impact of climate change due to heavy and untimely down pour. Similar was the cases in India in June 2013, a multi-day cloudburst centered on the North Indian state of Uttarakhand caused devastating floods and landslides in the country's worst natural disaster since the 2004 tsunami (Fig. 5): Washing away of the religious site of the Kedarnath in Uttarakhand in June 2013. In this devastation of the holy shrine of the Kedarnath, some parts of Himachal Pradesh, Haryana, Delhi and Uttar Pradesh in India experienced the flood, some regions of Western Nepal, and some parts of Western Tibet also experienced heavy rainfall resulting over 95% of the casualties occurred in Uttarakhand. As of 16 July 2013, according to figures provided by the Uttarakhand government, more than 5,700 people were presumed dead (CBS news, 2013) which included total of 934 local residents (Fox News, 2013). This figure shows one of the sites of devastation in Uttrakhand in July 2013 due to heavy cloud burst in the region (https://encrypted-

tbn1.gstatic.com/images?q=tbn:ANd9GcR4T_xQZ4a4eLwtvRfW4__EUxD4lNPULDkrO-mWxqv3Xqq-p6z5).

Thus, it is imperative that climate change is intensifying existing problems including excessive rain in some places and reduced rain in other places, runoff and increased heat stress, recurrent drought and floods, heavy loss of lives, loss of rural livelihood, and food insecurity. Bates *et al* (2008) have reported high rate of glacial melt due to increases in in temperature accelerating the rate of such incidents increased between 1950s and 1990s from 0.38 to 0.54 events per year. Table 2 depicts the impact of climate change from 2030 to 2090 with respect to change in temperature and precipitation resulting in runoff (Bartlett *et al*, 2010).

Table 2. Bartlett *et al* (2010) have anticipated climate change impact in Nepal for temperature, precipitation and runoff as given below:

Temperature	• **Significant rise in temperature (^{0} c)** ➢ 0.5 to 2 by the 2030 ➢ 1.3 to 3.8 by the 2060 ➢ 1.8 to 5.8 by the 2090 • Increased in the number of days and nights considered hot by current standards • Highest temperature increase during the months of June to August at high elevations
Precipitation	• **Wide range of mean annual precipitation changes:** ➢ -34 to +22% by the 2030s ➢ -36 to +67% by the 2060s ➢ -43 to 80% by the 2090s • **Increase in monsoon rainfall towards the end of this century:** ➢ -14 to 40% by the 2030s ➢ -40 to +143% by the 2060s ➢ -52 to 135% by the 2090s
Runoff	• Higher downstream flows in the short term but lower stream flows in the long term due to retreating glacier and snow melt and ice melt • Shift from snow to rain in winter months • Increased extreme events including floods, droughts and GLOFs

The table above portrays the impacts of climate change on temperature and precipitation triggering runoff in the 21st century in Nepal. This is very much an alarming situation for Nepal where majority of population depends on farming for livelihood. It is, therefore, fundamental for Nepalese leaders, planners, and resource manager to think very urgently and decisively to begin national plan of adaptation to climate change.

ANALOGY OF CLIMATE CHANGE EFFECT IN NEPAL

Two places (Kakani of Nuwakot district and Dhangadhi of Kailali district) were selected to compare 10 years' meteorological data (temperature, total rainfall and number of rainy days) in Nepal (Fig 6 and 7). Kakaniis in central high hills (2030-m altitude) whereas Dhangadhiis in far western Terai (210-m altitude). Comparison for observed meteorological traits was done between two nearby years. It was found that in both of the sites for five years, although the years were not same, there was a rise in change of T max whereas for T min there was a rise for six years in Kanaki and three years in Dhangadhi. In both the sites, there was rise of change in average T max and T min. For the total rainfall also same pattern was observed as was followed in T max. Similarly, a change in average rainfall was recorded for five years in both the sites. Number of rainy days in both the sites was found decreased for six years, however, average change in total number of rainy days in Kakani was found increased while in Dhangadhi it decreased.

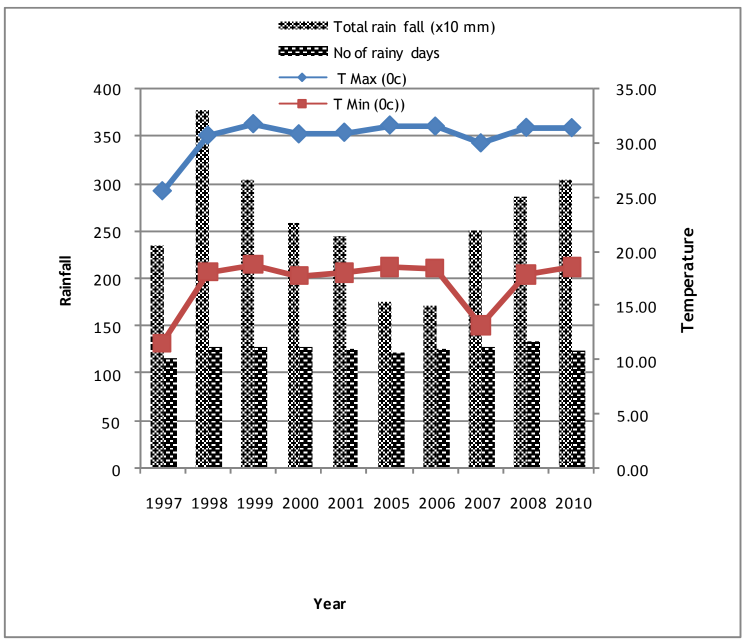

Figure 6. Ten years' meteorological data of Kakani (2030-m), Nepal

(Data received from the courtesy of Agriculture Environment Division in 2014, NARC)

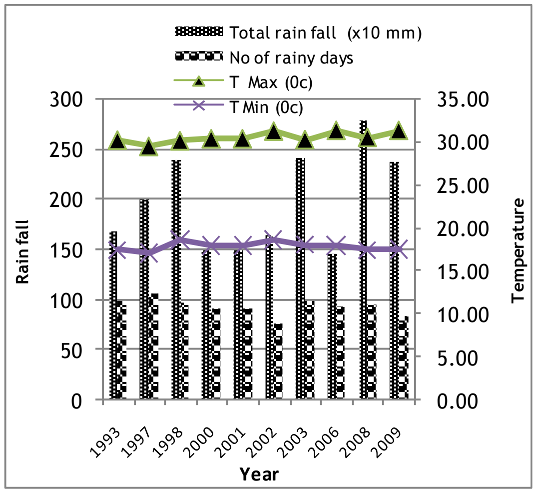

Figure7. Ten years' meteorological data of Dhangadhi (210-m), Nepal

(Data received from the courtesy of Agriculture Environment Division in 2014, NARC)

From 10 years' meteorological observation in Kakani and Dhangadhi it was found that change in amplitude of T max and T min is increasing in both locations. Total rainfall and number of rainy days in high hills site of Kakani is increasing while in Dhangadhi of far western Terai both the amount of rainfall and number of rainy days were decreasing over the period. Meaning to say that temperature and rainfall are affected in Nepal even in short span of 10 years. This could be the impact of climate change in Nepal where agriculture in these regions might have been affected due to the change in metrological parameters. Fluctuation in these parameters was more pronounced in Kakani than that of Dhangadhi. It suggests that mountains are more vulnerable to climate compared to Terai in Nepal.

ADAPTATION SCENARIO OF CLIMATE CHANGE IN NEPALESE PERSPECTIVE

In view of climate sensitive agriculture, farmers need timely information on weather and climate variability to adjust their farming practices to minimize adverse impacts on rural livelihoods, and food security (http://www.worldbank.org/en/news).The economies of developing countries depend heavily on climate-sensitive sectors such as agriculture, forestry, fishery, water supply, and other natural resources (Paudel, 2012). It is imperative that climate change adaptation is not separated from other priorities but is integrated into development planning, programs, and projects (World Bank 2008). FAO (2008) underlined the need to think of food, energy and climate as one interconnected issue. Thus, to save the world from impending climate catastrophe through mitigation viz; direct reduction of greenhouse gases and their offsets and adaptation viz; support towards adapting to the effects of climate change, are available options to be implemented in the immediate future. Of the several options, Nepal can select adaptation options based on hazard specificity and location specific preferences. FAO (2009) has provided practices to cope with climate change hazards, such as rain water harvesting and soil moisture conservation, slope stabilization and management, management of high/low temperature stress, crop diversification, community based seed production of staple crops, resource conservation, and cultivation of stress tolerant crop varieties. In Nepal, more than 90% of the population is dependent upon the land for fulfilment of their basic needs (food, fodder, fuel, fiber and timber). Anthropogenic causes such as deforestation overgrazing, and unscientific farming on steep slopes of Nepal and other developing countries have resulted in loss of flora and fauna, and have caused soil erosion, landslides in the hills, and flooding in the plain areas as well.

Of the many adoptive practices of coping adverse effect of climate change, Sloping Agriculture Land Technology (SALT) is one of the practices identified for promotion (FAO, 2009). Slope land management by plantation of fodder trees and appropriate crops such as citrus, tea and coffee on terrace to control erosion should be promoted in the mid-hills. Important option prioritized to stabilize the slopes is the hedge row planting. The alleys not occupied by permanent crops should be planted alternately to cereals such as corn, upland rice, cotton, fruits, vegetables, and legumes, etc. This cycle of cropping provides the farmers with several harvests throughout the year. The intervention would identify best suitable model for the mid-hill region.

Other viable and practical practices of adoption with respect to climate change on agriculture could be tunnel/plastic house farming and off season vegetable cultivation and community centered small scale fruit (apple, apricot, walnut, and mandarin orange), vegetable, and potato seed storage and so on. Hence, priority should be given for the development of localized tunnel farming technology by using new ways and techniques that are being practiced along north- south road accessible areas in the mid-hills from east to west of the country. Localized tunnel cultivation systems are sustainable and cause low environmental pollution to agriculture systems, in addition to reducing the high/low temperature risks that make income generation from off season production of vegetables; viz., tomato, cole crops (crops belonging to cruciferous family). Based on climatic suitability, rice, wheat, legumes and oilseeds are the major commodities of the Terai. Rice, maize, wheat, pulses and oilseeds are major commodities in the hills. And potato, barley, wheat, buckwheat, amaranth, and different millets are the commodities suitable for the mountains where these are being grown from time immemorial in Nepal. It has been established that quality seed alone can increase crop yields up to 10-25%. Seed production groups for important food crops (rice, maize, wheat, barley, millet) have shown encouraging results in many parts of the country. Improved seed produced by users' groups in a community based concept has helped increased crop production. This practice is one of the coping measures to mitigate climate change effect by availing quality seed to local communities. Along with other resource-conserving farming practices, conservation agriculture can improve rural incomes and livelihoods by reducing production costs, managing agro- ecosystem productivity, encouraging diversity for more sustainably, and minimizing unfavorable environmental impacts, especially in small and medium-scale farms.

NEPAL'S EFFORTS TO ADDRESS CLIMATE CHANGE

Nepal ranks the fourth most climate-vulnerable countries in the world and is highly exposed to a range of water related hazards such as floods, droughts and landslides (http://www.worldbank.org/en/news). A cabinet meeting of the Council of Minister of the Government of Nepal (GoN) was held at the base of the Everest in December 2009. The meeting came ahead of the United Nations Climate Summit in Copenhagen (known as Cop15), which began on 15th December 2009. A 10-point 'Everest Declaration' of the cabinet includes developing communities' capacity to cope up with climate change and working together with other countries to mitigate the impact of global warming (Shrestha, 2009). The declaration also supported developed countries' plans to contribute 1.5% of GDP to a climate fund and bring down greenhouse gases to pre-industrialization levels. Year round snow caped Himalayas including the Mount Everest in Nepal have experienced impact of climate change thereby immense glacier retreat in the Himalayan region. Had the Himalayan peaks are devoid of snow what would be the fate of rivers flowing from those mighty water towers, the Himalayas? The Himalayas are responsible to supply water to the perennial rivers flowing in the Indo-Gangetic, the Mekong, and Tibetan plateaus. Ultimately, Europe and the entire Asia-Pacific region would be affected immediately and in the long run the impact would be for the entire earths' civilization and the climate as a whole. Hence, there is no question of victimizing from the impact of climate change for a single country like Nepal whose contribution on global climate change is negligible (around 0.02%); i.e., miniscule compared to developed and industrialized countries (Paudel 2010).

A number of adoptive strategies have been applied to address consequences of climate change in agriculture in Nepal. Paudel (2012) has highlighted released of drought tolerant varieties of rice, wheat, maize and legumes. These varieties can withstand drought and can yield even in some fluctuation of moisture which should not be limiting production under stress environment. Rice in Nepal is mostly under transplanted condition, however, drought tolerant cultivars could be cultivated as direct seeding when the rainfall is unpredicted and there are very slim chances of cultivating transplanted rice as a result of change in rainfall patterns. On the other hand, varieties that can withstand submerged condition have also been released by the research such as Sworna Sub-1, IR-64, and Sanwa Mansuli are introgressed containing sub-1 gene which is submergence tolerant. It has been reported that up to 17 days of complete submergence could tolerate by Swarna Sub-1 rice variety under submerged condition. For high hill and temperate conditions (2500-m and above) cold tolerant rice varieties of Chandannath-1 & 3 and other have been developed and popularized especially in Jumla and Karnali regions (Paudel, 2011) where there is acute shortage of food and around 3.9 million people in the area suffered from hunger and malnutrition (Paudel, 2010). Similarly, rice varieties Machhapuchhere-3 and Chhomrong Local have been popularized in upper high hills of more than 2000-m (Karki, *et al*, 2010). Likewise, improved varieties of maize, wheat, maize, tomato and potato have been developed to address situation brought about by climate change such as emergence of new insects, pests and diseases and natural disasters of flood, drought, hail storm and many more. All of such negative consequences of climate change are not sufficiently addressed thereby efforts to limit these consequences of climate change on agriculture should immediately be taken into consideration in the highly vulnerable country like Nepal. Aside from releasing different varieties of crop, Nepal Agricultural Research Council (NARC) has recommended technologies to address vagaries of climate change (Paudel, 2012); these include resource conservation technologies of zero tillage, bed planting, permanent bed planting, strip tillage, minimum tillage, surface seeding, crop residue management and so on and so forth. There are composite technologies to address the effects of climate change on agriculture; these include gray leaf spot disease management of maize by growing resistant varieties. The crop husbandry technologies to mitigate adverse effect of climate change are early planting and wide spacing, balanced use of chemical fertilizers and integrated nutrient management, integrated pest management, and selective application of pesticides.

Nepal is blessed with diverse climate conditions ranging from 60-m to 8,848-m, the top of the world, despite this boon in Nepal, climate change has shown impacts on many indigenous breeds of animals and varieties of crops which are in the verge of extinction. These flora and fauna of plants and animals have been boon for the resource poor populace of Nepal. They include many indigenous crop species of aromatic rice: *Basmati, Thapa Chini, Kalanamak, Jhinuwa, KanakJira, Chananchura, TundeMasino, Anandi* (red and white), many local varieties of rice (*Ghaiya, Jundi, Marshii*), wheat, maize (*Sathiya, Murali, Dhinde, Sete, Panheli*), finger millet (*Okhle, Dalle, Paundure, Jhapre, Mutthe*), buck wheat (bitter, sweet, *Chuchhe, Bharule*), many grain legumes, vegetable legumes, and other minor crops (foxtail millet, sorghum, naked barley, *Panicum* millet, *Aamaranthus*, proso millet (white, yellow). Similarly, for animals including buffalo (*Parkote, Lime*), cattle (Yak and *Lulu* of high hills, Sri of mid hills, reported as extinction and NARC has recently recovered this species from Taplejung district of eastern hills), *Achhamigai* (smallest cow recorded in the world), goat (*Chyangra* for Pasmina wool), *Bhyanjlung* of sheep (carpet wool production), goat (*Khari, Sinhal,)*, *Bampudke Sungur* (native pig), *Sakhini Kukhura* (native fowl), and many other unrecorded species of crops and animals are endangered. There is a need to conserve such very important genetic materials which are becoming endangered due to the effect of climate change.

Important cereals of rice, maize and wheat yields in warm environments can be raised significantly by modifying agronomic practices of timely planting, incorporating residues and following appropriate crop rotations as proved beneficial in resource conservation techniques. Clearly crops of rice, wheat and maize yield in lower latitudes may decrease due to global warming, and may be further affected by water scarcity or drought. One approach to dealing with these heat-related constraints is to improve germplasms of these crops to provide higher tolerance to stresses associated with changed environments. Hence, new varieties screened by Nepal Agriculture Research Council (NARC) should be demonstrated to farmers focusing on enhancing the crop yield potential and to maintain yield under stress and fluctuation of environments including temperatures, rainfall and $C0_2$ concentration. In this way, they will assist in building cropping systems resilience to the global warming and natural hazards that could not jeopardize the livelihood of resource-poor farmers who depend on the harvest of these crops.

CONCLUSION

In the climate sensitive agricultural sector, farmers need timely information on weather and climate variability to adjust their farming practices and minimize adverse impacts on rural livelihoods, agricultural productivity and food security (http://www.worldbank.org/en/news). It has long been experienced that effect of climate change in general and agriculture in particular has been observed in Nepal. Changes in agriculture in varied agro-ecology of mountain, hill and Terai are observed with decrease in agriculture productivity due to the untimely onset of monsoon including erratic rain, flood, land slide, and droughts. Consequences of all climatic phenomena have resulted food and nutritional shortage in Nepal. Role of Nepal in global climate change is minimal compared to suffering from negative effect on agriculture which is the main stay of Nepalese people. Adaptation and mitigation are the available tools to address effect of climate change in agriculture and livelihood maintenance. Nepal is in the grip of climate change, however, there is very little to do with mitigation as Nepal does not emit significant quantity of greenhouse gases and the only way is the adaptation to cope up with effect of climate change. Development of crop varieties and animal breeds to suit to the changed environment are the viable adaptation strategies which could best address climate change scenario in Nepal. In this regard, agriculture research systems of Nepal has developed and maintained crop varieties and animal breeds to address climate change and such technologies have been popularized in the agro-ecological niches wherever feasible. This has helped, to some extent, sustain food security, and enhance livelihood in Nepal as well.

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CORRELATION OF CLIMATIC FACTORS WITH CEREAL CROPS YIELD: A STUDY FROM HISTORICAL DATA OF MORANG DISTRICT, NEPAL.

Badri Khanal[1]

ABSTRACT

The present study is based on the secondary sources of inforamation on temperature, rainfall and productivity of four major cereals (Rice, Maize, Finger Millet and Wheat) in Morang district of Nepal. A total of 17 years data (1995-2011) on yield of crops, annual total rainfall, annual mean maximum temperature and annual mean minimum temperature is analysed. The suitability analysis of crops shows that all the four cereals found to be suitable for cultivation in temperature range of Morang district, whereas irrgigation is required in addition to recorded rainfall in case of rice and wheat. The production of three cereals except millet (which is almost stable) has increased during the study period. The analysis of correlation coefficient shows that maize yield and minimum temperature have strong positive correlation (0.7755). The linear regression analysis showed that the yield of maize was significant and highly sensitive to combined effect of all three climatic factors (R^2 0.7414). Whereas, the yield of rice, millet and wheat were not statistically significantly related. At individul climatic factors level, yield of maize and wheat were significantly related with annual mean minimum temperature. The yield of these crops can be increased by crop managementmainly by altering the planting time, varieties and irrigation practices.

Key words : *cereals, correlation, rainfall, temperature, yield*

INTRODUCTION

Globally many initiatives has been made in agriculture sector for betterment in farming technology and crop mangement practices. This is aimed to increase the crop productivity to ensure food security ofgrowing population. The climatic factors has always played the vital role in the productivity of the crops. This has drawn the attention of agriculturist in background of global warming and climate change. Hence, in country like Nepal where almost 34 % of Gross Domestic Product (GDP) is contributed from agriculture sector (MOF,2014), the study of cliamtic factors to explain the crop yield is very important.

Analysis of climatic factors provides the level of association between crop and climate. Moreover, analyzing the impacts of historic climatic factors trends on crop production helps to identify the possible impacts of future climate, which also reviews the on-going efforts of adaptation and change in production. (Lobell and Field 2007; Lobell et al.2011).

One of the major climatic factor responsible for agricultural production is temperature (both maximum and minimum). According to IPCC 2007 the global average temperature has gone up by about 0.13^{0}C per decade since 1950 .The study suggests that warming trends in the Himalayan region and nearby is significant, generally higher compared to global

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average (Shrestha et al. 1999; Hu et al.2011, 2013). The study also suggests that the rate of warming is most often increases with increased elevation (Sharma et al. 2009; Hu et al.2013).

The study from Bhatta et al. 2014 shows that the responses of crop yields to a unit increment in mean temperature of growing season vary from -6 to 16 %, -4 to 11 % and -12 to 3% for three cereals, rice, maize and wheat, respectively, depending on the location and elevation in the Koshi basin of Nepal.

The review conducted by Malla, 2008, shows that 4^0C increase in temperature drops rice yield by 3.4% in Terai, increase by 17.9% in hills and 36.1% increase in mountain. For same level of temperature drop there was 1.8% decreases in yield in Terai but increase by 5.3 % in the hill and 33.3% in Mountain in case of Wheat. In case of Maize, at 4^0C temperature rise, the yield decline by 26.4 % in terai, 9.3% in hills but increase by 26.8 % in the Mountain. Increased temperature in sub-tropical region will decrease in potential wheat yield by 1.5-5.8% but will decrease by 17-18% in tropical zone (Agrawal and Kalra, 1994).

Similalrly, rainfall has imprortant role in rainfed agriculture like Nepal. Both the intensity and distribution of rainfall has effect on agriculture production. Drought has a negative impact on rural livelihoods that mainly depend upon rainfed subsistence agriculture. According to Thomas, 2008, drought is the major source of uncertainty in food production in Nepal and disturbs social harmony by creating water-use conflicts. A slight decrease in the rainfall and increase in temperature will have a negative impact in cereals yield which is a matter of great interest (Bhandari, 2013a).

The likely impact of climate in future on crop production is estimated by several studies. However, the impacts on production of crop due to historic climate trend are yet to be widely analysed (Lobell and Field 2007).

In this regard, the present study is aimed to fill the gap in exiting literature and provide a better reference for future analysis using informations for cereals crop yield and temperature and rainfall of one of the potential cereals producing district -Morang for year 1995-2011.The main impetus of present study is to examine the climate-crop yield relationships and to study the impact of historic trends of climatic factors on yield of rice, maize, finger millet and wheat in the Morang district of Nepal. This gives the idea on how production of selected cereals (Rice, Maize,Finger Millet and Wheat) is associated with these climatic factors.

MATERIALS AND METHODS

STUDY AREA

Morang district lies in Terai of Nepal in Eastern Development Region. The total area of the district is 1,855 Square Kilometer of which, almost 80% of the area is plain and rest lies in Churia and Mahabharat Hill Range. The altitute of the district varies from 60 meter to 2,410 meter above mean sea level. The latitude of the district is 26.20^0 – 26.53^0 East and Longitude is 87.16^0 to 87.49^0 North. The 56.5 % of the total land is used for agriculture purpose and remaining for other purposes. The soil of the district are devided into three categories based on land, elevation and soil texture as Sandy loam (hill range); Loam and Clay (Chure range), and Sandy Clay Loam and Loam (Terai range). The major source of livelihood in district is agriculture, which contributes almost 37.48% of total Gross Domestic product of district (**BSO,2006**).

DATA

The study is based on the secondary sources of information. The production and yield of the four cereals was collected from the various issues of "Statistical Information on Nepalese Agriculture", Ministry of Agricultural Development, Nepal (MoAD,2012). As, both the rice and maize are produced during two seasons in Morang (Spring and Summer), the total of these two is used for the study purpose. Similalry, the data regarding, annual rainfall, annual mean maximun temperature and annual mean minimum temperature was collected from Department of of Hydrology and Meterology Nepal (CBS,2008 ; CBS, 2011). All the information regard ing yield of crops and climatic information were collected for 17 years starting from 1995 to 2011 and analysed. All the other relevant informations were collected from other sources of information.

ANALYTICAL FRAMEWORK

The relationship between yield of major cereals and three climatic factors was analyzed through linear regression with the null hypothesis (Ho) that there was no statistically significant correlation between climatic elements (rainfall and temperature) and yield of the crops. For this, first of all, Pearson correlation coefficient was calculated by examining degree association between different pairs of explanatory variables and between explanatory variables and dependent variables through zero order correlation matrixes. The sample correlation coefficient is

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{(n-1)s_x s_y}$$

Where $\bar{x}$ and $\bar{y}$ are the sample means of X and Y, s_x and s_y are the sample standard deviation of X and Y.

Linear regression model was used to estimate relationship between yield of rice, maize, millet and wheat and selected explanatory variables. Four linear models assumed for each crop, three for considering single variable and one for combined of all three variables. Thus, the linear function assumed for the present study was:

$Y=\alpha+\beta_1X_1$

$Y=\alpha'+\beta'_2X_2$

$Y=\alpha''+\beta''_3X_3$

$Y=\alpha'''+\beta'''_1X_1+\beta'''_2X_2+\beta'''_3X_3+\mu$

Where, Y= yield of the crop

X_1=annual rainfall (mm)

X_2= annual mean maximum temperature (^{0}C)

X_3= annual mean minimum temperature (^{0}C)

μ = disturbance or error term

α= constant value and β_1, β_2 and β_3 are regression coefficients of the respective variables, whose significance is tested.

The overall significance of regressions was tested using f-test with ANOVA approach. The test consists of null hypothesis (H_o) that all regression coefficients are simultaneously not statistically different from zero versus alternate hypothesis (H_1) that all the regression coefficients (β's) are statistically different from zero simultaneously. The test statistic used was f-test, which was calculated as:

$$Fcal = \frac{MSS_E}{MSS_R} = \frac{ESS/k-1}{RSS/n-k}$$

Where, ESS = regression sum of square; RSS= residual sum of square; k-1 is degree of freedom for regression and n-k is degree of freedom for residuals where n is number of observations and k is numbers of explanatory variables.

RESULTS AND DISCUSSION

The suitability of all the four crops was tested through comparing the actual climatic factors of the Morang district with the cardinal climatic factors for the crops. The Table 1 gives the cardinal requirements of temperature and water, and actual value of rainfall and temperature during year 2010/2011(March 2010-April 2011).

The temperature and water requirement of the crops varies according to their growth stages. Rice can be grown in wide range of temperature ranging from 20-40^{0}C, however, 30-35^{0}C for germination, 26.5-29.5^{0}C during flowering and 20-25^{0}C during the gain fill period is optimum. It can be grown as rainfed crop in area having 200 cm of well distributed rainfall. Mostly 80-200 cm of water is required for the crop. The optimum temperature for maize is 21^{0}C for germination and 32^{0}C for growth. Water requirement varies from 25 cm to 500 cm. As finger millet is a hardy crop, it grows well in range of 12-45^{0}C temperature, whereas optimum temperature is 18-27^{0}C, and the water requirement is 750mm. Wheat crop can be grown in a range of 3.5 -35^{0}C , however, seed germination takes place well during 20-25^{0}C. Higher than 27^{0}C is not good for anther formation and pollination. The temperature during the grain filling period should be less than 25^{0}C. The well distributed rainfall of 40-110 cm is enough for wheat crop.

As the temperature of the Morang district varies from 18.1 to 35.5^{0}C during spring and 22-32.8^{0}C during summer season, it is suitable area for cultivation of cereals like rice, maize and finger millet. Likewise, winter temperature varies from 8.8 to 33.1^{0}C in which is also suitable for wheat crop. The water management for the crop depends upon the rainfall of the area. Mostly, the crop like rice and wheat requires the irrigation as water requirement of rice is high and there is low winter rainfall for wheat.

Table 1: The cardinal requirements of crops and recorded climatic factors of Morang district

Cereal Crops	Cardinal Requirements		Climatic Factors in Year 2010/2011					
	temperature Range ^{0}C	Water Level mm	Spring crops season (March-June)		Summer / Kharif crops season (July-October)		Winter /Rabi crops season (November-April)	
			Temp^{0}C	rainfall mm	Temp^{0}C	rainfall mm	Temp^{0}C	rainfall
Rice	20-40*	800-2000*	18.1-35.5	564.7	22-32.8	1329.7		
Maize	20-35*	250-5000*	18.1-35.5	564.7	22-32.8	1329.7		
Millet	18-27 (optimum)**	700**			22-32.8	1329.7		
Wheat	3.5-35*	400-1100*					8.8-33.1	23

* Bhandari, 2013b ** www.plantvillage.com

The production of all the selected cereals was increasing, except millet (which was almost stagnant over the years) however their growth rate was different. The rice growth rate was more prominent than others. The annual rainfall fluctuated between 1,300 mm to 2,677 mm during the period (Fig 2). Though the fluctuation in rainfall over the years was not explained much by the trend line (only 6 %), it was in decreasing trend in Morang district.

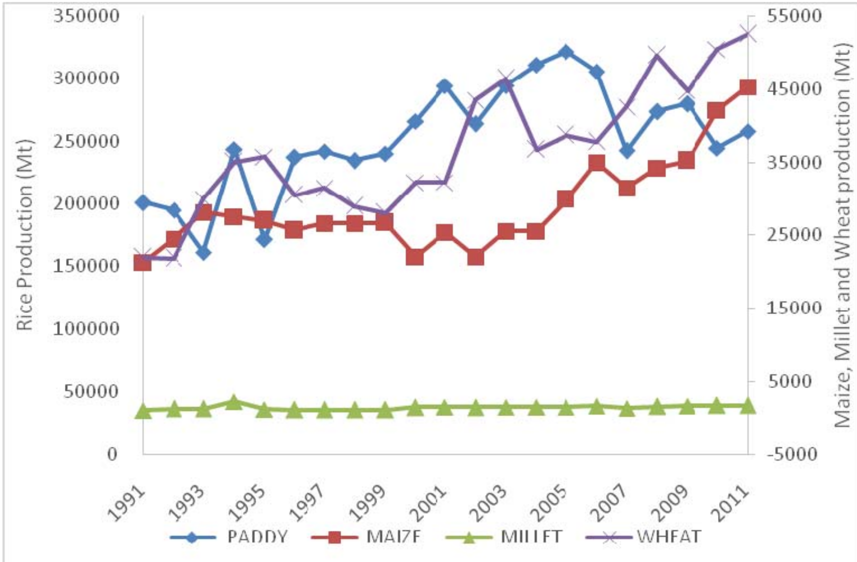

Fig 1: Production trend of major cereals in Morang district

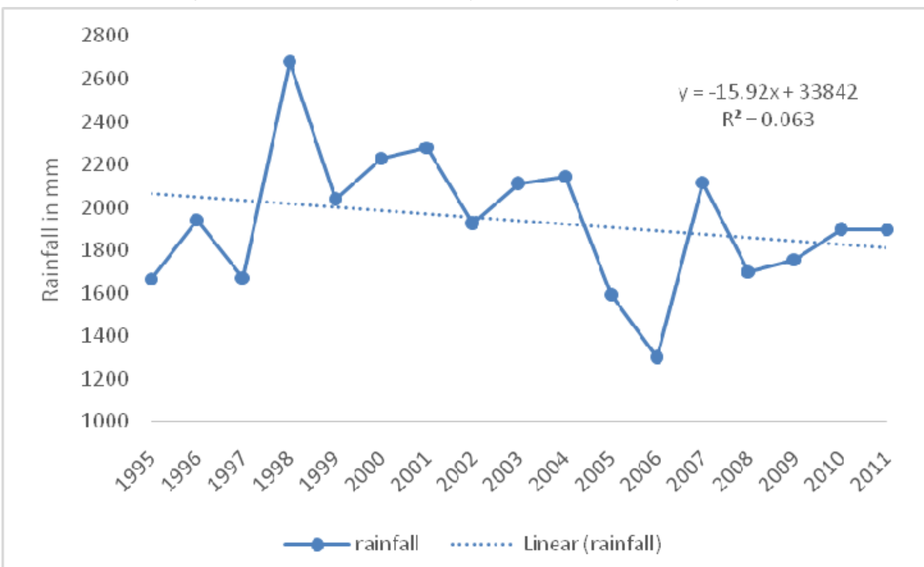

Fig 2: Trend of annual total rainfall over the years in Morang district

The mean maximum temperature from 1990 to 2011 varied from 29.5 to 30.9^{0}C (Figure 3). The trend line showed that the maximum temperature was increasing over the year , though change was statistically not significant.

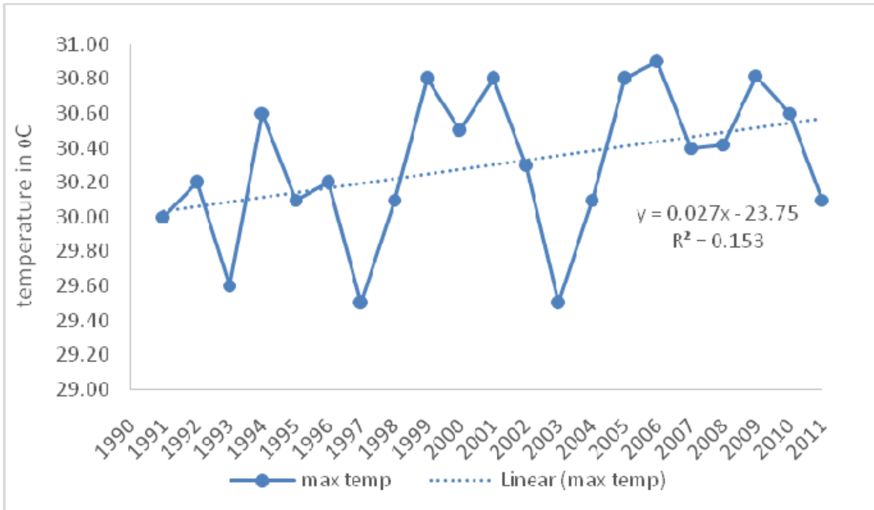

Fig 3: Trend of annual mean maximum temperature over the years in Morang district

The annual mean minimum temperature varied from 18.6 to 20.5^{0}C during 1990-2011. The trend line followed increase over the period and which was statistically significant.

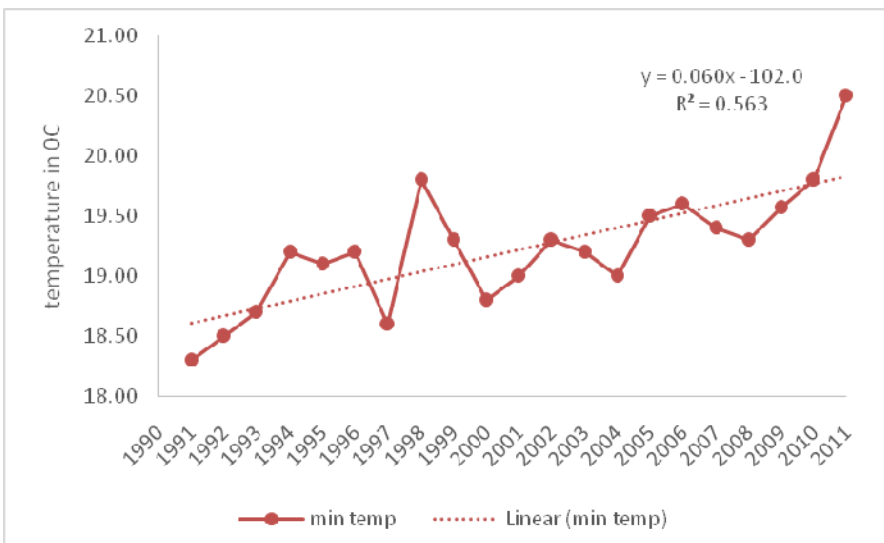

Fig 4: Trend of annualmeanminimum temperature, over the years in Morang district

RICE

The correlation coefficient between rice yield and rainfall showed negligible negative correlation (-0.14) which was not statistically significant at the 0.05 level since the P-value is greater than 0.05. It indicated that there was no correlation between rainfall and rice yield.

Regression analysis indicated that rainfall explains only 2.01 % of rice yield (R^2=0.0201). The regression equation is

Y = 3231.2 + (-0.15)* rainfall

There was non-significant negligible positive correlation and weak positive correlation in between rice yield and the mean annual maximum temperature (0.27) and mean annual minimum temperature (0.37), respectively as the measured P value is greater than tabulated value at 0.05 confident level.

The regression analysis did not support relationship between mean annual maximum temperature and rice yield. The result shows that mean annual maximum temperature (R=0.27, R^2=0.75) and mean annual minimum temperature (R=0.36, R^2=0.135) explained only 7.5 and 13.5% of rice yield, respectively.
The regression equations are

Y = -3668.6 + 217.7 * mean annual maximum temperature
Y = -2529.1 + 282. 5 * mean annual minimum temperature

The combined effect of all the three variables namely annual rainfall, mean annual maximum and minimum temperature showed the P value of 0.4460 which is greater than 0.05. This accepts the null hypothesis, hence concluded that the combined effect of these three variables had no significant correlation with rice yield. Only 17.95 % of rice yield could be explained by combination of all three variables.

The regression equation is given as:

Y = -5989.4 + (-0.0997)* annual rainfall + 142.94 * mean annual maximum Temp + 247.13 * mean annual minimum temperature + 341.67

MAIZE

The analysis showed that correlation coefficient between maize yield and annual rainfall, annual mean maximum temperature and mean minimum temperature had non-significant weak negative (-0.39), non-significant negligible positive (0.15) and significant strong positive (0.77) correlations, respectively. The regression results showed that annual rainfall, mean annual maximum temperature and men annual minimum temperature explained 15.07, 2.3 and 60 % of maize yield, respectively.

The regression equations for different climatic variables are as follows

Y = 2733.1 + (-0.38)* annual rainfall

Y = -1375.25 + 110.845 * mean annual maximum temperature

Y = -8752.08 +554.988 * mean annual minimum temperature

The combined effect of all the three variables namely annual rainfall, mean annual maximum and minimum temperature showed calculated P-value of 0.0004 which was less than tabulated value. This rejects the null hypothesis and concluded that the combined effect of all three variables had significant correlation with maize yield. The R square value of combined all three factors was 0.74, which means 74.14 % of maize yield was explained by combined effect of the three climatic variables

The Regression equation is given as:

Y = -5698.6 + (-0.37)* annual rainfall + (-81.8) * mean annual maximum temperature + 563. 3 * mean annual minimum temperature + 177.77

MILLET

In case of millet, the analysis revealed that correlation coefficient between millet yield and annual rainfall, annual mean maximum temperature and mean minimum temperature had non-significant weak negative (-0.39), non-significant weak positive (0.30) and non-significant weakly positive (0.36) correlations, respectively. The regression results showed that annual rainfall, mean annual maximum temperature and mean annual minimum temperature explained 9.4, 9.3 and 24.3 % of millet yield, respectively.

The regression equations for all the three variables are as follows

Y = 1310.2 + (-0.121)* annual rainfall
Y = -1646.4 + 89.70 * mean annual maximum temperature
Y = -892.8346 + 101.72 * mean annual minimum temperature

As the P-value (0.2916) for combined three variables was greater than tabulated value at 0.05 level, therefore the null hypothesis was accepted. Thus, the combined effect of annual rainfall, mean annual maximum and mean annual minimum temperature had no significant correlation with millet yield. Only 24.21 % of millet yield was explained by annual rainfall, mean annual maximum temperature and mean annual minimum temperature. The Regression equation is given as:

Y = -2026 + (-0.102)* annual rainfall + 53.45 * mean annual maximum temperature + 86.71 * mean annual minimum temperature + 121.59

WHEAT

In the case of wheat, its yield had non-significant weakly negative (-0.26), non-significant negligible positive (0.19) and non-significant weakly positive (0.49) correlations with annual rainfall, mean annual maximum temperature and mean annual minimum temperature, respectively. The regression results showed that annual rainfall, mean annual maximum temperature and mean annual minimum temperature explained 6.5, 3.5 and 23.9 % of wheat yield, respectively.

The regression equations are as follows is

Y = 2450.6 + (-0.19)* annual rainfall
Y = -1065.8 + 103.7 * mean annual maximum temperature
Y = -2993.6 + 262.23 * mean annual minimum temperature

When the three variables rainfall, maximum and minimum temperature were combined for analysis, the calculated P value (0.1919) was greater than tabulated value at 0.05% confident level. This accepted the null hypothesis and concluded that the combined effect of these three variables had no significant correlation with wheat yield. The R square value of combined all three factors was calculated as 0.30, which meant only 30 % of wheat yield was explained by effect of annual rainfall, mean annual maximum temperature and mean annual minimum temperature together in combination. The regression equation is given as:

Y = -2997.7 + (-0.17)* annual rainfall + 16.56 * mean annual maximum temperature + 253.76 *mean annual minimum temperature + 219.67

CONCLUSION

The suitability analysis of selected crops shows that, all the four cereals of the study namely rice, maize, millet and wheat) are suitable in climatic condition (temperature and rainfall) of Morang district. The crops like rice and wheat requires more water than rainfall of the area, which necessitate additional irrigation. The yield of three major cereals rice, maize and wheat was found to be increasing over the years. However, millet production was almost unchanged. The correlation coefficient between rice yield and climatic factors showed that only mean annual minimum temperature had correlated with weak association. In case of maize, annual rainfall and mean annual minimum temperature had correlated with yield. The correlation between mean annual minimum temperature and rainfall had strong positive correlation (0.77). In case of millet all the three factors were weakly correlated with yield. Wheat yield had weakly correlated only with mean annual minimum temperature.

The result concludes that the mean annual minimum temperature explains the larger portion of the crop yield variation than both the mean annual maximum temperature and annual rainfall in all the four cereals. But, the annual rainfall contributed higher in the yield of rice, millet and wheat than mean annual maximum temperature, whereas the reverse was found in case of maize. Though, the only maize crop was found to be significantly explaining the crop yield by combined of all the variables i.e. annual rainfall, mean annual maximum temperature and minimum temperature, remaining crops yield were also defined by few proportion by these factors. The rainfall and mean annual maximum temperature was found to be not significantly explaining yield of all the crops.

Thus, the study of these factors is helpful to identify relationship between the climatic factors and yield potentiality of crop. The yield of these crops can be increased by altering the plantation date, choosing the suitable varieties, managing the irrigation facility, and other improved technologies based on the established relationship of crop and climatic factors.

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USE OF PESTICIDES AND ITS RESIDUE ON VEGETABLE CROPS IN NEPAL

Dilli Ram Sharma[1]

ABSTRACT

Farmer field survey and lab residue analysis studies were carried out to examine the use of pesticide in vegetable fields and its potential effects on human health and environment. Field information were collected using semi-structured questionnaires face to face interview with 200 farmers from three districts (Bara, Dhading and Kavre) of central region of Nepal. The recent study showed that the use of chemical pesticides in Nepal is 0.396Kg a.i./ha. The farmers' field survey showed that 72 percent of the farmers paid attention on acquiring information about the effectiveness of pesticide to control the target pests. While 65 percent of the farmers noticed the expiry date of pesticides, and only a few farmers considered the adverse effects of pesticide on human health and environment. The result showed that majority of them (51.5%) kept the remaining pesticides in their house freely, whereas 23.5 percent farmers destroyed the remaining pesticides; either buried or burnt. It was also found that 22.5 percent of farmers did not care and threw the remaining pesticides outside the house and in the fields. Residues analysis of 75 samples of 13 vegetables indicated that 58%t of the vegetable samples contained no detectable level (NDL) of the monitored pesticides, 38% samples resulted in trace level of the pesticides residue or below the minimum residue level (MRL), while 4% samples showed above MRL (EU Standard). Present study revealed ample scope for improvement on pesticide use and exposure, for which there is need of strong policy implementation, strengthening training, extension services and various awareness programs to farmers and agro-vets for judicious use of pesticides, health safety and environment protection.

Key-word*:*health, safety,knowledge, pesticide, residue

INTRODUCTION

Pesticides are widely used in agriculture to increase the yield, improve the quality, and extend the storage life of food crops (Fernndez-Alba and Garca-Reyes, 2008). In Nepal, there are 67 pesticides importers. Eight thousands five hundred fifty one resellers have received training on safe use of pesticides and storage management, of which 3493 license holders have been selling the pesticides through agro-vets. One thousands ninety eight types of pesticides by trade name, 108 common names have been registered for use under Pesticides Act 1991 and Rules 1993. According to the latest estimate, the annual imports of pesticides in Nepal is 345 tons (a.i.) with 33.25 percent insecticides, 48.35 percent fungicides, 15.49 percent herbicides, 2.37 percent Rodenticides, 0.034 percent bio-pesticides and 0.50 percent others, respectively. The gross sales and values account NRs. 374.90 million ($4 million) per year (PRMS, 2014).

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The presence of pesticides in food commodities has been always a matter of serious concern (Sharma et.al, 2012). In Nepal, Food Act 1967 and Food Regulation 1970 have established and implemented MRLs for pesticides in food products, but limited to cereals, pulses and their products, bottledwater and infant foods. Department of Food Technology and Quality Control (DFTQC) constantly monitor pesticide residues level in food products (Koirala and Tamrakar, 2008). The level of pesticide residues in food stuffs are generally legislated so as to minimize the exposure of the consumers to harmful or unnecessary intake of pesticides (Zorka and Serder, 2009). Nepal has already the system of quarantine for plants, animal and food. Different regulatory agencies under the Ministry of Agriculture Development are working at different custom points mandated to check pesticide safety of the food products. However, it has not been effective in practice so far at custom points due to technical lack of and inadequate laboratory facilities. Therefore, pesticide monitoring in food is necessary for domestic food products as well as entry and exit of food products.

Nepal is included under the category of LDC which has limited use of pesticide per capita and/or hectare. So, in comparison to other countries in the Asia Pacific Region, the use of chemical pesticides in Nepal is the lowest (142 gm a.i. /ha) (Thapa, 1997). Recently, Plant Protection Directorate (PPD) has revealed that 396 gm a.i./ha chemical pesticides are being used in Nepal (PPD, 2015). Pesticide use, however, is much more intensive in areas that have greater access to markets(Sharma,2014). The use is higher in areas with intensive commercial farming of vegetables, fruits, tea, and cotton. Under the present scenario (Thapa, 1997; Palikhe, 2007), judicious and prudent use of pesticide by the Nepalese farmers is largely disregarded. The study also revealed that more than 85 percent of imported pesticides are applying only in vegetable crops in Nepal(Sharma et.al, 2015). All types of pesticides are not only repeatedly but also carelessly used. Farmers do not always know the active ingredient. Sometimes outdated pesticides are sold to farmers. Farmers use a mixture of chemicals together, and therefore, when incidents occur, it is difficult to specify which chemical is the main cause.

Most pesticides are broad spectrum in nature and kill target as well as non-target organisms. There are few safer pesticides, but their use has been extremely limited due to lack of publicity and farmers' knowledge. In fact, all pesticides endanger the health of both producers and consumers. However, majority of the farmers are unaware of pesticide types, level of poisoning, safety precautions and potential hazards on health and environment (Yassin *et al*., 2002). The resultant effects on human health include cancer, birth defects, reproductive problems, tumors and damage of liver, kidney and neural organs. To prevent such hazards, Nepal has also banned 15 pesticides includingPIC (Prior Informed Consent) listed pesticides (Methyl Parathion and Monocrotophos) in the country. Highly persistent types (POP pesticides), Phosphamidon and Organo-mercury fungicides, organochlorine including endosulfan and others some hazardous chemical pesticides have been banned in the country (PRMS, 2015). However, because of an open and porous border with India, there is a considerable, but unknown quantity of trade beween farmers close to the border. Hence, illicit/illegal import of pesticides issue needs to be addressed in multilateral approach with neighboring countries to prevent potential infiltration of banned/ unregistered pesticides (Palikhe, 2005).

Government of Nepal has developed policy for judicious use of pesticides and safety regulations, which has not yet been materialized at the farmer's level due to lack of studies on other alternatives of pest management, such as biological, botanicals, and safe chemicals including indigenous knowledge of farmer's practices, as basic component of Integrated Pest Management (Shrestha and Neupane, 2002). These are the basic components of IPM. The IPM-FFS was initiated in Nepal in 1997 with the support of Food and Agriculture Organization (FAO) (PPD, 2010). It has been an important approach of pest control strategy which encourages applying measures that causes least disruption of agro-ecosystem. Therefore, establishment and functioning of bio-agent rearing laboratory, studies of locally available botanical pesticides and residue study laboratories can exploit locally available natural resources of pest management and substantially help farmers, researchers, and policy makers to implement related acts. Vegetable is a very important crop grown from high hill to terai in Nepal. There are 3243521 vegetables growers reported in Nepal, which is about 69.3 percent of the total household (CBS, 2010). More than 200 vegetables can be grown in Nepal but only 50 species are in commercial cultivation (SEAN, 1995). India is the second largest producers of vegetables after China which produces 87.53 million tons (Chadha, 2001) and accounts for 13.4 percent of world productions (Karanth, 2002.).

PESTICIDE USE PATTERN

Recently PPD, PRMS has studied the use pattern of pesticides in Nepal and found that 45% of respondents stated that the amount of pesticide use every year increased whereas 32% indicated that the amount of pesticide use every year decreased and 23% indicated that they didn't notice any change (Table 1). Increasing use of pesticides on vegetables is a growing environmental problem and food safety threat in Nepal where vegetable farming is becoming more intensive and a widespread (PPD, 2015)

Table1: Pesticide Knowledge and Perception of Farmers

No	Pesticide use situation	Frequency	Responses in percent
1	Use of pesticide decreased	380	32
2	Use of pesticide increased	532	45
3	Not so noticeable difference	276	23
	Total	1188	100

Source: PPD (2015)

On development region basis, the study also observed that the amount of pesticide used in FWDR is about 31.27 a.i.kg (5.43%). The MWDR accounted for 45.66 a.i.kg (7.94%) followed by WDR 66.35 a.i.kg (11.53%), CDR 261.50 a.i.kg (45.48%) and EDR 170.19 a.i.kg (29.62%). The average per hectare consumption of pesticides in Far West, Mid-West, Western, Central and Eastern development region was 0.146 a.i.kg/ha, 0.225 a.i.kg/ha, 0.276 a.i.kg/ha, 1.015a.i.kg/ha, 0.616 a.i.kg/ha respectively. Details are provided in Table 2. On ecological basis, highest average pesticides use was in Terai (0.995 a.i.kg/ha) followed by Valley (0.470 a.i.kg/ha) Hill (0.314 a.i.kg/ha) and High hill (0.085 a.i.kg/ha) (Table 3) (PPD, 2015).

Table 2: Regional Scenario of pesticides use

Regions	**Total pesticides applied(kg)**	**Percentage**	**Quantity(a.i.kg/ha)**
FWDR	31.27	5.43	0.146
MWDR	45.66	7.94	0.225
WDR	66.35	11.53	0.276
CDR	261.50	45.48	1.015
EDR	170.19	29.62	0.616
Total	574.97	100	

Source: PPD (2015)

Table 3. Ecological Scenario of pesticides use

Ecological Belt	**Total Pesticide applied (a.i. kg)**	**Percentage**	**Quantity (a.i. kg/ha)**
High hill	23.83	4	0.085
Hill	114.4	20	0.314
Terai	342.4	59	0.995
Valley	94.22	17	0.470
Total	574.9	100	-

Source: PPD (2015)

GOVERNMENT POLICIES AND PROGRAMS ON PESTICIDE

There is a regulatory infrastructure established for the management of pesticides in Nepal. It covers all handling and use aspects of pesticides. The importers wishing to market and sell pesticides must submit an application dealing with the use of pesticides, toxicity and the correct use of pesticides in agriculture and health sector from the health point of view. No pesticide may be imported into the country without the appropriate certificate of importation issued by Registration Authority.

Large numbers of persistent chemical pesticides have been banned for agriculture and public health from 9th April, 2001 and also hazardous pesticides have been phased out from the use since 9th April, 2001. At present, prohibition on the use of Quinalphos, Ethion, Monocrotophos and Phorate in the tea field is being campaigned and implemented from 9th, May, 2005 because these pesticides are highly toxic. The pesticides to be imported, distributed, traded and used should be friendlier and less hazardous to health and environment More emphasis has been given to use organic pesticides as an alternative of chemical pesticides to control crop pests. Development and use of some microbial and botanical pesticides which are eco-friendly has opened a new field of bio-pesticides. The best know form of bio-pesticide is the *Bacillus thuringensis* (Bt). Eco-friendly neem formulations are also being used currently. IPM has been widely accepted as the alternative to pesticide application. The significant being phasing out of an environmental unfriendly pesticides are rigorous approval of the newer and more safer and specific molecules. Government has already conducted or is regularly lunching training programs to educate the concerned personnel. In Nepal, as in most of the other developing countries in the region, the capabilities, expertise and resources to fully implement the regulation are limited. Further, there is a need to strengthen the scientific and technical base for health and environmental risk assessment.

Government has initiated to analysis residue of vegetable in the vegetable whole sale market by applying rapid bioassay residue analysis technology. Rapid Pesticide Residue Analysis Laboratory established in the Kalimati vegetable and fruit whole sale market and it gave very good result for monitoring the use of pesticides in the vegetables and fruits. Due to the grand success of Rapid Pesticide Residue Analysis Laboratory, Government is establishing 6 more Rapid Pesticide Residue Analysis Laboratories in the different cities of Nepal very soon.

OBJECTIVE

The objective of the study was to document pesticides use patterns and its residue on vegetable crops.

METHODOLOGY

The study was conducted in selected vegetable pockets of three districts representing vegetable production areas in the mid hills and terai of central development region of Nepal. The three districts, namely: Bara, Dhading and Kavre are the main producers of vegetables to feed the huge population of Kathmandu valley and with massive amount of pesticides application as well.

The survey was conducted in vegetable crop seasons. For this, semi-structured questionnaire was prepared and initially tested on a group of farmers in Kathmandu district. The questionnaire was finalized incorporating their comments and suggestions. Then, two hundred vegetable growing farmers were selected as mentioned in the sampling frame and interviewed using semi- structured questionnaires in six vegetable pockets of three districts, i.e. Bara, Dhading and Kavre.

Seventy five fresh samples were collected and analyzed at accredited laboratory for determining the residual level (MRL) on major common vegetables grown in study pockets. The samples of different fresh vegetables collected from study areas in each district.

RESULT AND DISCUSSION

1. FARMER'S KNOW HOW ABOUT PESTICIDE APPLICATION

Majority of the farmers had lack of knowledge about the proper use of pesticides. Farmers mostly applied pesticides without knowing the population of insect pests, natural enemies and crop condition. It was clear from the survey that 72 percent of the farmers paid attention on acquiring information about the effectiveness of pesticide to control the target pests. While 65 percent of the farmers noticed the expiry date of pesticides, and only a few farmers considered the adverse effects of pesticide on human health and environment (Table 4). This study showed that overwhelming majorities of the farmers were not concerned about the adverse effects of pesticides on human health and environmentpollution. Hence, the practices of buying pesticides focusing on effectiveness to target pests and ignoring adverse effects of pesticides on human health and environment, which harm to everyone is a serious concern.

Table 4. Farmer's practices while buying the pesticides in vegetable growing areas

		Farmers mainly concerning on pesticide effects									
Ecological zone	**District**	**Label contain**		**Effectiveness of pesticide to control the target pests**		**Adverse effect of pesticide on human health**		**Adverse effects of pesticide on environment**		**Expiry date of pesticide**	
		Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)	Freq	(%)
Terai	Bara	43	43	92	92	18	18	17	17	84	84
Mid hills	Dhading	17	34	23	46	1	2	0	0	34	68
	Kavre	10	20	29	58	1	2	1	2	12	24
Mid hills total		27	27	52	52	2	2	1	1	46	46
Grand Total		70	35	144	72	20	10	18	9	130	65

2. HANDLING OF LEFT OVER PESTICIDES

Farmers purchased pesticides from Agro-vets and applied to their crops for managing pests. They did not get the actual required amount of pesticides; so they bought whatever available amount from the shop and used in their crops. The result showed that majority of them (51.5%) kept the remaining pesticides in their house freely, whereas 23.5 percent farmers destroyed the remaining pesticides; either buried or burnt. It was also found that 22.5 percent of farmers did not care and threw the remaining pesticides outside the house and in the fields (Table 5). Hence, it was clear that the handling of remaining pesticide was improper and unsound practice, which further created adverse effects to human health and polluted environment.

Table 5. Handling of leftover pesticides by farmers in vegetable growing areas, 2012

Eco-zone	District	Keep in house/ store freely		Bury/burn		Throw outside their house		Give to their friends	
		Freq	Percent	Freq	Percent	Freq	Percent	Freq	Percent
Terai	Bara	59	59	29	29	11	11	1	1
Mid hills	Dhading	9	18	6	12	32	64	3	6
	Kavre	35	70	12	24	2	4	1	2
Mid hills total		44	44	18	18	34	34	4	4
Grand Total		103	51.5	47	23.5	45	22.5	5	2.5

3. PESTICIDE RESIDUE ANALYSIS

Residues of twelve pesticides were analyzed using Gas Chromatography MS method in 75 samples of different 13 vegetables (carrot, cucumber, brinjal, okra, cowpeas, green beans, tomatoes, chilli, cauliflower, bitter guard, bottle guard, potato and pumpkin) selected for this study are common vegetables in Nepal (Figure1).

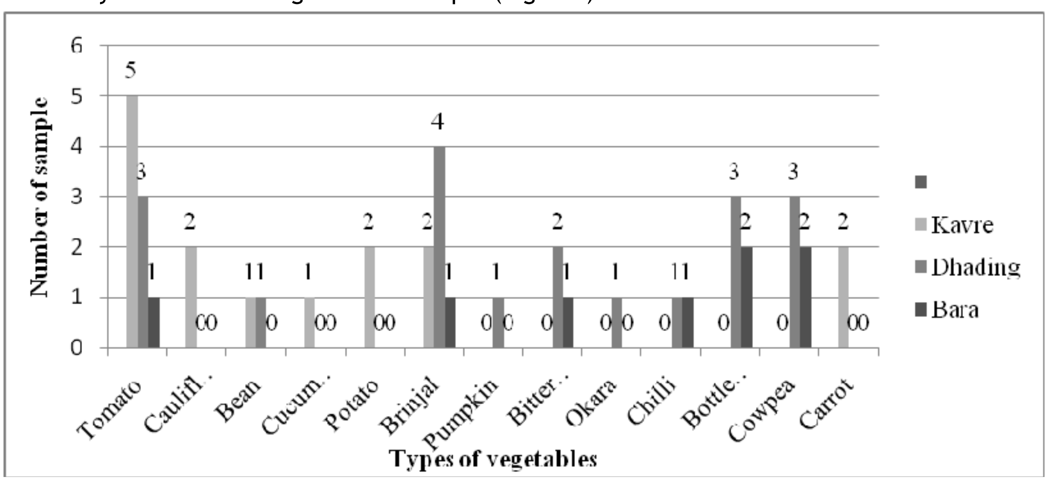

Figure 1. Fresh vegetable samples analyzed for pesticide residues from Kavre, Dhading and Bara

STUDY AREAS

Most of the vegetable samples analyzed did not contain pesticide residues above the accepted maximum residue limit (MRL) as adopted by EU standard, although some pesticide residues have been detected in certain levels. The result obtained showed that 58 percent of the vegetable samples analyzed contained no detectable level (NDL) of the monitored pesticides, 38 percent of the samples resulted in trace level of the pesticide residue or level below the MRL, while four percent of the samples showed above MRL (Figure 2).

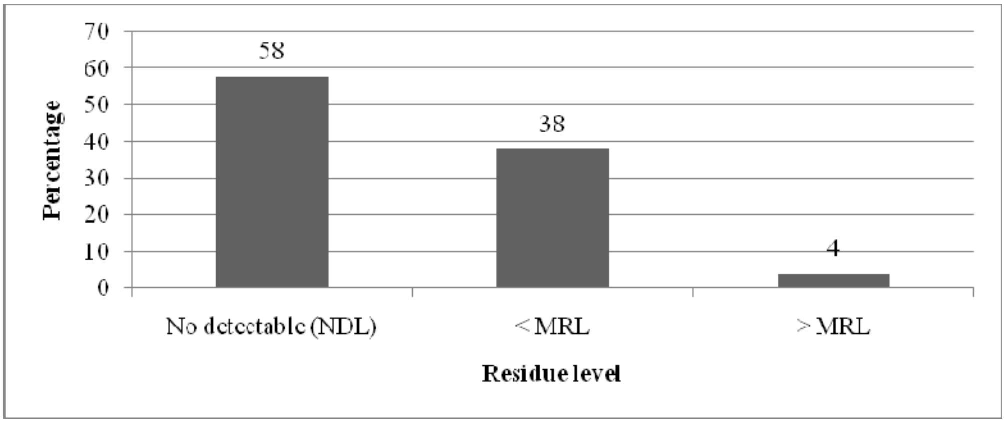

Figure 1. Vegetable sample analysis and residue detected under different categories

The analysis detected the highest concentration of Cypermethrin in tomato and brinjal. Likewise, concentration of Deltamethrin was the highest in cowpea followed by cauliflower, tomato and brinjal. The concentration of Carbandazim and Mancozeb were also the highest in tomato followed by bottle guard and chilli.

CONCLUSION AND RECOMMENDATION

Pesticide Act 2048 has not mentioned residue part of pesticides and it is urgent to revise and incorporate in the Act. A sound system of monitoring for pesticide residues at the local level and residue analysis at market place can control fruit and vegetables growers, who are competing with chemical imports. This will encourage consumers to trust local produce. Establishment of regional centre is necessary for the prevention and management of pesticide poisoning, enhanced surveillance, training, and community action. Dissemination of information about insights, experience and lessons learnt from research and interventions is necessary as recommendations to interlink global policy and local action for prevention and management of pesticide hazards. Therefore, information, education and communication sectors need strengthening to raise awareness about proper use of pesticides and its safety measures.

Residues analysis of 12 insecticides from 75 samples of 13 vegetables indicated that over half of the vegetable samples contained no detectable level (NDL) of the monitored pesticides, 38% samples resulted in trace level of the pesticides residue or below the minimum residue level (MRL), while 4% samples showed above MRL (EU Standard). Pesticide Act 2048 has not mentioned residue part of pesticides and a sound system of monitoring for pesticide residues at the local level and residue analysis at market place is lacking.

RECOMMENDATION

- Selection of appropriate pesticides and their handling and use as per the label are the most important steps for safe use of chemical pesticides. For this, the Government needs to develop mechanisms for enforcing the acts and regulations for the overall management and use of pesticides, adopting FAO guidelines with adequate educational and training interventions.
- Long-term implications of pesticide use on human health and environment need to be studied for eco-friendly sustainable agriculture, safety to human health and the environment as a whole.
- The quality of pesticides and their residue on marketable products is required to monitor regularly for public safety. Therefore, establishment of the Rapid Pesticide Residue Analysis Laboratory and systematized residue monitoring plan should be enforced in the country.

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REMOTE SENSING AND ITS APPLICATION IN AGRICULTURAL PEST MANAGEMENT

M.C. Acharya[1] and R. B. Thapa[2]

ABSTRACT

Agricultural production is significantly affected by biotic- living organisms, such as predator, parasites, pathogens and abiotic factors, like temperature, humidity, rainfall etc. To manage the pests, monitoring and forecasting has been an integrated part of the crop production system in developed countries. In recent years, remote sensing has become popular in pest monitoring, yield forecasting, and early warning to crop growers for timely management of potential pests in agriculture. This paper highlights basic functioning of remote sensing and its application in agriculture with main emphasis on pest management.

Key words: Remote *sensing, precision agriculture, pest management, yield prediction, early warning*

INTRODUCTION

Remote sensing refers to noncontact measurements of radiation reflected or emitted from agricultural fields, which are based on the interaction of electromagnetic radiation with soil or plant material. It is an outgrowth of aerial photography (Andreo, 2013). Remote sensing, today, incorporates new technologies that provide increasingly efficient, complete, accurate, and timely information. These new technologies, together with historical photographs, provide the information as a practical management tool for site-specific management of crops (Cassady *et al*., 2002). The supply of remotely sensed data greatly increased with the launch of the Earth Resources Technology Satellite (ETRS)-I in 1972 (Aggarwal, 2004). From an orbit of 570 miles above the earth, the satellite can complete a full observation of earth every 18 days. Its multispectral imagery is collected in four visible and infrared wavelength bands of 100 mile wide passes over the earth. This source of data has opened a new dimension to the capability to obtain information about earth resources, particularly crops. The corn blight watch experiment (NASA, 1974) conducted by several agencies of NASA and USDA and others provided a prototype remote sensing system, integrating technique of sampling, data acquisition, storage, retrieval, processing, analysis and information dissemination in a quasi operational system environment (MacDonald *et al*., 1972). Remote sensing along with Global Positioning Systems (GPS), Geographic Information Systems (GIS) and Variable Rate Technology (VRT) are additional technologies that scientists can implement to help farmers maximize the economic and environmental benefits of area-wide pest management through precision agriculture (Huang *et al*., 2008).

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Early warnings and forecasting based on biophysical methods provide appropriate time for managing pest damage and can thus minimize crop loss, optimize pest control and reduce the cost of cultivation (Prasad and Prabhakar, 2012). The results showed that remote sensing procedures could quantitatively recognize corn leaf blight over broad areas. Hence, the most promising application of remote sensing technology is its ability to obtain information about agricultural crop production system. With a minimum amount of ground sampling, remote sensing data permit identification and area measurements of crops, assessment of crop stress, pest damage, yield forecasts, range surveys and mapping of major soil boundaries including many non- agricultural applications. According to Fitzgerald (2000), multi spectral remote sensing (MRS) allowed farmers to detect early infestation of mites in large scale cotton fields due to color shifts and changes in canopy appearance over time. Now-a-days, computer-based systems have increased the speed and accuracy of forecasting, and minimizing its costs.

METHODOLOGY

Available and relevant literature were gleaned through Google search and other various sources, i.e. various journals, websites, published reports and theses including institutions working in the field of climate, GIS, and remote sensing for gathering necessary information especially in line to basic principles of remote sensing and its potential use in agriculture and crop pest management aspects. Valuable information have been extracted and presented in this article.

BASIC PRINCIPLE OF REMOTE SENSING

1. FUNCTIONING OF REMOTE SENSING

Electromagnetic energy refers to all energy that moves with the velocity of light in a harmonic wave pattern. The wave concept explains the propagation of Electromagnetic energy, but this energy is detectable only in terms of its interaction with matter. In this interaction, Electromagnetic energy behaves as though it consists of many individual bodies called photons that have such particle-like properties as energy and momentum (Sabins, 1976). Using different kinds of sensors of electromagnetic radiation (EMR), from aerial photographs and satellites, one can remotely collect data and analyze them to obtain information about the object or phenomenon sensed. The functioning of the remote sensing is shown in Figure 1. This includes data acquisition and analysis. Satellite maintains its energy through self emission or from huge energy source sun with propagation of energy through atmosphere and losses due to absorption, scattering etc. (Tempfli *et al.*, 2009).

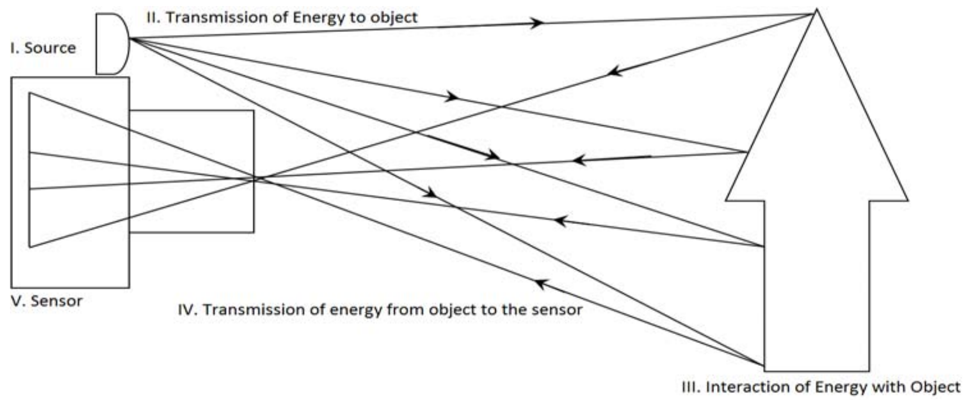

Figure 1. Working of a camera with flash gun (Process of data acquisition)

2. PHYSICAL BASIS FOR REMOTE SENSING

The physical basis for remote sensing is the distinctive character of electromagnetic radiance from natural and manmade scenes (Holmes and MacDonald, 1969). Remote sensing in this sense is defined as the acquisition of information about the earth's surface from measurements of radiated energy made by aircraft-or spacecraft-borne sensors. The major objective of remote sensing is to detect, measure, record and analyze energy in selected portions of the electromagnetic spectrum (Figure 2). The variations in electromagnetic fields that can be measured and used to discriminate among objects are spectral, spatial and temporal (Landgrebe, 1973). Electromagnetic radiation is energy propagated through space between electric and magnetic fields. The electromagnetic spectrum is the extent of that energy ranging from cosmic rays, gamma rays, X-rays to ultraviolet, visible, and infrared radiation including microwave energy (Shannon, 2000). Out of the electromagnetic spectrum, the region from 0.3 μm to 100 μm is used for remote sensing. The electromagnetic spectrum of greatest interest to use in remote sensing is the optical wavelengths, which extend from 0.3–15 μm. This is divided into different reflective part: i) 0.38-3 μm, ii) 0.38-0.72 μm (visible part), iii) 0.72-3 μm (infrared), iv) 0.72-1.3 μm (near infrared), v) 1.3-3.0 μm (middle infrared) and emissive part: 7-15 μm far infrared (emissive/ thermal infrared).The visible portion extending from 0.4-0.7 μm is the most familiar because our eyes are sensitive to radiation at those wavelengths. However, other portions of the spectrum are equally important for remote sensing because of the level of energy reflected or emitted from materials normally varies with the wavelength throughout the spectrum (Tempfli *et al*., 2009).

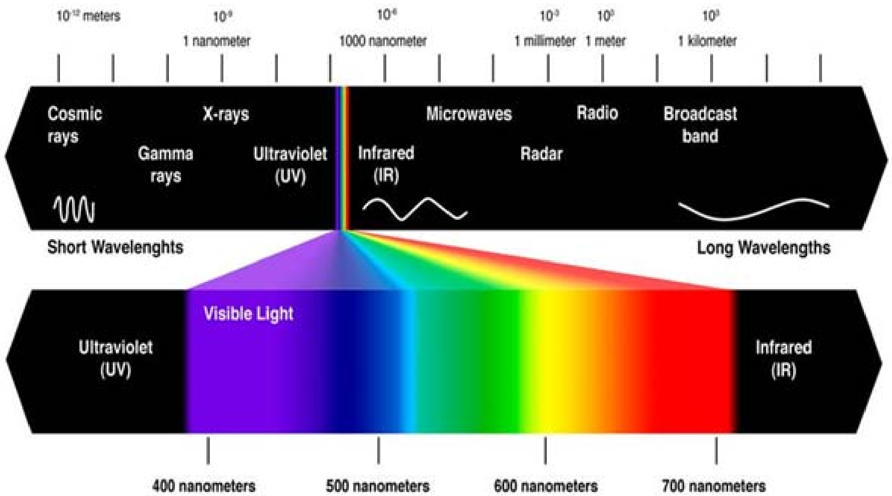

Figure 2. Electromagnectic Spectrum (*Source: Zamy Zuly, 2013 "The Electromagnetic Spectrum". Retrieved December 3, 2013, from* www.zulyzami.com/The+ Electromagnetic + Spectrum)

The sun is the most important source of EMR for remote sensing and emits radiation as a lack body at about 6000k. In the case of earth, the surface material (soil, water and vegetation) radiate about 300 k. This is thermal IR having its peak at about 9.7 µm and can be sensed by radiometers and scanners. Solar radiation, on the other hand, has its peak at about 0.5 µm. When the sun is present we observe terrestrial features by virtue of reflected solar energy. Certain sensors (i.e. Radars) supply their energy to illuminate features under observation such systems are called active systems as distinct from passive systems which observe features in natural light.

When radiation falls on the earth's surface three major types of interactions occur: i) a part is reflected, ii) another part is absorbed, and iii) remaining part is transmitted. The energy balance is expressed as: EI (λ)=ER (λ)+EA(λ)+ET(λ), Where, EI = Incident energy (near a given λ), ER = Reflected energy, EA = Absorbed energy, and, ET = Transmitted energy. In remote sensing, we are largely concerned with reflected radiation which is the radiation that causes our eyes to see colors, causes infrared film to record vegetation, and allows radar images of the earth to be created (Shannon, 2000). It is primarily concerned with diffuse reflection because it contains spectral information dependent on the color of the reflecting surface. The reflectance characteristics of earth surface features are often expressed quantitatively in terms of R_λ called spectral reflectance defined as the ratio of the energy reflected from an object to the energy incident upon the object, i.e. R_λ=(ER (λ)/(EI (λ). A plot of R_λ of a surface as a function of λ is called a spectral reflectance curve which is of great importance (Tempfli *et al.*, 2009).

3. PHYSIOLOGICAL BASIS OF REMOTE SENSING

This includes leaf reflectance, canopy reflectance, crop canopy temperature and vegetation indices, which are outlines as follows:

Leaf reflectance: An understanding of physiological properties of plants and their interaction with incident radiation is important in crop condition assessment through remote sensing. The striking features of leaf reflectance are high absorbance in the blue (0.45µm), red (0.65 µm) and reduced absorbance in the green (0.55 µm), high reflectance in the NIR (0.75-1.2 µm) and again very high absorbance in the FIR regions of the spectrum (Figure 3). The absorbance in the visible region of EMR spectrum is due to plant pigments (carotenoids, chlorophyll a and chlorophyll b, which is called photo synthetically active radiation (PAR).The abrupt increase in reflectance near 0.75 µm is due to internal structure of the leaf and the canopy geometry. Any physiological disturbance in leaf leads to an increase in leaf reflectance in the visible region. The leaf moisture is largely the cause of very strong absorption throughout the FIR region (1.3–2.5 µm) (Liew, 1997).

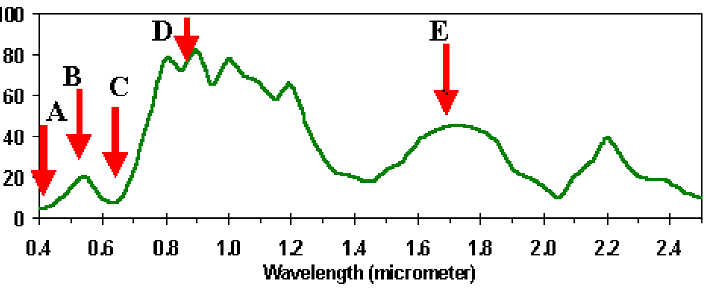

Figure 3. Typical reflectance spectrum of vegetation (*The labelled arrows indicate the common wavelength bands used in optical remote sensing of vegetation: A: blue band, B: green band; C: red band; D: near IR band; E: short-wave IR band* (Source: Liew, 1997)

Canopy reflectance: Robust empirical relationships between remotely sensed canopy reflectance and ground-measured biophysical and biochemical parameters of vegetation have been established via different models. Mathematical functions of two or more spectral bands are used rather than direct reflectance data to minimize the negative impact of interfering factors, such as the surrounding land cover, bare soil, or climatic/atmospheric conditions. These functions are called vegetation indices (VIs), each designed for optimal correlation with a particular vegetation feature (*Malenovsky et al., 2009)*.

Crop canopy temperature: Colaizzi *et al*. (2010) demonstrated radiometer footprint model to estimate sunlit and shaded components for row crops. Crop evapo-transpiration is the basic physiological process that determines the canopy temperature when an aerodynamically rough canopy has sufficient supply of water; leaves are generally cooler than the ambient air because of the heat lost through transpiration. However, when the moisture in the root zone becomes limiting under soil moisture stress, evapo-transpiration decreases due to partial closure of stomata and thus the canopy's temperature rises relative to that of non stressed crop. The difference between canopy and air temperature (Tc-Ta) measured at the time of maximum surface temperature could be used as an indicator of crop water status and crop yield. The most useful wavelength region for canopy temperature measurement and quantification is the thermal infrared band (8–14 μm). Currently thematic mapper (TM) of LANDSAT, Advanced Very High Resolution Radiometer (AVHRR), On Board US National Oceanic and Atmospheric and Administration (NOAA) satellites and the Indian National Satellite (INSAT) provide data in thermal infrared channels.

Vegetation indices: A vegetation index is an indicator that describes the greenness— the relative density and health of vegetation— for each picture element, or pixel, in a satellite image. Rouse (1973) developed a transformation of radiance values of near infrared (NIR) and red (R), the two contrasting spectral bands and called it vegetative index (VI). The ability of an optical sensor to resolve features within specific wavelengths of the optical spectrum and slice wavelengths into smaller increments is referred to as a sensor's spectral resolution. The main purpose of spectral vegetation indices is to enhance the information contained in spectral reflectance data, by extracting the variability due to vegetation characteristics (i.e. LAI, vegetation cover) and to minimize soil, atmospheric, and sun-target-sensor geometry effects (Moulin and Guerif, 1999). The greenness vegetation index (GVI) and perpendicular vegetation index (PVI) developed subsequently can be employed to monitor the photo synthetically active biomass as well as the vigor and the condition of plant canopy. The VI is generated from the data obtained by satellites, like LANDSAT, SPOT, IRS-IA, NOAA and AVHRR. The normalized difference vegetation index (NDVI) of AVHRR sensor is the most often used for monitoring the vegetation status on a global scale. NDVI is the difference in the radiance values of NIR and visible spectrum divided by their sum.

4. TYPES OF REMOTE SENSING

Beginning with the early use of aerial photography, remote sensing has been recognized as a valuable tool for viewing, analyzing, characterizing, and making decisions about our environment. In the past few decades, remote sensing technology has advanced on three fronts: 1) from predominantly military uses to a variety of environmental analysis applications that relate to land, ocean, and atmosphere issues; 2) from (analog) photographic systems to sensors that convert energy from many parts of the electromagnetic spectrum to electronic signals; and 3) from aircraft to satellite platforms (Levin, 1999). Conventional remote sensing is of two types: i) Aerial photography, and ii) Satellite imagery.

Aerial photography: The term, "remote sensing," was first introduced in 1960 by Evelyn L. Pruitt of the U.S. Office of Naval Research (Baumann, 2014). However, the first aerial photograph was taken in 1858, 102 years before the term "remote sensing" came into existence. USDA has been using it operationally since the 1930's to record land use and in soil mapping. The photographs are taken from an aircraft, with the axis of the aerial camera kept vertical, horizontal or oblique. However, for environmental survey purpose vertical photographs are suitable for obtaining uniform coverage. The photographs are taken from an aircraft flying at a particular height (Baumann, 2014).

Even today with products from the space systems competitively priced, aerial photography remains a powerful and sometimes optimum tool to use for both routine and specialized applications. Two variants of aerial photos, each obtainable in black and white or color, are the vertical (sees Earth straight downward) and the oblique (sees at various angles, usually less than 45°). Photography commonly takes place in the visible but film sensitive to the very near infrared or ultraviolet allows image-taking in those spectral regions. The uses of aerial photography in the management of biosphere reserve make this type of remote sensing very important. Its advantages are superior spatial resolution, relative simplicity of photography and film processing, relatively low cost equipment, and providing considerable amount of information. But its disadvantage is the range of sensitivity is confined by film emulsion technology to the visible and near infrared regions (o.4 to 1μm) (Short, 2005).

Satellite Imagery: Today, many satellites, with various remote sensing instruments, monitor the Earth's surface. These satellites and their respective remote sensing programs can trace their origins back to the CORONA and Land sat programs. CORONA was a secretive military reconnaissance program that continues to the present time through the advanced Keyhole satellites and Landsat was an open Earth resources program that also continues through more advanced Landsats and other satellite resource monitoring programs. The period from 1960 to 2010 has experienced some major changes in the field of remote sensing. As satellites can cover much more land space than planes and can monitor areas on a regular basis. With advancement in technology, imagery became digital in format rather than analog. The digital format made it possible to display and analyze imagery using computers; sensors were becoming available that recorded the Earth's surface simultaneously in several different portions of the electro-magnetic spectrum. One could now view an area by looking at several different images, some in portions of the spectrum beyond what the human eye could view. This technology made it possible to see things occurring on the Earth's surface that looking at a normal aerial photograph one could not detect. The turbulent social movements of the 1960s and 1970s awakened a new and continuing concern about the changes in the Earth's physical environment. Remotely sensed imagery from satellites - analyzed and enhanced with computers - made it possible to detect and monitor these changes (Baumann, 2009).

The multispectral scanners in the satellites scan the earth line by line in many discrete light quality ranges (bands of spectrum) in the visible and thermal portions of the spectrum (0.3 to 14.0 μm). A scan line consists of several measurement values representing the energy reflected or emitted from the discrete blocks of surface area. The values are recorded on magnetic tapes which can be directly used in a computer for analysis. A computer can handle multispectral data simultaneously and make decisions about identification of surface features using statistical approaches.

APPLICATION OF REMOTE SENSING IN PEST MANAGEMENT

The factors which favor the development of pests and their effect on plant parameters that are detectable by remote sensors are shown in Figure 4.

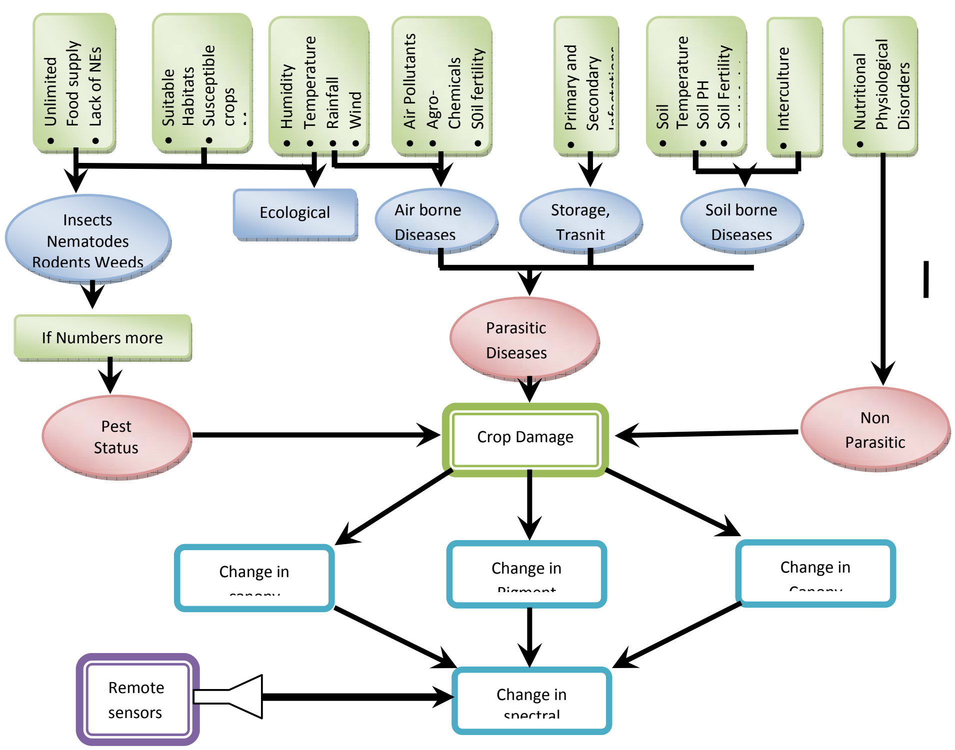

Figure 4. Development of crop pests and diseases leading to crop damage and its detection through remote sensing *(Source: Nageswara Rao, 1988)*

Remote sensing can be considered as a fast, non-destructive and relatively cost-effective method to study biophysical and biochemical parameters of vegetation across vast spatial areas (Ngie *et al*., 2014). Remote sensing (including aerial photography) can supply baseline information for land-use and other forms of spatial planning in areas where maps are not available and it is used as an input for the modeling of alternative land use options (i.e. agriculture or biological conservation) (Leeuw *et al*. 2010). Many of the potential research and management applications of remote sensing are tactical, i.e. they involve responses to particular conditions or situations that arise during the course of the season, such as insect pest management. The tactical questions often involve determining how field is changing, i.e. detecting an emerging pest population. Detecting change with remote sensing involves collecting images frequently and comparing them with previous images. Thus, the values from a location in one image may be compared with values from the same location in other images. Calibration of remotely sensed images is generally accomplished by laying out large panels of known properties that then appear in the image. The normalized difference vegetation index (NDVI) is used for the purpose as a most common index for multispectral data.

PRECISION SURVEY IN AGRICULTURE

Twenty five years of remote sensing in precision agriculture has been reported by Mulla (2013). Various types of precision systems have been applied in agriculture as shown in Figure 5. Based on the studies of over decades in USA, remote sensing has been used for various purposes of precision surveys (Eriction, 2014). Several studies have shown that the NDVI calculated from NOAA-AVHRR data has very strong correlation to the primary productivity of the cereal crop yields.

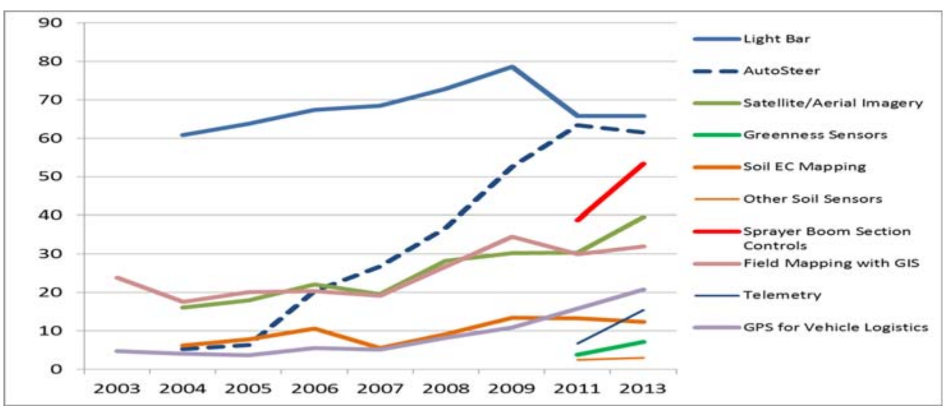

Figure 5. Decades of precision survey in agriculture *(Source: Eriction, 2014)*

Remote sensing of insect pests of fruit trees was pioneered in 1968, especially in citrus, detecting the insect infestation using presence of sooty mould. The use of remote sensing in agriculture in India started with the detection of wilt disease in coconut at Kerala Coast (Dakshinamurty *et al*., 1971). But later main emphasis was shifted to crop acreage estimation, crop condition assessment and yield forecasting using different crop simulation models (Shin *et al*., 2009; Basso *et al*., 2010; 2012). Some work has been done on forecasting of desert locust. Riley (1989) provided an exhaustive review on the use of remote sensing in the field of entomology. Optical and video imaging in near-infrared and microwave regions were used to quantify even the nocturnal flight behavior of *H. armigera* (Riley *et al.*, 1992). Recently, forecasting methods of potato late blight, apple scab, mango powdery mildew and rice blast are available (Sinha and Banik, 2009). The application of remote sensing in pest monitoring, detection, early warning and management aspects in the field of agriculture are summarized as follows:

1. Survey of ecological conditions and forecasting locusts

Over the years, strategies of Desert Locust control have evolved from curative efforts to an emphasis on prevention, i.e. finding and treating infestations before they form large hopper bands and swarms. This requires regular monitoring of locust breeding areas and the ability to quickly mount small scale control operations in many of the 60 countries affected by the Desert Locust. It has only been during this century that our understanding of the Desert Locust and its relationship with the environment has increased to a point that allows for better management of this pest through improved strategies of monitoring and control. Tucker *et al*. (1985) demonstrated potential of satellite remote sensing of ecological conditions of survey and forecasting the desert locust activity. Remote sensing imagery can assist in the detection of green vegetation and thereby help to guide ground survey teams. Since the late 1980s, imagery has been used in parts of West Africa and in the Red Sea area (Cressman, 1998). The use of satellite remote sensing technology has raised many hopes for forty years to support locust monitoring. The joint use of remote sensing data and of locust data issued from RAMSES for a period of 43 years (1965-2008) proved to be crucial. These locust data helped to prioritize the different areas according to their interest for the locust ecology. They allowed researchers to focus only on areas of major interest for the preventive control of this species (Lazar *et al*., 2015).

2. Assessment of crop infested with insect pests

In order to use visible and infrared images to detect stress in rice production caused by BPH infestation, several remote sensing techniques have been developed. Initial recognition of pest infestation by means of remote sensing will spreads, for precision farming practice. Normalized Difference Vegetation Index (NDVI), Standard difference indices (SDI) and Ratio Vegetation Index (RVI) are used for analyses using ENVI 4.8 and SPSS software. Using these indices as indicator can clarify the threshold for zoning the outbreaks (Ghobadifar *et al*., 2014).

The normalized difference vegetation index (NDVI) has been a popular index with some limitations to estimate LAI across diverse ecosystems. Cotton grown as a mono-crop in Guntur and Prakasham districts in Andhra Pradesh was severely infested by white fly, *Bemisia tabaci* during kharif 1985. Landsat-5 (MSS & TM) false color composites were used for the assessment of the condition of the cotton crop. The technique involved visual detection of changes in the red color on Landsat FCC of 28/11/1985 in comparison to that on Landsat FCC of 11/12/1984, a normal year. The temporal chromatic profile techniques supported by ground truth data collected on 9/12/1985 were used in delineating the affected areas. Regions showing 50-80% damage by the pest could be easily identified. Huwang *et al*. (2008) suggested that land surface temperature (LST) and modified normalized difference water index (MNDWI) were of great potential in discriminating and monitoring the aphid damage degree over a large area, only using thermal infrared band and multi-spectral satellite images.

3. Early detection of wild hosts and reducing the population build up

Wild radish, winter peas, wild mustard, vetch and curly duck harbor insects that later attack cotton and soybean in Mississippi State, USA. Remote sensing has been used to detect the wild host plant areas early in season and also to detect pest infestations within cotton fields and crop maturity levels related to these pest infestations during the cropping season. Cotton generated more than $483 million and soybean $ 174 million to the state economy (Ray, 2001).

4. Early detection of insect pests

Early detection of the pest infestation could reduce overall applications of pesticides using variable rate application technology, thus saving the producer's money. During non-cropping periods, tarnish plant bugs feed and reproduce on broad leaf wild host plants. Remote sensing and spectro-radiometry showed distinct differences between broad leaf hosts and non-host grasses. High spectral resolution remote sensing imagery with more bands and narrower bandwidth is required for remote sensing diagnosis of crop disease stress (Qin *et al*., 2003).

5. Locating hot spots of pest infestation in crops

Preliminary remote sensing revealed spider mite infestations reddish hot spot patterns in cotton fields and discerned them from healthy and drought stressed cotton in 1999. This information may be useful in the targeting of precision pesticide applications. Because spider mites and aphids occur in heterogeneous areas of the fields, it is possible that these “hot spots” can be differentiated from other sources of variation, using the wavelengths in the NIR (Reisig and Godfray, 2006)

6. Monitoring conditions favourable for pest outbreak

Various factors such as intensive cultivation, mono-cropping, changing weather conditions and indiscriminate use of pesticides have resulted in frequent outbreaks of crop pests and diseases causing huge crop losses. Minimizing these losses is one way of enhancing grain production and remote sensing tool has been found very useful in monitoring large areas frequently. The Earth observing systems are useful in monitoring weather and ecological conditions favorable for crop pests and diseases. Weather conditions such as temperature, humidity (moisture), sunshine hours (light) and wind play major influence on the densities of pest population and their natural enemies. Among the weather parameters that can be remotely sensed, type of cloud, extent of cloud cover, cold cloud duration (a surrogate for rainfall) are the most easily retrievable. Such information was used by phytopathologists to study rust diseases of wheat crop (Das, 2013).

7. Remote sensing of individual species of insects

Locusts: Traditional ground locust surveys are inadequate to address the enormous spatial scale of the locust problem in a limited window of time dictated by the pest’s development. Remote sensing (satellite information) appears a promising tool in locust monitoring. Satellite data are increasingly used for monitoring and forecasting two locust species, the desert and the Australian plague locust. (Latchininsky, 2013).

Moth flight: It is extremely difficult to observe and quantify high altitude insect movements using traditional entomological techniques. Thus, the deployment of special-purpose entomological radars in the late 1960s (Schaefer, 1976) has greatly added to our knowledge of insect flight behaviour at high altitudes. Entomological radar observation programs have, up until now, been strongly focused on large insects (moths, migratory grasshoppers) flying under stable boundary layer conditions at night (Wood *et al.*, 2008). RADAR observation of *Spodoptera exempta* have shown that this species at least in its gregarious phase is an obligate wind borne migrant and that the aggregation of flying moths, particularly by storm front outflows, is a major factor in the outbreak of caterpillars. By contrast, *Heliothes armigera*, in India shows little tendency to undertake long range migration above the altitude at which wind speed exceeds flying speed.

*Aphids and spider mites***:** Remote sensing was used for detection of cotton aphid and spider mite infested cotton in the San Joaquin Valley (Reisig and Godfrey. 2006). Wavelengths in the NIR were fair to moderately accurate predictors of aphid- and mite-infested cotton. Concentration of airborne aphids up to 1200 m. above the sea level have been detected by using very powerful 10 cm RADARS.

***Plant hoppers and leaf hoppers*:** Millimetric radar studies in Philippines have shown that plant hoppers and leaf hoppers associated with rice engage predominate in short range flights. Prasannakumar *et al*. (2013) in India used hyperspectral remote sensing to detect the brown planthopper (BPH), *Nilaparvata lugens* (Stal.), stress on rice plants under glasshouse as well as field conditions and revealed that variation in plant reflectance due to BPH damage was smaller at shorter wavelengths (350-730 nm) and larger at longer wavelengths, viz., NIR (740-925 nm) followed by mid infrared (MIR) (926-1800 nm), which indicated the possibility of detection of BPH stress on rice and thereby issuing prompt forewarning to stakeholders.

8. Survey of insect pests of crops and fruit trees

Sooty mould has been used to indicate the presence of corn leaf aphid, *Rhopalosiphum maydis* and sweet potato white fly, *Bemicia tabaci* Glover. In a study, photographs were taken from 2000 meters and different levels and areas if infestation were successfully measured with the aid of photographic enhancements and computerized area estimation methods. The white fly induced sooty mould could be detected on cotton from 300 meters and photographs from 2000 meters yielded good resolution of mould growth patterns. A number of insect pests like soft scale, *Coccus hesperidium*, infesting citrus groves; citrus mealy bugs, *Phenococcus citri*, citrus black fly, *Aleurocanthes woglumi* produce honey dew that serves as host medium for sooty mould fungus. This mould blackens foliage and thus provides a clue for quick detection of insects by aerial photography. Wavelengths in the NIR were fair to moderately accurate predictors of aphid and mite infested cotton (Reisig and Godfrey. 2006).

9. Mapping of geographical distribution of pests along with GIS

GIS is another tool, which can be used effectively for mapping geographical distribution of pests, delineating the hotspot zones. GIS methods can be divided into two sub groups-Remote Sensing and Digital Cartography. Fundamentally, GIS techniques create data abstractions to describe the real world life systematically classifying features into a series of thematic layers. Each layer can be evaluated independently or features between two or more layers can be analyzed together. Remote sensing has also been used in conjunction with GIS for monitoring changes in crop conditions. Mino *et al*. (1998) used multi-temporal satellite data to distinguish grasslands of different ages, monitor changes in management and evaluate grassland quality. District wise geographical maps of rice and cotton pests have been prepared at NCIPM (Kanojia *et al*., 2000).

10. As an aid in precision farming

Precision Farming (PF), also called Precision Agriculture (PA) or site specific crop management (SSCM) is an integrated information- and production-based farming system that is designed to increase long term, site specific and whole farm production efficiency, productivity and profitability while minimizing unintended impacts on wildlife and the environment" (Earl *et al.*, 1996). The basic principle of PF is to maximize the efficiency of inputs as measured by outputs, which is to optimize inputs according to field variability in order to maximize yields diminishing production costs and environmental impacts of agricultural practices, by giving the right amount of input at the right place and the right time. Rapid advances in remote sensing for precision agriculture have occurred over the last twenty five years. Satellite imagery has improved in spatial resolution, return visit frequency and spectral resolution. Aerial hyperspectral imagery has revolutionized the ability to distinguish multiple crop characteristics, including nutrients, water, pests, diseases, weeds, biomass and canopy structure (Andreo, 2013). There is a significant potential in precision agriculture for combining archived remote sensing data with real-time data for improved agricultural management (Thenkabail, 2003).

11. Rainfall and outbreak of pests

Flying moths of the east - African armyworm, *Spodoptera exempta*, are concentrated by convergent winds associated with rain storms and the subsequent mass laying of the aggregated moths leads to massive outbreaks of destructive caterpillars. Remote sensing of rain storms in the appropriate areas thus presents the prospect of rapidly locating potential outbreaks (Holt *et al.*, 2000).

12. Survey of habitats of insect vectors of animal diseases

Remote sensing imagery (from high-resolution aerial photography to coarse-resolution satellite imagery) when combined with GIS spatial analyses techniques can play an important role in existing vector surveillance and control programs at local and regional scales (Washino and Wood, 1993). By applying the remote sensing and GIS techniques for mapping vector habitats, vectors' presence, abundance and density, assessing the risk of vector-borne diseases, disease transmission, spatial diffusion, we can find the root cause of the disease infection, and source of infection. (Palaniyandi, 2012). With the availability of multispectral, multi-temporal and real time satellite data products, GPS assisted geo-referenced epidemiological data are being integrated under the umbrella of the GIS software for mapping distribution of vector borne diseases (including malaria, Japanese encephalitis, filariasis, schistosomiasis, Ross river virus disease etc.

CONCLUSIONS

Remote sensing has been used to provide useful information on crop condition, detection of development of pest population in remote and inaccessible areas. Its aims is to bridge gaps in the existing systems securing a regular information flow about the areas affected by insect pests and diseases and other yield reducing factors on a nationwide basis. Based on research findings on some crop pests and diseases, it can be used in agriculture insect pest management decisions, timely planning and getting different information in many specific areas such as i) survey of ecological conditions and forecasting insect pest outbreaks, ii) assessment of crop condition, iii) early detection of wild hosts and reducing the population build up, i.e. radish, winter peas, wild mustard etc. harbouring bugs attacking cotton and soybean, iv) early detection of insect pests, i.e. tarnish bugs in cotton fields, v) locating hot spots of pest infestation, i.e. spider mite infestation in cotton, vi) monitoring conditions favourable for pest outbreak and take management decisions in advance, vii) remote sensing of individual species of insects, i.e. locusts, moths and aphids etc., viii) survey of insect pests of crops and fruit trees, i.e. aphids in corn, scales and mealy bugs in citrus fields, ix) mapping geographical distribution of pests, along with GIS, x) as an aid in precision farming, xi) rainfall and outbreak of pests, and xii) survey of habitats of vectors of vertebrate pests.

Forecasting system for insect pests in Agro-ecosystem provides opportunity to inform farmers about possible out breaks for preparedness and taking of timely action to apply biocontrol agents, mechanical means and pesticides, which ultimately cuts down the cost of production and serves as a tool in precision farming. Hence, recent advancements in the field of remote sensing provide ample scope to use this technology in agriculture for pest monitoring, detection and timely management with high precision.

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USE OF BIOLOGICAL AGENTS FOR DISEASE MANAGEMENT OF TOMATO IN BHAKTAPUR OF NEPAL

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ABSTRACT

The experiment was conducted in tomato crop grown under plastic house in farmers' field condition in two VDCs of Bhaktapur District in two seasons in 2011/2012. The objective of the studies was to train the IPM facilitators for the production and multiplication of bio-control agents (Trichoderma harzianum, Trichoderma viride and Pseudomons fluorescens), to advocate the benefit of bio-control method for protection of crops and reduce the use of chemical pesticides in vegetables and to taste the efficacy of commercially available bio-pesticides. Trichoderma viride,T.harzianum, Pseudomons fluorescens and Bavistin were applied in seed and seedlings treatment, and foliar spray. The result revealed that seed and seedlings treated with T. species and Pseudomons fluorescens were healthier than those treated with chemical fungicides and produced higher yield.

Key Words: Biological agents, bio-pesticides, disease management, tomato

INTRODUCTION

Tomato is an important crop for income generation of urban and rural farmers of Nepal but they are facing some problems of insects and diseases. Among them damping off, late blight, mosaic virus, nematode in disease and aphid, white flies, leaf minor and fruit borer insects are major problems in mountain and mid hills of Nepal in tomato. Damping off is common occurrence in nursery beds and young seedlings resulting in reduced seed germination and poor stand. Late blight, caused by *Phytophthora infestans* fungus is one of the destructive diseases in tomato and potato where 20-90 % losses occurr annually. The fungus can attack on leaves, stems and tubers of potato and leaves, stems and fruits in tomato. Host resistance with fungicide application, chemicals, biological and integrated disease management can control the disease.

Forcelini et al.(2001) and Deising et al. (2008) focused on increasing use of chemicals has become an issue on alarming increase in fungicide resistance of plant pathogens in number of crops in modern agricultural practices in several countries. Biological control methods involving the use of natural antagonist of pathogens and predators, parasitoids and parasites have been suggested a safe alternative of chemical method of disease and insect control.

Depending upon the host variety and environmental factors, 25-75% losses are caused annually by damping off. The fungus have a wide range of crops to attack under the

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families Solanaceae, Crucifereae, Leguminosae and Chenopodiceae. A numbers of fungi like *Pythium*, *Phytophthora*, *Rhizoctonia* and *Fusarium* are most common and *Alternaria*,*Botrytis*, *Phoma*, *Sclerotinia*, *Sclerotium*, *Aphanomyces*, *Pyrenochaeeta*, *Ozonium Glomorella* etc. can also cause damping off (Gupta and Paul,2001).

Several fungi, bacteria, virus and nematodes that attacks plants and cause several billion rupees worth of agricultural losses each year in Nepal. Some chemicals used to control these diseases may also contribute to environmental contamination and toxicity to animals and human. Nowadays, some biological agents are applied and found effective for disease and insect management. Beneficial fungi and bacteria those have potential to suppress soil borne diseases specially damping off, wilts, *Phytophthora*, and *Pythium* are available in the market.

Cultural practices, biological control, chemicals and integrated disease management can reduce the incidence and intensity of different kinds of diseases in crops. But we should consider the impact of the used chemicals on animals and human health, effect on environment, cost effectiveness as well as sustainability in production.

METHODOLOGY

The tomato seed was treated by *Trichoderma viride*, *T. harzianum*, *Pseudomonas fluorescens* @5g/kg and Bavistin@ 2g/kg seed half an hour before sowing in each one meter square area of replicated nursery plots on Chaitra 12, 2067. Observation of the germination and disease status was conducted in seven days interval until transplanting.

The seedlings (20 numbers) were treated by the same bio-fungicides ie@10g/liter of water and Bavistin@5g/liter of water, before planting in all the plots in 45 × 60 cm spacing under the plastic house. Same cultural practices were used in all treatments. Late blight and other foliar diseases were observed in both locations and all biological and chemical fungicides were sprayed 3 times in 15 days interval.. Dalila variety of tomato was sown in Bageswori and Shrijana was sown in Sudal VDC in spring and summer season. Economic analysis was done by comparing biological and chemical fungicides. Number of damping off affected seedlings and healthy seedlings were recorded in nursery bed and calculation was done as follows:

Damping off (%) = Damping of seedlings ×100 / Number of total seed planted
Healthy seedlings (%) =Total seedlings - Damping off seedlings

For the sustainability of the disease and insect management methods in farmer's level, disease scoring, simple statistical test i.e. overlap test in case of yield, benefit-cost ratio, and Duncan's multiple range test (DMRT) were applied during the analysis.

RESULT AND DISCUSSION

EFFECT OF TREATMENTON DAMPING OFF AND HEALTHY SEEDLINGS

Tomato seedlings were observed and counted after germination. Some seeds could not germinate due to its low viability and disease attack before the emergence from ground level and some died after emergence which is called damping off disease. Healthy seedlings having vigorous, dense and long roots were counted while transplanting in the main field and found following results.

Table-1: Influence of bio and chemical fungicides applied in seed treatment on Dalila variety of tomato against damping off in nursery bed at Bhaktapur district.

Treatments	Spring Season		Summer Season	
	Damping off affected plants (%)	**Survived plants at transplanting (%)**	**Damping off affected plants(%)**	**Survived plants at transplanting (%)**
T.viride	10	90	12	88
T. harzianum	12.5	87.5	14.5	85.5
P. fluorescens	13.5	86.5	13.5	86.5
Bavistin	21.25	78.75	25.0	75.0
Control	30	70	37	63
CV %	88.45	8.22	57.55	21.43

Survived and healthy seedlings of tomato were found in higher percentage in both season crop in the plot treated by *T. viride* (90% and 88%) and *T. harzianum* (87.5% and 85.5%) followed by *Pseudomonas fluorescens* (87.5% and 85.5%). Whereas chemical fungicide used plots have less healthy seedlings (78.75% and 75.0 %) as compared to bio agents used plots in both seasons.

The occurrence of damping off disease and healthy seedlings in tomato nursery in Shrijana variety on spring and summer season was found as follows-

Table2. Influence of bio and chemical fungicides applied in seed treatment on Shrijana variety of tomato against damping off in nursery bed at Bhaktapur district

Treatments	Spring Season		Summer Season	
	Damping off (%)	Survival plant at transplanting (%)	Damping off (%)	Survival plant at transplanting (%)
T. viride	22.62	87.38	15	85
T. harzianum	15.48	84.52	20	80
P. fluorescens	12.98	87.02	18	82
Bavistin	34.29	65.71	33	67
Control	41.52	58.48	44	56
CV %	23.44	23.44	6.43	25.53

We found, there is no significant difference in healthy seedlings of the tomato among *Trichoderma* and *Pseudononas fluorescens* treated plots in both seasons. But the significant difference in healthy seedlings were found less in Bavistin treated plots in spring (65.71%) and summer season (67%) as compare to *Trichoderma* and *Pseudononas fluorescens* treated plots. Similar results were found by the control plot also.

The attack of damping off disease in tomato found more in summer season as compared to spring season due to favorable temperature, humidity and environment and not proper work while applied bio agents or chemical fungicide. Therefore, we should practice other integrated approaches to reduce the incidence of damping off. Integrated approaches includes choose the nursery in sunny place, add manure to raise soil fertility and aeration, sown the seeds with wider spacing, raise the soil and provide proper drainage. Sharma (2011) found that the application of bio-agents in controlling Fusarium infection of seeds can cause 100 % germination and 90% control of disease.

EFFECT OF TREATMENT ON ROOT LENGTH AND NUMBER OF LEAVES AT TRANSPLANTING

Bio-agents while used in disease control produce enzymes and antibiotics to defence the pathogen. Then plant can observed more food from its rhizosphare which results plant vigor, long and more fiber roots and more number of leaves. Root length and number of leaves at transplanting were observed and recorded as follows.

Table 3. Influence of bio and chemical fungicides in root length and number of leaves at transplanting of Shrijana tomato applied in seed treatment

Treatments	Spring season		Summer Season	
	Root length (cm)	Leaves (No)	Root length (cm)	Leaves (No)
T. viride	2.5	6	3.5	6
T. harzianum	3.5	7	3.7	6
P. fluorescens	2.5	7	2.9	7
Bavistin	1.5	6	1.8	6
Control	1.3	5	1.5	5
CV	24.28	6.75	18.61	19.63

The root length of tomato at transplanting was found higher (3.5 and 3.7 cm) in *Trichoderma harzianum* followed by *T. viride* (2.5 cm and 3.5 cm) in both seasons. Root length of seedlings in Bevistin applied plots found less (1.5 cm and 1.8 cm) as compare to other bio-fungicides. The lowest root length (1.3 & 1.5 cm) and number of leaves (5 & 5) were found in control plots in both seasons.

The root length in both varieties found higher in summer crop than the spring due to hardiness of soil structure during same duration. But the number of leaves found no significant different in variety and seasons. The root length and number of leaves at transplanting of Shrijana variety in two seasons are as follows.

Table 4. Influence of bio and chemical fungicides in root length and number of leaves of Dalila tomato at transplanting

Treatments	**Spring season**		**Summer Season**	
	Root length (cm)	**Leaves (No)**	**Root length (cm)**	**Leaves (No)**
T. viride	4.3	5.2	4.5	6
T. harzianum	5	4.8	5.3	7
P. fluorescens	4	7	4.2	7.5
Bavistin	3.7	4	3.9	5
Control	3	3.9	3.4	5
CV	9.23	12.59	8.32	9.22

The root length of seedlings were found higher in *T. harzianum* (5 .0 and 5.3 cm) treated plots in both seasons followed by *T. viride* (*4.3* and 4.5 cm). Molecules produced by *Trichoderma* and / or its metabolic activities also have potential for promoting plant growth (Yadidia et al., 1999). Bavistin treated plots were found shorter root lengh (3.7 and 3.9 cm) as compare to *Pseudomonas fluorescens* (4.0 and 4.2 cm) and *Trichoderma* treated plots.There is significant difference in root length in Bevistin treated and control plot.

EFFECT OF TREATMENT ON AREA COVERAGE BY THE PLANT

Bio-agents besides antagonist and mycoparasitism characteristics, they have potential character to increase seed germination percentage, root and shoot length, fresh weight and dry weight in many plants. These results have seen in the trial tomato also. More area was covered by bio-control agents treated plant as compare to chemical fungicide treat (Figure 1).

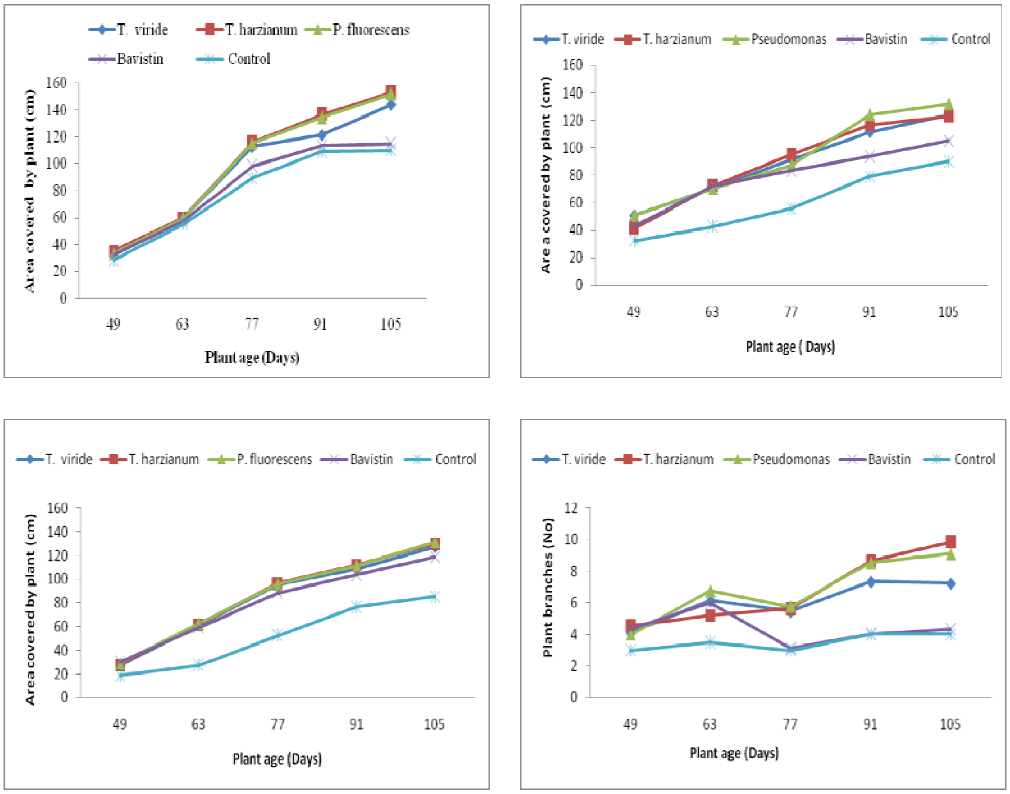


Figure 1. Area coverage by plant in different plant stage in spring and summer season Dalila and Shrijana tomato (A=Dalila spring, B=Dalila Summer,C= Shrijana Spring, D=Shrijana Summer)

Antagonists belonging to the genus *Trichoderma* are among the most commonly isolated soil fungi. Due to their ability to protect plants and contain pathogen populations under different soil conditions, these fungi have been widely studied and commercially marketed as bio-pesticides, bio-fertilizers and soil amendments (Francesco et al.,2008).

The colonization of the root system by rhizosphere competent strains of *Trichoderma* results in increased development of root / or aerial systems and crop yields (Harmen and Kubicek, 1998). Recent research indicates that corn whose roots are colonized by *Trichoderma* strain T-22 require about 40% less nitrogen fertilizer than corn whose roots lack the fungus (Howell et al., 2000).

Seed germination percentage, root length, shoot length, fresh weight, dry weight and vigor index were significantly increased by *T. viride* and *P. fluroescens*. *T.viride* inoculated cotton plants increased 2.7 and 2.4 fold, where as *P. fluorescens* increased 2 and 1.8 fold for shoot and root length respectively(Shanmugaiah et al, 2009).We clearly understands that bio-fungicide treated seed have longer root length as compare to chemical fungicide treated seeds. The observation results were found as similar which other researchers found.

Trichoderma species exert beneficial effect on plant growth and development (Harman, et al., 2004). *Trichoderma* strains can act colonizing the soil and/or parts of the plant, occupying the physical space avoiding the multiplication of pathogens, producing cell wall degrading enzymes against the pathogens, producing antibiotics that can kill the pathogens, promoting the plant development and inducing the defense mechanisms of the plant (Monte and Llobell, 2003). *Trichoderma* bio-control strains have evolved numerous mechanisms for both attacking other fungi and enhancing plant and root growth (Harman, 2000). Damping off caused by *Pythium indicum* in tomato seedlings had found good control by using *Trichoderma viride, T. harzianum* and *Laetisaria arvalis (*Krishnamoorthy and Bhaskaran, 1990). Application of plant based formulation of *Trichoderma harzianum* to nursery beds of egg plants was found effective in producing vigorous seedlings (plant height and seedling weight) with least root galling (Rao et al, 1998). Rhizobacteria–*Azosperillum sp., Azotobacter chroococcum* and *Pseudomonas fluorescens* found useful in improving emergence of tomato and reducing the damping off of tomato caused by *Rhizoctonia solani* (Gupta el al, 1995).

According to our study as well as other studies done by scientists, the application of bio-control fungicide effectively control the damping off disease in tomato rather than the chemical pesticide. Because due to the various characters like soil colonization, physical space occupying and competition in food, antibiotics and enzymes produce against pathogens and promoting the plant development may be the aggregate result in less damping off in *Trichoderma* applied plot. Similarly, *Pseudomonas fluoresecns* have found useful in improving emergence of tomato and reducing the damping off of tomato.

TREATMENT EFFECT ON DISEASE PREVELANCE ON FIIELD

Damping off, late blight, mosaic virus, wilt and nematode are major disease in this location in spring and summer crop of tomato. Farmers when observed wilt, late blight and mosaic virus in their filed, they recorded in both location in both seasons. Positive sign indicates prevalence of the diseases in the field.

Table 5. Disease status in spring and summer season in Dalila tomato at Bhaktapur district.

Treatments	Spring season				Summer Season			
	FW	BW	LB	MV	FW	BW	LB	MV
T. viride		+	+	+		+	+	+
T. harzianum			+	+		+	+	+
P. fluorescens			+	+			+	+
Bavistin		+	++	+		+	++	+
Control	++	+++	+++	++	+	++	+++	++

FW=Fusarium wilt, BW=Bacterial wilt, LB=Late blight, MV=Mosaic virus

Table 6. Disease status in spring and summer season Shrijana tomato at Bhaktapur district.

Treatments	Spring season				Summer Season			
	FW	BW	LB	MV	FW	BW	LB	MV
T. viride		+	+	+		+	+	+
T. harzianum			+	+		+	+	+
P. fluorescens			+	+			+	+
Bavistin		+	++	+		+	++	+
Control	++	+++	+++	++	+	++	+++	++

FW=Fusarium wilt, BW=Bacterial wilt, LB=Late blight, MV=Mosaic virus

Due to the temperature, humidity, moisture of soil, the incidence and intensity of disease we found different. Bacterial wilt found slightly more in summer than in spring crop in both varieties due to high soil moisture. Similarly, late blight found more in summer crop than the spring.

EFFECT OF TREATMENT ON YIELD

The mature and ripen fruits of tomato were harvested in separate and weighted. The average yield of two varieties of tomato in spring and summer season were found as follows.

Table 7.Yield effect on two varieties of tomato in two seasons at Bhaktapur

Treatments	Yield of Shrijana variety (t/ha)			Yield of Dalila Variety (t/ha)		
	Spring	Summer	Average	Spring	Summer	Average
T. viride	89.51	87.65	88.58	101.2	86.21	93.72
T. harzianum	95.68	90.95	93.31	116.0	87.04	101.5
P.fluorescens	94.44	84.57	89.51	100.0	86.63	93.31
Bavistin	80.86	71.81	76.34	64.81	78.39	71.6
Control	59.26	52.06	5. 566	53.06	52.47	52.77

In Shrijana variety, we found distinct difference in yield between bio and chemical fungicide used plots. The maximum and similar yield were found from *T. harzianum* (95.68 t/ha) and *Pseudomonas fluorescens* treated plot (94.44 t/ha) followed by T. *viride* (87.65 t/ha) used plot in spring crop. Whereas lower yield was obtained from Bavistin used plot (80.86 t/ha). In control plot, the yield found lower (52.06 t/ha) due to attack of different diseases. Similar yield trend have found in summer season tomato also. In case of Dalila variety, the yield found higher in *T. harzianum* treated plot (116.0 t/ha) followed by *T. viride* (101.2 t/ha) and *Pseudomonas fluorescen* (100.0 t/ha) in spring crop. There is higher difference in yield between Bavistin (64.81 t/ha) and bio-fungicide treated plots. The lowest yield was found from control plot (53.06 t/ha). Similar yield trend was found in summer crop in Dalila variety.

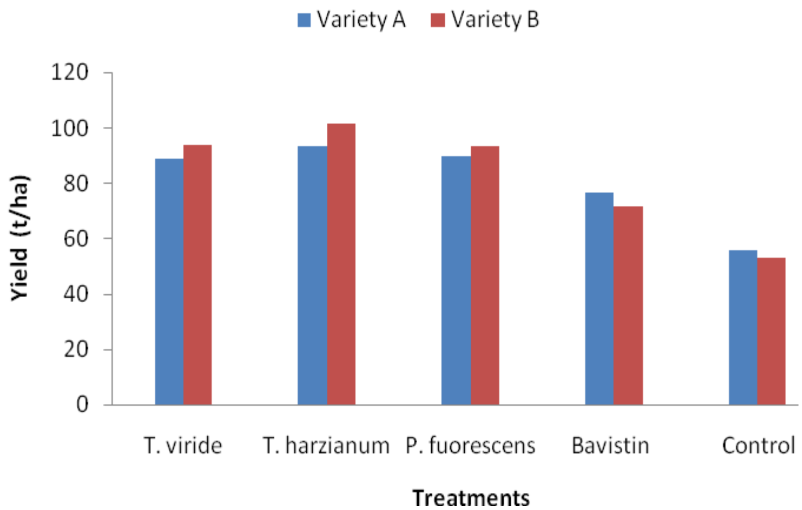
Many researchers have done the research using bio-fungicides in effective disease control. Among them some are mentioned below to support our studies.
Trichoderma species are now the most common fungal biological control agents in antagonistic action against wide range of fungal plant pathogens (Kucuk and Kivanc, 2008).

Due to the antagonistic potential in *Trichoderma,* the effective application of *Trichoderma species* as an alternative to chemical control against a wide set of fungal plant pathogens (Chet, 1987; Harman and Bjorkman, 1998). *Trichoderma species* are beginning to be used in reasonably large quantity in plant agriculture, both for disease control and yield increases. It is also useful for producing transgenic plants resistant to diseases and the enzymes themselves are beneficial to biological control and other processes. (Harman, 2006).

Pseudomonas fluorescens are aggressive colonizers of the rhizosphere of various crops, and have broad spectrum antagonistic activities over plant pathogens, such as antibiosis (Cartwright, et al., 1995; Rasales, et al., 1995). Some species of *Pseudomonas* have been recognized as antagonists of plant fungal pathogens and antibiotic producers (O'Sullivan and O'Gara, 1992).

Strains of *Pseudomonas fluorescens* have known biological activity against certain soil-borne phytopathogenic fungi and antagonist activities against *Macrophomina phaseolina*, *Rhizoctonia solani*, *Phytophthora nicotianae var.parasitica*, *Phythium sp. Fusarium sp.* (Ahmadzadeh,et al., 2006).

The yield of tomato in spring season in both varieties found higher than in summer season. It's due to the lower incidence of late blight as well as nematode.



Variety A= Shrijana, Variety B=Dalila

Figure 3. Yield effect in tomato after the application of bio and chemical fungicides

The yield response found higher in Shrijana variety on bio-fungicide applied plots as compared to same treatment of Dalila variety. But in Bavistin and control plot found responded higher in Dalila variety as compared to Shrijana variety due to soil characters and environment. It's may be the genetic character of the plant.

Table 8. Analysis of variance (ANOVA) table

Sources	Degree of Freedom	Sum of squares	Mean squares	Computed F value
Replication	2	1081.62	540.81	11.26***
Season	1	8892.19	892.81	18.59***
Variety	1	54.74	54.74	1.14
Season × Variety	1	20.55	20.54	0.43
Treatment	4	14955.74	3738.94	77.87*
Season × Treatment	4	641.42	160.36	3.34*
Variety× Treatment	4	363.38	90.84	1.89**
Season × Variety × Treatment	4	978.18	244.55	5.09**
Error	38	1824.59	48.02	
Total	59	20813.05		

Average of three replications CV= 8.49 % ***=Very highly significance at 5% level ** =High significance at % 1% level *= Significance at 5% level NS= non significance

Replication and season found very highly significance. Variety and season as well as season, variety and season found high significant. Treatment and variety and treatment found significance. But variety and season cannot found any significance.

Interaction effect of seasons and treatments on yield (t/ha)

Season / Treatment	Season Spring	Summer
T.viride	95.37b	86.93c
T.harzianum	105.86a	88.99bc
P.fluorescens	97.22b	85.59c
Bevistin	72.84d	75.1d
Control	56.16e	52.26c
F test	Significant	
LSD	8.005	

Interaction effect of seasons, varieties and treatments on yield (t/ha)

Season	**Spring**		**Summer**	
Treatment	**Dalila**	**Shrijana**	**Dalila**	**Shrijana**
T.viride	101.22 ab	89.51 bc	86.20 bcd	87.66 bcd
T.harzianum	116.05 a	95.68 bc	87.03 bcd	90.94 bc
P.fluorescens	100.00 a	94.44 bc	86..62 bcd	84.67 bcd
Bavistin	64.81 efg	80.87 cde	78.39 bcd	71.81 def
Control	52.05	59.26	52.47	52.06
F test	Highly Significant			
LSD	15.06			

Season, variety and treatment were analyzed and these results were found.

Table 9. Main effect on season, variety and treatments of tomato yield (t/ha)

Factors	Level	Yield (t/ha)
Season (Factor A)	Spring	85.492
	Summer	77.777
	F test	***
	LSD	4.76
Variety (Factor B)	Dalila	82.589
	Shrijana	80.679
	F test	NS
	LSD	-
Treatment(Factor C)	*T. viride*	91.152
	T. harzianum	97.427
	Pseudomonas	91.41
	Bavistin	73.97
	Control	54.212
	F test	NS
	LSD	7.530
	SEm±	1.265
	CV	8.49

***=very highly significance NS=Non significance

Table 8. Economics of bio and chemical fungicide application for the control of damping off and late blight in Dalila variety tomato at Bhaktapur

Treatments	Yield (t/ha)	Deviation from the control		Cost of seed and seedling treatment and two sprayings			Fixed cost (NRs)	Total cost (NRs)	Net profit (NRs)	Benefit cost ratio
		Yield (t/ha)	Value (NRs)	Chemicals	Labor	Total				
T.viride	93.72	40.95	3280.2	2.25	25.0	32.25	60.0	87.25	3192.9 5	37.59
T. harzianum	101.5	48.73	3552.5	2.25	25.0	32.25	60.0	87.25	3465.25	40.71
P *fluorescens*	93.31	40.54	3265.8	2.25	25.0	32.25	60.0	87.25	3178.55	37.43
Bavistin	71.6	18.83	2506.0	1.75	25.0	31.75	60.0	86.75	2419.25	28.88
Control	52.77	-	847.0	-	25.0	30.0	60.0	85.0	1762.0	21.72
Mean	82.58									
SEm±	1.265									
LSD 0.05	7.530									
CV(%)	8.49									

Benefit cost ratio of Dalila variety was analysed and found highest in *T. harzianum* (40.71) used plots followed by *T.viride* (37.59) and *P. fluorescens* (37.43). Bavistin found lower (28.88) than other bio-agents and control found the lowest (21.72) benefit cost ratio. But according to the theme of benefit cost ratio, we found all these treatments were economically viable.

Table 9. Economics of bio and chemical fungicide application for the control of damping off and late blight in Shrijana variety tomato at Bhaktapur

Treatments	Yield (t/ha)	Deviation from the control		Cost of seed and seedling treatment and two sprayings			Fixed cost (NRs)	Total cost (NRs)	Net profit (NRs)	Benefit cost ratio
		Yield (t/ha)	Value (NRs)	Chemicals	Labor	Total				
T.viride	88.58	35.43	3543.2	2.25	25.0	32.25	60.0	87.25	3950.95	40.61
T. harzianum	93.31	37.65	3732.4	2.25	25.0	32.25	60.0	87.25	4140.15	42.77
P *fluorescens*	89.51	33.85	3580.4	2.25	25.0	32.25	60.0	87.25	3988.15	41.03
Bavistin	76.34	20.68	3054.0	1.75	25.0	31.75	60.0	86.75	3461.75	35.2
Control	55.66	-	2226.4	-	25.0	30.0	60.0	85.0	2636.40	26.19
Mean	80.68									
SEm±	1.265									
LSD 0.05	7.530									
CV(%)	8.49									

The benefit cost ratio of Shrijana variety found higher in *T. harzianum* (42.77) followed by *P. fluorescens* (41.03). Bavistin found lower benefit cost ratio (35.2) as compare other bio-agents but higher than the control (26.19). Benefit cost ratio is the ratio of gross return to the cost of cultivation which can also be expressed as returns per rupee invested. Any value greater than 2 is considered safe to the farmers from every rupee invested (Ready and Ready, 2002). On the other hand, a minimum B: C ratio of 1.5 for agricultural sector has been fixed for any enterprises to be economically viable (Bhandari, 2003).

CONCLUSION

It can be concluded and recommended that the application of *T. harzianum for the control of damping off disease in Shrijana* variety found highest yield followed by *P. fluorescens* and Bavistin as compared to Dalila variety. But time of application, pH, texture, moisture, suitable condition for parasitism affected the efficacy of bio-control agents (Spadaro and Gullino, 2005; Inam-Ul-Haq,et al.2009). In disease control by *Trichoderma spp.* sandy clay loam soil gave better *Fusarium* contol than clay loam (Spadaro and Gullino, 2005). *Trichoderma* favour acidic soil (Chet and Baker, 1981; Papavizas, 1985)and nutritional conditions (Kucuk and Kivanc, 2008). *Pseudomonas* has evaluated promising bio-contol agents (Van Loon et al 1998; Lemanceau, 1993). Wahid (2006) found that using bio-control agents in combinations givebetter results than use of single only.

Acknowledgements

The financial support for this work was provided by National Agricultural Research and Development fund (NARDF) and the program was completed by joint effort of The IPM Trainers' Association, Nepal (TITAN), District Agriculture Development Office and District

Integrated Pest Management Committee of Bhaktapur. We are grateful to NARDF for financial support and Entomology Division of Nepal Agricultural Research Council for technical backstopping in project completion.

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LIVELIHOOD DIVERSIFICATION AND CLIMATE CHANGE ADAPTATIONIN INDO-GANGETIC PLAINS: IMPLICATION OF RAINFALL REGIMES

Gopal D Bhatta[1]; Pramod K Aggarwal[2] and Amit Shrivastava[3]

ABSTRACT

We investigate whether spatial variations in climatic resource such as rainfall have prompted livelihood diversification, local adaptation and household food availability in Indo-Gangetic Plains using data from a household survey of 2660 farm-families carried out in India, Bangladesh and Nepal. We found that on-farm livelihood sources are higher in high rainfall regime (1300-1800 mm) compared to medium (<1300 mm) and very high rainfall regime(>1800 mm). The off-farm sources are higher in medium rainfall regime. Although a large number of changes are attributed to harvest better yield, yet farmers made numbers of changes in response to climatic variability as well. Although agricultural livelihood and local adaptation are restrained by several climatic and non-climatic factors; the amount of annual rainfall significantly affects livelihood diversification, and the impact of climatic stressors becomes more pronounced when there is interaction with other non-climatic factors. The results imply that livelihood and adaptation strategies should be tailor made along the climatic and non-climatic resources.

Key words: Adaptation, Climate change, Indo-Gangetic Plain, Livelihood diversification, Rainfall regime

INTRODUCTION

The Indo-Gangetic Plains (IGP),a "bread basket" for much of South Asia, is considered to be highly vulnerable to climate change due to its huge population, a largely agrarian economy, a relatively limited and depleting resource base, and projected large changes in climatic risks (New et al., 2012; Saini, 2008; Aggarwal et al., 2004). While the region is self-reliant on cereal production, it has pervasive poverty and malnourishment (Gill et al, 2003; FAO, 2002). The changing climate is exacerbating existing vulnerabilities of the subsistence farming that predominates in many parts of IGP (Nelson et al., 2009; IPCC, 2007; Slingo et al., 2005).

Climate-related issues and farmers' livelihood strategies are different in different parts of IGP. For instance, many farmers in Nepal and north east India suffer from droughts and intermittent floods whereas coastal Bangladesh is a 'hotspot' of climate change (Nicholls et al., 2007).As an attempt to overcome some of the climatic and non-climatic challenges, farm households diversify their livelihood sources (Brown et al., 2006; UNDP, 2009). Several researchers (e.g. Bhatta and Aggarwal, 2015; Teweldemedhin and Kapimbi, 2012; Hailu and

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Hasan, 2012; Barrett et al., 2006; Marschke and Berkes, 2006; Barrett and Reardon, 2001) offer the reason that farm households follow agricultural diversification as a prominent coping strategy under uncertainty caused by climatic and non-climatic factors.

Coping with climatic variability is crucial to adapting to the changing environmental conditions, including climate change and variability (Cooper et al., 2008). Diversification on the farm and off-farm determine the strength of coping strategies farm households follow (Hailu and Hasan, 2012; Gebru and Beyene, 2012; Thornton et al., 2007); the larger the diversification portfolio on the farm and off-farm, the more successful are the farmers in coping adversities which in turn contributes to adaptation. Similarly, the strategies that have been shown to increase agricultural productivity and adaptation to climatic variability include integrated plant management practices and integrated farming systems (Hesterman and Thorburn, 1994), expansion of areas under cultivation to compensate for reduced yields during droughts, and switching to more drought resistant crops (Mongi et al., 2010), resource-conserving technologies (Harington and Hobbs, 2009; Ladha et al., 2009; Gupta and Seth, 2007), and enhancing water use efficiency. In addition, other farming practices that are important in response to the climatic risks are better management of the pasture lands, adoption of drought tolerant pasture species, better livestock management practices, cultivation of drought and flood tolerant varieties of the crops, disease and pest resistant cultivars, shorter cycle varieties, introduction of crop cover, planting trees, among others. Development of location-specific varieties, climate specific agronomic practices, and adoption of short season varieties to escape the late season droughts are some of the other adaptation strategies amidst climate change scenario (Bhatta and Aggarwal, 2015; Chhetri and Easterling, 2012).

The relationship between average annual rainfall, and farmers' livelihood,and local adaptation could be a matter of interest for many scholars to devise policies aiming at improving livelihoods and enhancing adaptive capacity of the farmers at the spatial level. It is because some environmental issues and threats posed by climate change to livelihoods are likely to be spatially variable and solution to such problems may often require supra-national considerations (GECAFS, 2008) based on spatial specificities. Since IGP possesses varied agro-ecological and biophysical conditions such as a distinct rainfall pattern from east to west of the region, farmers' strategies to manage available resources also differ. Since a large proportion of farm land in IGP is rainfed, annual rainfall is important not only in determining production but also how farmers in different rainfall regimes cope with climatic variability overtime. It is, therefore, important to understand whether key climatic (rainfall) and non-climatic resources (farm types) impact livelihoods and adaptation amid changing environmental conditions. We attempt to narrow down this gap through an investigation of a household survey carried out with 2660 farm-families in threebroader sub-regions in IGP (Bihar of India, coastal Bangladesh and Terai of Nepal). We hope that this study would provide policy makers and sectoral actors with process knowledge that could improve coping and adaptation strategies for climate change.

METHODS AND DATA

THE SITES AND SAMPLING PROCESS

A household survey was implemented in 2010-2011 in the three broad agro-ecological regionsin the Indo-Gangetic Plain (IGP) with average annual rainfall ranging from 930 mm to 3350 mm (CRU, 2013). The sites surveyed lie in the eastern region, which is characterized by relatively lower productivity, poorly developed infrastructure, food insecurity, smallholder subsistence farming and is prone to flooding and droughts (Aggarwal et al., 2004).The study sub-regions represent climate 'hotspots' (flood and salinity affected areas of coastal Bangladesh to drought prone areas of Nepal's Terai and Bihar, India), rainfall regimes (very high rainfall areas of coastal Bangladesh to high rainfall areas of Terai and moderate rainfall areas of Bihar), and the local livelihood systems (aquaculture based livelihoods in coastal Bangladesh to cereals and vegetables based livelihoods in Terai and Bihar).

The sampling process was done at three different stages (Bhatta and Aggarwal, 2015): I) broader sub-region was selected from India, Nepal and Bangladesh primarily based on similar climatic issues, II) smaller areas (mostly districts) were selected from each sub-region based on predominant rainfall pattern (7 districts each from Bihar and coastal Bangladesh and 5 from Terai), and III) finally layering a sampling frame in each site (10 km x 10 km) was done purposively in each selected district based on the area with some potential of piloting climate smart agriculture interventions. From each sampling frame, all villages were enumerated and 7 villages were selected randomly. Following simple random sampling, 20 households within each village were chosen. Therefore, the total sample size was 980 each in Bihar and coastal Bangladesh and 700 households in Terai.

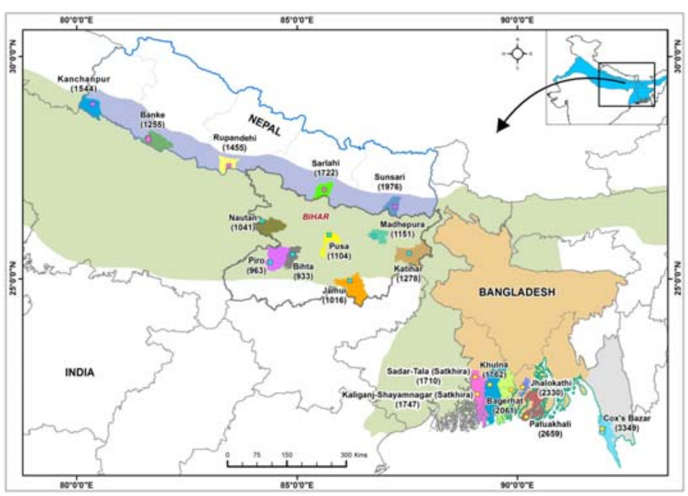

Figure 1. Sites surveyed in Indo-Gangetic Plain (Values in the parenthesis indicate average annual rainfall, mm)

SURVEY INSTRUMENTS AND DATA COLLECTION

A highly structured questionnaire was designed, pre-tested and the same questionnaire (available at:www.ccafs.cgiar.org/resources/baseline-surveys) was implemented across at all sites. The questionnaire included most of the qualitative information to map the behaviours of the farm households in several spectrums of the farm activities. The questionnaire has different components: socio-demographic information, sources of livelihoods, changes in farming practices including livestock and fisheries over the last 10 years, reasons of changing farming practices, household food availability, land and water resources, input and credit availability and use, climate and weather information, membership to community groups and household assets, among others. Before implementing surveys in each site, site survey team leaders and enumerators were provided with intensive training to ensure high level of precision on sampling and data collection.

DATA ANALYSIS

The historical rainfall data (1961 to 2010) for this study was extracted from the Climate Research Unit (CRU) gridded database. CRU time-series datasets are month-by-month variations in climate over the last several decades. The dataset comes on high-resolution (0.5 × 0.5 degrees) grids (CRU, 2013). Since the basic interest was to see any variations on livelihoods, adaptation and food available months along the prevalent rainfall gradient; functional relationship was tested. Before running functional relation, normality test was deployed and the variables satisfyingnormal distribution were subjected to functional analysis. In the first step, country-wise regression lines were fitted followed by line of the best fit across all sites using appropriate functional relation. Further to see more variation as per irrigated and non-irrigated farms along the prevalent rainfall gradient, data were disaggregated and appropriate functional relation was tested. For the ease of explanation,different sites were categorized into medium rainfall zone (<1300 mm annual rainfall), high rainfall zone (1300-1800 mm) and very high rainfall zone (>1800 mm). With this grouping, all of the sites in Bihar of India fall in medium rainfall regime, most of the sites in Terai fall in high rainfall regime and all sites in coastal Bangladesh in veryhigh rainfall zone.A rough proxy for adaptability was derived by adding up the number of changes that households have made in the last 10 years with respect to their farming practices. The idea here is that households that have already been making changes, and introducing new practices, are likely to be more adaptive to climatic risks, than those that have not been able to make adjustments or introduced any new innovations. The number of food available months is used in this analysis which is considered as the best bet proxy of food security at the household level.

RESULTS

LIVELIHOOD DIVERSIFICATION

Farmers derive their livelihoods through a variety of on-farm,non-farm and off-farm sources,and these sources are different across the sites. Majority of the farm-families in the studied sub-regions predominantly pursue agriculture-based livelihood strategies through intensification and diversification. In Bihar and Terai of Nepal, a majority of the farmers derive their livelihoods through food crops whereas livestock including fisheries is an important on-farm livelihood source in coastal Bangladesh. It should also be understood that integration is a historic phenomenon in smallholder farming systems in IGP.

Despite continuing economic centrality of agriculture in the surveyed sites, farm-families are often enforced to pursue off-farm livelihood strategies to cope with diverse challenges and risks and accumulate cash for present and future security. Off-farm sources of livelihoods in IGP are manifold: wage earning from other's farm, employment in several sectors, remittances, credit/loan and business, among others. These off-farm sources of income help farmers to complement agricultural activities. In Bihar, a large proportion of the farm-families are engaged in wage earning either in others' farm and/or in other non-farm sectors, followed by employment in different sectors. Farmers in the coastal Bangladesh also mostly engaged in wage earning followed by pursuing credit/loans from formal and informal sectors. In Nepal's Terai, a large proportion of farmers are deriving income through employment followed by the wage earning activities. In Bihar and Nepal's Terai, remittance accounts the third important source of off-farm livelihoods while business provides a third off-farm source to the farmers in the coastal Bangladesh.

The sources of on-farm livelihood and rainfall gradient across the sites in each country and across all sites in the region show a polynomial relationship (Figure2a). In Bihar, higher is the average annual rainfall; higher are the sources of livelihoods up to a certain extent. Similar trend turns true in coastal Bangladesh and Terai but the slope of the curve is steeper in Terai. On average, the numbers of livelihood options are higher in Nepal's Terai compared to Bihar and coastal Bangladesh. Although rainfall regime is higher in coastal Bangladesh, several other factors such as salinity, recurrent floods, sea level rise and cyclones limiton-farmlivelihood diversification.

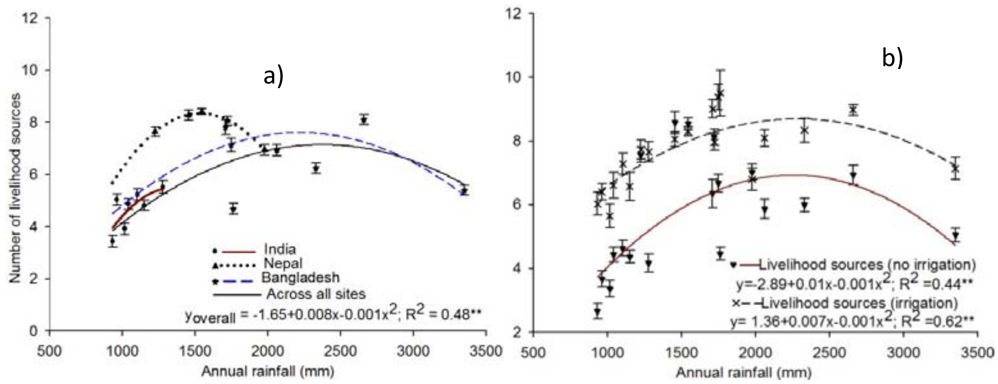

Figure 2. Relationship between annual rainfall, and number of livelihood sources (a) and number of livelihood sources within irrigated and non-irrigated farms (b) in IGP (Error bars indicate the 95% confidence interval of the mean)

The regression line (R^2 = 48%, p<0.01) across all sites follows sub-region specific regressions, that is, with increasing rainfall regime, number of sources of livelihood also increases up to a certain point. Although there could be several climatic and non-climatic factors affecting on-farm livelihoods, the current results portray that higher rainfall zone (1300-1800 mm) shows higher on-farm diversification. As expected, data disaggregation by irrigated and non-irrigated farms show similar trend and the higher level of diversification is associated to irrigated farms (R^2 = 62%, p<0.01) than rainfed farms (R^2 = 44%, p<0.01)(Figure2b). The results pinpoint that having irrigation facility serves as a precursor for livelihood diversification on the farm irrespective of the rainfall regime and its effect is more pronounced in higher rainfall zone. It is interesting to note that both regression lines move almost parallel along the rainfall gradient. This portrays, to some extent, that irrigation has homogeneous effect on livelihoods along rainfall regimes.

Rainfall regimes and number of off-farm livelihood sources show a significant polynomial relation (Figure3). Despite the lower rainfall regime, numbers of cash sources are more and they decrease at higher rainfall regime. Farmers in the Bihar, for instance, have more cash sources compared to Terai and coastal Bangladesh. With an increasing rainfall regime, number of sources of cash increases up to a certain extent in Bihar, Terai and coastal Bangladesh but the degree of increment with rainfall regimes is higher in Bihar compared to other sub-regions. Lower number of on-farm livelihood sources and higher number of off-farm sources in medium rainfall regime (<1300 mm) somehow signifies that farmers are slowly moving out of agriculture. While country-specific regression lines are concave to the origin, overall regression line is convex stating that farmers in relatively lesser rainfall area possess more sources of cash and it declines with increasing rainfall regimes.

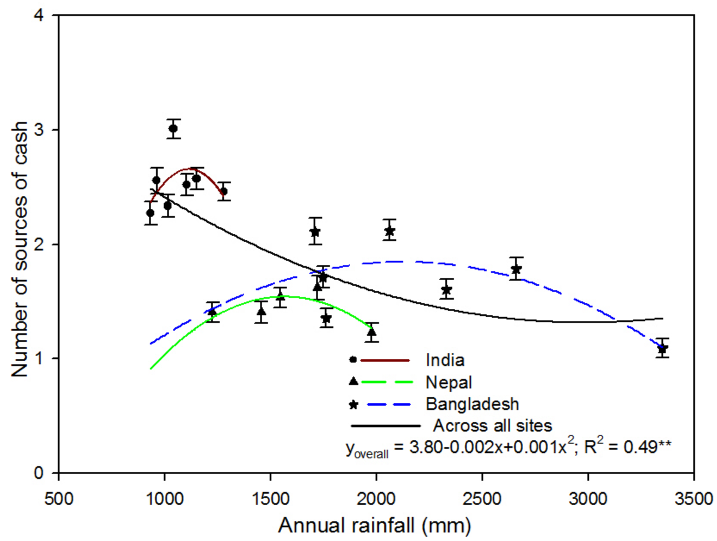

Figure 3. Relationship between annual rainfall and sources of cash (Error bars indicate the 95% confidence interval of the mean)

FARMING PRACTICES CHANGED AND ADAPTATION TO CLIMATIC RISKS

The number of changes in farm practices provides a proxy measure of adaptability. We asked farmers different changes they made on variety, breed, crop and livestock management, soil and water management, production practices and feeding, among others. Among the portfolio of changes in farming practices; frequent changes in varieties shows consistence result across sites and a large proportion of the households made several changes in the varieties. Changes in planting time and methods (such as late planting, early planting, early land preparation, mechanized planting) show variations in the sub-region. Changes in plant management (irrigation use and methods, agro-chemical use, and disease and pest management) showed consistent results both in Bihar and Nepal's Terai compared to coastal Bangladesh. A large chunk of the farmers made changes in livestock in coastal Bangladesh.

In Bihar, farming practices changed increases with increasing rainfall regime up to a certain extent. Unlike Bihar, Nepal and coastal Bangladesh show higher number of farming practices changed at a lower rainfall regime. There is no clear trend in terms of changing farming practices along the rainfall gradient across the sites (Figure4a). Number of farming practices changed over the last 10 years as per irrigated and non-irrigated farms along the prevalent rainfall gradient show polynomial relationship with average annual rainfall. With huge variation in irrigated farms, higher numbers of farming practices changed are noted at a medium rainfall regime (<1300 mm) both in irrigated and rainfed farms (Figure4b). With irrigation, farmers make higher number of changes. This is also substantiated by on-farm livelihoods as they are higher in the irrigated farms. However, both lines are statistically not significant (p>0.05).

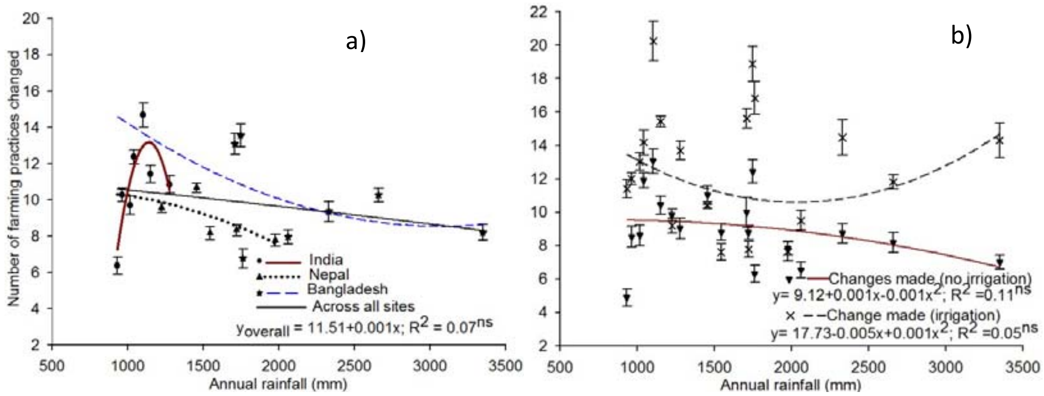

Figure 4. Number of farming practices changed (a) and as per irrigated and non-irrigated farm (b) along the rainfall gradient in IGP (Error bars indicate the 95% confidence interval of the mean)

Farmers make changes to farm practices in response to different stressors. Subsistence farmers' main interest is to secure on-farm production as an important livelihood strategy. We found that market-related factors are more frequently cited as reasons to changes in farm practices than climate-related factors (Figure5). Harvesting better yield, often by changing crops and/or varieties, remains the top reason for making changes in the farming practices across all regions and rainfall regimes. Issues related to land (e.g., declining fertility), labor (e.g., labor shortages), water (e.g., groundwater decline) and biotic factors (e.g., pest and disease outbreak in the particular crop and/or variety) are often frequently mentioned as reasons for making changes in the crops and/or varieties. Across rainfall gradient, very high rainfall regime (>1800 mm) shows lesser per cent of farmers making changes to adjust to the resource constraints, markets and climatic stressors but the per cent of farmers making changes to adjust to disasters (floods, cyclones, storm) are increasing. Ahmed et al. (2012) also noted that climatic hazards appear more frequently than other factors in coastal areas of Bangladesh, which requires an adjustment to such adverse events.

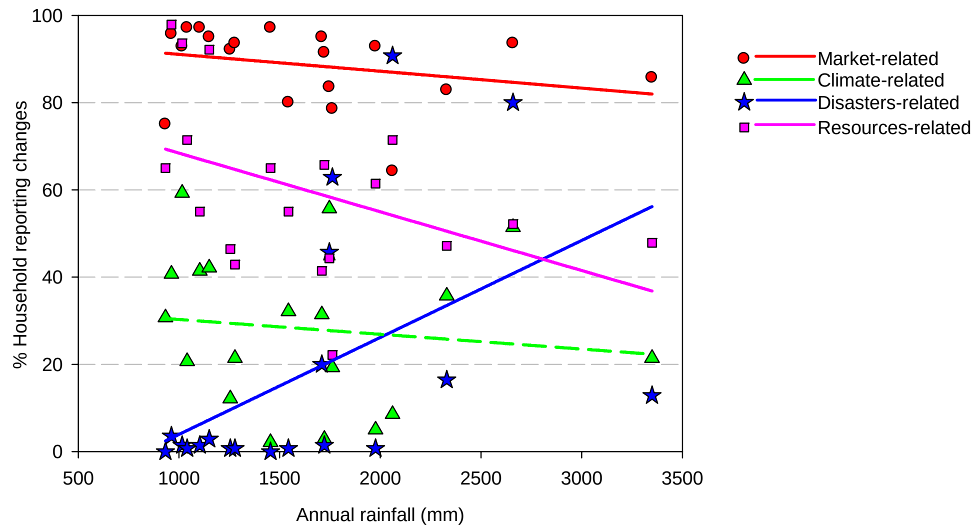

Figure 5. Different drivers of changes to farm practices over the last 10 year across rainfall regimes

In terms of climatic stressors, rainfall variability is the most frequently cited reason for making changes in farming practices in all sub-regions and across all rainfall regimes. Farmers also made frequent changes to adapt to droughts and floods that prevailed in many parts of IGP over the last 10 years. Late or early start of rain is another issue that some farmers in the surveyed areas experience. The growing number of cold spells during the winter season is now becoming another issue requiring adaptation to it in many sites.

HOUSEHOLD FOOD AVAILABILITY

We studied the number of food available monthsin a normal year. As we just studied number of food available months during a year, it only provides the food availability status in the household and through own farm production. With a large site variations, a majority of the farmers in the coastal Bangladesh support only a fraction of the year through own production. In contrast to this, a majority of the farmers in Bihar and Terai can produce food for their family almost throughout the year (almost 75% and 80% of the farm households in Nepal and Bihar are self-sufficient). Lower productivity of the crops, dominance of smallholder farmers and fewer number of livelihood sources are all contributing towards fewer months of food availability in the coastal Bangladesh.

With increasing rainfall regime, number of food available months increases in Bihar and Nepal's Terai (Figure6a). Coastal Bangladesh fails to show a clear pattern. The high rainfall regime in Bihar and Nepal shows higher months of food availability like on-farm livelihood sources. This supports the idea that more livelihood sources on the farm enhance household food availability. The overall regression line shows the higher number of food available months in a year at medium rainfall regime, which is basically due to the more food available months in Bihar. Since much of the household food availability in IGP revolves around the availability of rice and wheat, the lower production of these crops means less number of food available months. In the coastal Bangladesh, for instance, seasonal flooding due to heavy monsoon rain along with salinity intrusion causes frequent crop failure. Even in the dry season, there is the lack of fresh water for crop production (Karim and Mimura, 2008; Mirza et al., 2003). These all factors threaten on-farm production and household food availability. Farmers who have irrigation facility have more number of food available months than those who perform farming without irrigation facility. In both cases, relationship with rainfall is polynomial, that is, as rainfall regimes increase, the number of food available months decrease (Figure6b). Farmers with no irrigation facility show higher variations along the spatial gradient of rainfall.

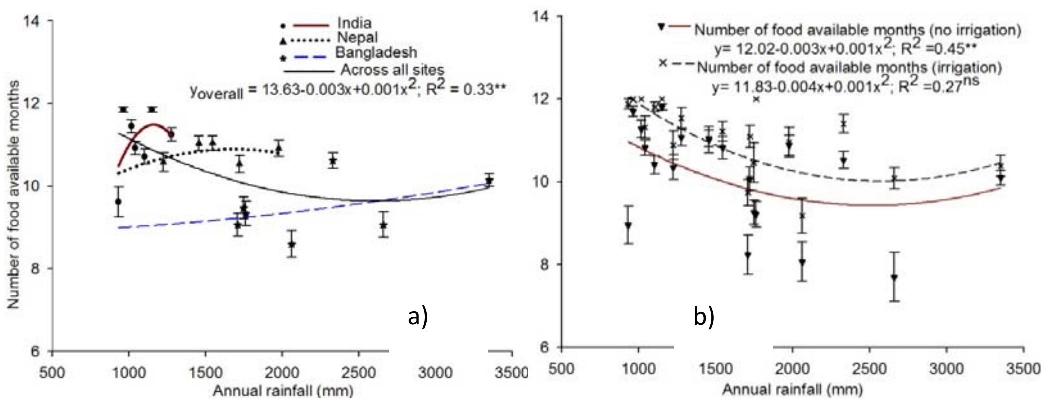

Figure 6. Number of household food available months in a normal year (a) and as per irrigated and non-irrigated farm (b) along the rainfall gradient in IGP (Error bars indicate the 95% confidence interval of the mean)

CORRELATION BETWEEN DIFFERENT VARIABLES

Correlation analysis was done to understand the degree of association between different variables. There is a significant relationship between land holding and on-farm livelihood sources, household assets, number of farm products sold, number of changes made in the farming and number of months of food availability per year (Table1). All of them are positively correlated. Similarly, farmers with more number of on-farm livelihood sources seem to possess more assets and more months of food availability. There is a strong relationship between a proxy measure of household adaptability- the total number of changes made in agricultural practices over the past ten years- and ones for the degree of agricultural diversification and number of farm products sold. This means that households that made more changes are producing a wider range of agricultural products; and conversely, those making few changes tend to be the least diversified households. Correlation test confirms a strong association between the number of changes made and the number of months of food availability. This means that the least food secure households made few changes in their agricultural practices, have relatively poor household assets, and are selling fewer types of agricultural products than more food secure households. This suggests that households that are pursuing adaptation strategies are enhancing their food security, as proposed by others (e.g. Di Falco et al., 2010). Households that had made more changes to their agricultural practices in the past ten years tended to have more assets; and those with few assets were farming in much the same manner as they have been for many years.

Table 1. Correlation between different variables

	On-farm livelihood sources	Off-farm livelihood sources	Household assets	Number of farm products sold	Number of changes made	Months of food availability
Land holding	0.30**	0.05^{ns}	0.36**	0.18**	0.19**	0.20**
On-farm livelihood sources		0.02^{ns}	0.46**	0.57**	0.53**	0.18**
Off-farm livelihood sources			0.12**	0.04^{ns}	0.20**	0.12**
Household assets				0.21**	0.23**	0.29**
Number of farm products sold					0.44**	0.15**
Number of changes made						0.20**

, Significant at 0.05 and 0.01 level of probability; ns: non-significant (p>0.05) monotonic*

DISCUSSION

There are several factors that farmers have to consider to make decision on farming activities, and their ability to adjust with the risks arisen from climatic and non-climatic factors makes some farmers (some regions) more adaptive/innovative than others. Changes in climatic variability and mean values will bring additional complexity in decision making by the smallholder farmers, who are highly vulnerable to these climatic risks (Gregory et al., 2005). The crux of the problem is whether or not climatic variability and change serves as a driver of livelihood diversification. It is obvious assertion that technological innovation in farming does not evolve with respect to climatic factors alone; non-climatic drivers such as market, and other socio-economic and institutional factors also play important and even stronger role. Often it is too complex and difficult to isolate the climatic factors from other driving forces of change (Tschakert, 2007; Raid and Vogel, 2006; Ziervogel et al., 2006; Eakin, 2005). But the impact of climate change and variability becomes more pronounced when there is an interaction with other non-climatic stressors (Mongi et al., 2010). Albeit much is still unknown about characteristics of the future climate, exploring the ways how the farmers with different resource endowments respond to specific climatic conditions can offer insights about how farming community might be able to adapt to future climate. The farmers' livelihood strategy and local adaptation along the climatic and non-climatic resources such as annual rainfall and farm characteristics in IGP needs to be understood for policy implications.

Higher level of on-farm diversification is associated with high amount of rainfall (1300-1800 mm). Both at medium and very high rainfall zones corresponding mostly to Bihar of India and southwest coastal Bangladesh respectively, on-farm diversification are limited. There could be several factors behind it. While salinity, floods and sea level rise are main constraining factors in the coastal Bangladesh, non-climatic factors such as off-farm employment opportunities limit on-farm diversification in Bihar. Livelihood strategies are also the product of the interaction between the portfolio of choices and constraints a farmer have. Since other environmental data and non-climatic information were not collected from the different sites, we are unable to identify other crucial parameters that likely influence livelihoods, farmers' adaptability and household food security. Similarly, climatic resource (such as annual rainfall) may vary in different villages within the same sampling frame (100 km^2), that may also affect local livelihoods. Economic background of the farmers also effect on-farm livelihoods. Since we didn't collect information on income and hence we can't establish relationship between household income and livelihood diversification. Ipso facto, farmers across the sites are deriving their livelihoods from multiple sources on the farms and off-farms. As there is no exactly a single livelihood strategy across the sites, diversification of livelihoods is a common strategy followed by the local communities to adapt to uncertainty (Bhatta and Aggarwal, 2015; ICIMOD, 2009), coping with the varieties of risks (Marschke and Berkes, 2006; Turner et al., 2003) and ensure food security at the local level (Hailu and Hassen, 2012). The implication of on-farm livelihood diversification is that some of them may be short-term coping mechanisms but some of them may lead to adaptation to vagaries of climatic and non-climatic risks (Marschke and Berkes, 2006).

Availability of irrigation facility enhances on-farm diversification across different rainfall regimes. Assured irrigation facility coupled with better water use efficiency enables farmers to diversify cropping systems and minimize risk from increasing drought spells and erratic rainfall patterns. Furthermore, farmers with irrigation facility can compensate inadequacy of rainfall by means of irrigation, which is an outcome of induced innovation (Chhetri and Esterling, 2012). With assured irrigation, farmers could produce more using inputs. Higher on-farm production also makes food available to the farmers throughout the year. Irrigation as such is not an innovative technology; however, the presence of irrigation expedites adoption of improved technologies such as high-yielding varieties of the crops and the use of agro-chemicals, and also enhances farmers' capacity to adapt to climatic risks (Chhetri and Easterling, 2012).

The off-farm cash sources are higher in the medium rainfall regime (<1300 mm). Although country-specific regression lines show increasing sources of cash with increasing rainfall regimes, the regression across all sites shows opposite trend. This finding is in congruence with Barret et al. (2005) and Babulo et al. (2008) who found that crop production alone is less likely to cover even the household consumption requirements in relatively lesser rainfall areas and hence farmers go for off-farm diversification to minimize risks. Similarly, Mertz et al. (2010) found that income from rainfed crops and/or livestock are mostly frequently mentioned in the wetter zone and migration based income, particularly through remittance, is important in the drier zone. The opposite movement of regression line also implies that there is interaction of socio-economic and biophysical factors with rainfall amount. This could be a good finding that livelihood strategies are location specific and policies aimed for a broader geographical area would have less meaning.

Individual farm-family and farming community are used to adapting to a range of environmental and socio-economic stresses (Bhatta and Aggarwal, 2015; Ojha et al., 2014). At the farm level, adaptation to climatic variability includes changes in farming practices (farm technologies and the way of farming). Adaptation may occur in relation to, for instance, agronomic or fisheries aspects regarding food production; or pricing policies and market opportunities (Kristjanson et al., 2012; Gregory et al., 2005). Some of these adaptations are not responses that are unique to climate disturbances, such as diversifying livelihoods, but importantly have been clearly identified in this research as deliberate consequences of climate triggers. These adaptations occur in order to change the nature of the risks when living in a variable and changing climatic system.

Many of the farm practices changed in IGP sites are related to crop and varieties. Kristjansen et al. (2012) also found that crops and/varieties are frequently changed over the last decade in East Africa. Varietal adoption alone, however, will have limited impacts on agricultural production, especially in the resource scarce areas. Farmers under such environment use different production technologies to avail the benefit from the new varieties. The development of suitable varieties, adoption of modern tools, and increased access to agro-inputs make varietal efforts more profitable in risk-prone environments (Pandey and Velasco, 2002). In general terms, we could state that all practices directed towards the success of cultivated crops are essential to food security, not only in the context of climate change. This is so because crop cultivation is subjected to the variability and unpredictability of weather events and pests and diseases, thus, all practices enhancing crop survival can be valid for climate change adaptation.

CONCLUSION

The implication of climatic and non-climatic resources such as rainfall and farm types on livelihood diversification, household food security and farmers' adaptation remain understudied in IGP. We found that farmers in the medium rainfall regime diversify less on the on-farm but more on the off-farm activities, indicating that agriculture is becoming less important in medium rainfall zone. On contrary, the farmers in the medium rainfall regimes often cope with the changing circumstances by frequently altering farming practices. They also have relatively lower number of food deficit months compared to those at high and very high rainfall regimes. Although agricultural production and local adaptation are restrained by several climatic and non-climatic factors; the amount of annual rainfall significantly affects livelihood diversification, and the impact of climatic stressors becomes more pronounced when there is interaction with other non-climatic factors. For instance, irrigation availability has shown higher number of on-farm livelihood options, more number of changes in farming practices over time and higher food security along the spatial gradient of rainfall. This proves that farming systems operate better in the presence of non-climatic resources, which could somehow counteract the impact of climatic stressors. The study also finds that resource rich farmers (such as those having irrigation on the farm) are better adapted, well diverse in terms of livelihood sources and have food available almost throughout the year than resource poor farmers (those who don't have irrigation). Therefore, in order to promote livelihood and adaptation under changing climatic conditions, resource poor farmers should be given proper care and provision of irrigation should be established.

Household perception of current and future adaptation needs point to important measures that are not directly climate-related. It makes sense that these more immediate and visible drivers have significantly greater influence on food insecure smallholder farmers than do concerns over long-term changes in the climate. Emphasis on increasing agricultural productivity is the imperative if the smallholders, who are reeling under tremendous environmental and socio-economic pressure with many roots in climate change, have to feed themselves. This is most likely also the case in similar regions in other parts of South Asia and the tropics and sub-tropics, particularly in the areas with a large concentration of smallholder subsistence farming predominates

ACKNOWLEDGEMENTS
The authors wish to express our gratitude to all members of site survey team for their hard work in collecting data. We would like to thank all interviewees in the local communities in different countries. Thanks are due to Patti Kristjanson for providingconstructive suggestions and required inputs in this study. We appreciate the support from CCAFS's numerous investors and CGIAR centre colleagues and partners. CCAFS baseline work was carried out with funding by the European Union (EU) and with technical support from the International Fund for Agricultural Development (IFAD).

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BIOPESTICIDES: EFFECTIVE ALTERNATIVE TO ORGANIC NEPAL

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ABSTRACT

Historically agriculture has been the major -culture to the majority of the Nepalese people, however, in recent days, the trend is gradually shifting towards other sectors like business and services. The dependency on agriculture both on direct and indirect has been declining from 90% to 65%, indicating towards its specialization, commercialization and diversification. This has further necessitated to the high input based agriculture, especially chemical fertilizers, pesticides and seeds. At the same time, considerable interests are pounding on the organic agriculture. This fact has becoming evident due to growing demands of organic produce within and outside the country. Nepal can earn money by producing and exporting of organic agricultural produce to its neighboring countries- China and India. In this context, Nepal is situated on the strategic point where it may take the advantages from the flourishing economy of its giant neighbors. Nepal can choose natural farming as well to rely on the use of biorational compounds like biopesticides for combating biotic and abiotic stresses. Very importantly, such products need producing within the home country and are made accessible to the farmers.

Key words: Biopesticides, Biotic stresses, Biorational compounds, Chemical pesticides, Fertilizers, Producers

INTRODUCTION

Chemical pesticides are substances used to control pests that are associated with agricultural crops. This includes fungicides, herbicides, miticides or acaricides, nematicides, rodenticides, avicides, mulluscicides, fumigants etc. Only few of the pesticides are plant origin and most of them are made with minerals and other elements. Modern use of chemical pesticides dates back to 1867, when Paris Green was first used to manage Colorado potato beetle. After that, various inorganic or plant originated pesticides came into existence. The successful discovery of the use of dichloro-diphenyl-trichloroethane (DDT) by the Swiss scientist Paul Hermann Müller in 1939 opened the floodgates worldwide for more and more pesticide synthesis and use, especially for the control of agricultural pests and vector-borne diseases. In Nepal, DDT and pyrethrum were use in 1950 from USA exclusively for Malaria control for Gandaki Hydropower Project. Subsequently, in November 1952, DDT became the chemical pesticide to be introduced in Nepal by Ministry of Health / the then His Majesty's Government of Nepal. This marked the introduction of pesticides in Nepal (Thapa, 1997, FAO, 2001). Not only this but also in 1955, Paris green, Gammexene and nicotine sulfates were imported for the same purpose of eradicating malaria. These pesticides were mostly provided by US Agency for International

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Development (USAID), which sponsored programs through grant assistance primarily for the control of vector-borne diseases. Since then, the use of pesticides as plant protection materials has steadily increased, with the introduction of high yielding varieties of rice, maize, wheat and vegetables which led to the formation of the Agriculture Inputs Corporation in 1967 to deal with agricultural inputs including pesticides. Nepal has a history of using chemical fertilizers and pesticides for more than forty years for higher agriculture production yields. The different groups of pesticides introduced in Nepal in different periods are: Organochlorines- 1950s; Organophosphates - 1960s, Carbamates- 1970s, Synthetic pyrethoids- 1980s. The use of chemical provides instant benefits but in long run these chemicals destroy the production capacity of the soil. They also leave negative impact on the life of the human beings, and lead to other environmental problems too. They often lead to breaking down of the resistance of the pests against the toxicity of the pesticides leading to pest outbreak, resistance and resurgence. Such realization gave birth to the concept of Integrated Pest Management (IPM) in 1990s with increasing emphasis of biopesticides. However, in Nepal, search of biopesticides has been the recent practices roughly after 2000. In support of Department of Agriculture through Plant Protection Directorate, *Metarhizium anisopliae* and *Trichoderma viridae* were started formulating in the private sectors for the first time in Nepal (GC *et al.,* 2008).

Most pesticides that are used in Nepal are broad spectrum in nature, which pose the effects both target and non-target organisms. Fewer of the compounds are safer, but their use has been extremely limited because of the farmers' choice. General tendencies of choosing chemical pesticides in Nepal are based on their knock down effects as higher the rate of killing better their values and vice versa. Majority of the farmers are unaware of pesticide types, dose, frequencies and waiting periods and safer disposals. The resultant effects on human health include cancer, birth defects, reproductive problems, tumors and damage of liver, kidney and neural organs. To prevent such hazards, Nepal has also banned 16 pesticides including PIC (Prior Informed Consent) listed pesticides (Methyl Parathion and Monocrotophos) in the country. Highly persistent types (POP pesticides), Phosphamidon and Organo-mercury fungicides, organochlorine including endosulfan and others some hazardous chemical pesticides have been banned in the country (PRMS, 2013). However, because of an open and porous border with India, there is a considerable, but unknown quantity of trade between farmers close to the border. Hence, illicit/illegal import of pesticides issue needs to be addressed in multilateral approach with neighboring countries to prevent potential infiltration of banned/ unregistered pesticides (Palikhe, 2005).

OBJECTIVE

- To explore the national scenario of organic agriculture and importance of biopesticides in organic farming
- To aware the use of chemical pesticides in agriculture and their consequences

NATIONAL SCENARIO

Every government in Nepal has been considering that agricultural development is in top priority, but the export situation is not that encouraging. Looking into the agro-ecological potentiality, Nepal can pursue agricultural development through the adoption of organic agriculture. Yet, Nepal has added advantages of adopting organic agriculture because of its organic nature of production and readily available markets in neighboring countries, the China and India. Organic agriculture systems promote the environmentally, socially and economically sound production of crops with respect to the natural capacity of plants and local conditions (Sharma, 2005). It aims to optimize quality production and is an emerging area, so this is the right time to begin organic agriculture in Nepal. Since there are various places in Nepal which is still beyond the reach of these chemical inputs due to lack of transportation facility. So we have still time to aware them of the situation and stop using such chemical inputs. Because of this, farmers of Nepal are still far from all the negative environmental effects of the inorganic method. For a country bestowed by nature with tremendous organic agricultural potentiality, this must be the right choice; however, it has not been able to harness it properly. Considering the level of awareness and scale of production, Nepal is still at infant stage for the promotion of organic agriculture. The promotion of inorganic farming techniques causes the deterioration of soil condition as well as it causes the undesirable effects. The chemicals decrease the quality of our food which is evident in the case of rapid loss of rice flavor as a result of excessive use of chemical fertilizers. What is missing today is the lack of availability of organic inputs such as organic fertilizer and biopesticides in one hand and also authentication of Nepalese niche products through certification. Market for organic produce is quite rudimentary and legal certification hasn't started. Most of the organic production and marketing system in Nepal is on the basis of community trust. In many cases, organic certification has becoming out of reach of majority of farmers. There has been lacuna in research on the technologies to support organic agriculture.

In the name of commercial farming, there has been rampant application of in-organic inputs, which is not only hazardous to both human life and the environment but also hinders in exports. Soil fertility is degrading day by day, and people are suffering with critical diseases even up to cancers due to the use of pesticide contaminated foods. If we do not become timely conscious and create awareness, the situation will be beyond our control, and become a great threat to our country. Necessary steps must be taken towards the institutionalization of organic farming in Nepal. Our initiative actions in this regard can be recognition for the future generations.

Along with the commercialization and knockdown effects, usages of chemicals have increased dramatically in recent decades. Even though the average fertilizer and pesticides consumption in Nepal is very low (26 kg and 396 gm a.i. per hectare respectively) but injudicious use is widespread especially in commercial area (Thapa, 1997; PPD, 2014). Some of the areas like Panchkhal are the living example with the consequences of mishandling and overuse of chemical pesticides where the people are suffering from skin irritation, headache, nausea, and the cases of skin cancer. The ignorance and awareness among the rural people leads to present consequences. Their usages have been concentrated mainly in cash crops destined for export, or the local market: particularly tea, vegetables, rice, cotton, bananas and several other crops. Unfortunately the regulation of pesticide trade and use and the ability of small-scale farmers to use the products effectively and safely have lagged behind. This is grossly lacking due to unavailability of effective alternative pest control compounds in Nepal. There is great influence of the multinational companies to promote chemical pesticides as numerous companies are involved in this business. Farmers are tempted by higher returns using chemicals, and feel the higher price of organic products does not offset the lower yield. Pesticides related problems in Nepal are difficult to notice except poisoning cases which however, may have posed long term effects to the non-target organisms, environments and human-beings. The result is often environmental contamination, severe health problems and un-profitable crop production. Pesticide misuse has been evident at many levels starting from import, storage, usages, waiting periods and handling of the empty containers. In majority cases, waiting periods are seldom considered. Fishing, dipping vegetables like tomato and brinjal and other crops are some of the obvious malpractices. Use of sub-standard and date expired pesticides with low public awareness are some of the common phenomenon in the inaccessible areas of Nepal. In general, systematic studies are lacking to monitor the undesirable side effects. Department of Agriculture through the involvement of Plant Protection Directorate has initiated Rapid Bioassay for Pesticide Residue (RBPR) facility in one of the market hobs of vegetables in Kathmandu (PPD, 2014). It has revealed that, some of the vegetables produced in some pocket areas possess pesticide residues excessively indicating the urgent needs of interventions, like organic agriculture.

METHODOLOGY

A lot of research articles related to the use of chemicals for the control of agricultural pests, production and use of chemical pesticides in different era , situation of organic farming, importance and use of biopesticides for pest management were reviewed. Information and feedback of biopesticides for the control of agricultural pests management in organic farming and consequences of chemical pesticides were gathered by interaction with the farmers, field visits, seminars and meetings. So, the paper is prepared based on documented materials and synthesis of experiences.

IMPORTANCE OF BIOPESTICIDES IN ORGANIC AGRICULTURE

Organic agriculture is more suited to the small holding farmers where majority of the farmers in Nepal owns less than a hectare of land. Organic produce not only contributes to the GDP but also helps in reducing the poverty through securing income. Organic agriculture is often inexpensive and easier for small farmers; it is not only because of price premiums, but also because of lower production costs. The technologies adopted in organic agriculture can decrease the costs of production as chemical inputs are substituted by locally available and cheaper organic inputs. There are substantial evidences of enhancing profitability and income of poor farmers through diversifying of the products. In order to create the awareness on organic movement, capacity building coupled with availability of organic inputs is important aspects. Hence, it has not been delay of the development of organic agriculture in the country. As a result, Government of Nepal has encouraged organic producers and exporters through subsidized program. Some of the Government laboratories as well as private industry have initiated biopesticide productions with their own efforts. Despite of the Government emphasis, organic movement has not been moving to the desired level in Nepal. Several reasons are associated for this. Government has made available chemical fertilizers on subsidized rate as well as supported for the organic fertilizer producers with some seed money however, not on the organic pesticide production. Considerable level of awareness and interest has been arisen among the producers, consumers and policy makers about the organic produce but the production is still below than 5%. Yet, it has to be widely realized that inorganic pesticides are more poisonous compared to fertilizers. Hence, increasing emphasis has to be given on the production and utilization of organic pesticides. Similarly, certification system of organic products is often cumbersome and expensive. This can be made accessible and easier by providing the subsidy and also by rendering the services in the field level. It should also formulate a policy in regards to organic agricultural development, so that Nepal can gradually become an organic country.

Elsewhere, agricultural sector is impacted by climate change and such impacts are seldom considered in a country like Nepal because of the poor research backups. Nepal's vulnerability in the agriculture sector is related to water, drought, floods etc. Commercial farming is heavily dependent on external inputs such as chemical pesticides and fertilizers. Such practices often invite undesirable results such as outbreak of insect pests and diseases as soil and water pollution. In some way, these issues can be well addressed through organic agricultural systems which can help to reduce agricultural GHG emissions through energy conservation, lower levels of carbon-based inputs, lower use of synthetic fertilizer and pesticides, and other features that minimize GHG emissions and sequester carbon in the soil. As soil is a major store of carbon, if organic agricultural systems are adopted overall soil quality can be improved. Scientific evidences suggest that widespread adoption of organic farming practices would offset 23% of greenhouse gas emissions from agriculture through soil carbon sequestration alone. The result is that agricultural soils have the capacity to take up carbon through roots, litter, harvest residues, and animal manures used in agricultural production. Similarly, use of biopesticides avoids the need of deadly poisonous chemical compounds from the plants and agricultural fields. The off-season production of vegetables and other numerous products can be exported if they are less contaminated with chemicals.

The demand of organic agriculture is increasing both in the internal as well as external markets (Ramesh *et al.,* 2005). It is estimated that about 5% of households of urban areas are consuming organic products and almost 50% are found to have desire in Nepal. Most of the farmers are well aware about the negative repercussion of the indiscriminate use of the agro-chemicals in their farm and opined that they would like to shift from inorganic towards organic agriculture; however, availability of production inputs like biopesticides and marketing for such products is the greatest bottleneck. Biopesticides are certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals. Microbial pesticides consist of a microorganism (e.g., a bacterium, fungus, virus or protozoan) as the active ingredient. Microbial pesticides can control many different kinds of pests, although each separate active ingredient is relatively specific for its target pest. For example, there is insect pathogenic fungus, *Metarhizium anisopliae,* which is effective to the ranges of insects (GC and Keller, 2005). Its production has been initiated with the local strains of Nepal. It avoids the need of synthetic pesticides. Bacteria based Bt, Nuclear polyhederosis virus and protozoan parasitoids are other bioagents, whose formulations are available in different forms. *Trichoderma* is another useful biofungicides. They can be used against diseases. Biopesticides are usually inherently less toxic than conventional pesticides. Biopesticides generally affect only the target pest and closely related organisms, in contrast to broad spectrum, conventional pesticides that may affect organisms as different as birds, insects, and mammals. Biopesticides often are effective in very small quantities and often decompose quickly, thereby resulting in lower exposures and largely avoiding the pollution problems caused by conventional pesticides. When used as a component of Integrated Pest Management (IPM) programs, biopesticides can greatly decrease the use of conventional pesticides, without decreasing crop yields. To use biopesticides effectively, however, users need to know a great deal about managing pests.

In this situation strengthening of awareness and import control would hardly accomplish the goal of organic Nepal. Since Nepal needs increasing its agriculture production to meet the demands of increasing population as well as to extend its niche markets in the international level. Support system be institutionalized and strengthened from seeds, fertilizers, biopesticdies, market promotion through certification and export. All domestic organics reach to consumers without labeling. Consumers have a belief that organic food is healthier, less polluted and more natural, than conventionally produced foods. Many of the consumers are of the view that quality of the organic products is good and that's why these products are expensive. Geographically, Nepal lies in very strategic positions for marketing organic products to its giant neighbors, the China in the North and India in rests of the areas. Nearly half of the world's population lies in these countries indicating greatest demand of such foods. The economy of these countries is rising and very vibrant and large number of people is demanding such foods. Nepal can alter its shifts and utilize its niche products in making economy robust.

FINDING AND CONCLUSION

There has been growing interests in organic agriculture in developing countries because of the availability of natural inputs as well as human resources. Also it is due to its wider variability in agro-climates. Nepal can use traditional and indigenous farming practices and knowledge because of its small production units. It manages and enhances diversity, to incorporate biological principles and resources into farming systems, and to ecologically intensify agricultural production. This leads to an increased engagement in farming which can trigger greater opportunities for rural employment and economic upliftment. Thus through greater emphasis on use of local resources contributes to the empowerment of farmers and local communities. It has very rich botanical diversity, which can also be utilized both in the form of organic manure and pesticides

Similarly, the use of household and municipal wastes offers greater potentiality to be transformed to produce nitrogenous based fertilizer equivalent numerous ton of urea. The poultry litter can also be used in place of inorganic fertilizers. Both of these wastes in Nepal are estimated to represent only 10% of the total organic waste available for the recycling in Nepal. Other large sources of organic wastes in the country are diary, cattle, sheep, goat, piggery, aquaculture, meat and fish processing which are also useful in the farming. If all these wastes are completely recycled, the country can potentially recover and recycle the organic waste to replace the inorganic fertilizer.

Bio-fertilizer, microbial fertilizer, and conservation of soil and symbiosis will be able to generate another 25%, making the organic options for fertilizer available in the country provided the technologies for organic fertilizer are well developed and commercialized (Veeresh, 1999). Rapidly growing food markets in domestic market, and half of the world population in the vicinity of Nepal, it can be a food bowl for safer food. Many report suggests, Indian organic food market has begun growing rapidly. With a population of over 1.3 billion, China has emerged as the world's largest consumer market for food and beverage (F&B), surpassing the United States in 2011. According to a recent study conducted by the Economist, China is the second fastest growing F&B market out of all major Asian countries, with an average annual growth rate of 30% in the past five years, according to the Ministry of Commerce. Way out for export oriented agriculture should focus on safer food market opportunities that exist in India and China and Nepal has comparative advantage for it due to its very diverse agro-ecology, and proximity to world's largest and growing organic food markets. Nepal can move ahead in this endeavor with capitalizing alternative bio-pesticides, fertilizer, crop varieties, and organic crop production techniques/technologies. For this purpose, a starting point can be alternative pesticides that are being developed in Nepal that can support for organic crop production. Nepal's rich biodiversity of local germpalsm along with its wider networks also provide an access for selection of crop varieties that are resistant/tolerant to major diseases and pests. Some agricultural areas in Nepal (in hills and mountains) have never used chemical fertilizers and pesticides for farming and by default these areas can well support the organic farming. The shift to inorganic in many areas are not very long, hence there is significant local and indigenous knowledge system still available for organic crop management. In order to move forward formation of a task force members consisting of cross section of experts, Government agencies, export agencies, processing/manufacturing industries, NGO, Universities, etc. can be involved.

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PERCEPTION AND ECONOMICS OF DRY DIRECT SEEDED RICE IN TERAI OF NEPAL

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ABSTRACT

Transplanting is widely practiced methods of rice establishment in puddled soils require large amount of labor and water, which are becoming scarce and expensive in Nepal. A field survey was carried out in six districts of terai region of Nepal during 2010. Sixty farmers, ten from each district were randomly selected. They were interviewed using face-to-face method based on semi-structured questionnaires to know their perception towards constraints, and economics of dry direct seeded rice (DDSR). Farmers were mostly using transplanted rice (TPR) because of less weed infestation and better crop establishment, but they were concerned with high cost of cultivation, higher water requirement and deterioration of soil after puddling operation. Farmers perceived DDSR as a cost reducing and less water requiring technology whereas severe weed infestation, poor crop establishment and reduced grain and straw yield were the major nuisance. Nevertheless, the B:C ratio of DDSR (2.0) was found higher than TPR (1.63). Therefore, DDSR could be an alternative to TPR in reducing cost of cultivation; however weeds are serious problems.

Key words: *cost, dry direct seeded rice, productivity, transplanted rice, weed management*

INTRODUCTION

Rice (*Oryza sativa* L. var. *Indica*) is the staple food of about half of the world's population, the majority of which is located in Asia (Palis *et al.*, 2010). In Nepal, rice is commonly planted by transplanting seedlings of 20-25 days on puddled soil. However, transplanting is becoming increasingly difficult due to shortage and high cost of labour, scarcity of water, loss of soil physical properties and increase in cost of cultivation (Rao, 2010). Whereas DDSR is becoming popular as it is cheaper alternative to transplanting. The direct-seeded area in Asia is about 29 million ha, which is approximately 21% of the total rice area in the region (Pandey and Velasco, 1999). Dry seeding saves labor at transplanting, provide faster and easier crop establishment. It involves less drudgery, provides additional benefit in raising the crop through saving 29% of total cost of production of the transplanted rice (Ho, 1998). DDSR reduces the irrigation requirement by 30% of the total water (1400-1800 mm) required for rice culture (Gopal *et al*., 2010), and have a high tolerance of water deficit (Yadav *et al*., 2004). Direct seeding of rice also allows early establishment of the wheat crop because rice crop mature 7-10 days earlier than transplanted crops (Balasubramanian

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and Hill, 2002). Yield in DDSR is often lower than TPR principally owing to poor crop stand and high weed infestation (Singh *et al.,* 2005).

Generally, water availability and the opportunity cost of labor are the major determinants of DDSR adoption. Dynamic labour markets are increasing in Nepal, though foreign labour markets attracted most of the Nepalese youths. Therefore, the transplanting method, although effective in controlling weeds, may not be feasible when labour is scarce and water availability for establishment is low or uncertain. In order to save water and labor and promote conservation agriculture (CA), with no/reduced tillage, it is absolutely essential to replace TPR with DDSR (Mann *et al*., 2007). It was felt necessary to assess farmer's perception towards DDSR over TPR with respect to its economics, constraints, and the choice of suitable weed management technology by the farmers in three clusters of CSISA (Cereal System Initiative for South Asia) project.

MATERIALS AND METHODS

In 2010, sixty DSR growing farmers, twenty from each cluster were randomly selected from the master list of farmers of CSISA project who adopted the technology in the previous year (In 2009). First cluster include Bara and Parsa districts (B/P), second Chitwan and Makwanpur (C/M) districts of central terai region, and third include Nawalparasi and Rupandehi (N/R) districts of western terai region of Nepal (Figure 1).

The region under study was very important in terms of trade and commerce along with modern agricultural technology. Rice, wheat and maize were the major cereals grown in these districts. Direct seeding of rice was practiced traditionally in Parsa, Bara, and Rupandehi districts by some ethnic groups like Tharu.

Figure 1: Map of Nepal showing study area under CSISA project during 2010.

Survey was conducted using of face-to-face interview method based on semi-structured questionnaires constituted general demographics, assess to resource, cropping system, perceptions of direct seeding in rice, perception of relative damage to crop yield caused by different weeds, use of herbicides to control weeds, and cost and return of direct seeded and transplanted rice. Farmer's perception to constraints and advantages of DDSR and TPR were ranked by using five point scales of variables comprising most, relatively more, moderate, modest, and not at all, using scores of 1.00, 0.75, 0.50, 0.25, and 0.00, respectively. The priority index for each variable was calculated by using formula of Miah (1993).

$$I_{prob} = \Sigma \frac{S_i f_i}{N}$$

Where, I_{prob} = Index value for intensity of problem

I_{prob} = Index value for intensity of problem

Σ = Summation S_i = Scale value of i^{th} intensity

f_i = Frequency of i^{th} response N = Total number of respondents

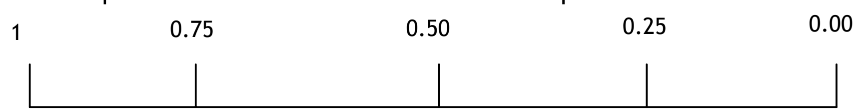

Figure 2: Scale value for intensity of constraints and advantages by farmers in cluster area of CSISA

The information collected from the field was analyzed by using computer software package i.e. Statistical Package for Social Science (SPSS) and Microsoft Excel.

RESULTS AND DISCUSSION

I) LAND HOLDING OF FARMERS

Most of the households in the clusters were small land holders i.e. less than 2 ha (60%) (Figure 3). Besides cultivation their own land, farmers were found to be involved in share cropping. The average size of own land holding was slightly higher in B/P (1.95 ha) than M/C (1.39 ha) and N/R (1.54 ha). The study revealed that, the average size of total own land holding was 1.32 ha, which is greater than the national average size of land holding 0.83 ha (MoAD, 2013).

II) LAND USE ARRANGEMENT

By the surveyed farmers most of the area cultivated was under TPR (58.63 ha) as compared to DDSR (27.62 ha). This is because most of the farmers in all clusters preferred TPR under irrigated condition and DDSR under less irrigated condition. Unirrigated medium land and rainfed lowland condition due to shortage of water. Pandey and Velasco (1999) also reported higher adaptation of DSR by smallholder farmers mainly under unirrigated condition. Mann *et al.* (2006) reported that the rice in Punjab province in India has recently expanded to 0.65 million hectares of non-traditional belt, where puddling is not much practiced due to severe shortage of water.

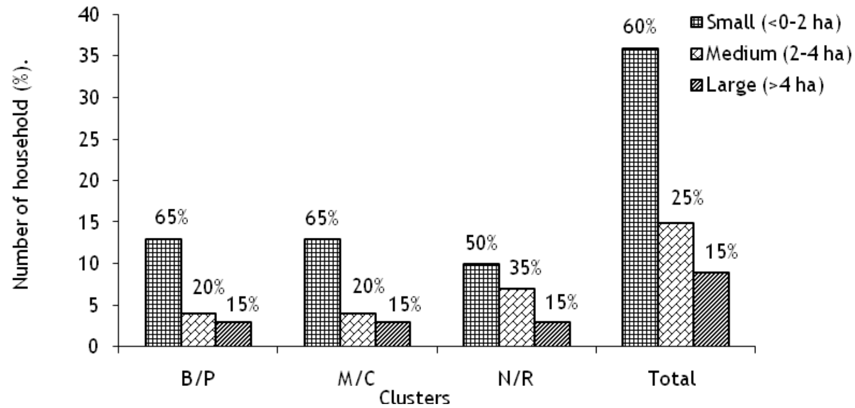

Figure 3. Distribution of land landholding by clusters of the field survey in Bara/Parsa (B/P), Makwanpur/Chitwan (M/C), and Nawalparasi/Rupandehi (N/R) districts in 2010

III) CROPPING SYSTEM

Rice-wheat was the pre dominant cropping system in surveyed area. In total, this was followed by Rice- fallow- maize, Rice-fallow-fallow and Rice-lentil-maize cropping system. Rice-wheat was followed by Rice-lentil-maize in B/P, Rice-wheat-maize and Rice-fallow-maize in M/C, and Rice-fallow-maize in N/R (Table 1). The dominant rice based cropping system might be due to food habit of Nepalese farmers and tradition. Rice meets more than 50% of the total calories requirement of the Nepalese people (NARC, 2007).

IV) ADOPTION OF DDSR BY FARMERS

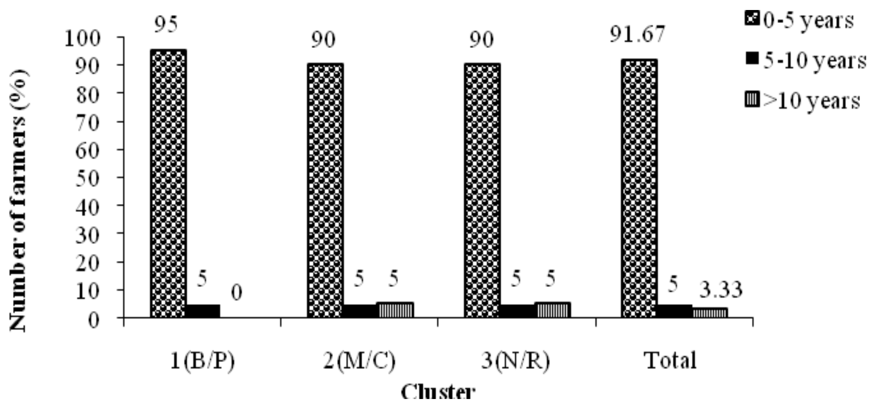

Figure 4. Adoption of DDSR by cluster in Bara/Parsa (B/P), Makwanpur/ Chitwan (M/C), and Nawalparasi/Rupandehi (N/R) districts in 2010

Since 5 years the number of DDSR grower is increasing rapidly in all clusters (Figure 4). In B/P, 95% farmers were new comers, while 5% adopted DDSR since 5-10 years. Similarly, in M/C and N/R, 90% farmers adopted DSR since 0-5 years, 5% of the farmers were adopted since 5-10 years and remaining 5% growers adopted this method of cultivation since more than 10 years. Dry-seeded rice is a traditional practice developed by farmers to suit the agro-ecological conditions in systems ranging from shifting cultivation in the humid forest zones to intensive cultivation in the rainfed lowlands (Johnson *et al.*, 1991; My *et al.*, 1995) in Asia, Africa, and Central and South America. In India, dry-seeding is extensively practiced in rainfed lowlands, uplands, and flood-prone areas, while wet-seeding remains a common practice in irrigated areas (Misra *et al.*, 2005).

V) WILLINGNESS TO ADOPT DRY DIRECT SEEDED RICE

The result showed high willingness of farmers to adopt DDSR in cluster regions. Generally, 95 % farmers in N/R, 90 % farmers in B/P and 85 % farmers in M/C under study will continue to practice DDSR in next year. In general 90% farmers will adopt DDSR in next year (Figure 5). The high willingness of adoption of this method could be due to advantages of reduced labor requirements and drudgery, earlier crop maturity, more efficient water use and higher tolerance of water deficit, and often higher profit in areas with an assured water supply (Balasubramanian and Hill, 2002).

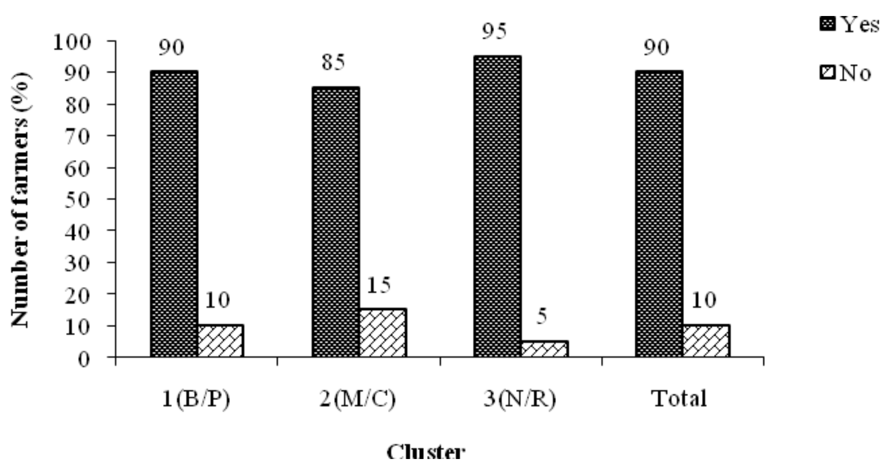

Figure 5. Willingness of farmers adopting DSR in next year by cluster in Bara/Parsa (B/P), Makwanpur /Chitwan (M/C), and Nawalparasi/Rupandehi (N/R) districts in 2010

VI) PERCEPTION OF FARMERS ON MERITS AND DEMERITS OF DDSR and TPR

Rank order index showed that low cost of cultivation was the strength of DDSR followed by less irrigation requirement (Table 1), while farmers ranked increased weed infestation, poor crop establishment, and reduced grain and straw yield in DDSR as the major problems (Table 2). Famers ranked less weed infestation, and better crop establishment in TPR as the major advantage over DDSR (Table 3). High cost of cultivation, higher irrigation requirement in puddling, and deterioration of soil physical properties due to puddling were the major problems of TPR ranked by farmers (Table 4). In a study of farmer's perceptions on DSR, benefits perceived by farmers included increased cropping intensity and productivity, the efficient use of early season rainfall and available soil nitrate, reduced water use (700–900 mm rainfall per crop), and lower risk of drought at maturity (Rao and Moody, 1994).

Table 1. Rank order index for merits of direct seeded rice by clusters of the field survey in Bara/Parsa, Makwanpur/Chitwan, and Nawalparasi/Rupandehi districts in 2010

S.N.	Cluster	Bara/ Parsa		Makwanpur/ Chitwan		Nawalparasi/ Rupandehi		Total	
	Merits	**Index**	**Rank**	**Index**	**Rank**	**Index**	**Rank**	**Index**	**Rank**
1	Reduced cost of cultivation	0.95	I	0.91	I	0.90	I	0.92	I
2	Less irrigation requirement	0.57	II	0.58	II	0.65	II	0.61	II
3	Increased fertilizer efficiency	0.31	IV	0.35	IV	0.43	III	0.36	IV
4	Timely crop establishment	0.30	V	0.33	V	0.37	V	0.33	V
5	Increased soil health condition	0.48	III	0.46	III	0.38	IV	0.44	III

Table 2. Rank order index for demerits of direct seeded rice by clusters of the field survey in Bara/Parsa, Makwanpur/Chitwan, and Nawalparasi/Rupandehi districts in 2010

S.N.	Cluster	Bara/ Parsa		Makwanpur/ Chitwan		Nawalparasi/ Rupandehi		Total	
	Demerits	**Index**	**Rank**	**Index**	**Rank**	**Index**	**Rank**	**Index**	**Rank**
1	Increased weed infestation	0.95	I	0.97	I	0.97	I	0.96	I
2	Reduced grain and straw yield	0.51	III	0.48	III	0.53	III	0.51	III
3	Increased disease infestation	0.35	IV	0.33	IV	0.33	IV	0.34	IV
4	Poor crop establishment	0.62	II	0.67	II	0.58	II	0.62	II
5	Difficult to fertilizer management	0.05	V	0.02	V	0.06	V	0.04	V

Table 3. Rank order index for merits of transplanted rice by clusters of the field survey in Bara/Parsa, Makwanpur/Chitwan, and Nawalparasi/Rupandehi districts in 2010

S.N.	Cluster	Bara/ Parsa		Makwanpur/ Chitwan		Nawalparasi/ Rupandehi		Total	
	Merits	**Index**	**Rank**	**Index**	**Rank**	**Index**	**Rank**	**Index**	**Rank**
1	Increased grain and straw yield	0.50	II	0.31	V	0.28	V	0.36	IV
2	Water stagnation	0.38	IV	0.40	III	0.46	III	0.41	III

3	Less weed infestation	0.85	I	0.88	I	0.93	I	0.89	I
4	Less disease and pest infestation	0.30	V	0.32	IV	0.31	IV	0.31	V
5	Better crop establishment	0.42	III	0.57	II	0.50	II	0.50	II

Table 4. Rank order index for demerits of transplanted rice by clusters of the field survey in Bara/Parsa, Makwanpur/Chitwan, and Nawalparasi/Rupandehi districts in 2010

S.N.	Cluster	Bara/ Parsa		Makwanpur/ Chitwan		Nawalparasi/ Rupandehi		Total	
	Demerits	**Index**	**Rank**	**Index**	**Rank**	**Index**	**Rank**	**Index**	**Rank**
1	High cost of cultivation	0.9	I	0.887	I	0.875	I	0.887	I
2	High irrigation requirement	0.75	II	0.737	II	0.725	II	0.737	II
3	Deteriorates soil	0.55	III	0.587	III	0.6	III	0.579	III
4	Delay harvesting	0.225	IV	0.225	IV	0.237	IV	0.204	IV
5	Low fertilization efficiency	0.075	V	0.062	V	0.062	V	0.066	V

VII) ECONOMICS OF PRODUCTION

Transplanted rice required more cost to cultivate as compared to direct seeded rice. Net return per hectare was higher in DDSR than in TPR in all clusters (Table 5). On an average B:C ratio was higher in the DDSR (2.00) as compared to the TPR (1.63). Labour saving and low irrigation requirement were the major components contributed for low cost of cultivation, and higher farm-gate price of paddy at earlier harvest of DDSR were the main reasons for this profitability as compared to TPR. Sah (2006) observed low cost DDSR technologies in farmer's field, and concluded that DDSR was superior to farmers practice (TPR). Several researches showed that, DDSR can reduce up to 50% labor requirements for rice cultivation (Singh *et al.,* 1994). Direct seeding reduced labor wages about US $29–36 compared with transplanted rice ($177–183) (Rashid *et al*., 2009), and DDSR required 13% less irrigation water than TPR. This was due to the lower amount of water applied during land preparation.

Table 5. Benefit and cost analysis of DDSR and TPR by clusters of the field survey in Bara/Parsa, Makwanpur/Chitwan, and Nawalparasi/Rupandehi districts in 2010

Particulars	Bara/ Parsa		Makwanpur/ Chitwan		Nawalparasi/ Rupandehi		Total	
	DSR	**TPR**	**DSR**	**TPR**	**DSR**	**TPR**	**DSR**	**TPR**
Cost of cultivation (Rs.,000)/ha	49.10	64.40	54.04	71.34	53.93	70.23	52.53	68.65
Gross return ha^{-1} (Rs.,000)	99.05	102.95	114.13	124.13	101.07	109.57	104.75	112.22
Net benefit ha^{-1} (Rs.,000)	49.95	38.55	60.09	52.79	47.13	39.33	39.29	32.66
B:C ratio	2.02	1.59	2.11	1.74	1.87	1.56	2.00	1.63

Note: DSR- direct seeded rice, TPR- transplanted rice

CONCLUSION

Increased weed infestation, poor crop establishment and reduced grain yield were major constraints of DDSR, whereas high cost of cultivation and higher water requirement were major constraints of TPR. In spite of realizing the lower yield in DDSR as compared to TPR, the net benefit and B:C ratio were higher in DDSR because of lower cost of cultivation as compared to TPR. Thus DDSR is preferred for better return, less irrigation requirement, low cost of cultivation, and less drudgery.

ACKNOWLEDGEMENT

We are grateful to the International Maize and Wheat Improvement Center (CIMMYT) for providing financial support for this study; Cereal System Initiative for South Asia (CSISA) for providing valuable advice, help and technical support, particularly for selecting the research tools and household study.

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PRODUCTION COST AND MARKET ANALYSIS OF MANDARIN IN DHADING DISTRICT OF NEPAL

D. Shrestha[1]

ABSTRACT

A study was conducted in 2010 to explore the value chain of the mandarin business in two VDCs; Nalang and Jogimara of Dhading district, Nepal. Information were collected through survey from 60 mandarin growers, 4 collectors, 2 agroinput traders, 2 fruit nurseries, 4 technical service providers, 4 dealers, 4 wholesalers, 4 retailers and 20 consumers. Different direct actors and organizations were found to be involved in micro, meso and macro levels of the mandarin value chain. The technical structure of the mandarin value chain was found as the input provision, mandarin production, intermediary trading, retailing, and consumption. The value chain was linked to different regions of the country. On an average, mandarin producers incurred total variable cost of NRs 10.40 per kg of mandarin. Their gross margin was NRs 8.44 per kg of mandarin. The cost of marketing of the traders, wholesalers, and retailers were NRs 3.56, 5.38 and 1.98 per kg of mandarin respectively whereas the margins of each of them were NRs 2.54, 2.36 and 5.01 per kg of mandarin respectively. The role of traders was found dominant in both purchasing of mandarin from producers and supplying to other districts. The majority of producers were not getting adequate training, support and supervision from concerned organizations. The major weakness in mandarin value chain was unorganized marketing system. Intermediaries and retailers were always found to be in profit. Therefore, the concerned organizations should bring policies in fixing the market price of mandarin based on cost of production. An upgrading strategy with the technology based processed mandarin production has a great opportunity to enter in the new value chain for further improvements in the existing mandarin business.

Key words: *Mandarin, marketing, value chain*

INTRODUCTION

Nepal has been a predominantly agrarian economy since time immemorial. The development efforts over the last few decades have doubtlessly strengthened our industrial base. However, agriculture continues to be the mainstay of our economy and even today 65.6 per cent of population depends on it (CBS, 2010).

Mandarin contributes to augmenting food availability, improvements in nutrition, generation of employment and income and also helps in maintaining the environment (Shah, 1992; Gurung, 1993; Shrestha et al., 1998; Tomiyashu *et al.,* 1998). The total area under cultivation, productive area and production of citrus in Nepal during 2013/14 were 38,988 ha, 25,497 ha and 2,24,357 mt, respectively. Similarly, the total area under cultivation, productive area and production of mandarin in Nepal are 25,408 ha, 16,528 ha and 1, 49,316 mt, respectively. The area under mandarin is 65.16 per cent of the citrus

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fruits and 26.3 per cent of the total area covered by fruits in the country. Citrus, particularly the mandarin is the most important commercial fruit crop in the hills of Nepal. Dhading is one of the potential district for mandarin production in the mid hills of Nepal with 509 ha area under mandarin cultivation with a production area of 305 ha and production of 3,050 mt (ABPSD, 2014).

Although Dhading district has a number of mandarin production pockets in Nepal, the productivity has not increased significantly over the years as per the expectations of Agriculture Perspective Plan (APP) due to several technological constraints. For example inadequate information on pricing mechanism and poor knowledge on linkages along the chain, farmers are receiving lower price for mandarin fruits while middleman are taking the highest proportion of share. As a result farmers are unwilling to invest more in the mandarin cultivation. Inadequate knowledge of value chain and inefficient product flow and market information, producers are always suffering from poor share of profit from the business.

Hence, this study was conducted to explore production cost and market analysis of mandarin in Dhading district, Nepal.

MATERIALS AND METHODS

Nalang and Jogimara VDCs of Dhading district were purposively selected for this study based on the area coverage, production, number of growers and access to road facilities. As a whole, 60 respondents comprising 30 mandarin growers from each VDC, were selected randomly. During the study, 4 collectors, 2 agroinput traders , 4 technical service providers, 4 traders, 4 wholesalers, 4 retailers and 20 consumers from Dhading district and 2 citrus nurseries from Gorkha district were selected for getting information on marketing and value chain study randomly. Pre-tested interview schedule was used to collect the primary data from the selected farmers applying face-to-face interview method. Focus group discussions and key informants survey were done to collect the relevant information. At final phase, group interaction with key informants including all stakeholders of value chain was conducted for the validation of data collected. The secondary data were obtained through reviewing publications of concerned institutions. The data obtained from the field were analyzed through SPSS and MS-EXCEL and interpreted.

RESULTS AND DISCUSSION

COST OF PRODUCTION OF MANDARIN

The production of mandarin depends on the levels of inputs used like manure, fertilizer, human labor, chemicals and irrigation. Table 1 represents the VDC wise cost of production and return from mandarin in Dhading district. The average cost of production per hectare was NRs 140.34. The cost of production per hectare was higher in Nalang VDC (NRs 141.97) compared to Jogimara (NRs 138.70). The benefit cost ratio analysis showed that the mandarin cultivation was profitable enterprise with the B/C ratio greater than one i.e. 3.32 for Nalang and 2.73 for Jogimara VDC. This finding was also supported by Gupta and George (1974) as they found B/C ratio ranging from 1.85 to 2.64 in Indian condition depending on the size of orchard. The benefit cost ratio was higher in Nalang VDC. The higher cost of production and return in Nalang VDC might be due to the higher amount of inputs (ie manure and fertilizers) used for producing the mandarin orange than Jogimara VDC. The slightly higher benefit cost ratio might be due to only consideration of variable cost while calculating cost of production.

Table 1. VDC wise cost of production and return from mandarin orange in Dhading district, 2010

VDC	Cost (Rs/hectare)	Return (Rs/ hectare)	B/C ratio
Nalang	141.97	471.35	3.32
Jogimara	138.70	378.65	2.73
Total	280.67	850.00	3.02

Analysis of contribution of variable cost items to the total cost

The Ordinary Least Squares (OLS) estimates of the contribution of variable cost items to the total cost of mandarin production in Nalang and Jogimara VDCs in Dhading district are presented in the table 2 and 3.

Table 2. Contribution of variable cost items to the total cost in Nalang VDC, Dhading, 2010

Variables	Unstandardized coefficients		Standardized coefficients	T	P value
	B	SE	Beta		
Constant	838.12	234.86		3.57	0.001
Manuring and fertilizer cost	1.42	0.19	0.76	7.30	0.000**
Plant protection cost	2.96	1.47	0.21	2.02	0.054*
Irrigation cost	3.75	2.42	0.13	1.55	0.133

R= 0.899, R^2=0.809

Dependent Variable: Total cost, SE = Standard Error.

*Note: ** and * refers to significant at 0.01 and 0.10 level of significance, respectively.*

Manuring and fertilizer cost and plant protection cost had strong statistical significant factors contributing to the total cost. Both manuring and fertilizer cost and plant protection cost had positive contribution to the total cost. The irrigation cost was found insignificant in contribution to the total cost but it contributed positively to the total cost.

The value of multiple coefficient of correlation, R, was found to be 0.899 which indicates the strong correlation between dependent and independent variables in the analysis. This indicates that 89.9 per cent variation in dependent variable was explained by all independent variables.

Table 3. Contribution of variable cost items to the total cost in Jogimara VDC in Dhading district, 2010

Variables	Unstandardized coefficients		Standardized coefficients	T	P value
	B	SE	Beta		
Constant	1410.68	281.55		5.010	0.000
Manuring and fertilizer cost	1.03	0.21	0.694	4.835	0.000**
Plant protection cost	0.57	1.52	0.690	0.374	0.712
Irrigation cost	1.66	2.1	0.144	0.769	0.449

R= 0.697, R^2=0.486, Dependent Variable: Total cost, SE = Standard Error.
*Note: ** refers to significant at 0.01 level of significance.*

Manuring and fertilizer cost had strong statistical significant factors contributing to the total cost. Manuring and fertilizer cost had positive contribution to the total cost. The plant protection cost and irrigation cost were found insignificant in contribution to the total cost but both the costs contributed positively to the total cost. The value of multiple coefficient of correlation, R, was found to be 0.697 which indicates the strong correlation between dependent and independent variables in the analysis. This indicates that 69.7 per cent variation in dependent variable was explained by all independent variables.

REVENUE AND GROSS MARGIN

The average revenue per hectare and per kg of mandarin is presented in the Table 4. The average revenue per hectare was NRs. 425 whereas the average revenue per kg was NRs 13 from the mandarin production. Among the two VDCs, the producers of Nalang VDC were getting the higher revenue from both per hectare and per kg basis which were NRs 471 and NRs 14 respectively. This might be due to the better management practices adopted by the producers of Nalang VDC.

Table 4. Average revenue from mandarin production by VDC in Dhading district, 2010

Revenue (NRs)	VDCs		Average revenue
	Nalang	Jogimara	
Per hectare	471	379	425
Per kg	14	11	13

Table 5 shows the average gross margin per hectare and per kg from mandarin production by VDC.

Table 5. Average gross margin from mandarin production by VDC in Dhading district, 2010

Gross margin (NRs)	VDCs		Average gross margin
	Nalang	Jogimara	
Per hectare	329	240	285
Per kg	10	7	8

The average gross margin from the mandarin production was NRs 285 per hectare and NRs 8 per kg of mandarin. In comparision, Nalang VDC captured the higher gross margin in both per hectare and per kg of mandarin as compared to Jogimara VDC. It may due to the reason that most of the mandarin growers from Nalang sell their produce directly to the retail markets.

PRICE OF MANDARIN FRUIT

For the marketing of the mandarin, the activities start right from the point of the production. In the context of mandarin marketing activities in Dhading district, the intermediaries and the retailers were found to play major role. Similarly, the retailers also had direct access to the mandarin producers for the exchange function. The distribution of mandarin producers by place of selling and VDC is presented in the Table 6.

Table 6. Distribution of mandarin producers by place of selling and VDC

Place of selling	VDCs		Total
	Nalang	Jogimara	
Farm gate	20 (66.67)	16 (53.33)	36 (60.00)
Market	4 (13.33)	2 (6.67)	6 (10.00)
Farm gate + Market	6 (20.00)	12 (40.00)	18 (30.00)
Total	30 (100.00)	30 (100.00)	60 (100.00)

Note: Figure in parentheses indicates percentage.

The majority of the mandarin producers (60 %) sold their produce at farm gate where as only few producers (10 %) sold their produce directly to the market. It was found that 30 per cent producers sold part of the production in the market and remaining part from the farm gate. In both the VDCs, most of the farmers were engaged selling the produce from the farm gate and few farmers were selling directly to the market.

QUANTITY OF MANDARIN SUPPLY

Figure 1 illustrates the volume mapping of mandarin supply in Dhading district. It was found that the the intermediaries were the major agents for the transaction of mandarin to consumers outside Dhading district. From the discussions with the value chain actors of Dhading district, it was found that 88 per cent of the total produce i.e. 3,030 metric ton was consumed by the local consumers. Only 12 per cent of the remaining produce was transacted to other districts namely Kathmandu, Pokhara, Narayangadh, and Birgunj including some negligible volume to India from the intermediaries.

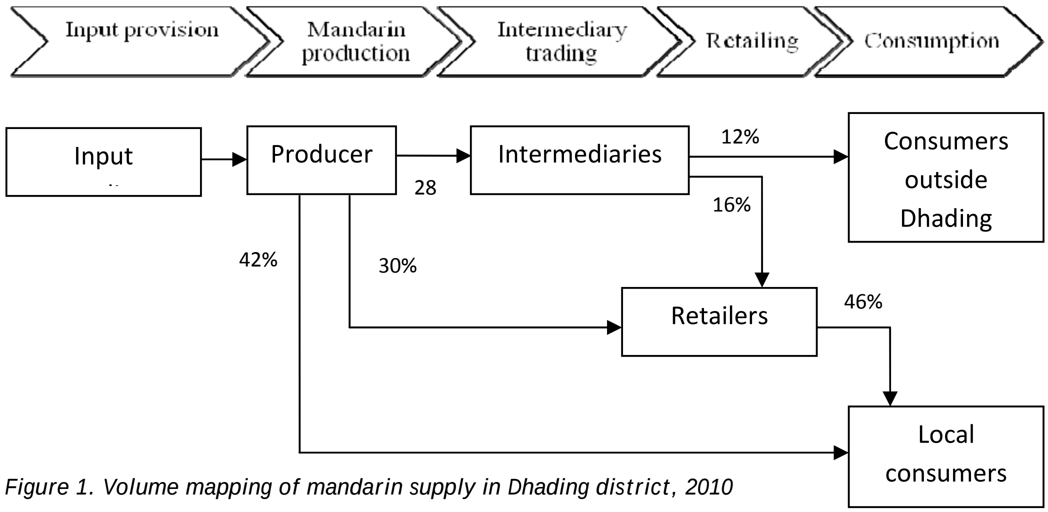

Figure 1. Volume mapping of mandarin supply in Dhading district, 2010

VALUE CHAIN MAP

Figure 2 illustrates the existing value chain map of mandarin in Dhading district which was explored during the study.

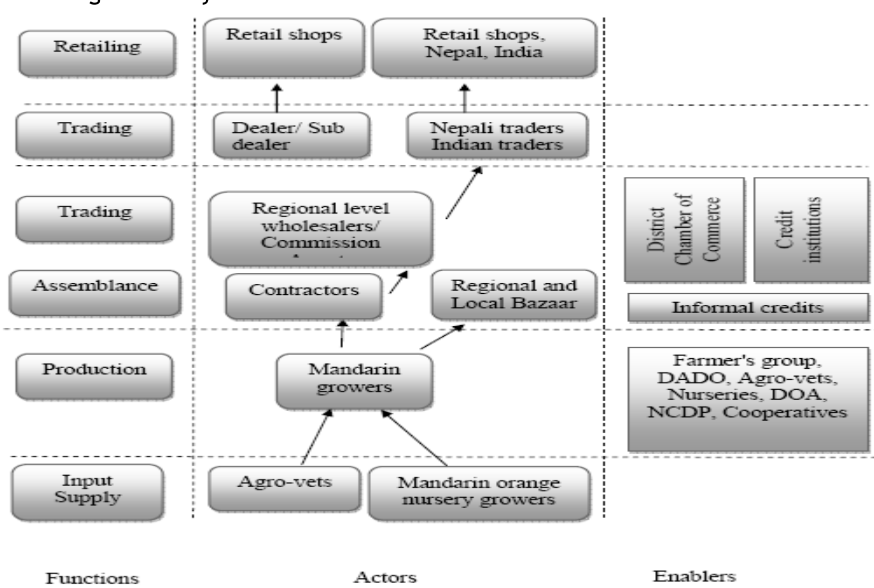

Figure 2. Value chain map of mandarin in Dhading district, 2010

As seen in the figure, value chain map of Dhading district comprises of whole range of actors right from the input suppliers (agrovets and nurseries) to the ultimate consumers. Input suppliers were supplying the necessary inputs to the mandarin producers. Mandarin producers were involved in selling the produce of their orchards on contract basis to the contractors and also direct selling to the consumer. Mainly contractors and traders were found contracting the fruit orchards, harvesting of fruits, transporting and assembling the produce at the nearest road head, storing, packaging, transporting and selling to wholesale market. From there, mandarin oranges were sold to local traders and retailers and then finally reached to the consumers within and outside the district. But, the important part of the value chain, i.e. processing, was found missing in the entire value chain of mandarin in Dhading district.

MARKETING COST, PRICE SPREAD, MARGIN, MARKETING EFFICIENCY AND PRODUCER'S SHARE

Figure 3 illustrates the summary of costs, margin, marketing efficiency and producer's share on consumer's rupee (NRs) per kg of mandarin in the mandarin value chain.

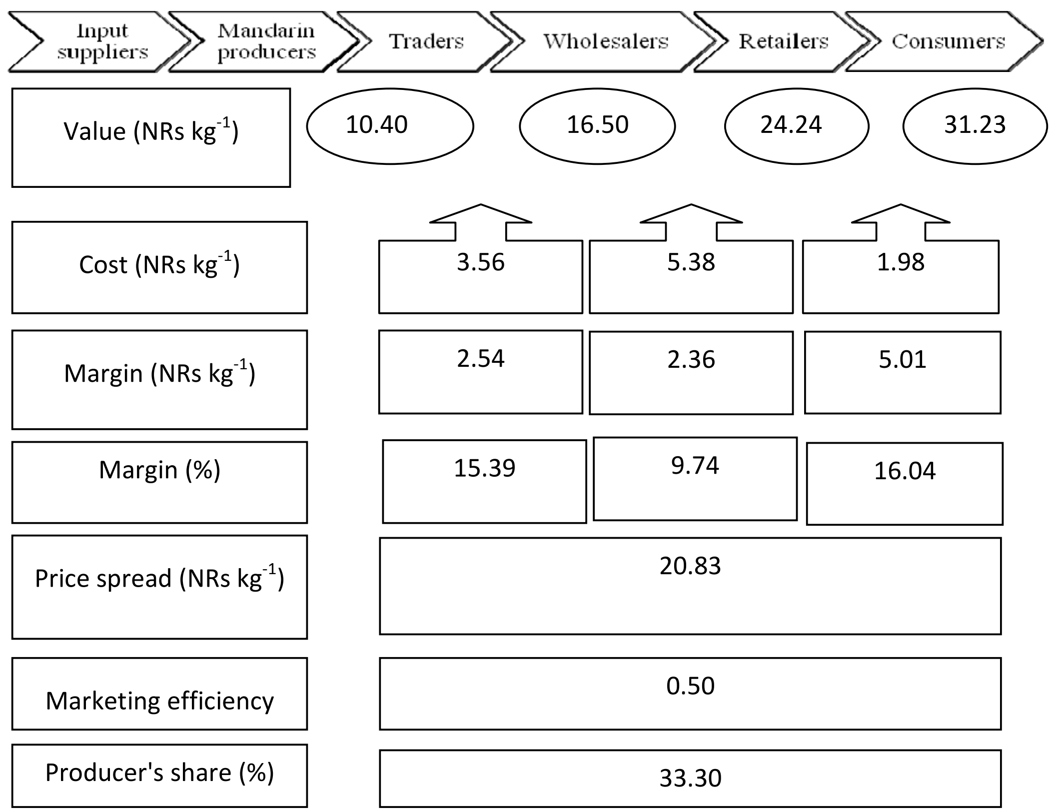

Figure 3. Marketing cost, margin, price spread, marketing efficiency and producer's share in the core process of mandarin value chain

The average farm gate price per kg of mandarin was NRs 10.40. The average selling price of traders and wholesalers was found to be NRs 16.50 and NRs 24.24 respectively. The average retail price was NRs 31.23. The price spread was NRs 20.83 per kg. In the study it was found that the retailers were having the highest margin (NRs 5.01) among the actors of mandarin value chain in Dhading district. The marketing efficiency of this chain was 0.50. Similarly, the producer's share on consumer NRs in this chain was 33.30.

CONCLUSION

Marketing of unprocessed mandarin was dominant in the mandarin value chain of the Dhading district which indicates lack of processed products. Gross margin and high B/C ratio received by the mandarin growers showed that the mandarin farming is a profitable business. While looking at the margin of intermediaries and retailers, their function in the mandarin value chain is always profitable because the downward swing of the market price never made their earnings negative. The retailers earned the biggest margin than others. It was one of the reasons for high price for consumer. The contractors were the main intermediary actors in the mandarin market chain of Dhading district. They were the main actor for inter-regional distribution of mandarin fruit.

ACKNOWLEDGEMENT

The authors express their sincere thanks to the research fund of NARDF for the financial support for this project. Kind responses from all the respondents, Research Directorate of Institute of Agriculture and Animal Sciences (IAAS), Rampur, Chitwan and colleagues are highly acknowledged.

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PROFITABILITY AND RESOURCE USE EFFICIENCY OF BUCKWHEAT (FAGOPYRUM ESCULENTUM MOENCH) PRODUCTION IN CHITWAN DISTRICT, NEPAL

S.C. Dhakal[1], P.P. Regmi[2], R.B. Thapa[3], S.K. Sah[4] and D.B. Khatri-Chhetri[5]

ABSTRACT

The study was designed to determine the profitability and resource use efficiency of buckwheat production in Chitwan. The study used 42 buckwheat growers from 300 farmers adopting different pollinator friendly practices. Descriptive and statistical tools including Cobb-Douglas production function were used on data collected from structured interview schedule to accomplish the objectives. The benefit cost ratio (1.25) indicates that buckwheat production was profitable. The magnitude of regression coefficients of buckwheat implied that use of tractor and nutrient cost had significant positive effects on gross return. According to estimated allocative efficiency indices, it is suggested to reduce labor and seed cost by about 148% and 143%, respectively and; increase the use of tractor and nutrient inputs by about 63% and 19%, respectively. Extension of modern technologies with adjustment on resource use explains for increase in return and profit from buckwheat production which indirectly promotes and ensure forage for pollinators in study area.

Key words: *Allocative efficiency, buckwheat, pollinators, profitability, resource use efficiency*

INTRODUCTION

Buckwheat (*Fagopyrum esculentum* Moench, family Polygonaceae) is one of the important under exploited crops of Nepal and is popularly known as “Pseudo cereal". It is a minor crop occupying 10,339 ha of land area, majority of which lies in mid-hills, with the production of 10,021 t and productivity of 0.97 t/ha (MoAD, 2012). It contains best high quality digestible protein with balanced amino acids and minerals (Eggum *et al*., 1981). It is free from cholesterol and fits the modern desirable form of diet (Francischi *et al*., 1994). Buckwheat is cultivated for its use as staple food, animal feed, vegetable, soup, beverage and medicine. Area under buckwheat in Chitwan in 2014 was 1500 ha and productivity was 0.8 t/ha (DADO, 2014).

Buckwheat is cross pollinated and an entomophilic plant, which is pollinated mainly by honey bee. The cultivation of buckwheat along with beekeeping could produce 50 to 100 kg of honey per ha due to its extended flowering period for more than 30 days (Rajbhandari, 2010). Aryal *et al*. (2014) reported that quality and quantity of buckwheat production was improved with bee pollination in a study at Chitwan and suggested buckwheat production along with bee farming and conservation of natural pollinators.

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Pollination is a critical link in the functioning of ecosystems and it is essential for the production of a wide range of crops. Several studies have shown that pollination makes a very significant contribution to the agricultural production of a broad range of crops, in particulars fruits, vegetables, fiber crops and nuts (Gordon and Davis, 2003). Crop pollination services are being hampered by a decline in the number and diversity of pollinator populations throughout the Hindu Kush Himalayan region (Partap *et al*., 2001). Pollinator loss in Chitwan has been attributed to habitat loss resulting from misuse of fertilizers and pesticides, reluctant in beekeeping, deforestation, loss of natural vegetation, increased commercial agriculture, use of high yielding varieties and; many other abiotic and biotic factors (Devkota, 2013).

Pollinator friendly practices are those which increase forage for pollinators through mixed crop types over a growing season, planting crop with long flowering period, growing crop with mass flowering, mixed crop types with at least one pollinator attractant crop, greater crop genetic diversity, patches of non crop vegetation, shade tree cultivation, strip cropping, conservation of grass lands etc. Secondly, practices for reducing use of chemicals like selective weeding to conserve weed for pollinators, organic farming, use of less toxic chemicals and less use of inorganic fertilizers are also pollinator friendly practices. The third category of pollinator friendly practices is managing for bee nest sites through no till agriculture, hand tillage, leaving dead trees and fallen branches undisturbed, avoidance of flood irrigation etc. The fourth category of pollinator friendly practices is use of managed pollinators through beekeeping and introducing nesting sites for bee pollinators (FAO, 2008). The present buckwheat production practice under study could be treated as one of the important pollinator friendly practices as it has extended flowering period, mass flowering characteristics, pesticide free production and good forage for bees and other pollinators.

While making production decision, farmers consider costs of production and yield of the crop which ultimately affect rate of adoption and sustainability of any crop. So, profitability study on buckwheat is expected to reveal valuable information relating to farms and farmers growing this crop. However, most of the farmers producing buckwheat lack management techniques, apply inappropriate use of resources, which is mainly due to inadequate knowledge on resource optimization. The future of buckwheat production in the study area depends very much on the awareness of its profitability and resources use efficiency in the context of growing competitive crops in winter season, specially with vegetable crops. Keeping this in view the study was undertaken to determine profitability and resource use efficiency of buckwheat production for the promotion of livelihood of growers and forages for pollinators.

METHODOLOGY

STUDY AREA

The study was conducted at Chitwan district in Nepal where, Global Pollination Project (GPP-FAO) was successfully implemented for five years (2009-2014). Chitwan district is located in the central region of Nepal at geographical line of $20^0$21'' to $27^0$46'' North Latitude and $83^0$35'' to $84^0$48'' East Longitudes. The climatic situation of the district varies from sub-tropical to tropical giving favorable conditions for growing diverse crop species. Total area of the district is about 223839 ha, of which 25.3% is agricultural land (DADO, 2014).

Six Village Development Committees (VDCs) namely Padampur and Jutpani from eastern Chitwan; Phulbari and Mangalpur from Central Chitwan; and Meghauli and Sukranagar from Western Chitwan were selected randomly. These VDCs were among the nine VDCs of Global Pollination Project-FAO (GPP-FAO) conducted in the district, for study on pollination management with special focus on best pollination management practices. Western part of Chitwan is more popular in buckwheat production.

SAMPLING METHOD AND DATA COLLECTION PROCEDURE

Two farmers' group formed under GPP for the promotion of pollination friendly practices, with size of twenty five members in each group were randomly selected from each VDC. Thus a total of 50 farmers from each VDC and 300 farmers in total were the number of farmers selected for study on pollinator friendly agricultural practices. These 300 farmers were studied for ten common pollinator friendly practices namely mustard production, buckwheat production, surface seeded mustard production, surface seeded buckwheat production, organic rice production, organic maize production, bitter gourd production, bee keeping, kitchen gardening and maize cucurbits mix cropping. Among 300 farmers selected under study on pollination friendly practices, 42 were growing buckwheat concentrated in western part of Chitwan. Primary data was collected with the use of structured interview schedule using face to face interview technique in April, 2014.

TECHNIQUES OF DATA ANALYSIS

After the collection of necessary information it was coded and entered in SPSS data entry sheet and analyzed by using STATA 12. Collected data were analyzed with descriptive and quantitative methods. The budgeting technique employed in the study was the gross farm income and gross margin.

Cost, Return and Profitability

All variable inputs like human labor, tractor labor, seed, inorganic fertilizers and organic manures were considered and valued at current market prices of the year 2014 to calculate cost of production.

Total variable cost = $C_{labor}+ C_{tractor}+C_{seed}+ C_{fert}+ C_{manure}$

Where,

C_{labor} = Cost on human labor used (NRs./ha), $C_{tractor}$ = Cost on tractor labor used (NRs./ha), C_{seed} = Cost on seed (NRs./ha), C_{fert} = Cost on inorganic chemical fertilizers (NRs./ha) and C_{manure} = Cost on organic manures (NRs./ha)

Gross return was calculated by multiplying the total volume of main product of buckwheat by the average price at harvesting period (Dillon and Hardaker, 1993). Thus gross return was calculated by using following formula:

Gross return (NRs./ha) = Total quantity produced (kg/ha) × Price of buckwheat (NRs./kg)

Gross margin calculation was done to have an estimate of the difference between the gross return and variable costs. Gross margin was calculated by using the method as given by Olukosi *et al*. (2006) using following formula;

Gross Margin (NRs./ha) = Gross return (NRs./ha) - Total variable cost (NRs./ha)

Furthermore average cost per Kilogram of buckwheat production was calculated as the ratio of total variable cost (NRs.) to total production (kg). Similarly average gross margin (NRs./kg) was calculated as the ratio of gross margin(NRs./ha) to productivity (kg/ha).

Benefit cost ratio is the quick and easiest method to determine the economic performance of a business. It is a relative measure, which is used to compare benefit per unit of cost. Undiscounted benefit cost ratio was estimated as a ratio of gross return and total variable cost. Thus, the benefit cost analysis was carried out by using formula;

$$B/C\ ratio = \frac{Gross\ return\ (NRs.)}{Total\ variable\ cost\ (NRs.)}$$

Production Function Analysis

Koutsoyiannis (1977) defined production function as a technical relationship between factor inputs and output. Cobb-Douglas type of production function was used to determine the contribution of different factors on production and to estimate the efficiency of the variable factors of production in buckwheat production. It is most widely used multiplicative and non linear form of production function used in agricultural research and is convenient for the comparison of the partial elasticity coefficient (Prajneshu, 2008). The marginal productivity of factors, marginal rate of substitution and the efficiency of production can be calculated directly from parameters in Cobb-Douglas type of production function. Thus, Cobb-Douglas production function of the following form was fitted to examine the resource productivity, efficiency and return to scale.

$Y= aX_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4}e^u$
Where,
Y= Gross return (NRs./ha),
X_1= Cost on human Labor (NRs./ha),
X_2= Cost on tractor labor (NRs./ha),
X_3= Cost on seed (NRs./ha),
X_4= Cost on sources of plant nutrients (NRs./ha),
e=Base of natural logarithm,
u = Random disturbance term,
a=Constant and
b1, b2, ..., b4=Coefficients of respective variables.

The Cobb-Douglas production function in the form expressed above was linearised in to a logarithmic function with a view of getting a form amenable to practical purposes using Ordinary Least Square (OLS) technique as expressed below;

$lnY= lna+b_1lnX_1+b_2lnX_2+b_3lnX_3+b_4lnX_4+u$
Where,
ln= Natural logarithm, and u= Error term

For the calculation of return to scale on buckwheat production, coefficients from Cobb-Douglas production function was used and calculated using formula;
Return to scale (RTS)= $\sum bi$
Where, bi = Coefficient of i^{th} explanatory variables.

Return to scale with value greater than unity represents increasing return to scale, value equal to unity represents constant return to scale and vale less than unity represents decreasing return to scale.

Resource Use Efficiency
The allocative efficiency of a resource used was determined by the ratio of Marginal Value Product (MVP) of variable input and the Marginal Factor Cost (MFC) for the input and tested for its equality to one i.e. (MVP/MFC)=1 . Following Goni *et al*. (2007) the efficiency of resource use was calculated as;
r= MVP/MFC

Where, r= Efficiency ratio, MVP= Marginal value product of a variable input and MFC= Marginal factor cost.

The standard way to examine such efficiency is to compare MVP with the MFC of each variable input. If MFC_{Xi} divides MVP_{Xi}, the result will be equal to the value of MVP_{Xi} because MFC at all cases is equal to 1. As the MFC is price of input per unit, the MFCs of all the inputs will vary while calculating the ratio of MVP to MFC. However, the denominator will always be one, and therefore, the ratio will be equal to their respective MVP (Majumder *et al*., 2009). The marginal value productivity of a particular resource represents the additional to gross return in value term caused by an additional one unit of that resource, while other inputs are held constant. The most variable, perhaps the most useful estimate of MVP is obtained taking resources, as well as gross return at their geometric means (Dhawan and Bansal, 1977). Since all the variables of the model were measured in monetary value, the slope coefficients of the explanatory variables in the function represent the MVP, which was computed by multiplying the production coefficient (elasticity, in this particular case) of a given resource with the ratio of geometric mean value of output and input variables (Rabbani *et al*., 2013).

Therefore, MVP_{xi}= dy/dxi, which is the product of regression coefficient with ratio of geometric mean of gross return to the level of use of i^{th} resource.

According to the conventional neo-classical test of economic efficiency, decision rule for resource use efficiency is that a efficiency ratio (r) equal to unity indicates the optimum use of that factor, the ratio more than unity indicates that gross return could be increased by using more of the resource and the ratio of less than unity indicates the excess use of resource which should be decreased to minimize the loss.

Again, the relative percentage change in MVP of each resource required to obtain optimal resource allocation, i.e. r=1 or MVP= MFC was estimated using the following equation below;

$D= (1-MFC/MVP) \times 100$

Or, $D= (1-1/r)\times 100$

Where, D= absolute value of percentage change in MVP of each resource and r = efficiency ratio (Mijindadi, 1980).

RESULTS AND DISCUSSION

SOCIO-ECONOMIC CHARACTERISTICS

The average age of respondents was about 45 years with 7 years of schooling on an average. The average age of respondents' household head was about 52 years with about 5 years of schooling on an average. About 52% respondents were female and rest 48% was male among the study population. Family type in the study area was dominated by joint type (55%), followed by nuclear (45%). The average numbers of male, female and family size was 3.04, 3.36 and 6.40 respectively, and was higher than the national average family size 4.5 (CBS, 2011). Most of the respondents were indigenous (57%) followed by Brahmin/Chhetri (41%) and others (2%) which is because of concentrated dwelling of Tharu communities in Buckwheat growing study area. The study revealed that economically active members were about 73% which was higher than district average of 61.91% (DDC, 2013). It shows that there is dominancy of young and energetic group of people. Among the economically active population 52% were engaged in agriculture as primary occupation followed by about 24% as student. The average land holding of buckwheat growing households was 0.79 ha.

COST OF PRODUCTION

Human labor was an important and largely used input in the production of buckwheat. It was required for different operations such as land preparation, seed sowing, fertilizer application, harvesting, threshing and cleaning etc. It was computed in terms of man day and converted to monetary term valuating at prevailing wage rate. The cost of human labor in buckwheat production per hectare was estimated at about NRs. 12920 (Table 1). Labor cost accounted about 53% of total variable cost in buckwheat production. It has shown that buckwheat production activity in the study area is labor intensive. Tractor is labor saving modern tillage technology. In the study area, all the farmers used tractor as tillage equipment for their land preparation. Per hectare costs of tractor was about NRs. 6167, which accounted about 25% of total variable cost of buckwheat production. Per hectare costs of organic manures was about NRs. 2312 which constituted 9% of the total variable cost (Table 1). Major types of organic manures used in the study area were farm yard manure, poultry manure and compost.

Almost all the farmers used chemical fertilizers, mainly urea and DAP. Per hectare costs of inorganic fertilizer was estimated at about NRs. 1760 accounted about 7% of total variable cost. Buckwheat growers did not use any form of pesticides. Similarly, buckwheat growers did not irrigate their crop as they used to grow buckwheat in unirrigated land with residual moistures after rice or other rainy season crops. As regards the production of buckwheat, the per hectare cost on seed accounted NRs. 1262, which constituted about 5% of total variable cost of production (Table 1).

Table 1: Average cost of buckwheat production (NRs./ha)

Items of cost	Mean	Percent of total cost
Human labor	12920.25	52.91
Tractor labor	6166.94	25.25
Seed	1261.59	5.17
Organic manure	2311.90	9.47
Inorganic fertilizers	1759.95	7.21
Total cost	24420.63	100.00

Source: Field survey 2014

RETURNS FROM BUCKWHEAT PRODUCTION

Farmers in the study area were growing buckwheat on an average at 0.37 hectare of land with per hectare physical volume of output as 9 ton (Table 2). Per hectare gross return was calculated by multiplying the total amount of yield by their respective per unit farm gate price of buckwheat. The average farm gate price of buckwheat was NRs. 34 per kilogram. Per hectare gross return and total variable cost were estimated as NRs. 30601.90 and NRs. 24420.63, respectively. Per hectare gross margin of buckwheat production was estimated at NRs. 6181.27. Cost and gross margin were also estimated on per kilogram basis and they were estimated at NRs. 27.17 and NRs. 6.86, respectively. It was observed that the overall undiscounted BCR considering total variable cost was 1.25. Thus, it was found that buckwheat production was profitable in the study area.

Table 2: Economic statement of buckwheat production in the study area

Measuring criteria	Average value
Area (ha.)	0.37
Productivity (t/ha)	0.90
Average revenue (NRs./kg)	34.00
Gross return (NRs./ha)	30601.90
Total cost (NRs./ha)	24420.63
Gross margin (NRs./ha)	6181.27
Average cost (NRs./Kg)	27.13
Average gross margin (NRs./kg)	6.86
Benefit cost ratio	1.25

Source: Field survey 2014

RESOURCE USE EFFICIENCY IN BUCKWHEAT PRODUCTION

Agricultural production is the result of a combination of different inputs used. The individual effect of these inputs can be explained to certain degree by multiple regression analysis, but the isolation of the effect of each variable may be very difficult in tabular technique (Islam and Dewan, 1987). Estimated values of the coefficients and related statistics of Cobb-Douglas production function are shown in Table 3. Four explanatory variables namely human labor cost, tractor use cost, seed cost and nutrient cost were considered to show their effects on production of buckwheat. Out of these four variables tractor cost and nutrient cost were significant at 5% level. The regression coefficient for tractor cost was 0.562, which had depicted that with 100% increase in cost on tractor, gross return could be increased by about 56%, which might be resulted from the higher productivity contributed due to more number of primary tillage. Similar to this, Rabbani *et al*. (2011) using revenue type of Cobb- Douglas production function resulted power tiller cost as significant factor on mustard production in Bangladesh. Likewise, the regression coefficient for nutrient cost is 0.247, which had indicated with 100% increase in nutrient cost, the gross return could be increased by about 25%.

Table 3: Estimated value of coefficients and related statistics of Cobb-Douglas production function of buckwheat production

Factors	Coefficient	Std. Error	t-value
Constant	2.510	1.690	1.48
Human labor cost (NRs./ha)	0.153	0.095	1.60
Tractor cost (NRs./ha)	0.562*	0.257	2.18
Seed cost (NRs./ha)	-0.098	0.131	-0.74
Nutrient cost (NRs./ha)	0.247*	0.101	2.43
F-value	19.110**		
R square	0.673		
Adjusted R-square	0.640		
Return to scale	0.864		

Note: **Significant at 1% level of confidence * Significant at 5% level of confidence

Source: Field survey 2014

The coefficient of multiple determination (R^2) is a summary measure which tells how well the sample regression line fits the data (Gujarati, 1995). The coefficient of multiple determination R^2 of the model was 0.67 for buckwheat production. It indicates that about 67% of variations in gross return have been explained by the explanatory variables, which were included in the model. The value of adjusted R square was 0.64 indicating that after taking into account the degree of freedom (df) 64% of the variation in the dependent variable explained by the explanatory variables included in the model. The measures of the overall significance of the estimated regression F value was 19.11 and it was significant at 1% level implying that all the explanatory variables included in the model are important for explaining the variation of the dependent variable in buckwheat production.

The concept of return to scale was applied to the production function to determine the stages of production in which farmers were allocating their resources. Returns to scale reflect the degree to which a proportional change in all inputs caused proportional change in the output. The summation of all production coefficients indicate return to scale. The sum of the coefficients of different inputs stood at 0.864 for buckwheat production. This indicates that the production function exhibited a decreasing return to scale implies that if all the inputs specified in the function are increased by 100% income will increase by about 86%. Similar to this Wosor and Nimoh (2012) reported decreasing return to scale in chilli pepper production with value 0.304. Also, Rabbani *et al*. (2013) reported decreasing return to scale in mustard production with value 0.651.

The estimated MVP of different inputs used in buckwheat production is presented in Table 4. The study revealed that ratio of MVP to MFC of the human labor cost was positive and less than one which indicated the overuse of this resource. Similarly ratios of MVP to MFC of the tractor cost and nutrient cost were positive and greater than one, indicated their under-utilization. On the other hand, for seed cost the ratio of MVP to MFC was negative which demonstrated that it was over-utilized and less profit could be obtained by increasing on seed cost. Study result showed that all the inputs were not utilized to optimum economic advantage. Result agrees with the findings of Goni *et al*. (2013) and Rabbani *et al*. (2013).

Table 4: Estimates of measures of allocative efficiency of inputs used in buckwheat production

Inputs	Geometric mean	Coefficient	MVP	MFC	MVP/ MFC	Efficiency	Percent adjustment required
Human labor cost (NRs./ha)	11092.81	0.153	0.403	1.00	0.403	Over utilized	-148.311
Tractor cost(NRs./ha)	6042.57	0.562	2.716	1.00	2.716	Under utilized	63.176
Seed cost (NRs./ha)	1226.29	-0.098	-2.333	1.00	-2.333	Over utilized	142.856
Nutrient cost(NRs./ha)	5878.20	0.247	1.227	1.00	1.227	Under utilized	18.500

Source: Field survey 2014

The adjustment in the MVPs for optimal resource use in Table 4 indicated that for optimal allocation of resources, tractor and nutrient cost were required to increase by about 63% and 19% respectively. The human labor and seed costs were required to reduce by approximately 148% and 143%, respectively. A similar result of over utilization of labor and under utilization of fertilizer was assessed by Ibrahim and Ayinde (2011) in the production of hybrid and open pollinated maize in Nigeria. Chapke *et al*. (2011) also reported that for optimum allocation of resources more than 88% increase in fertilizer was needed whereas, 127% reduction was required for seed for sorghum production in India.

CONCLUSIONS

The study showed that buckwheat production is a reasonably profitable enterprise, although its productivity is still low. Possible reasons for the near to the ground profit are due to less priority of farmer to this crop as compared to other competitive crops, allocation of marginal and unirrigated land for buckwheat production and limited production technologies and; under and over utilization of production inputs. However, higher gross return from per hectare of land can be realized by increasing the level of resources applied to buckwheat production principally tractor power along with manures and fertilizers. The analysis of resource use efficiency on buckwheat production shows that all the resources considered in the study are inefficiently utilized. Thus, to obtain economic advantage, farmers are recommended to reduce primarily labor force and increase use of tractor and nutrients. As buckwheat is exportable and pollinator friendly crop, judicious use of inorganic sources of nutrient is advised. The level of adjustments for use of various resources to earn optimum returns will serve as a bench-mark guideline for the buckwheat growers in the area, government agencies, and agro-based companies. Thus if proper uses of resources could be ensured, buckwheat production could be a more viable and attractive commercial enterprise for the promotion of food, income and forage for pollinators.

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ASSESSING LOCAL PRACTICES OF ORGANIC VEGETABLE PRODUCTION IN BHADAURE TAMAGI, KASKI, NEPAL

Saraswati Bhurtyal[1], Dharma Raj Dangol[2] and Ananda Raj Joshi[3]

ABSTRACT

This study assessed local practices of organic vegetable production through two focus group discussions and a household survey with 66 randomly selected households of ward number 1 and 2 of Bhadaure Tamagi Village Development Committee, Kaski district of Nepal. The study found that most of the farmers were growing varieties of organic vegetables by using local practices for household consumption as well as for marketing mainly by using livestock manure, and organic biopesticides prepared locally. In addition, organic vegetable production in the area has helped to increase their income and contributed to strengthen traditional seed exchange practice, conservation of local seeds and agro biodiversity. In order to sustain current production trend and enhance marketing of organic vegetables, the study recommends targeted interventions of organic farming related to capacity building, technology support and market promotion of the produces.

Key words: *Local practices, marketing, production of organic vegetables, small holder farmers*

INTRODUCTION

Organic farming has been adopted and proved to achieve food security of the farmers through creating a balance between agro ecosystem and human health (Bhatta et al., 2008; Khanal, 2008; Pokhrel and Pant, 2009). It is therefore seen as an advantageous investment for the small holder farmers of Nepal (Sharma, 2004). Farmers in most areas have perceived organic farming practice in line with the existing values, past experiences and present needs of the farmers and market.

So, it was not difficult for them to convert inorganic vegetable farming to the organic one (Kafle, 2011). More over, organic farming offers resilience against adversities, especially climate change by enhancing adaptive capacity of farming community and to mitigate it (Dahal, 2011). Still there are farmers practicing organic farming regardless of enabling environment of organic farming. However, there is very little information available regarding the existing practices of organic production adopted by small holder farmers in Nepal. Hence, this study was carried out to i) assess farmers' socio-economic status, farming practices and production system adopted for organic vegetable farming; ii) analyze

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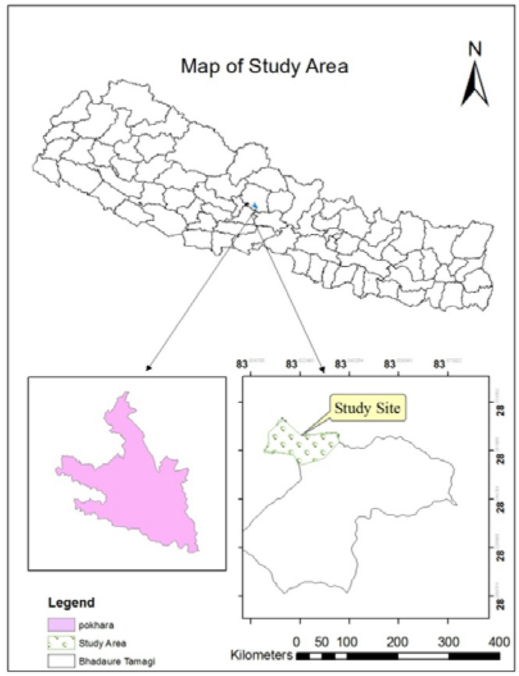
the marketing system of organic vegetables adopted by community and market functionality.

METHODOLOGY

STUDY SITE



The following criteria were applied to select study site: 1) Community practicing organic vegetable production, 2) Ethnic community or marginalized community, 3) Periurban areas of Pokhara and 4) Marketing of vegetables to Pokhara. Accordingly, the study site was ward number 1 and 2 of Bhadaure Tamagi VDC of Kaski district, where farmers are doing organic vegetable production. Kaski district shares its boundary Lamjung in east, Syangja and Parbat districts in west, Manang and Myagdi in north and Tanahun in south (DADO, 2011). The study site has a temperate climate with altitude ranging from 1500 to 2000 meter above sea level. The study site is 9 km away from Naundanda of Bhupisherchan Highway and is connected by an agricultural road. Managing irrigation water for vegetable production is a major challenge in the study site.

Data Collection Methods

Preliminary survey

Pre-survey field visits were conducted to gather preliminary information regarding the organic practices for vegetable production, market chain, and existing condition of marketing and awareness of consumers of the sites. This information was used in preparing questionnaires and designing a sampling framework.

Key informant interview

It was used to gather information on the useful farming practices, local knowledge and innovations in managing soil nutrient and disease pests for organic production as well as for finding the farmers' constraints to produce organic vegetables. The local leaders, active farmer, middle man, seller and the consumers were key informant for data collection during the survey (from preliminary survey to focus group discussion.

Focus group discussion (FGD)

Two Focus Group Discussions (FGD) were conducted in each study area after the field survey. The participants for each FGD were from 6-10. In FGD, both male and female farmers participated.

Household Survey

A representative sample (n=66 households) was randomly selected among the organic farming practicing farming households through the simple random sampling procedure. Sample size was determined by choosing 90% confidence level and assuming 50% variation in the population (Bartlett et al. 2001). Households were selected by using simple random sampling method with the help of computer random numbers from the purposively selected 11 organic vegetable producer groups of ward 1 and 2 of the VDC. Semi-structured questionnaires were administered to the sampled farmers being involved in organic production.

Household survey helped find out the local organic practices, skills and technologies, to know out the existing marketing situation of organic products and list out the awareness and willingness of organic consumers.

Case Studies

Two case studies were used to collect in-depth information of selected farmers including male and female among the households. Motivating factors for farmers to adopt organic vegetables production, existing marketing situation of organic vegetables and awareness level of retailers and consumers as well as the constraints of the market, market prices and market margin in the organic vegetables of pokhara. It was done after the household structured questionnaire survey.

Transect walk

Village transect walk was also done to have a direct observation of the area, to observe real field situation, to validate FGD findings, and to familiarize with the location.

Literature Review

The secondary information related to the study was collected from available literatures such as books, journal papers, proceedings and district profile, annual report, and national policy documents.

Data Analysis

Quantitative data collected were analyzed by using Statistical Package for Social Science (SPSS) version 16.0 and qualitative date were analyzed by analytical descriptions. Descriptive statistics was used to analyze data.

RESULTS AND DISCUSSION

SOCIO ECONOMIC STATUS OF RESPONDENTS

Among 66 randomly surveyed households, 60% households were Gurung, 20% were Brahman and 20% were Dalits. Among the respondents, 26% respondents were male and 74% were female. In terms of educational status, 49% respondents were able tosimply read and write, 32% had secondary education, 7% had primary education, 6% had higher education and remaining 6% were illiterate.

Agriculture (89%) and pension (12%) were the main income sources for surveyed households being agriculture as a main occupation for most households (93%) followed by business (3%) and services (4%). This situation is similar to other organic farming locations, such as Kafle, 2011 also reported farming as the main occupation of a majority (89%) of the farmers in Phoolbari VDC of Chitwan.

All respondents have their own land i.e. inherited from their ancestors. They gave the area of their land in *hal* in Nelpali. One *hal* is equivalent to 2 ropani. Therefore, land area has been converted to ropani from *hal*. Average land holding of the surveyed households is 13.30 ropani including khetland, bariland, home gardens, kharbari, and private forest. In addition, 40% households were found taking land (average land size being 2.7 ropani) on rent for growing crops. Around 81% households were found to cultivate their all land. Most of the farmers (61%) cultivate organic vegetables for household consumption and, if surplus, then they sell in the market for earning money.

Farming practices

Almost all respondents (99%) reported that they raise livestock. Among them, 91% households have raised buffalos and goats. The average number of buffalo owned per household was 2. Livestock manure (mainly of buffalo and goat) was the primary source of manure for organic vegetable production in the study area. Of the total respondents, 50% households reported to use improved farm yard manure (FYM), however, only few households (11%) have improved cattle shed for producing quality organic manure from FYM. And, 82% households reported that they were using cattle urine to prepare organic manures and pesticides (Table 1).

Table 1. Farming practices for organic vegetable production in study area

S.N.	Farming practices	Percentage	
		Yes	No
1.	Cattle shed improvement	11	89
2.	Urine collection	821.8	18
3.	Farm Yard Manure improvement	50	50

Source: Households Survey and Focus Group Discussion, 2012

The study found that 94% households were using biopesticides to manage insect and diseases in the organic vegetable production. Most of the households (90%) purchased biopesticides (such as, Tycostar, Neem F, Margosom) from market and only a few (8%) prepared biopesticides by themselves .They prepare liquid manure that contains a mixure of animal urine and pieces of neem (*Azadirachta indica*), banmara (*Eupatorium* spp.), chilli (*Capsicum annuum*), bakaina (*Melia azadarach*), etc. while preparing local biopesticides. They were using hoeing and hand weeding methods to manage weeds.
Besides using biopesticides, farmers also reported of using alternatives to control insects and diseases. Among the options, mostly used measure was ash application in the fields (100%), followed by cattle urine (91%), hand picking (89%) and integrated cropping system (50%). Integrated cropping system included pest resistant crop cultivation and mixed cropping with aromatic plant species to manage pests such as integrating cole crops, root crops, legumes, tomatoes, brinjal, coriander, garlic, onion, chillies, potatoes, fruit trees and fodders. Integrated cropping system also reduces the need for procuring inputs and stimulates market-orientation among farmers for higher income (Singh et al. 2012). This type of organic farming practices offers resilience against adversities, especially climate change by enhancing an adaptive capacity of the farming community and to mitigate it (Dahal, 2009).

For soil nutrient improvement, majority of respondents found to be using traditional FYM (92%), improved compost (56%), liquid manure (56%), cattle urine (89%), and poultry manure (73%) while few respondents replied that they use green manure (2%) and goat manure (47%) for improving soil in their land (Table 2).

Table 2. Farming practices for soil nutrients improvement in study area

S.N.	Farming practices	Percentage	
		Yes	No
1.	Traditional FYM	92	8
2.	Improved compost	56	44
3.	Green manure	1	99
4	Liquid manure	56	44

5	Cattle urine	89	11
6	Poultry manure	73	27
7	Goat manure	47	53

Source: Households survey, 2012

Organic vegetable growers collect local seeds and conserve them for organic vegetable production. Organic seeds have very good market not only in Nepal but also in India. A firm called Gorkha Seeds has been producing organic tomatoes at Nakhhu in Lalitpur district for last few years to cater to the domestic market as well as demand from India. Indian traders from Raxaul of India have demanded organic tomatoes and they have started supplying Shrijana tomatoes to India (Republica National Daily, 2010).

Market of organic vegetables forces to use local and hybrid seeds for organic vegetable production in the study site. 85% households of the study area were found using local and hybrid seeds. Farmers have been using different sources to get seeds for vegetable production in the study sites (Figure 1).

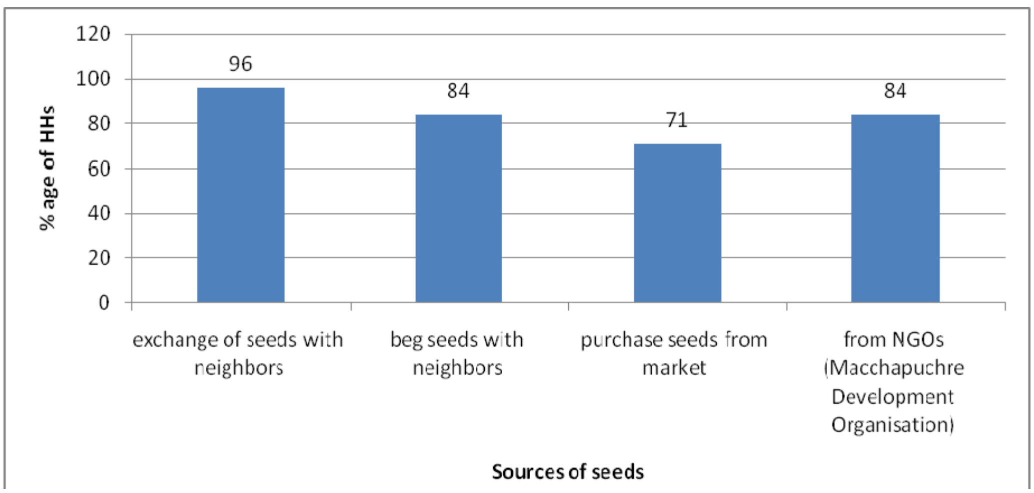


Figure .Different existing source of seeds (Source: household survey, 2012)

Majority of respondents (86%) felt that the availability of local seeds and seedlings has been increased with the adoption of organic farming. Majority of respondents (89%) also reported that there is an increase in the trend of using local seeds of vegetables such as cowpea (*Vigna radiata*), bean (*Phaseolus spp*.), potato (*Solanum tuberosum*), local tomato (*Lycopericon esculentom*), pumpkin (*Cucurbita pepo* var pepo), broad leaf mustard. All respondents reported that organic vegetable production practices have increased crop production and species diversity in the study area. Singh et al. (2012) also found that organic vegetable practices enhanced species diversity and crop production.

PRODUCTION SYSTEM FOR ORGANIC VEGETABLE FARMING

Respondents grew 22 types of vegetables in the study area. The total vegetable harvested in a year was found to be 37, 126 kg/year(Table 3).

Table 3. Production of organic vegetables in study area

S.N.	Name of crops	Botanical Name	Total Production (Kg)
1.	Carrot	*Daucus carota* L. subsp. *sativus* (Hoffm.) Acreng	990.00
2.	Pumpkin	*Cucurbita pepo* L. va*r. pepo*	990.00
3.	Eggplant	*Solanum melongena* L.	1320.00
4.	Ginger	*Zingiber officinale* Rosc.	1320.00
5.	Turmeric	*Curcuma domestica* Valeton	1320.00
6.	Coriander	*Coriandrum sativum* L.	1320.00
7.	Summer squash	*Cucurbita pepo* L. var*. condensa* Bailey	1320.00
8.	Radish	*Raphanus sativus* var. *radicula* L.	1452.00
9.	Cabbage	*Brassica oleracea* L. var. *capitata* L.	1650.00
10.	Brocauli	*Brassica oleracea* L.var. *italica* Plenck.	1650.00
11.	Garlic	*Allium sativum* L. var. *sativum*	1762.00
12.	Broadbeans	*Vicia faba* L.	1782.00
13.	Soyabean	*Glycine max* (L.) Merr.	1782.00
14.	Cucumber	*Cucumis sativus* L.	1848.00
15.	Cauliflower	*Brassica oleracea* L. var*. botrytis* L.	1980.00
16.	Beans	*Phaseolus vulgaris* L.	1980.00
17.	Onion	*Allium cepa* var. *cepa* L.	2310.00
18.	Hot chilli	*Capsicum annuum* L. var. *minimum* Mill.	2310.00
19.	Broadleaf mustard	*Brassica rapa* L. subsp. *pekinensis* (Lour.) Olsson.	2640.00
20.	Tomato	*Lycopersicon esculentum* Mill.	2640.00
21.	Pea	*Pisum sativum* L.	2400
22	Potato	*Solanum tuberosum* L.	3000

Source: Focus Group Discussion, 2012

Similarly, they grow paddy *(Oryza sativa)*, maize *(Zea mays)*, finger millet (*Eleusine coracana)*, wheat (*Triticum aestivum*), upland paddy (Ghiaya, Juhari, Bageli, etc.) for household consumption by using local organic practices.

Respondents reported that food is sufficient for 8 months on an average in study site. However, it was found that farmers have in fact improved the level of food security after being introduced organic farming methods (Singh et al., 2012). China also showed similar results that improvement in food security in terms of nutrition and quality, optimization of the agricultural structure and ensuring profit for both farmers and the company involved for organic vegetable production, processing and trading (Brandt, 2007).

MARKETING SYSTEM OF ORGANIC VEGETABLES

Farmers were producing organic vegetables using available local resources since several years. However, it has been 2 years since farmers were producing organic vegetables from marketing point of view. Out of total respondents, 60 %) households grew organic vegetables to sell while 40% of households grow for own consumption. Around 61% households ' sold surplus (after own consumption) organic products and 39% farmers sold the whole production to earn money. A majority of households (56%) sold organic vegetables to their to neighbor, 13% farmers to local shop, 4.5% farmers to local traders, and 51% farmers to traders from outside the village.

Organic farmers of Bhadaure VDC reported that they sold their organic vegetables such as cauliflower, cabbage, broccoli, radish, leafy vegetables, knol khol, coriander, potato, carrot, hot chilli, pea, cowpea, tomato, beans etc to "The Bazaar." The Bazaar is one of the working business house that facilitate marketing of organic vegetables from farmers to the consumers through its market outlets located in Pokhara city. The bazaar also supplies organic products to Shree Complex of Pokhara city. The organic vegetable growers of the other districts have market place in the Kathmandu valley for the diverse products ranging vegetables like lettuce, spinach, turnip, carrot, cabbage, tomato and leek are the major ones (Aryal et al., 2009).

The marketing channels of organic vegetables in Bhadaure Tamagi is (i) production in farmers field (ii) collection center (iii) display at market outlets and (iii) ultimately to consumers. Similar type of marketing channels of organic products was reported from Kathmandu valley (Aryal, 2008). In the study site, generally, farmers take their organic vegetables in a collection center (Deurali) where traders from Pokhara city can buy it to take them to the consumers. In addition, farmers directly sell their organic vegetables to neighbors, local shops and local traders in the villages apart from "The Bazaar"

CONCLUSION

Farmers in the study are using local manures and biopesticides to produce organic vegetables Organic vegetable production has increased by using local available resources for making organic manures, FYM, improvement of cattle shed, and using of cattle urine. These are the main practices for organic vegetable production in the study site. FYM and cattle urine are used for soil management; whereas cattle urine collection, use of ash, and integrated farming practices were targeted for pest management. Organic vegetable production trend is increasing in the study area over the time. The peoples' perception at local level indicates that 100% respondent of the Bhadaure Tamagi V.D.C has experienced change in organic vegetable production and that too increasing in the growing vegetables for home consumption as well as the market purpose. Hence, organic farming can attract periurban small holder farmers and contribute to improve their livelihoods and build their resilience.

ACKNOWLEDGEMENTS

We would like to thank USC Canada Asia, Dr. Pratap Kumar Shrestha, Mr. Bharat Bhandari and Nepal Permaculture Group for providing financial and technical support for the study. In addition, we are grateful to Machhapuchhchre Development Organization, Mr. Guna Kumar Shrestha and Mr. Bimal Lamichhane, Ms. Manita Gurung, Ms. Devi Gurung, Ms. Gaulaxmi Gurung, and Ms Mina Sunar for their logistic support in the field survey and discussion and the farmers of the study sites for providing their valuable experiences and knowledge on the research topic.

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ANALYSIS OF THE IMPACT OF PRAGANNA IRRIGATION PROJECT (PIP) ON INCOME AND EMPLOYMENT IN DANG DISTRICT OF NEPAL

Y. Padhyoti[1], J.P. Dutta[2], P.P. Regmi[3], N.K. Chaudhary[4]

ABSTRACT

A survey research was conducted to assess the performance of Praganna Irrigation Project with respect to farm income and employment in Dang district of Nepal. Simple random sampling was used to select 60 beneficiaries and 30 non-beneficiaries as sampling units to comprise a sample size of 90. Representatives of WUGs and officials of PIP were interviewed through checklists. Altogether there were 75 WUGs, which are responsible for distribution of irrigation water equitably and collection of irrigation charges effectively. A comparative study was made between the beneficiaries and non-beneficiaries under PIP. The total farm assets of beneficiaries were estimated at NRs. 1,150,975 and differed significantly with the non-beneficiaries with total farm assets of NRs. 875,185. A significant difference was observed between on farm income of beneficiaries (NRs.183,260) and non–beneficiaries (NRs. 31,453). The net farm income of the beneficiaries and non-beneficiaries were estimated at NRs. 79,993 and NRs. 13,077 respectively and the difference were significant among the categories of respondents. The total farm income was significantly affected by landholding, total variable cost, cropping intensity, and employment in case of beneficiaries whereas only employment significantly affected total farm income in case of non-beneficiaries. Gini coefficients for gross household and gross farm income were calculated at 0.37 and 0.44 respectively for beneficiaries and 0.44 and 0.27 respectively for non-beneficiaries. So, there existed inequality in distribution of gross household and gross farm incomes within both categories. The study also indicated the huge potentiality of PIP for increasing farm income in the command area of PIP.

Key words: Employment, Farm Income, Irrigation, Income inequality

INTRODUCTION

Agriculture is the main stay of majority of Nepalese people and irrigation is the major input for agriculture. Because of its rugged terrain, only 17 percent of Nepal's total land area is suitable for farming (CARE, 2001). Of the total geographical area, the land suitable for arable agriculture is estimated at 2,641,000 ha. Of this land, the potential irrigable area under surface and groundwater sources is about 1,766,000 ha (NPC, 2008). However, till the end of the Ninth Plan the total irrigation facility achieved both by surface and ground water irrigation is around 1,121,441 ha owing to the rugged topography and landform (NPC, 2002).

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Irrigation permits the use of land throughout the year by way of producing two or three crops and by cultivating long duration crops. In other words, it facilitates the intensive use of scarce land resources and it is also essential for increasing the use of yield increasing inputs and enhancing the cropping intensity and crop productivity (Moorhty, 1997).

According to Khanal (2003) irrigation management is the mechanism, processes and institutions involved in getting water to farmer’s field. Roth (1999) defines it as a wide variety of task that guarantees sufficient, timely and equitable water distribution to users. Development of irrigation is a complex socio-technical phenomenon. It involves collective action by the people and includes multiple activities including the maintenance of irrigation infrastructure, organizing local community, and delivering water to users for meeting crop water requirement. Varying demand and supply of irrigation water over time and space has further increased complexity in managing irrigation systems (WECS, 2001).

The objective and goals of irrigation sector is to develop controlled and year-round irrigation in a sustainable way through proper utilization of available water resources for increasing the agricultural productivity thereby raising livelihoods of rural community (HMG, 2002). The target set for the development of irrigation infrastructure during the Tenth Plan period was 193,600 ha, through development of new irrigation schemes in 129,600 ha and rehabilitation and improvement of FMISs in 64,000 ha, that included 52,600 ha under surface and 77,000 ha ground water schemes (NPC, 2002). At the end of the Plan period, the achievement in the development of irrigation infrastructure was in 87,485 ha, including development of new schemes in 73,187 ha and rehabilitation and improvement of FMISs in 14,298 ha that include surface (25,504 ha) and groundwater (47,683 ha) schemes (NPC, 2008). The basic function of irrigation is to compensate for permanent water deficits and to smoothen the climatic variations of local precipitation (AFEID, 2008).

Alam (1991) examined the impact of irrigation on income distribution in Gazipur District, Bangladesh, focusing on farmers in Sador and Kapasia Upazilas. Data from 80 respondents, of whom half had access to irrigation, showed that irrigation reduced income inequalities slightly. Smaller farmers benefited more because they did not need to incur costs in hiring labour. Generally, access to irrigation facilities was considered satisfactory.

Silliman and Lenton (1985) reviewed evidence from 45 micro-studies, 25 of them from India, and with few exceptions they confirmed a positive relationship between irrigation and employment. Studies from India in the mid 1980s showed that the increase in days worked on irrigation schemes, compared to rainfed conditions, was over 100 percent in the Damodar valley canals in West Bengal, over 150 percent in Ferozepur (Punjab), 61 percent on the Dantiwada canal in Gujarat, and over 100 percent under the Kakitiya canal in Andhra Pradesh (Chambers, 1985).

Irrigation can play a central and dynamic role in the improvement of rural livelihoods, but is often subject to criticisms of inefficiency in water use, high capital and recurrent costs, lack of sustainability, and association with inequity in the distribution of both land and water (Hasnip et. al., 2001).

METHODOLOGY OF STUDY

To study the performance of PIP on employment and farm income, 90 respondents (60 beneficiaries and 30 non-beneficiaries) were selected by random sampling technique from the households who use water of PIP as beneficiaries and not using the water from PIP as non-beneficiaries. The primary data were generated directly from the farmers-beneficiaries and non-beneficiaries, officials of DOI, DANG and PIP, Chailahi and representatives of WUGs by using pretested questionnaire and PRA tool and checklist whereas secondary data were collected through various government and non-government agencies like office of selected VDCs namely - Chailahi, Sonpur, Sisania, and Lalmatia, DADO and DIO DANG.

The collected data were coded, processed, classified, and organized into various tables in order to facilitate the analysis from which meaningful inference could be drawn. The data was analyzed by using EXCEL and SPSS softwares. Conventional analysis was used for understanding the sample characteristics such as farm income and employment.

To study the income inequality, Lorenz curve was used. The curve below the egalitarian line indicates the existence of inequality. The more unequal the income distribution, the Lorenz curve lies further below the egalitarian line.

Gini concentration ratio, developed by Corrado Gini in 1913, was used as a measure of relative distributional inequality.

Gini Ratio = Area between curve and diagonal/Area under diagonal and is given by the formula,

$$\text{Gini Coefficient (G.C.)} = \frac{1}{100^2}\left[\sum x_i y_{i+1} - \sum x_{i+1} y_i\right]$$

where,

x_i = Cumulative % of X variable, and

y_i = Cumulative % of Y variable.

0≤ G.C≤1, 0 denoting completely equal distribution (Kanel, 1993).

Income of both the beneficiaries and non-beneficiaries was regressed with the selected variables. Coefficient of multiple regressions (R^2) was calculated for finding the variation in income explained by the included independent variables. Similarly, statistical test for the values of coefficients of explanatory variables was tested at five and one percent level of significance.

$$Y = a_o + a_1X_1 + a_2X_2 + a_3X_3 + a_4X_4 + a_5X_5 + a_6X_6$$

where,
Y = Farm income (in '000 NRs)
X_1 = Economically active family members (in number)
X_2 = Land holding (in hectare)
X_3 = Cropping intensity (in percentage)
X_4 = Total asset (in '000 NRs)
X_5 = Total variable cost (in '000 NRs)
X_6 = Total employment (in mandays)
a_0 = Intercept
a_j= regression coefficients (i=1,2,3,.......)
X_1........X_6 = Explanatory variables.

RESULT AND DISCUSSION

Gross Household Income

On- and off-farm incomes constituted the gross household income. Here, on-farm income referred to the value of both total products and byproducts and the land rent. Off-farm income included incomes of rented out labour, service, business, and other professional works.

The study revealed that the total annual gross household income of NRs. 442,400.13 was significantly high for beneficiaries as compared to NRs. 126,803.21 of non-beneficiaries (p value <0.01). The average gross household income of beneficiaries (NRs. 183,260.11) was also found significantly higher than that of beneficiaries (NRs. 31,453.12).

In totality, sample farmers obtained the average annual gross income of NRs. 337,198.95. On the basis of composition of gross household income sample farmer received 65 percent of income from farm and 35 percent from off-farm sources (Table 1).

Table 1. Sources and average annual household income by category of respondent

Respondent Category	(Amount in NRs.)		
	On-farm Income	Off-farm Income	Total
Beneficiaries	183260.11**(41.42)	259140.02(58.58)	442400.13**(100)
Non-beneficiaries	31453.12 (24.80)	95350.09(75.20)	126803.21(100)
All farmers	132658.02(64.86)	204540.93 (35.14)	337198.95 (100)

*** indicates significant at 1 percent level of significance.*

Gross Farm Income

Income from both crop and livestock activities such as sale and consumption of crop and livestock products and byproducts along with land rent constituted the gross farm income. The study revealed that the income from the crop is significantly higher than that from livestock in both the case of beneficiaries and non-beneficiaries (p value <0.01). It also revealed that the income from crop is significantly higher in case of beneficiaries (NRs. 154,568.70) as compared to non-beneficiaries (NRs. 25,436.67) (p value <0.01). However, the income from livestock to beneficiaries (NRs 28,691.67) was not significantly higher than non-beneficiaries (NRs 6,016.67).

Table 2. Distribution of gross farm income by respondent category

Respondent Category	Crop	Livestock	Total
Beneficiaries	154568.70**(84.34)	28691.67(15.66)	183260.37(100)
Non-beneficiaries	25436.67**(80.87)	6016.67(19.13)	31453.34(100)
All farmers	111524.68(84.06)	21133.33(15.94)	132658.01(100)

*** indicates significant at 1 percent level of significance.*

Net Farm Income and Management and Investment Income (MII)

Net farm income referred to the gross farm income less the total variable cost incurred in the farm. Management and investment income was realized by deducting total fixed cost and total variable cost. The study revealed that the average total variable cost of the beneficiaries (NRs. 103,267.63) was significantly higher than that of non-beneficiaries (NRs. 18,376.57) (p value <0.01). Net farm income of beneficiaries (NRs. 79,992.48) and non-beneficiaries (NRs. 13,076.55) were significantly different (p value < 0.01). The management and investment income were also significantly different between the beneficiaries (NRs. 61,878.94) and non-beneficiaries (NRs. 9,759.91).

Table 3. Net farm income and MII by category, 2009

Respondent Category	Gross Farm Income	Average Total Variable Costs	Net Farm Income	MII
Beneficiaries	183260.11	103267.63**	79992.48**	61878.94**
Non-beneficiaries	31453.12	18376.57	13076.55	9759.91
All farmers	50603.61	25049.66	25553.94	21840.99

*** indicates significant at 1 percent level of significance.*

Regression Analysis for Beneficiary Households

In order to analyze the influence of various factors responsible for farm income of beneficiary households who had access to irrigation and farm income of non-beneficiaries who did not have access to irrigation, regression model was run considering total farm income as dependent variables and total variable cost, land holding, cropping intensity, economically active family members, total assets and farm employment as independent variables. This was done to find whether or not the irrigation had played significant role in farm income. The model specification is shown below:

Y = b1X1 + b2X2 + b3 X3 + b4X4 + b5X5 + b6X6

where,

Y = Gross household income (in '000 NRs.)
X_1 = Land holding (in hectare)
X_2 = Total variable cost (in '0000 NRs.)
X_3 = Total asset (in '000 NRs.)
X_4 = Cropping intensity (in percentage)
X_5 = Total employment (in mandays)
X_6 = Economically active family members (in number)

Table 4. Estimates of income function for beneficiary households, 2009

Variables	Specification	Unit	Unstandardized Coefficient	Standard Error	Standardized Coefficient	t-value	P-value
'Y'=Farm income in NRs., a dependent variable							
Constant			473.703	254.026		1.865	.068
X1	Land holding	ha	12.49	12.84	.121	1.99	.o50*
X2	TVC	'000 Rs.	0.974	0.460	.922	2.168	.035*
X3	Total assets	'0000 Rs.	0.077	.165	.197	1.810	.053
X4	Cropping Intensity	%	0.688	.179	.332	3.841	.00**
X5	Employment	MD	.262	.102	1.105	2.168	.03*
X6	EAFM	No.	13.72	6.17	.198	1.70	.07

R = 0.81, R^2 = 66.2

Durbin – Watson statistics = 2.11

The regression analysis showed that the independent variables namely landholding, total variable costs, employment, and cropping intensity had significant effect on farm income whereas total assets and EAFMs did not have significant role in farm income. Details of effects of independent variables on dependent variable are discussed below.

Landholding

Landholding had significant effect in farm income i.e. increase in landholding had increased the farm income significantly ($p < 0.05$). This could be due to large landholding leading to higher production with the availability of irrigation facility which ultimately lead to increase in total farm income.

Total Variable Cost

Significant effect of total variable cost was observed on gross farm income. So, increase in farm income was associated with the increase in variable cost i.e. increase in use of variable resources in farm ($p < 0.05$). In other words, use of various inputs in the farm including effective management of irrigation in the farm lead to higher production which ultimately results in increased farm income.

Total Assets

The assets possession had positive effect on farm income of the beneficiaries but not significant ($p > 0.05$). This means increase in total assets of respondents did not increase the farm income significantly. This could be due to farmers had not paid their attention towards acquiring more assets related to farming. They had rather acquired assets which were not related to agriculture.

Cropping Intensity

Increase in cropping intensity leads to increase in total cropped area and production which generally results in increase in gross income (given that the current market price of products do not drop significally as compared to the previous or base year). It means that increase in cropping intensity would lead to increase in total farm income. Such result was found in this study too i.e. increase in farm income was observed with the increase in cropping intensity ($p < 0.01$).

Total Employment

The effect of on-farm employment on total farm income was found significant ($p < 0.03$). That means increase in no. of employee in the farm also increased the farm income. This could be due to better management on cultivation practices and other farm operation as a result of increased farm employment

Economically Active Family Members

Positive relationship was found between farm income and economically active family members. But, this relationship was non significant ($p > 0.05$). That means increase in EAFM would not increase total farm income significantly. This was because the employment opportunity in the study area was quite less. So, increase EAMs did not increase the total income of the household.

Table 5. Estimates of income function for non-beneficiary households, 2009

Variables	Specification	Unit	Unstandardized Coefficient	Standard Error	Standardized Coefficient	t-value	P-value
'Y'=Farm income in NRs., a dependent variable							
Constant			-13.829	4.684		-2.952	.006
X1	Land holding	ha	10.22	6.22	.121	1.50	.09
X2	TVC	'000 Rs.	0.66	0.34	.799	1.69	.06
X3	Total assets	'0000 Rs.	0.077	.165	.197	1.810	.053
X4	Cropping Intensity	%	.087	.033	.110	1.61	.08
X5	Employment	MD	.112	.97	.8765	2.22	.021*
X6	EAFM	No.	8.77	3.11	.123	1.66	.09

R = 0.76, R^2 = 0.69, Durbin – Watson Statistics = 1.91

Regression Analysis for Non-beneficiary Households

The regression analysis for non-beneficiary households showed that the independent variables namely landholding and employment had significant effect on farm income whereas total assets, total variable costs cropping intensity and EAFMs did not have significant role in farm income. Details of effects of independent variables on dependent variable are discussed below:

Landholding

Land holding had no significant effect in farm income i.e. increase in land holding would not significantly increase the farm income (p>0.05). This could be because of non availability of irrigation facility which is very important from crop cultivation point of view.

Total Variable Cost

Significant effect of total variable cost was not seen on farm income (p>0.05). So, increase in farm income was not significantly associated with the increase in variable cost i.e. this could be due to no or very less availability of assured irrigation water without which use of inputs will have less effect on production and ultimately on farm income.

Total Assets

The effect of total assests on farm income among non-beneficiary households was simailr to beneficiary households. In other words, the effect of total assets possession had positive effect on farm income of the beneficiaries but not significant (p>0.05). This means increase in total assets of respondents did not increase the farm income. This could be due to farmers had not paid their attention towards acquiring more assets related to farming. They had rather acquired assets which were not related to agriculture.

Total Employment

The effect of total employment engaged in farm on total farm income was found significant ($p<0.03$). That means increase in no. of employee in the farm also increased the total farm income. This could be due to better management on cultivation practices and other farm operation as a result of increased involvement of farm employment

Economically Active Family Members

The positive relationship was found between farm income and economically active family members. However, this relationship was non-significant ($p>0.05$). That means increase in EAFM would not increase farm income. This was because people of non-beneficiaries category had very less land holding and thus people would be engaged in other off-farm instead of farm activities. This would ultimately decrease the farm income.

Income Distribution

Information on gross incomes per household and per farm were collected in order to acquaint the state of inequality in income distribution. The study showed that the gross income per household per year of the beneficiary households varied from NRs. 68,100 to NRs. 2,638,500. Poorest 10 percent of beneficiary households earned a mere 2.09 percent of gross household income. In contrast, the richest 10 percent households earned 36.05 percent of gross household income. Similarly, the lower 50 percent households earned only 20.51 percent of gross household income in comparison to 79.49 percent earned by upper 50 percent. It revealed that there exists wide disparity in distribution of gross household income among the beneficiaries (Table 6).

Table 6. Distribution of gross income per household of beneficiary households, 2009

Value in '000 NRs.

Income Level per Year	No. of HH	Percent of Household	Income Percent	Cumulative	
				Percent of HH	Percent of Income
68.100-124.351	6	10	2.09	10	2.09
124.352-151.850	6	10	3.24	20	5.33
151.851-192.700	6	10	4.02	30	9.35
192.7001-233.479	6	10	4.87	40	14.22
233.478-293.700	6	10	6.29	50	20.51
293.701-332.863	6	10	7.05	60	27.56
332.864-459.884	6	10	9.37	70	36.93

459.885-576.800	6	10	11.68	80	48.61
576.801-749.500	6	10	15.34	90	63.95
749.501-2638.500	6	10	36.05	100	100

As shown in Table 7, gross income per farm per year of beneficiary households varied from NRs. 46,500 to NRs. 101,015,000. Poorest 10 percent of beneficiary households earned only 2.92 percent of total farm income whereas the richest ten percent earned 28.63 percent of that income. Similarly, lower 50 percent of beneficiary households earned only 25.01 percent of farm income in contrast to 74.99 percent earned by upper 50 percent. Therefore, it could be said that there exists a wide inequality in farm income distribution among the beneficiaries.

Table 7. Distribution of gross income per farm of beneficiary households, 2009

Value in '000 NRs.

Income Level per Year	N. of HH	Percent of HH	Percent of Income	Cumulative	
				Percent of HH	Percent of Income
46.50-62.0	6	10	2.92	10	2.92
62.001-73.65	6	10	3.78	20	6.7
73.651-96.690	6	10	4.73	30	11.43
96.691-126.825	6	10	6.11	40	17.54
126.826-146.150	6	10	7.47	50	25.01
146.151-167.700	6	10	8.56	60	33.57
167.701-191.900	6	10	9.72	70	43.29
191.901-238.500	6	10	12.2	80	55.49
238.501-346.392	6	10	15.88	90	71.37
346.393-1010.150	6	10	28.63	100	100

Gross income per family of the non-beneficiary households varied from NRs. 47,250 to NRs. 371,500. Poorest 20 percent of them earned 10.22 percent of gross household income in contrast to 35.28 percent earned by richest 20 percent (Table 8).

Table 8. Distribution of gross income per household of non-beneficiary households, 2009

(Income in'000 NRs.)

Level of Income per Year	No. of HH	Percent of HH	Percent of Income	Cumulative	
				Percent of HH	Percent of In come
47.250-86.800	6	20	10.22	20	10.22
86.801-103.200	6	20	15.11	40	25.33

103.201-124.450	6	20	17.85	60	43.18
124.451-148.100	6	20	21.54	80	64.72
148.101-371.500	6	20	35.28	100	100

Farm income per family of the non-beneficiary households varied from NRs. 2,700 to NRs. 146,600. Poorest 20 percent of them earned 4.59 percent of gross household income in contrast to 48.81 percent earned by richest 20 percent (Table 9).

Table 9. Distribution of gross income per household of non-beneficiary households, 2009

(Income in'000 NRs.)

Level of Income per Year	No. of HH	Percent of HH	Percent of Income	Cumulative	
				Percent of HH	Percent of In come
2.700-11.450	6	20	4.59	20	4.59
11.451-20.250	6	20	10.26	40	14.85
20.251-27.000	6	20	15.17	60	30.02
27.001-38.200	6	20	21.17	80	51.19
38.201-146.600	6	20	48.81	100	100

The pattern of income distribution of beneficiary and non-beneficiary households is presented in Figures 1 and 2 respectively. As inequality line of per farm income of beneficiary households is closer than the inequality line of their household income, it could be stated that the disparity in distribution of household income is greater than farm income. Whereas, in non-beneficiary households, per farm income varied widely than per household income implying the greater inequality in farm income.

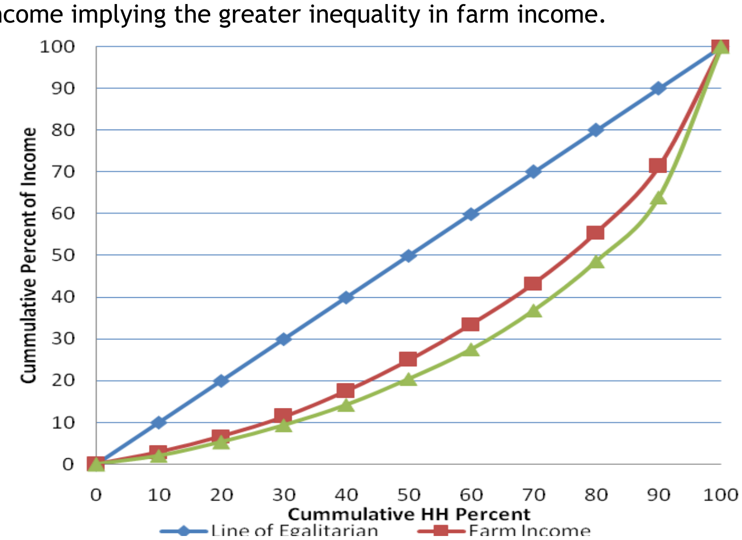

Figure 1. Lorenz Curve for distribution of gross incomes per farm and household of beneficiary households

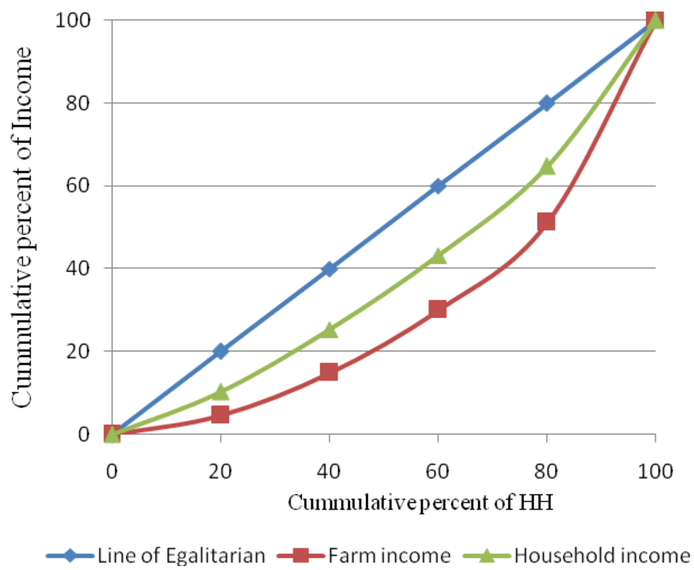

Figure 2. Lorenz Curve for distribution of gross incomes per farm and household of non-beneficiary households

Gini Coefficients for gross income per household and per farm of beneficiaries and non-beneficiaries are presented in Table 10. These coefficients revealed that disparity prevail in both the categories for both the household and farm incomes which were almost similar to their counterparts between the categories. From this study it is inferred that gross income was widening the disparity, while farm income was helping in reducing that disparity among the beneficiary households. In contrast to beneficiaries, it was just reverse for non-beneficiaries.

Table 10. Gini coefficients for gross incomes per household and farm by category of respondents

Category of Respondent	**Total Farm Income**	**Total Gross Income**
Beneficiaries	0.37	0.44
Non-beneficiaries	0.44	0.27

CONCLUSION

Praganna Irrigation Project lying in Deukuri valley of dang district, Nepal was implemented by the Department of Irrigation of Government of Nepal. The main aim of the project was to develop irrigation infrastructure to irrigate 5,799 ha agricultural land of four VDCs of Deukuri valley namely Chailahi, Sonpur, Sisania and Lalmatia. Major part of the project was focused on to upgrade the traditional irrigational system developed by the farmers covering 5,130 ha. In the impact study of PIP on farm income 73.33 percent of the beneficiaries said that there is increase in cereal production whereas 38.33 percent said that there is increase in vegetable production. However, only 53.33 percent of them addressed on increased farm income. The total annual gross household income of NRs 442,400.13 was significantly high for beneficiaries as compared to NRs 126,803.21 of non-beneficiaries ($p < 0.01$).

The income from the crop is significantly higher than that from livestock in both the case of beneficiaries and non-beneficiaries ($p<0.01$). it also revealed that the income from crop is significantly higher in case of beneficiaries (NRs. 154,568.70) as compared to non-beneficiaries (NRs. 25,436.67) ($p<0.01$). The management and investment income were also significantly different between the beneficiaries (NRs. 61,878.94) and non-beneficiaries (NRs. 9,759.91). Among 60 beneficiaries, majority of respondents (56.67%) were moderately satisfied with present level of operation and management of PIP followed by high and very high, indicating average performance of the PIP.

From regression analysis it was found that there was significant effect of total variable cost on farm income ($p<0.05$), The assets possession had positive effect on total farm income of the beneficiaries but not significant ($p>0.05$), farm income was found with the increase in cropping intensity ($p<0.01$). The effect of total employment engaged in farm on farm income was found significant ($p<0.03$), this could be due to better management on cultivation practices and other farm operation as a result of increased involvement of farm employment.

The gross income per household per year of the beneficiary households varied from NRs. 68,100 to NRs. 2,638,500. Poorest 10 percent of beneficiary households earned a mere 2.09 percent of gross household income. In contrast, the richest 10 percent households earned 36.05 percent of gross household income. Gini Coefficients for gross income per household and farm of beneficiaries and non-beneficiaries revealed that disparity prevail in both the categories for both the household and farm incomes which were almost similar to their counterparts between the categories. It is inferred that gross income was widening the disparity while farm income was helping in reducing that disparity among the beneficiary households. It was just reverse for non-beneficiaries.

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EFEECT OF DIFFERENT PRIMING METHODS IN RICE (ORYZA SATIVA)

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ABSTRACT

Good germination of rice is considered critical for the plant life cycle. A laboratory experiment was conducted in IAAS, Lamjung campus, Sundarbazar tostudy the effect of different priming methods in rice. The experiment was done in completely randomized design using 12 treatmentsreplicated thrice. The treatments consisted;Control (No priming), Hydro priming (soaking of seeds in distilled water for 72 hrs), PEG6000 - 5% and 10%, $CaCl_2$ – 0.5% and 1%, KCl – 2% and 4%, KNO_3 – 1% and 2% and NaCl – 1.8% and 3.6% where seeds were soaked for 12 hours followed by 12 hours drying. Both hydro priming and PEG improved germination energy, germination index, germination speed, radical length, and plumule length. The effect due to varied doses were not observed in the priming substances except PEG 6000, where PEG6000 – 5% was better as compared to PEG – 10% in overall observations.

Keywords: *Halopriming, hydropriming, osmopriming, polyethylene glycol (PEG), seed priming.*

INTRODUCTION

Rice *(Oryza sativa* L.*)* is a major food crop for the people of Asia; nearly 90% of the world's rice is produced and consumed in this region. Germination and seedling establishment are critical stages in the plant life cycle. Cereal production is widely limited by poor seed germination and crop establishment (Jones and Wanbi, 1992). Germination tends to be irregular and can extend over long periods particularly in drought-prone environments (Bougne *et al.*, 2000). The resulting poor crop germination leave gaps in the canopy, which are rapidly filled by vigorously growing weeds at the onset of the short rainy season which compete with the crop plants for light, water and nutrients (Kropff and Van Laar, 1993). Accelerating and homogenizing the germination process is a prerequisite for a good crop establishment, the efficient use of resources, and eventually to increase yields (Harris, 1996).

Seed priming can be low cost technology which can replace the traditional transplanting method which takes more labour force and longer duration to maturity compared to primed seed cultivation. Crop failure may occur reducing crop productivity if poor seed germination behavior occurs in field crop (Ghiyasi *et. al.*, 2008) which can be addressed by priming treatment leading to better germination and establishment in any crop (Basra *et. al.*, 2005; Ghiyasi *et. al.*, 2008). Rapid seed germination and stand establishment are critical factors for crop production under stress conditions. In many crop species, seed germination and early seedling growth are the most sensitive stages to stresses. Seed

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priming is known as the seed treatment which improves seed performance adverse under stressful environmental conditions (Ashraf and Foolad, 2005). Seed priming is defined as pre sowing treatments in water (hydropriming) or in an osmotic solution (osmopriming) that allows seed to imbibe water to proceed to the first stage of germination, but prevents radicle protrusion through the seed coat. Presowing treatment with inorganic salts (halo priming) not only promotes seed germination of most crops, but also stimulates later growth, metabolic processes and, hence, ultimate crop yield. Seed priming stimulates a different biochemical changes in the seed that are essential to initiate the germination process e.g. water imbibition, breaking of dormancy, activation of certain enzyme etc. (Ajour *et al.*, 2004). Primed seeds emerged 12h earlier than non primed seeds (Dell-Aquila and Tritto, 1990). This is due to increase in activity of enzymes such as amylase, protease and lipase which have great role in breakdown of macromolecules for growth and development of embryo that ultimately resulted in early and higher seedling emergence. The most important priming treatments are osmopriming, halopriming and hydro priming.

MATERIALS AND METHODS

The experiment was conducted in Agronomy lab of Lamjung Campus of Institute of Agriculture and Animal Sciences, Sundarbazar, Lamjung. Sookha dhan -2 variety of rice was used in the experiment. The experiment was carried out in completely randomized design consisting of 12 treatments replicated 3 times. The treatments consisted of priming with different priming substances followed by re-drying for 12 hours. The treatments used were Control (No Priming), Hydro priming (soaking of seeds for 72 hrs), PEG6000 5% and 10%, $CaCl_2$ – 0.5% and 1%, KCl – 2% and 4%, KNO_3 – 1% and 2% and NaCl – 1.8% and 3.6% for 12 hours followed by 12 hours drying. Observations were taken regularly for germination and counting was done regularly until final germination was recorded. For radical and plumule length reading was taken in 5^{th} day with a measuring scale.

All the recorded data were tested for normality and homogeneity and analyzed using SPSS. The mean separation was done using LSD (at 5% level of significance).

RESULTS AND DISCUSSION

GERMINATION ENERGY(GE)

The results shows that there was significant difference between different priming methods on GE (Table 1). Hydro priming, KNO_3 - 2% and PEG – 5% showed significantly higher GE than control and NaCl – 3.6%. However, no any priming substances used brought significant alterations to GE when used in varied levels.

GERMINATION INDEX(GI)

All the priming methods (hydro priming, KNO_3, KCl, NaCl, PEG and $CaCl_2$) showed significantly higher germination index than control at both the levels but in case of KNO3, KCl, and CaCl2, there was statistical similarity between the varied doses (Table. 1). However, significant decrease in germination index was observed with increase in level of NaCl and PEG.

GERMINATION SPEED(GS)

Hydro priming, KCl – 1%, KNO_3 - 2%, NaCl – 1.8%, PEG – 5% and $Cacl_2$ – 1% showed higher GS than control and NaCl – 3.6%. There was statistical similarity among varied doses of all chemicals except NaCl, where increase in salt concentration significantly reduced the GS.

Table 1. Effect of different methods of priming on rice germination indices in Sundarbazar, Lamjung during 2014.

Treatment	Germination energy (GE)	Germination index (GI)	Germination speed (GS)	Radical (cm)	Plumule (cm)	Radical:plumule ratio (cm)
T1 (control)	90^{b}	6.556^{d}	94.54^{b}	3.860^{c}	1.467^{c}	2.676
T2 (hydro priming)	100^{a}	9.361^{a}	100^{a}	5.373^{ab}	2.453^{a}	2.302
T3 (KCl@1%)	95^{ab}	9.167^{ab}	100^{a}	4.680^{bc}	1.940^{b}	2.467
T4 (KCl@2%)	95^{ab}	8.361^{bc}	98.25^{ab}	5.033^{b}	1.720^{bc}	2.924
T5 (KNO_3@2%)	98.33^{a}	9.028^{ab}	100^{a}	5.273^{a}	1.820^{bc}	2.910
T6 (KNO_3@4%)	95^{ab}	8.694^{ab}	98.33^{ab}	4.867^{b}	1.887^{b}	2.582
T7 (NaCl@ 1.8%)	93.33^{ab}	9.139^{ab}	100^{a}	5.387^{ab}	2.047^{ab}	2.637
T8 (NaCl@3.6%)	83.33^{b}	7.694^{c}	90.93^{b}	4.200^{bc}	1.467^{c}	2.939
T9 (PEG6000@5%)	100^{a}	9.333^{a}	100^{a}	5.940^{a}	2.433^{a}	2.450
T10 PEG6000@10%)	93.33^{ab}	8.500^{b}	96.58^{ab}	4.400^{bc}	1.680^{bc}	2.718
T11 ($CaCl_2$@0.5%)	96.67^{ab}	8.333^{bc}	96.39^{ab}	5.127^{ab}	1.927^{b}	2.668
T12 ($CaCl_2$@1%)	93.33^{ab}	8.944^{ab}	100^{a}	4.580^{bc}	1.527^{bc}	3.041
N	94.44	8.593	97.92	4.893	1.864	2.693
LSD	8.061	0.7214	5.110	0.8523	0.4201	(ns)
CV	5.0%	5.0%	3.1%	10.3%	13.4%	18.6%

ns: non significant at $p< 0.05$. Different letters indicate significant difference at $p< 0.05$.

RADICAL LENGTH

Hydro priming, KCl – 2%,KNO_3 - 2% and 4%, NaCl – 1.8%, $CaCl_2$ – 0.5% and PEG – 5% resulted higher radical length than control. Different levels of KCl, NaCl and $CaCl_2$ were statistically similar (Table 1) but variation among different doses were observed in KNO_3 and PEG, where increase in level of both chemicals significantly decreased the radical length.

PLUMULE LENGTH

Hydro priming, Nacl – 1.8% and PEG – 5% resulted significantly higher plumule length than other priming methods. There was no sigmificant difference between different levels of KCL, KNO_3, and $CaCl_2$ (Table 1) but among various level of NaCl and PEG there was significant difference which indicates that with increase in levels of both chemicals there is decrease in plumule length.

RADICAL TO PLUMULE RATIO

There was no significant difference between for root:shoot ratio because there was corresponding growth of radical and plumule among various priming methods.

Pre-germination metabolic activities are completed during seed priming, making the seed ready for germination compared with unprimed seeds (Sadeghi *et al.,* 2011). The embryo expands and compresses the endosperm due to effect of priming (Liptay and Zaiffa, 1993). Due to this compression force of the embryo and hydrolytic activities on the endosperm cell wall, that deforms the tissues that have lost their flexibility upon dehydration (Lin *et al.*, 1993), producing free space and facilitating root protrusion after rehydration. Due to faster water uptake and earlier initiation of metabolic processes, there is fastest rate of germination obtained by seed priming. Seeds would be simultaneously subjected to processes of repair and deterioration and force between the two determines the success or failure of the treatment due to which early seed germination occurs during priming (McDonald, 2000). Good germination and emergence is the key to control stand establishment. Seed hydration of wheat, barley and oats seeds improved the uniformity of seedling emergence (Kibite and Harker, 1991). Hydro priming enhanced seedling establishment and early vigor of upland rice, maize and chickpea, resulting in faster development, earlier flowering and maturity and higher yields (Harris *et al.,*1999). There is rapid and uniform seed germination of several cereal crops specially rice as seed priming was done (Basra *et al.*, 2005; Jie *et al.*, 2002).

Cell growth and division play a great role in early stages of germination and seedling growth this needs the transmission of necessary nutrients like soluble sugars and low weight proteins from storage organs of seed to growth sites for transpiration (Bewley and Black, 1994). Significant improvement in radicle and plumule length may be attributed to earlier germination induced by primed over un-primed seeds (Farooq *et al.*, 2005), which resulted in vigorous seedlings with more root and shoot length than the seedlings from un-primed seeds.

CONCLUSION

In many rainfed areas, germination and subsequent seedling growth can be inhibited by adverse conditions in the field. Priming is helpful in reducing the risk of poor stand establishment under a wide range of environmental conditions. Hydro priming and PEG6000 – 5% resulted better performences compared to other priming methods for different germination indices in the experiment. Therefore, it is advisable to practice hydro priming or priming with PEG6000 – 5% as a successful technique for increasing and hastening of seed germination and better crop stand.

ACKNOWLEDGEMENT

We would like to show our sincere gratitude to IAAS, Lamjung Campus, lab assistants and colleagues who directly or indirectly helped us with our research activities.

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INFLUENCE OF BIOGASS SLURRY AND UREA ON YIELD AND QUALITY OF OKRA(ABELMOSCHUS ESCULENTUS L.) FRUITS

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ABSTRACT

The study was conducted on sandy loam soil at IAAS Rampur, Chitwan during May to September, 2012 to evaluate the effect of different combinations of biogas slurry and urea on production of okra, laid out in a two-factor RCBD with three replications. Altogether ten treatments consist of two varieties namely Arka Anamika - open pollinated and Jaikisan-62-F1 hybrid and four different levels of biogas slurry and urea combination (urea$_{75\%}$+biogas slurry$_{25\%}$, urea$_{50\%}$+biogas slurry$_{50\%}$, urea$_{25\%}$+biogas slurry$_{75\%}$ and biogas slurry$_{100\%}$) and only inorganic chemical (75:60:50 kg NPK/ha) as control. All treatments were based on fulfillment of required nitrogen for the crop. The results showed that application of urea$_{50\%}$+biogas slurry$_{50\%}$ increased plant height, leaf area, number of leaves and number of nodes at final harvesting. Treatment urea$_{50\%}$+biogas slurry$_{50\%}$ allow maximum number of pickings/plant (23.2) and number of fruits/plant (23.5) resulting highest yield/plant (376.3 g). Among the varieties, Jaikisan-62 is superior in terms of growth, yield and post harvest character than Arka Anamika. The net return (Rs. 474,136/ha) and mean B/C ratio was highest (2.59) in Jaikisan-62 treated with urea$_{50\%}$+biogas slurry$_{50\%}$. So, for the commercial production hybrid variety is suggested.

Key words: Biogas slurry, hybrid variety , open pollinated variety, okra

INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is one of the economically important, most popular summer vegetable crops in Terai, inner Terai and lower hills of Nepal (Acharya, 2004). It is a nutritious vegetable, which plays an important role to meet the demand of vegetables of the country during dry season (Adhikari *et al.*, 2009). In 2012, okra was cultivated in 9,609 ha of land with a total production of 108,806 MT and an average productivity of 11.32 MT/ha covering 3.9% of total vegetable cultivating area in Nepal (MoAD, 2012). However, the productivity is not satisfactory in Nepal (Shakya *et al.*, 2002).

In the context of Nepal where most farmers lack sufficient resources for profitable food production (Adhikari, 2001), dry season vegetables production such as okra through cost-effective techniques of fertilization and proper variety selection seems promising. Nitrogen is the most limiting major nutrient in Nepal. Large amount of nitrogen rich biogas slurry is being wasted in the urban and rural Nepal, which can be used as an organic substitute of chemical fertilizers for higher crop production. Different hybrid and open pollinated

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varieties of okra are grown in Nepal to meet the increasing demand by using excessive inorganic fertilizers but the economic analysis of open pollinated versus hybrid variety has not yet been done.

METHODOLOGY

The experiment was conducted during April, 2012 to September, 2012 at horticulture farm of IAAS, Rampur, Chitwan having sandy loam textured soil with 4.84 pH, 2.61% organic matter, 0.105% available nitrogen, 96.27 kg available phosphorus ha^{-1} and 257.54 kg available potassium ha^{-1}. The mean maximum temperature (38.3 ^{0}C), minimum temperature (25.0 ^{0}C), relative humidity (92.2%) and rainfall were (159.7 mm) during the crop growing season. The experiment was laid out in a two factor randomized complete block design with ten treatments; consisting of two variety (Jaikisan-62; hybrid and Arka anamika-open pollinated) and five different levels of urea and biogas slurry combinations ($urea_{75\%}$+biogas $slurry_{25\%}$, $urea_{50\%}$+biogas $slurry_{50\%}$, $urea_{25\%}$+biogas $slurry_{75\%}$, biogas $slurry_{100\%}$ and only inorganic chemical as control) and three replications. All treatments were based on fulfillment of required nitrogen for crop. The total experimental area was 235.75 m^2 (20.5m x 11.5m) with an individual plot size of 2.5m x 1.5m i.e. 3.75 m^2. Seeds soaked overnight in water were sown directly in hills with 50cm between rows and 30cm within rows, and thinned to one plant per hill 15 DAS. Each plot consisted of 5 rows and each row of 5 plants. Fertilizers were applied at the rate of 75:60:50 Kg NPK/ha. Phosphorous and potash were applied at the time of seed sowing. Urea was applied as per treatment description in which half dose was applied at the time of seed sowing and remaining was top-dressed equally at 30 and 60 days after seed sowing. Biogas slurry was collected in the plastic drum from outlet and tested in laboratory for NPK content. Average nutrient content of biogas slurry collected was 1.78% total Nitrogen (Kjeldahl digestion), 2.53% total phosphorous (Bary and Kurtz number one), 1.53% total potassium (Ammonium acetate extraction method) and 7.17 pH. Biogas slurry was applied as per treatment description, 5 cm away from plant stem for 6 times in 1:1 dilution with water at 15 days interval (i.e. 0, 15, 30, 45, 60 and 75 DAS). Observations on various vegetative, reproductive and quality parameters were recorded. Analysis of variance for all parameters was done using statistical analysis through MSTAT-C program. All the analyzed data were subjected to DMRT for mean separation at 5% level of significance.

RESULT AND DISCUSSIONS

PLANT HEIGHT

There was significantly different among the varieties on plant height at 90 DAS (Table 1). Maximum plant height was observed in Jaikisan-62 (134.9 cm) than Arka Anamika (129.5 cm). The higher plant height in Jaikisan-62 under the same growing condition might be due to the genetic makeup of the variety and the greater capacity of plants to absorb nutrients from the soil.

The effect of different combination of biogas slurry manure with urea was highly significant (P<0.001) (Table 1). At 90 DAS, the highest plant height was recorded in $urea_{50\%}$+biogas $slurry_{50\%}$ (138.6 cm) being at par with $urea_{25\%}$+biogas $slurry_{75\%}$ (136.1 cm) followed by biogas $slurry_{100\%}$ (132.8 cm) being at par with $urea_{75\%}$+biogas $slurry_{25\%}$ (131.3 cm) and lowest in Control (122.2 cm).

Vijaya and Seethalakshmi (2011) also recorded the continuous increase of plant height in eggplant by supplying 50% organic and 50% inorganic manures.

DAYS TO 50% FLOWERING

Jaikisan-62 produced 50% flower earlier (48.1 days) than the Arka Anamika (50.3 days). It might be due to its lowest branching habit of Jaikisan-62 and showed first flower earlier than Arka Anamika which was shown.

$Urea_{50\%}$+biogas $slurry_{50\%}$ produced 50% flower earlier (48.2 days) being at par with other combinations. However, the chemical fertilizer showed delayed in bearing 50% flowering (51.5 days). Kafle (2010) also found shorter days to 50% heading in Green Coronet (F_1) cabbage applied with biogas slurry compost than chemical fertilizer.

The earliness in flowering could be attributed to the faster enhancement of vegetative growth and storing sufficient reserved food materials for differentiation of buds into flower buds whereas the delayed flowering by the inorganic fertilizer treatment could be due to extended vegetative phase of the plant by the availability of inorganic nitrogen. These results are in close conformity of the findings of Renuka and Ravi Shankar (1998).

Table 1. Effect of biogas slurry and urea combinations on Plant height, days to 50% flowering, days to first harvest and harvest duration at Rampur, Chitwan, Nepal, 2012.

Treatments	Plant height 90 DAS (cm)	Days to 50%flowering	Days to 1st harvest	Harvest duration
A. Fertilizer level				
N_1-Control ($NPK_{Chemicals}$)	122.22^c	51.50^a	55.83^a	44.17^d
N_2 ($urea_{75\%}$+biogas $slurry_{25\%}$)	131.3^b	49.33^b	56.00^a	52.17^{ab}
N_3 ($urea_{50\%}$+biogas $slurry_{50\%}$)	138.6^a	48.17^b	54.17^{ab}	54.17^a
N_4 ($urea_{25\%}$+biogas $slurry_{75\%}$)	136.1^a	48.50^b	52.50^b	47.83^c
N_5 (biogas $slurry_{100\%}$)	132.8^b	48.67^b	53.33^b	51.33^b
SEM±	1.068	0.558	0.757	0.7904
$LSD_{0.05}$	3.173**	1.659**	2.249*	2.348**
B. Varieties				
Arka Anamika	129.46^b	50.33^a	55.87^a	49.13^b
Jaikisan-62	134.92^a	48.13^b	52.87^b	50.73^a

SEM±	0.675	0.353	0.479	0.4999
$LSD_{0.05}$	2.01**	1.049**	1.422**	1.485*
CV%	3.98	2.78	3.41	5.88
Grand Mean	132.192	49.233	54.367	49.933

*Means with same letter within columns do not differ significantly at p=0.05 by DMRT, * significant at 5% (p<0.05), ** significant at 1% (p<0.01)*

DAYS TO FIRST HARVEST

Varieties were found highly significant (*P*<0.001) (Table 1) different for this character. Jaikisan-62 took the shorter period (52.9 days) for days to first harvest than Arka Anamika (55.9 days). It might be due to the earlier flowering occurred in Jaikisan-62.

Similarly, among the fertilizer combinations $urea_{25\%}$+biogas $slurry_{75\%}$ took lowest days to first harvest (52.5 days) being at par with biogas $slurry_{100\%}$ (53.3 days) and $urea_{50\%}$+biogas $slurry_{50\%}$ (54.2 days). Days to first harvest was found to be comparatively longer in $urea_{75\%}$+biogas $slurry_{25\%}$ (56.0 days) being at par with control (55.8 days).

The variation among the varieties for the first harvest might be due to difference in fruit maturing period. Significant difference among varieties for 50% flowering also supports the hypothesis. Earliness in okra was highly associated with days from anthesis to edible pod formation (Agrawal *et al.*, 1984). Kafle (2010) also found shorter days to harvest in cabbage in biogas slurry compost treatment and longer days in chemical fertilizer.

HARVEST DURATION

Duration of the crop harvest varied significantly (P<0.05) with respect to varieties (Table 1). The higher harvest duration (50.7 days) was recorded in Jaikisan-62 than in Arka Anamika (49.1). Chapagain (2008) also reported similar effect of harvest duration in variety Anokhi (56.7 days) followed by Arka Anamika (54.7 days) and both were statistically at par.

The effect of fertilizer combinations was highly significant (*P*<0.001) (Table 1) to the harvest duration of crop. Similarly, higher harvest duration was recorded in $urea_{50\%}$+biogas $slurry_{50\%}$ (54.2 days) which is statistically at par with $urea_{75\%}$+biogas $slurry_{25\%}$ (52.2 days) followed by biogas $slurry_{100\%}$ (51.3 days). Lowest harvest days were recorded in control (44.2 days).

Shorter harvest duration in control was due to lack of moisture. Seed took longer time for germination. In the subsequent treatment biogas slurry manure helps to absorb moisture from the soil and kept it for longer time resulting faster germination and crop entered into reproductive phase early due to more suitable environmental condition. According to Duzyaman (1997) harvest duration of okra should be of at least 2 to 3 months for better economic return.

NUMBER OF FRUITS/PLANT

The differences between varieties for number of fruits per plant were highly significant ($p<0.01$), whereas fertilizer level differ significantly ($p<0.05$) (Table 2). Interaction effect between varieties and applied fertilizer combination was also found significant ($p<0.05$).

Jaikisan-62 produced highest number of fruits (24.0) per plant than Arka Anamika (20.6). It might be due to the higher plant height of Jaikisan-62 bearing more number of nodes per plant than Arka Anamika and varietal differences may be also the cause.
Similarly, highest number of fruits per plant (23.5) was observed in combinations of $urea_{50\%}$+biogas $slurry_{50\%}$ which is being at par with $urea_{25\%}$+biogas $slurry_{75\%}$ (22.5) and biogas $slurry_{100\%}$ (22.5) followed by $urea_{75\%}$+biogas $slurry_{25\%}$ (22.1) and the lowest number of fruits per plant were observed in control (21.1). Naidu *et al.* (1999) observed higher number of fruits per plant (24.3) with application of 50% FYM + 50% inorganic nitrogen.

Similar result was obtained by Shahbaz in 2011 where minimum number of fruits per plot (176) in okra was observed in control treatment..

FRTUIT YIELD/PLANT

The highly significant difference ($p<0.001$) was observed in the yield per plant of Jaikisan-62 and Arka Anamika varieties (Table 2). Jaikisan-62 exhibited higher yield per plant (383.8 g) than the Arka Anamika (310.2 g). It is because Jaikisan-62 being superior in bearing higher number of fruits per plant and containing higher number of nodes at final harvesting.

The effect of biogas slurry and urea alone or with combinations showed highly significant difference ($p<0.001$). The highest yield per plant (376.3 g) was obtained from the $urea_{50\%}$+biogas $slurry_{50\%}$ which was at par with $urea_{25\%}$+biogas $slurry_{75\%}$ (374.4 g). This is followed by biogas $slurry_{100\%}$ (351.5 g), $urea_{75\%}$+biogas $slurry_{25\%}$ (326.7 g) and lowest was observed in control (305.9 g). This might be due to bioslurry affected the pH and organic matter status of the soil which helps to release of indigenous nutrients of soil and soil applied NPK (Shahbaz, 2011). Bokhtiar *et al.* (2008) reported that organic manures, when applied with chemical fertilizer gave better yield than individual ones.

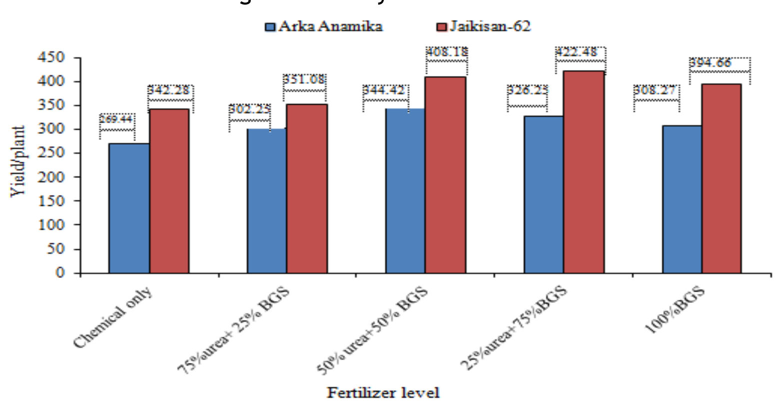

Figure 2. Showing interaction effect of fertilizer level and varieties on yield/plant

Ghimire (2011) also found highest yield of sweet pepper in 50% organic (FYM) and 50% inorganic (urea) combinations.

The interaction effect of varieties and different combinations of biogas slurry and urea was also found significant ($p<0.05$). Highest yield per plant (422.4 g) was obtained by the Jikisan-62 treated with $urea_{25\%}$+biogas $slurry_{75\%}$ which is at par with Jaikisan-62 treated with $urea_{50\%}$+biogas $slurry_{50\%}$ (408.2 g). Arka Anamika gave highest yield (344.3) with $urea_{75\%}$+biogas $slurry_{25\%}$. But among the interaction treatment lowest yield per plant was obtained by the Arka Anamika treated with chemical (269.4 g).

Nair and Peter (2001) also found that application of both organic and inorganic fertilizers increased fruit yield.

Table 2. Effect of biogas slurry manure and urea combinations on okra varieties on number of fruits/plant and fruit yield/plant at Rampur, Chitwan, Nepal, 2012.

Treatments	Number of fruits/plant	Fruit yield/plant (g)
A. Fertilizer level		
N_1-Control ($NPK_{Chemicals}$)	21.09^{c}	305.9^{d}
N_2 ($urea_{75\%}$+biogas $slurry_{25\%}$)	22.05^{bc}	326.7^{c}
N_3 ($urea_{50\%}$+biogas $slurry_{50\%}$)	23.50^{a}	376.3^{a}
N_4 ($urea_{25\%}$+biogas $slurry_{75\%}$)	22.46^{ab}	374.4^{a}
N_5 (biogas $slurry_{100\%}$)	22.46^{ab}	351.5^{b}
SEM±	0.379	4.820
$LSD_{0.05}$	1.127*	14.32**
B. Varieties		
Arka Anamika	20.61^{b}	310.2^{b}
Jaikisan-62	24.01^{a}	383.8^{a}
SEM±	0.240	3.049
$LSD_{0.05}$	0.713**	9.058**
A×B		
SEM±	0.536	6.817
$LSD_{0.05}$	1.594	20.25
CV%	4.17	6.40
Grand Mean	22.312	346.951

*Means with same letter within columns do not differ significantly at p=0.05 by DMRT, * significant at 5% (p<0.05), ** significant at 1% (p<0.01)*

EFFCTS ON COSTS OF PRODUCTIOIN, NET RTURN AND BENEFIT COST RATIO

In Chitwan,the highest total cost of production (NRs. 201,760) was in variety Jaikisan-62 treated with biogas slurry$_{100\%}$ and the lowest total cost of production (NRs. 165,740) was found in variety Arka anamika treated with urea$_{75\%}$+biogas slurry$_{25\%}$.

Table 3. Benefit cost ratio of okra production by using different level of biogas slurry, urea and their combination at Rampur, Chitwan, Nepal (2012)

Treatments	Total cost of cultivation (Rs/ha)	Productivity (t/ha)	Okra selling price (Rs/kg)	Gross Income (Rs/ha)	Net benefit (Rs/ha)	B:C ratio
Manures X variety						
Arka Anamika + Chemical fertilizer	170655	19.52	25	487917	317262	1.86
Jaikisan-62 + Chemical fertilizer	178955	21.40	25	535083	356128	1.99
Arka Anamika + Urea$_{75\%}$+ biogas slurry$_{25\%}$	165740	20.22	25	505417	339677	2.05
Jaikisan-62 +Urea$_{75\%}$+biogas slurry$_{25\%}$	174040	22.70	25	567500	393460	2.26
Arka Anamika + Urea$_{50\%}$+biogas slurry$_{50\%}$	174980	23.19	25	579667	404687	2.31
Jaikisan-62 +Urea$_{50\%}$+biogas slurry$_{50\%}$	183280	26.30	25	657417	474137	2.59
Arka Anamika +Urea$_{25\%}$+biogas slurry$_{75\%}$	184360	20.83	25	520750	336390	1.82
Jaikisan-62 +Urea$_{25\%}$+biogas slurry$_{75\%}$	192660	21.95	25	548833	356173	1.85
Arka Anamika+biogas slurry$_{100\%}$	193460	21.58	25	539417	345957	1.79
Jaikisan-62 +biogas slurry$_{100\%}$	201760	25.15	25	628833	427073	2.12

Biogas slurry was locally available resources, which was obtained at the rate of Rs. 7 per liter. People were ready to pay higher cost if okra is grown organically. The highest net return (NRs. 474,136) was obtained from Jaikisan-62 treated with $urea_{50\%}$+biogas $slurry_{50\%}$. The lowest net return (NRs. 317,261) was from control in Arka anamika. B:C ratio was the highest (2.59) from Jaikisan-62 treated with $urea_{50\%}$+biogas $slurry_{50\%}$ and the lowest B:C ratio (1.79) ratio was found in Arka anamika treated biogas $slurry_{100\%}$.

CONCLUSIONS

Out of the two varieties evauated Jaikisan-62, hybrid was superior to Arka Anamika on growth, reproductive and yield characteristics suggesting that , for the commercial okra cultivation hybrid variety could give better return than open pollinated cultivars. . The benefit cost ratio was highest in Jaikisan-62 in the treatment $Urea_{50\%}$+Biogas $slurry_{50\%}$ combinations and the lowest in Arka Anamika with biogas $slurry_{100\%}$.

Similarly, between fertilizer combinations the combinations of 50% organic and 50% inorganic fertilizer produce higher yield than the control in all cases.

ACKNOWLEDGEMENT

I would like to express my sincere thanks to the authorities of Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan, Nepal and also very greatful to the members of my advisory committee.

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PRESENT STATUS AND FUTURE STRATEGY OF FORAGE DEVELOPMENT IN NEPAL

Banshi Sharma[1]

ABSTRACT

Livestock is an integral part of agricultural production system in Nepal. Animal feed have been one of the major production inputs drawing attention of the producers. There is excess green forage available during the monsoon period, but for the remaining six months, over the winter and spring, there is a lack of feed. In commercialized farming situations farmers compensate for shortages of forages with supplementation of expensive concentrate feeds. There are different cultivars of oats presently cultivated in Nepal. The winter crops oat is highly important to livestock raisers in Nepal. Oats are largely self-pollinated so farmers can save their own seed for several crops, provided that rogueing is carried out and the usual precautions are taken against mechanical contamination. Oat straw is good, palatable roughage and is also excellent bedding. With the introduction of multi-cut cultivars and new management technologies, the yield of fodder oats has gone up from 15-20 t/ha – 50-93 ha/ha. Non-legumes and legumes cropping can increase the condition of soil. So that farmers can be benefitted in subsequent cropping. Cost of production of livestock and its product can be lower down with better feeding practices of forage crops round the year.

Key words: Fodder, forage, livestock, nutrition, strategy, technology

BACKGROUND

Livestock is an integral part of agricultural production system in Nepal. Animal feed have been one of the major production inputs drawing attention of the producers as it alone shares nearly 65-70 percent of the production cost of milk and meat from ruminants(Sharma, 2012).

In between 1960- 1970, different farms for the development of livestock were established at various ecological zones of Nepal such as Pokhara, Chitlang, Jiri, Jumla, Panchasaykhola etc. Feeds and forage development program was also carried out as a part of farm's activities.

After the intervention of Department of Livestock Services (DLS), Livestock Development Project from 1980's forage cultivation and seed production activities had been popularly accepted by the farmers. Over 20 different forage crops are grown for seed production. Major species grown by the farmers are oat, vetch, berseem, stylo, molasses, mulato, joint-vetch etc. The domestic production of forage seeds meets only 66 percent of the total requirements. Current production of forage seed in Nepal is only 73 tons whereas the demand of farmers and government programs are very high (Tara, 2005).

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The major feed resources in Nepal are agricultural by-products and forage. Winter forage crops (oat, vetch, berseem and fodder pea) and perennial forage species (Napier, Stylo, Molasses, mulato etc.) on marginal lands are increasing each year. Till now, about 0.1 percent of the cultivated land brought under forage cultivation and over 4,000 ha of pasturelands have already been improved (Pande, 1994).

The genus Avena comprises about 70 species; a few are cultivated. *Avena sativa L.* is known as white oat. White oat and red oat (A. byzantine) is the main oats grown for fodder and grain. They are hexaploids and modern cultivars may contain genetic material from both species. For smallholders, assuring access to seed of improved cultivars is very important this involves producing seed of acceptable quality and marketing it so that it is within easy reach of farmers. Both species are hexaploids with 42 chromosomes (6n=42). Oat was found in 4000 years old remains of Egypt. Oats are a crop of Mediterranean origin; not as old as wheat and barley, but their domestication dates back to ancient times (Suttie and Raynolds, 2004).

Cultivation of oats (*Avena sativa L.*) in Nepal was started some 100 years ago by landlords in the Terai region in order to provide green fodder during the dry winter months for their elephants (Pariyar, 2006). Oat (Bundel 851) was imported from Jhansi India in the year 1990. The yield of fodder oats has gone up from 15-20 t/ha to 50-93 t/ha. For commercial dairy pocket areas, the oat cultivars Awapuni, Swan, Caraville, Charisma, Canadian and Kent are recommended up to an elevation of 1600 m asl. Oats+ vetch is the best mixture for high yields and improved soil fertility (Pariyar, 2002). Among the cultivated forage crops, oat is the main fodder crop that can fit with the existing mixed crop livestock farming systems in Terai and hill zones (Upreti, 2005).

After oat, Berseem (*Trifolium alexandrinum*) is the most promising fodder species which provides green fodder during November- March, It is a traditional cultivated fodder legume which is in cultivation practices on farm since over last 40 years in the sub tropical region of the country (Kandel , 2006).

On the average of three years, common vetch (*Vicia sativa*) produced forage maximum forage yield (5.4 t/ha) among four winter forage legumes from two cutting management practices, which is highly significant to one cutting management practices (Munakarmi , 2000).

Fodder pea is one of the important winter forage crop in Nepal. The demand for winter legume forage crop is very high. Grass pea with less toxic materials to livestock shall be good alternatives in harsh climatic areas.

Oat with vetch mixture is a promising means of increasing winter forage for dry winter season in the eastern hills (Kshetri *et. al*, 1993).

INTRODUCTION

Livestock rearing is more in mountain and high hills (Sharma, 2002). The contribution together with production of food (meat, milk, and eggs), fibre, hides/skins and transportation amounts to about 15% of GDP which is 31% of Agricultural GDP (LMP, 1993) and 51 per cent of this contribution is derived from the hills, 38 per cent form Terai and 9 per cent from the mountains (APP,1995). Livestock population, in relation to arable land and animals per person, are large by Asian standards, with approximately 7.2 million cattle, 5.2 million buffalo, 9.7 million goats, and 0.8 million sheep (MOAD, 2011/2012).

Livestock production is a very important industry both on a national scale and for farming families; yet animal productivity is constrained by lack of fodder. The estimated total fodder production in Nepal is 6.1 million tons TDN (Total Digestible Nutrients), only 64 per cent of the fodder required by livestock (Pariyar,2004).

There is excess green forage available during the monsoon period, but for the remaining six months, over the winter and spring, there is a lack of feed. In commercialized farming situations farmers compensate for shortages of forages with supplementation of expensive concentrate feeds. As concentrates are expensive, animals are not fed to their requirement thus introducing costs without significantly increasing production. This has serious implications for competitiveness of the local products against imported products and for the sustainability of livestock production systems.

Leasehold Forestry and Livestock Programme (LFLP) is being implemented in 22 mid-hill districts. Its goal is to reduce the poverty of 44,300 household in mid-hills through the increased production of forest and livestock products. Under livestock development component, the program is designed to cover goat/forage production and development, livestock trainings & services and livestock implementation support. This program provides appropriate seed and planting materials of Stylo, Molasses, Napier, Brachiaria and broom grass, to help develop the lease hold plots and increase the availability of green forage. Availability of forage has reduced the drudgery of women for the collection of fodder from the forest and other community land. Supplied fodder and grass seeds to the leasehold forestry groups, resulted in increased green coverage of the leasehold forestry plots. The vegetative ground cover in new sites is on an average only 32 percent, which increases to 50 percent after one full growing season and gradually expands to an almost full coverage of 90 percent in seven years old sites. The degree of satisfaction by both female and male is high on grasses and fodder seeds and Napier slip distribution. To use the fodder to boost the income of the leasehold groups and to reduce poverty, the program provides all eligible member households with two mature vaccinated and drenched female goats. The Program has distributed 65,880 she goats and 3,493 bucks. Average number of goats per household differs significantly from before program (0.82 AU/HH) to after program (1.54 AU/HH) and the quality of goats has been improved over time. The increment in goat number is by 90 percent. The average household income of households in the LFUGs has been increased by 71 percent.

PRESENT STATUS OF FORAGE DEVELOPMENT IN NEPAL

The estimated total production in Nepal is about 15 million tones of dry matter, 6.1 million tons of TDN and 0.68 million tons of Crude protein. Nationally, only meet about 70 percent of the fodder required by the livestock produced. Of the total land area of Nepal, 20 percent is crop land, 12 percent is grass land, 30 percent is forest, 5 percent is shrub-land and 25 percent has other users (Giri, 1990). Fodder from the 3.0 million ha of cropland contributes to 47 percent of the total available TDN. Fodder from 5.5 million ha of forest contributes 30 percent of the total available TDN. The total available TDN produced from 706 thousand ha of shrub land is 7 percent per year. Fodder from the 1.7 million ha of grassland is 5 percent of the available TDN, and almost 1.0 million ha of non-cultivated inclusion contribute 11 percent of the total available TDN.

Berseem, vetch, cowpea and oats known varieties have been cultivating in Nepalese soil from last 45 years. But many of them are not registered yet in the national system. The production of forage crops and their marketing has been limited due to non-registration. Registration of all varieties of oat, berseem, vetch and cow pea which have been farming in Nepal would be done. The combination of legumes and non-legumes forage is in 40:60 ratios. The best combination in mid hill is to be found out.

Livestock is the main source of organic manure required for maintaining the soil fertility. It provides nine million tons manure annually to three million hectares cultivated land through the use of feed from grazing land (19%), crop by product (37%), forest biomass (35%), and secondary plant residues (9%) in Nepal (Sherchand , 2001).

The forage seed mapping study (TLDP, 2002) estimated that a minimum 32,800 ha of land will have to be planted under perennial and annual forage crops to meet animal requirements.

Inadequate feed supply and poor nutrition during the dry winter months (December to April) is one of the biggest constraints to the promotion of livestock development in Nepal. The grazing lands except the alpine meadows are under heavy grazing pressure (Pariyar, 1993). The fact that ruminants are underfed has resulted in late maturity, high calf and adult mortality, poor lifetime performance, and infertility in cattle and buffaloes (Sherchand and Pradhan 1997).

The area under oats in Nepal has been estimated to be 10,000 ha and the productivity of green fodder 12 t/ha in two cuts(Pariyar, 2005).The total area under oats is 15,600 hectares and 150,000 households are now cultivating oats (NPAFC, 2014). The area under berseem is estimated of 1,500 ha with 3, 000 households are cultivating berseem (NPAFC, 2014). Fodder pea and vetch have been cultivated along with oat.

Among different oat cultivars maximum fodder production was obtained from Kamdhenu (5.2 Mt DM/ha) followed by Netra (5 Mt DM/ha), Omihi, 83INC19G3 and Kent (4.7 Mt DM/ha) in Dhaibung VDC in Rasuwa district (Rajbhandari *et al*, 2010).

Among cultivars, Kent proved to be the best producer of green forage (35.55 – 40.72 t/ha) (Mandal and Premy, 2005). The average GM production from oat+ vetch in fertilizer application and zero fertilizer application was 41.4 _+9.51 Mt/ha and 27.7+_6.4 Mt/ha respectively (Pradhan, 2001).

The highest amount of green matter from oat + berseem and berseem(47.42 t/ha and 47.24 t/ha respectively) was observed from on station a experiment, which was highly significant whereas on farm condition oat + berseem mixture yielded highest amount of green matter (33.2 t/ha) (Shivakoti,1996).

Fresh forage of swan and kent varieties yields ranged between 7-9 t/h (low), 11-18 t/ha (mid) and 19-22 t/ha (high). No significant differences in production were observed between the 2 varieties and different times of sowing within an altitude (Kshetri, et. al 1993).

This experiment aimed to investigate the green matter production of three different combination of oat and legumes at four levels of Nitrogen (N0, N40, N70 and N100).The average GM yields at N70(70kg N/ha) was 20.9 T/ha i.e.34 percent higher compared to that of N0 level-control(Shrestha, 1991).

An experiment comprising four cutting heights 3,5,7 or 9 cm of six cultivars (kent, swan, Amuri, Caraville, JH 810 and JH 822) of oat with three replications was conducted at Khumaltar (NPFRP) in F/Y 2046/47 under rain fed condition to assess forage production. There was no significant effect of cutting heights on green matter production (Pariyar *et al*, 1991).Major research issue is that the seed production of leguminous and non-leguminous is very limited quantity. The farmers do not know the exact time of cutting for more biomass.

Seed is easily produced, so farmers do not have to buy often and farmer sales have greatly accelerated the spread of improved cultivars. Oats are largely self-pollinated so farmers can save their own seed for several crops, provided that rogueing is carried out and the usual precautions are taken against mechanical contamination. Oat straw is good, palatable roughage and is also excellent bedding.

The Terai region has larger share of cropped land (50%). In contrast, for grazing land, the mountain region accounts for the bulk of the grazing land. Rice and wheat (75% and 57%) of the total respectively, are the main crops in the Terai which are major sources of crop residues for winter feeding.

Among the cultivated forage crops, oat is the main fodder crop that can fit with the existing mixed crop- livestock farming systems in Terai and hill zones. 23 cultivars of oats were selected for better hay production. The hay yield of cultivar Stempede (20.6 mt/ha) was significantly higher than the N264256.67 cultivar (14.4 mt/ha).

With the introduction of multi-cut cultivars and new management technologies, the yield of fodder oats has gone up from 15-20 t/ha – 50-93 ha/ha.

Oat seed is a source of income in many areas; oats can produce 2 t/ha seed after taking one cut for fodder.

Although Rajbhandary and Shah (1981) reported that livestock get the greenest matter from June – September and the quality of forage available during this period could be regarded as more or less adequate. Oats are grown by farmers up to about 4000 m, although the economic fodder production level is about 1600 m on irrigated land.

The inadequate feed supply and poor nutrition during the dry winter season (December – April) is one of the biggest constraints to the promotion of livestock development in Nepal. Since 1970's 30 fodder oat cultivars are evaluated in relation to their adaptation.

An initial trial was conducted to know the production performance of 10 cultivars of oat (*Avena sativa*) under rain fed condition at Parawanipur. The cultivars tested were 3412, *Canadian*, *Kent*, *323/02*, *Pakistani PDLV*, *Omihi*, *Bundel 1551*, *Swan (PAK) and Charisma. Canadian* variety performed better in this trial. The tested cultivars (Kent*, Canadian swan and cravilie*) did not differ significantly for green forage production. Highest green fodder yield was obtained from *Amouri*(17t/ha) and lowest from *Awapuni*(11.34 t/ha). *Amouri* and *swan* have been found to be the most potential oat cultivars under rain-fed condition (Osti *et. Al,1997*).

Oat should be sown within first week of December for greater green forage yield in the central Terai.

If 8-16 kg oat+ vetch green fodder can be made available / day during winter, over 33% reduction in the cost of concentrate can be achieved.

FUTURE POTENTIALS OF FORAGE DEVELOPMENT IN NEPAL

Forage mission have been implemented in Nepal from last two years and it will go for next three years. It covers 40 districts of Terai and mid hills. The program is tied up with artificial insemination mission in cattle and buffalo. The number of improved calves born will increased and the balance feed to them have to supply from forage mission.

The coverage of extra forage crops in 45,000 Ha areas. The majority of forage crops are winter forage crops followed by perennial and summer forage crops. The deficit of 34% in feed and fodder can be achieved.

The practices of hay and silage making can be enhanced. So that forage of high quality can be achieved in lean period or dry period of the year. The irrigation facility of forage crops will be enhanced. Multi-cut variety of forage will give us more biomass for increasing number of livestock.

CONCLUSIONS

1. In some districts, the activities are successful. So, there is need of expansion of successful stories to other districts too. The project can implement the activities according to forage seed and agro-ecological zones and apply more appropriate technology, so that the deficit forage seeds can be produced and ultimately, feed deficit will be mitigated.
2. Similarly, forages when combined with other feed ingredients, concentrate rations or when value added by treating with urea or making urea molasses mineral block (UMMB), will be more nutritive and give better results. So, along with commercialization of livestock industry, there is need of commercialization in the field of fodder and pasture development also.
3. Similarly, forages when combined with other feed ingredients, concentrate rations or when value added by treating with urea or making urea molasses mineral block (UMMB), will be more nutritive and give better results. So, along with commercialization of livestock industry, there is need of commercialization in the field of animal feed production.
4. The most important and crucial part of commercialization of animal feed is recent technology which can be easily adapted by small scale farmers too. There is need of technology and concept development by which farmers would motivate towards commercialization for preservation of animal feeds/fodders for winter period. Also, they can motivate only in production of fodders and feeds and selling to livestock entrepreneurs.
5. Nawalparasi is the one of the most vulnerable district due to climate change in western development region. The fodder plants are there but the number is not sufficient for current livestock population. The fodder plants are more in 17 Village

Development Committee (VDCs) of hilly areas. Therefore intensity of cropping can be increased and their wastage can be utilized for animal feed. New technology of complete ration shall be introduced and animal genetics resources awareness campaign shall be done. The mitigation majors can be made in collaboration with local Non Government Organization (NGO), local bodies and District Livestock Services Office (DLSO). The Regional Directorate of Livestock Services (RDLS) shall give guidelines and support to this effort. 70 percent of woman is involved in livestock keeping and gender issue shall be given high priority in hills too. The district was under Third Livestock Development Project (TLDP) and Community Livestock Development Project (CLDP) in the past. Therefore, production of milk and meat can be enhanced with environmental friendly livestock farming in this district.

6. For next three years 30,000 Ha forage crops are cultivated in Nepal to cope with rising demand from commercial dairy pockets areas of Nepal.

Agriculture contributes 35 percent of GDP. 591 billion Nepalese Rs have been contributed by Agriculture sector in F/Y 2070/2071 BS. Of which, 155 billion rupees is from livestock sector. Two third of livestock economy have been spent for livestock feeding. Therefore, livestock can be fed efficiently round the year. Non-legumes and legumes cropping can increase the condition of soil. So that farmers can be benefitted in subsequent cropping. Cost of production of livestock and its product can be lower down with better feeding practices of forage crops.

ACKNOWLEDGEMENT

I would like to thank Prof. Dr. Naba Raj Devkota from AFU for his suggestions for writing this paper.

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CONTRIBUTION OF AGRICULTURE SECTOR TO NATIONAL ECONOMY IN NEPAL

Santosh Adhikari[1]

ABSTRACT

Agriculture is the mainstay of majority of Nepalese people which provides employment, foods and shelter. However, the investment in agriculture in not encouraging, received only about 3 percent of total government outlays during 2002 to 2014. In the study, Gross Domestic Product was regressed with Domestic Savings, Government Expenditure on Agriculture and Foreign Direct Investment on Agriculture with the data from FY 2002/03 to 2014/15. Regression reveals the degree of association among these variables is significant at 5 % level of significance (R=0.991, P=0.005<0.05). The analysis showed that the contribution of Government Expenditure on Agriculture to Gross Domestic Product was found significant whereas the Domestic Savings and Foreign Direct Investment on Agriculture were found insignificant. The compound annual growth rate of Government's expenditure was found slightly lower than that of budget allocated to Ministry of Agricultural Development. In sum, the study concluded that the Government Expenditure on Agriculture is crucial for the national economy.

Key words: Expenditure on Agriculture, Domestic Savings, FDI, GDP

INTRODUCTION

Agriculture has been an important sector in the national economy for most of the developing countries (Mongues, *et al*, 2012) while it plays an important role in virtually in all social and economic activities of any country (Lawal, 2011). However, Cervantes-Godoy and Dewbre (2010) found that people in developing countries who depend on agriculture for their living are typically much poorer than people who work in other sectors of the economy and that they represent a significant share, often the majority, of the total number of poor people in the countries where they live in thirty years. Agriculture sector can contribute to employment, food security and raw materials for agro-based industries. In Nepal, agriculture has been contributing to more than 70 percent households (CBS, 2013), 66 percent employment (MoAD, 2015) and 35.12 percent share to National Gross Domestic Product (GDP) (MoF, 2014). Thus, agriculture is regarded as a major contributor to the national economy as well as individuals' livelihood. A strong and efficient agricultural sector would enable a country to feed its growing population, generate employment, earn foreign exchange and provide raw materials for agro-based industries. Agriculture sector has multiplier effect on any nation's socio-economic and industrial fabric because of its multifunctional nature (Ogen, 2007; MoF, 2014) however it is affected by favorable/unfavorable climatic conditions, resulting in the fluctuation of GDP thereby

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affecting overall economic growth (MoF, 2014). In this context, American Economist Walt Whitman Rostow (1960) in his Stages of Economic Growth explained that Agriculture is crucial for the "take-off stage" of nation's economic growth and development (Izuchukwu, 2011).

Government of Nepal (GoN) has realized the importance of agriculture and has prioritized in its plans, policies, and annual budget and programs since last three years. The MoAD reports states that every year budget under MoAD has increased substantially. However, the organized development of Nepal started along with the periodic plans after 1996. The first periodic plan has emphasized agriculture both as immediate action and laying of foundation for future progress and allocated Rs. 12 million to the agriculture out of Rs. 330 million (NPC, 1956). It was only in fifth plan (1975-80) which has prioritized agriculture sector and celebrated 2032 BS as agriculture year. Ninth periodic plan (1997-2002) is also important period for the agriculture sector. During that period, a long term strategy for agriculture sector, Agriculture Perspective Plan (APP) was designed and formulated for the overall national growth through agriculture growth (Mongues *et al*, 2012). Similarly, during the recent Thirteen Periodic Plan (2013/14-2015/16) Agriculture sector received proportionately higher budget (Table: 1) amount and proportion to national budget).

Table 1: Details of budget outlay in MoAD and its share to the national budget during 2002/03 to 2014/15

FY	**National Budget (Rs., 000)**	**MoAD Budget (Rs., 000)**	**Share of Agriculture Budget to National (%)**
2002/03	96,124,796	2,423,526	2.52
2003/04	102,400,000	2,472,945	2.41
2004/05	111,689,900	2,692,284	2.41
2005/06	126,885,100	3,178,473	2.51
2006/07	143,912,300	3,516,279	2.44
2007/08	168,995,600	4,176,853	2.47
2008/09	236,015,897	5,759,500	2.44
2009/10	285,930,000	7,876,587	2.75
2010/11	337,900,000	10,523,526	3.11
2011/12	384,900,000	12,431,084	3.23
2012/13	404,824,700	12,297,141	3.04
2013/14	517,240,000	21,403,127	4.14
2014/15	618,100,000	23,283,178	3.77

Source: MoAD, Budget and Program Section, 2015

Though MoAD received low budget, its absorption capacity is good and it is improving its absorption capacity in every successive year (Figure: 1). Five years ago, MoAD spent about 6.88 billion rupees in FY 2007/08 and its spending capacity enhanced to five years to 11.54 billion rupees in 2012/13. The share of spending out of allocated budget becoming better every year which is not less than 82 percent in all year.

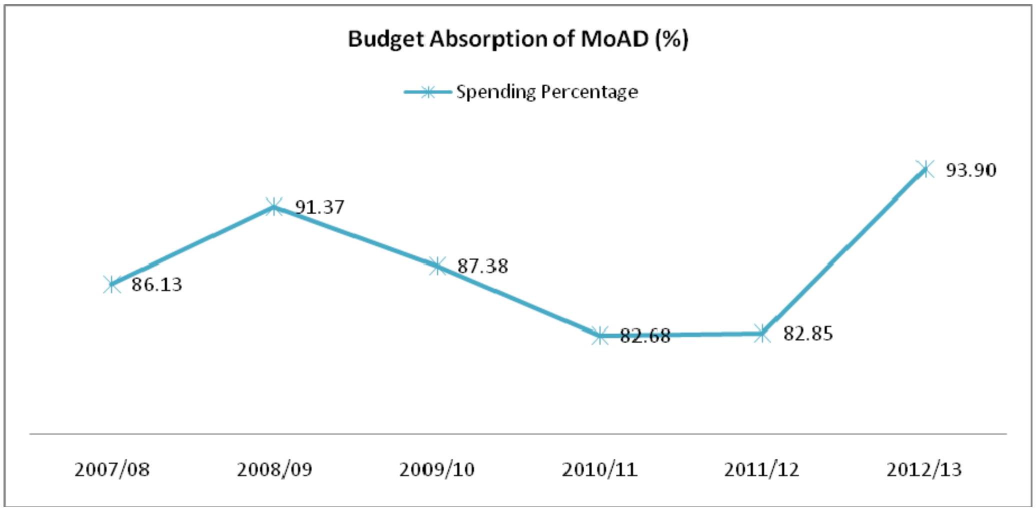

Figure 2: Trend of budget absorption (%) by MoAD during 2007/08 to 2012/13 in Nepal
Source: MoAD, Budget and Program Section, 2015

The Asian Development Bank (ADB) study revealed that there is low expenditure on agriculture indicating 4.75 percent of GDP during the first two years of TYIP (2008-10) and it is under 2 percent of GDP for the past 10 years in spite of the almost 70 percent agriculture dependent on rural population (Barrios, 2007).

Foreign aid has been important source of budget in developmental activities. The first five year periodic plan (2013-2018) had envisaged the acceptance of foreign assistances as per the complimentary budget (NPC, 1956) and developmental expenditure was completely financed by foreign aid (Gautam and Pokhrel, 2011). It continues to play an important role in socio-economic developments (MoF, 2013). Economic liberalization in Nepal after democracy in 1990 accelerated foreign assistances (Chaudhary, 2012). Now, Nepal receives such assistances from more than 40 donors officially (MOF, 2013).

Apart from the foreign aid, Foreign Direct Investment (FDI) also contributes significantly to the national economy. FDI occurs when a citizen of one county to acquires an asset to another country with the intention to manage that asset (Chaudhary, 2012). The major portion of the FDI goes to the manufacturing sector while agriculture receives lowest, i.e. 1

percent (Adhikari, …). Economists consider FDI as the most crucial factor in enhancing economic development and ensuring a reasonable standard of living for recipient countries of FDI (Chaudhary, 2012).

Domestic Saving is considered as the source of investment in any country. However, it is not encouraging. It is around 9 percent of GDP in FY 2070/71. (MoF, 2014).

OBJECTIVE OF THE STUDY

The purpose of this study is to review and analyze the trends and causes of change in government expenditures on agriculture and their compositions in Nepal to develop an analytical framework for determining differential impacts of various government expenditures on economic growth of Nepal.

Similarly, the study intends to find out the annual growth rate of the government expenditure on agriculture during FY 2002/03 to 2014/15.

MATERIALS AND METHODOLOGY

To study and analyze the numerical contribution of agriculture spending on National Economy, the study was conducted based on the secondary information provided by various organizations and archived from the several websites. The study collected information from The Secretariat of National Planning Commission, Ministry of Finance, MoAD, Central Bureau of Statistics and other institutes. The study focuses on the importance of spending on agriculture to the national economy and Gross Domestic Product (GDP). The information included mainly explains trend of investment to MoAD, AGDP, Domestic Savings, and Foreign Direct Investments in Agriculture.

The methodology includes the calculation of GDP at constant price of 2000/01 with the information provided on investment in agriculture, domestic savings, government expenditure on Agriculture and Foreign direct investment. The given model uses GDP as dependent variable in relation to the Domestic Savings, Government Expenditure on Agriculture and Foreign Direct Investment. Similar type of the study was also conducted by Izuchukwu in 2011 to analyse the contribution of agricultural sector on the Nigerian economic development.

The statistical formula for the given model is as follows:

$$GDP = \beta 0 + \beta 1DS + \beta 2GEA + \beta 3FDI + \mu t$$

Where,

GDP= Gross Domestic Product
DS= Domestic Savings
GEA= Government Expenditure on Agriculture
FDI= Foreign Direct Investment on Agriculture
μ= error Term

Similarly for the calculation of the Compound Annual Growth Rate (CAGR)of National Budget and budget to MoAD following formula was used with Table 1.

CAGR= $(P_0/P_n)^{1/n}-1$

Where,

CAGR = Compound Annual Growth Rate (National budget or budget to MoAD)

P_0 = Base year value

P_n = Present year value

n= Number of years

RESULTS AND DISCUSSIONS

The following table describes the regression analysis for the impact of agriculture in the Nepalese national economy, Gross Domestic Product (GDP) as dependent variable while Domestic Savings, Government Expenditure on Agriculture and Foreign Direct Investment on Agriculture are independent variables.

Table 3: Data Analysis of DS, GEA and FDI to total GDP

	standardized Coefficients		Standardized Coefficients		
Model	B	Standard error	Beta	T	Significant
(Constant)	3.669E8	5.462E7		6.718	.001
Domestic Saving	-.259	1.508	-.037	-.172	0.870
Government Expenditure in Agriculture	101.535	21.094	1.026	4.813	.005
Foreign Direct Investment	6.995	118.165	.004	.059	0.955

R=.991, R-square=0.983, Adjusted R-Square=0.972, standard error of the estimates 6.028*E7 (not significant)

The above Table 3 reveals that Government expenditure in agriculture (101.535) is the major contributing factor for the National Economy there by affecting GDP, i.e. for every unit change in Government Expenditure on Agriculture there is a corresponding change of 101.535 units in GDP. Interestingly the Domestic Saving shows negative coefficient and both DS and FDI are insignificant to the GDP with the respective P-values 0.870 > 0.005 and 0.955 > 0.005.

Table 4: ANOVA[b] Table

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	1.020E18	3	3.400E17	93.585	.000a
Residual	1.817E16	5	3.633E15		
Total	1.038E18	8			

a. Predictors: (Constant), Foreign Direct Investment, Government Expenditure in Agriculture, Domestic Saving

b. Dependent Variable: Total GDP

Table 4 shows the model shows goodness of fit and all three predictor variables i.e. Domestic Savings, Government Expenditure on Agriculture and Foreign Direct investment in Agriculture, contribute significantly to the National Economy in terms of GDP.
The R value of 0.991 explains that there is highly positive relationship among the predictor variables and GDP. Similarly, adjusted R^2 value of 0.972 states that 97 percent of the variation could be explained by the three independent variables while remaining 3 percent could not be accounted for.

The value of adjusted R^2 (0.972) is close to the R value (0.991) explains the model is fit for making generalization. Furthermore, F=93.585 proves the model's goodness of fit to the analyzed data.

The Compound annual growth rate analysis of National budget over 13 years from table 1 reveals that it has increased at the rate of 18.03% annually. Similarly, for budget to MoAD, it is 22.74 %.

CONCLUSION

The study regarding the contribution of domestic savings, government expenditure on agriculture and foreign direct investment on agriculture to the national economy reveals that these variables jointly contribute significantly thereby indicating the models goodness of fit. The study shows that government expenditure on agriculture is crucial for the GDP indicating per unit expenditure on agriculture could contribute more than 101 units to the GDP on the basis of analysis of data in the model tested. However, the government budget allocation to expenditure on agriculture is not that much interesting, receiving around 3 percent of the national budget thereby creating pressure to the ever increasing demands of farmers.

The annual budget growth rate of MoAD was found to be 22.74 % which is slightly higher than that of National budget. However, to satisfy the ever increasing demand of farmers to the service delivery, it is not sufficient.

The study has collected and analyzed as much data as available, however to come to the conclusion, it is recommended to study and analyze further time series information of many years.

ACKNOWLEDGMENTS

The author is highly indebted to Mr. Prakash Acharya, Agriculture Extension Officer at Western Regional Agriculture Directorate, Kaski, Mr. Diwas Raj Bista, Agriculture Extension Officer at Ministry of Agricultural Development, Kathmandu and Mr. Bikas Paudel Agri-Economist at Ministry of Agricultural Development, Kathmandu for their kind support and suggestions regarding data collection and analysis.

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TEA PESTS AND PESTICIDE PROBLEMS AND INTEGRATED MANAGEMENT

Gita Shrestha & Resham B. Thapa[11]

ABSTRACT

Tea is one of the most popular beverage and main cash crops of Nepal with a very high export potential. Its plantation has expanded over 19000 ha with production of nearly 21 million kg per annum providing employment opportunity to 12000 farmers and many traders in Nepal. This plant suffers from more than 300 recognized pests, of which 25-30 insect pests occur regularly in poorly managed tea garden and some of them are major ones causing significant crop loss. Their recognition of field occurrence and incidence helps in devising management options to reduce crop loss. Therefore, a study was conducted to monitor insect pests, ascertain their nature of incidence and time of occurrence in tea garden in terai (Bhadrapur), foot-hill (Barne) and mid- hill (Kanyam) of eastern Nepal. Information was gathered by interacting with local tea gardeners, close observation in the field, collection of species and their identification in the laboratory, which showed that both terai and foot-hills with warmer climate harbored higher number of species than mid-hills. Their integrated management is essential for sustainable tea production.

Key words: Tea insect pests, field incidence, integrated management

INTRODUCTION

Tea is the oldest known beverage, native to China. It is one of the important plantation crops in the world. Its cultivation, processing and trade is expanding globally. The industry has grown globally into a $20 billion (Kahn, 2015). Annually over 2.6 million mt of tea is consumed in more than 65 countries, where people drink some 4 billion cup of tea brew daily (Jain, 2001). It is an important commodity of international trade and it is also a cash crop and important export item of Nepal. Yield potential of tea has been estimated at 25,000 kg made tea per hectare per year with uniform weekly harvest. Nepalese tea, due to its unique flavor and aroma, is popular in domestic as well as international market. Tea industry and related trade provides employment and income to many people.

Research indicates that tea growing regions could decline in some parts of the world by up to 40 to 55 percent in the coming decades (Kahn, 2015). The productivity is declining due to unusual weather and large number of insect pests and diseases. About 5-10% crop loss has been estimated due to pest incidence, while crop loss has been increasing at present, which is as high as 15-25% (Sinha, 2010). Pest damage in China, decreased the yield by 10-20% in an average a year (Yongming, 1999). Mamun and Ahmed (2011) reported 10-15% loss in normal condition and as high as 100% in severe cases. It is even higher in Nepal due to indiscriminate use of pesticides. Therefore, it was necessary to study tea production scenario and insect pests through monitoring tea garden and identify their damage for better management to increase production/productivity of quality tea.

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METHODOLOGY

This study was done in three topographical domains- terai plain (Bhadrapur Tea Garden), foot hills (Barnae Tea Estate), and mid hill (Kanyam Tea Garden). Periodic field visits, field survey and monitoring of insect pests, sample collection and identification of the pests were done during the tea flushing seasons. Standard insect collecting net was used to sweep in the tea garden. Thirty sweeping from each site were collected separately, brought in lab, sorted out and identified. In addition, visual observation was done in the field to see their feeding damage and also discussed with the local tea farmers for management. Additional information were gleaned through available literature tea production and integrated management of tea insect pests prepared for farmers IPM practices.

RESULTS AND DISCUSSION

Tea production trend: The total acreage and production of tea in Nepal is presented in Table 1. Both private companies and small holder farmers are involved in tea gardening. Tea plantation has expanded over 19000 ha with production of nearly 21 million kg per annum providing employment opportunity to nearly 12000 farmers and many traders. Tea plant has deep root system and so holds the soil strongly and contributes to soil conservation in hilly area of Nepal. Hence, plantation contributes to raise farmers' livelihood through employment generation and to national AGDP with its national and international trade.

Table 1. Plantation and production trend of tea in Nepal (2001-2013)

	Tea Plantation (ha)				Tea Production (kg)		
FY in AD	Private	Small Holders		Total	Private	Small Holder	Total
		Farmers	Area				
2001/2002	8179	5575	4186	12346	5864720	1653855	7518575
2002/2003	8321	4314	12647	12643	6478000	1720000	8198000
2003/2004	8869	6252	6143	15012	7714669	3956535	11651204
2004/2005	8912	6854	6989	15900	7789893	4816188	12606081
2005/2006	8912	7154	7100	16012	8443907	5244330	13688237
2006/2007	9001	7593	7409	16420	9340754	5826989	15167743
2007/2008	9030	7791	7564	16594	9940311	6187179	16127490
2008/2009	9063	8184	7655	16718	999013	6218114	16208127
2009/2010	9159	8735	7968	17127	10237514	6370041	16607555
2010/2011	9331	9523	8120	17451	10749390	6688543	17437933
2011/2012	9798	9941	8351	18149	11416646	6893176	18309824
2012/2013	9953	11932	9084	19036	12120266	8467879	20588145

Source: NTCDB, 2014

Both orthodox and CTC tea are produced and processed in Nepal (Figure 1): orthodox tea gardens are in the mountainous regions of Nepal at an altitude ranging from 3,000 – 7,000 feet above the sea level. There are six major districts (Ilam, Panchthar, Dhankuta, Terhathum, Sindhulpalchok and Kaski), primarily in the eastern regions of Nepal that are known for producing quality orthodox tea. CTC tea is produced in lower altitudes in the fertile plains of Nepal, which are warm and humid, primarily in the Jhapa district, which is ideal for the production and processing of CTC tea. These gardens need to be well maintained following good production and management practices for quality tea production.

Tea Garden Establishment	Tea Leaf Picking	Orthrodox & CTC Tea Brands

Figure 1.Tea-garden establishment and tea harvesting to consumer markets of CTC and Orthrodox tea

Pest occurrence/incidence : Over millions of insects have been known to exist on this earth, however, only few of them perhaps one percent is considered as pests of crops. Almost all pests have their natural enemies (predators, parasitoids) and moreover, insects play important role in pollination of crops and also provide service to us with their valuable products. Occurrence of different species of insects and mite at three sites is presented in Table 2. Terai and food hills harbored all eighteen pests (seventeen insect species and one mite), while common looper (*Buzura suppressaria* Guen), red slug caterpillar (*Eterusia magnifica* Butler) and red spider mite (*Oligonichus coffeae* Niet) were absent in tea garden during flushing period in mid hills. Regular monitoring of tea gardens in different ecological domain could provide good knowledge of all prevailing pest problems and their natural enemies, and necessary management options to device for eco-friendly pest management.

Table 2. Occurrence of insect pests of tea in terai, foot hill and mid hills of eastern Nepal

SN	Common name	Scientific name	Order	Family	Occurrence		
					Terai	Foot hill	Mid hill
1	Common looper	*Buzura suppressaria* Guen	Lepidoptera	Geometridae	√	√	-
2	Red slug	*Eterusia magnifica*	Lepidoptera	Zygaenidae	√	√	-

	caterpillar	Butl					
3	Bunch caterpillar	*Andraca bipunctata* Walk	Lepidoptera	Bombycidae	√	√	√
4	Flush worm	*Caspeyresia leucostoma* Meyor	Lepidoptera	Eucosmidae	√	√	√
5	Tea tortix	*Homona coffearia* Nieth	Lepidoptera	Tortricidae	√	√	√
6	Leaf roller	*Gracilaria theivora* Walsm	Lepidoptera	Gracilariidae	√	√	√
7	Stem borer	*Zeuzera coffeae* Nieth	Lepidoptera	Cossidae	√	√	√
8	Root borer	*Bactocera rubus* Lin	Coleoptera	Cerambycidae	√	√	√
9	Cockchaffer	*Holotrichia impressa* Burn.	Coleoptera	Scarabaeidae	√	√	√
10	Red ant	*Oecophylla smaragdina* Fab	Hymenoptera	Formicidae	√	√	√
11	Brown cricket	*Brachytrypes portentous* Lin	Orthroptera	Gryllidae	√	√	√
12	Termite	*Microcerotermes* sp	Isoptera	Termitidae	√	√	√
13	Tea mosquito bug	*Helopeltis theivora* Wct	Hemiptera	Miridae	√	√	√
14	Tea jassid	*Emposca flavescens* Fab	Homoptera	Jassidae	√	√	√
15	Tea aphid	*Toxoptera aurantii* Boyer	Homoptera	Aphididae	√	√	√
16	Scale insect	*Saissetia coffea* Walk	Homoptera	Coccidae	√	√	√
17	Thrips	*Taeniothrips setiventris* Bagn	Thysanoptera	Thripidae	√	√	√
18	Red spider mite	*Oligonichus coffeae* Niet	Acarina	Tetranychidae	√	√	-

Based on their feedings on different plant parts, the pests were categorized into three major groups, i.e. leaf, stem and root feeders (Table 2). Almost all pests (thirteen insect species and one mite species) showed their presence and preference to leaves feeding. Four species, i.e. stem borer (*Zeuzera coffeae* Nieth), cockchafer (*Holotrichia impressa* Burn.), red ant (*Oecophylla smaragdina* Fab) and tea mosquito bug (*Helopeltis theivora* Wct) were found feeding on stems and six species, i.e. stem borer (*Zeuzera coffeae* Nieth), root borer (*Bactocera rubus* Lin), cockchafer (*Holotrichia impressa* Burn.), red ant (*Oecophylla smaragdina* Fab), brown cricket (*Brachytrypes portentous* Lin) and termite (*Microcerotermes* sp) harbored feeding on roots (Table 2). Along with insect pests some important natural enemies of the pests are shown in Figure 2 and 3.

Tea plants are subjected to attack by many pests species and also kept in balance by their natural enemies. According to Chen and Chen (1989), 1034 species of arthropods, 82 species of nematodes, 1 algal and 350 fungal diseases associated with tea plants globally.

Table 2. Incidence of insect pests to different parts of tea plant in eastern Nepal

SN	Common name	Scientific name	Order	Family	Pest incidence		
					Leaf	Stem	Root
1	Common looper	*Buzura suppressaria* Guen	Lepidoptera	Geometridae	√	-	-
2	Red slug caterpillar	*Eterusia magnifica* Butl	Lepidoptera	Zygaenidae	√	-	-
3	Bunch caterpillar	*Andraca bipunctata* Walk	Lepidoptera	Bombycidae	√	-	-
4	Flush worm	*Caspeyresia leucostoma* Meyor	Lepidoptera	Eucosmidae	√	-	-
5	Tea tortix	*Homona coffearia* Nieth	Lepidoptera	Tortricidae	√	-	-
6	Leaf roller	*Gracilaria theivora* Walsm	Lepidoptera	Gracilariidae	√	-	-
7	Stem borer	*Zeuzera coffeae* Nieth	Lepidoptera	Cossidae	-	√	√
8	Root borer	*Bactocera rubus* Lin	Coleoptera	Cerambycidae	-	-	√
9	Cockchaffer	*Holotrichia impressa* Burn.	Coleoptera	Scarabaeidae	-	√	√
10	Red ant	*Oecophylla smaragdina* Fab	Hymenoptera	Formicidae	√	√	√
11	Brown cricket	*Brachytrypes portentous* Lin	Orthroptera	Gryllidae	√		√
12	Termite	*Microcerotermes* sp	Isoptera	Termitidae	-	-	√
13	Tea mosquito bug	*Helopeltis theivora* Wct	Hemiptera	Miridae	√	√	-
14	Tea jassid	*Emposca flavescens* Fab	Homoptera	Jassidae	√	-	-
15	Tea aphid	*Toxoptera aurantii* Boyer	Homoptera	Aphididae	√	-	-
16	Scale insect	*Saissetia coffea* Walk	Homoptera	Coccidae	√	-	-
17	Thrips	*Taeniothrips setiventris* Bagn	Thysanoptera	Thripidae	√	-	-
18	Red spider mite	*Oligonichus coffeae* Niet	Acarina	Tetranychidae	√	-	-

Many natural enemies of tea tree insect pests haven been reported from neighboring countries, China and India. Weiliang (1991) reported 173 species of insects of tea tree pests belong to 29 families in 8 orders including 55, 19, 39 and 51 species of Coleoptera, Hemiptera, Diptera and Hymenoptera, respectivety, from Yunnan Province, China India, Similarly, Das et al. (2010) from India reported 94 species of predators and 33 species of paasitoids of tea insect pests. Such long term detail studies are need to record prevailing pests and their bioagents in tea gardens in Nepal. Eco-friendly management of the pests and conservation of such natural enemies following integrated approach help to maintain healthy tea garden and produce high quality tea.

		
Tea tortrix larva, *Homona coffearia*	Looper larva, *Buzura suppresaria*	Red slug caterpillar, *Eterusia magnifica*

		
Tea aphid, *Toxoptera aurantii*	Tea thrips, *Scirtothrips dorsalis*	Tea jassid, *Empoasca flavescens*

				
Tea mosquito bug *Helopeltis theivora*	Tea scale, *Fiorinia theae*	Tea looper, *Buzura suppresia*	Tea tortrix, *Homona coffearia*	Red spider mite, *Oligonychus coffeae*

Figure 2. Some insect and mite pests of tea

			
Lady beetle	Syrphid fly	Preying mantid	Spider

			
Lacewing	Predatory mite	Braconid parasitoid	Fungus attacked larva

Figure 3. Some natural enemies of tea insect and mite pests

Pest and pesticide management: The methods used to protect tea garden from pests consist of field sanitation, cultural practices including healthy saplings, mechanical means, biological agents and judicious use of agro-chemicals and integrated pest management (IPM). But for immediate protection, use of chemicals is the most preferred choice of the farmers. Pesticide use in tea in general is said to be several times higher than in other crops. Even then, productivity trend in 83 tea estates spreading over 35,423 ha in three agro-climatic regions of Northeast India showed a decline of productivity from 17-20 years of age irrespective of cultivars and agro-climatic conditions. In the surveyed area in eastern parts of Nepal, more than 2 out of 3 heard about IPM. But in practice, there was none of the farmers adopting IPM in their field even in surveyed eastern tea areas of Nepal (Koirala, 2011).

Pesticide application: Annual import of pesticide in Nepal was 345 tons (a.i.) consisting of 33.25% insecticides, 48.35% fungicides, 15.49% herbicides, 2.37% rodenticides, 0.034% bio-pesticides and 0.50% others, respectively, valued at NRs. 374.90 million ($ 4 million) per anum (Sharma et al., 2012). Among the agricultural commodity tea receives highest pesticide after cotton in Nepal (Thapa, 2003). Majority of farmers have been spending pesticides worth of more than NRs 9000 on their tea garden per annum (Koirala, 2011). The recent information gathering showed that tea farmers have been applying different pesticides to reduce pest incidence in their tea garden (Table 3). Koirala (2011) also reported nearly more than 20 different types of pesticides being used in tea garden. However, after the initiation of IPM on tea in Jhapa and Ilam farmers are aware of pesticide pollution and trying to explore alternative means of pest management in their tea gardens. Though farmers have been using WHO Cass II or safer pesticides, they are practicing cocktail preparation of two or more than two pesticides without knowing their compatibility, which is of serious concern to health and environment.

Table 3. Farmers applying different types of pesticides against target pests in their tea gardens

SN	Common name	Trade names	WHO Class	Target insect pests
1	Emamectin benzoate	Chemdoot (5%) SG, Kingstar (5%) SG, Proclaim-5 SG	II	Common looper, Red slug caterpillar
2	Flubendiamide	Fame-480 SC (39.35%) SC	II	Bunch caterpillar, Flush worm
3	Imidaclorprid	Admire (70%) WG, Allmida (17.8%) SL, Anumida (17.8%) SL, A-one (17.8%) SL, Atom Plus (17.8%) SL, Bildor (17.8%) SL, Champion (17.8%) SL, Chemida (17.8%) SL, Down-2000 (17.8%) SL, Guard (30%) SC, Himida (17.8%) SL, Imida-chlor (17.8%) SL, Jumbo (17.8%) SL, Maxforce-IC (2.15%) EC, Midas-2000 (17.8%) SL, Parrymida (17.8%) SL, Polar (30.5%) SC, Premise (30.5%) SC, Simida (17.8%) SL, Suryamide Gold (17.8%) SL, Tatamid (17.8%) SL, Tez (17.8%) SL, Magic (17.8%) SL, Victor (17.8%) SL, Yorker (17.8%) SL	II	Tea tortrix, Cockchafer, Stem borer, Root borer, Scale insects, thrips
4	Thiamethoxam	Actara (25%) WG, Arrow (25%) WG, Black Diamond (25%) WG, Caper (25%) WG, Maxima (25%) WG, Molara (25%) WG, Pele (25%) WG, Renova v, Slayer (25%) WG	II	Leaf roller
5	Metarhizium + Imidaclorprid	Cocktail spray mixing any of trade marks of Imidaclorprid with Metarhizium	-	Termites
6	Imidaclorprid + Thiamethoxam + Hexathyzox	Cocktail sprays mixing more than two pesticides	-	Tea mosquito bug, Tea greenfly, Tea aphid, Thrips
7	Insecticide + Magic Stick	Insecticide with adhesive materials	-	Scale insects
8	Dicofol	Coloner +S (18.5%) EC or servo oil and acaricide	II	Tea mites

Source: PRMS, 2013; EC=Emulsifiable concentrate, SC= Soluble concentrate, SG= Soluble Granule, SL= Soluble concentrate, WG= Water Dispersible Powder,

According to survey conducted by Koirala (2011), 40% of tea farmers applied pesticides ten times or more in one crop cycle. Pesticides are poisonous substances and they are to be handled with extreme care. On the basis of 'acute toxicity, pesticides are grouped into four 'hazard categories (Table 4). The label shows a square (set at an angle of 45°) divided into two triangles. The lower triangle colored according to the hazard category and the upper triangle show the symbols of toxicity.

Table 4. Hazard categories of plant protection formulations

SN	Classification Of pesticides	Signal word	Group	LD50 per kg body weight		Color Code	Signal on Container
				Solid	Liquid		
1	Extremely/highly toxic	Skull and cross bones 'POISON' in red	IA Ib	10 or less	40 or less	**Bright Red**	
2	Highly toxic	POISON' in red	II	10-100	40-400	Bright Yellow	
3	Moderately toxic	DANGER	III	100-1000	400-4000	**Bright Blue**	
4	Slightly toxic	CAUTION	NH	Over 1000	Over 4000	**Bright Green**	

Again, based on the types of pesticides used, various signs and symptoms of diseases/disorders have been observed among the tea growers and the relative risk also observed to be high. Lack of adoption of adequate protective measures were noticed to have increased the declining state of the health of farmers (Sharma, et al., 2012; Dey et al., 2013). For instance, in India, during the period of April 2010 to March 2011, a total 15321 samples were analysed by 2l participating laboratories. Residues were found in 1044 (6.8%) samples, out of which the residues were detected above maximum residue (MRL) in 188 (1.2%) samples (DACMA. 2011). Farmers in Assam often used pesticides ranging from high to extremely hazardous categories, like Organochlorides, Organophosphates, Carbamates and synthetic pyrethroids.

Some of the signs and symptoms felt by farmers with a higher prevalence were excessive sweating (31.8%), stinging /itching eyes (33.8%), dry/sore throat (20.5%), skin redness/white patches (32.8%), numbness/muscle weakness/muscle cramps (30.5%) chest pain/burning sensation (34.1%), excessive salivation (33.1%) (Dey et al., 2013). To reduce the pesticide environment pollution and MRLs on tea product, safer pesticides as a last resort have to be considered based on threshold of tea pests rather than routine application of pesticides. These days microbial and botanical bio-pesticides have gained popularity against different insect pests of various crops (Roy and Muraleedharan, 2014; Mukhopadhyay and Chakraborty, 2008).

In Nepal, MRLs of fresh vegetables has been started in Kathmandu valley, however, exportable commodities, like, tea, coffee, honey have not received such serious concern.

The MRLs of pesticides in tea have changed recently (Table 5). This has created strong pressure to the farmers on tea garden pest management and compelled them to move for safer and bio-pesticide materials.

Table 5. Selected tea tolerances/MRLs in western countries

SN	Active Ingredient	US Tolerance (ppm)	EU MRL (ppm)	Codex MRL (ppm)
1	Acetamiprid	50.0	0.1*	none
2	Bifenthrin	30	5	30
3	Buprofezin	20	0.05*	30 (2013)
4	Carfentrazone-ethyl	0.10	0.02*	none
5	Chlorantraniliprole	50.0	0.02*	none
6	Chlorpyrifos	none	0.1*	2
7	Clothianidin	70	0.7	0.7
8	Deltamethrin	none	5	5
9	Dicofol	50.0	20	40 (2013)

*Source: William, 2013; * Indicates the lower limit of analytical detection.*

Integrated Approach: The integrated management of tea was initiated with the government effort during II-Phage of the National IPM Program (2009-2013) in Nepal (Thapa, 2013). Tea growers participated in IPM-FFS in tea (Figure 4). During their training, farmers learn the principles of IPM: i) grow healthy crops, ii) observe the field regularly, iii) understand the agro-ecosystem and conserve natural enemies, and iv) farmers become expert. Then they apply all sound practices of IPM and practice accordingly. In fact, tea IPM in farming community (Farmers groups) relies on community tea plantation planning for IPM technology based production, processing and marketing with good record keeping in green book by each tea farmer to prove the traceability complying all their rules and regulations and code of conduct with truthful labeling of the product strictly following Local Good Agricultural Practices (LGAP) developed by the government for safe quality tea production. The production and income from tea has been found higher with quality in IPM practiced tea garden than in FP tea garden. This is also a transitional phase to transfer traditional chemical farming to eco-rich organic farming.

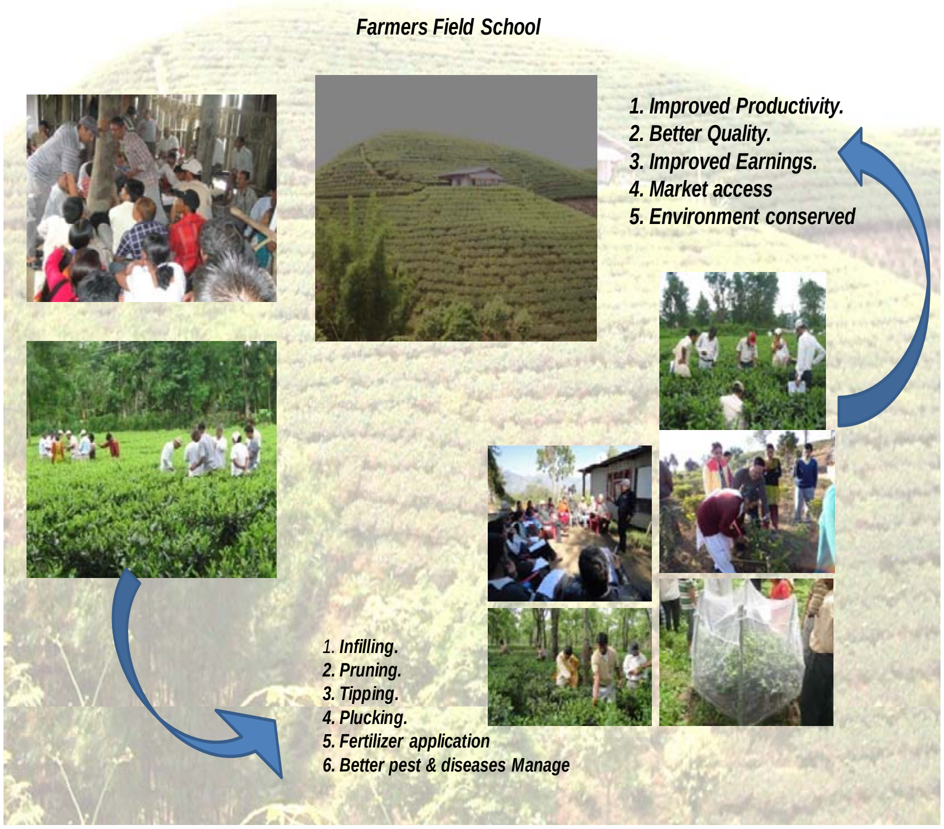

Figure 4. Participating farmers in IPM-FFS training and learning process

A comparative of organic and conventional farming system at two planting fields conducted in Tea Plantation in Malaysia clearly showed the advantage of organic farming system resulting in significantly higher soil pH (4.14 vs 3.38), leaf length (15.14 vs 13.19 cm), leaf width (7.33 vs 5.58 cm) as well as major polyphenol content in tea shoot (172.42 vs 107.03mg/g, while, conventional farming system revealed disadvantage of producing higher levels of ammonium (332.4 vs 45.2 kg/ha) and nitrate (39.0 vs 19.2 kg/ha) content in soil as compared to organic farming system (Chin et al., 2010).

Even after considering all above factors, tea cultivation and quality is affected by global warming. Climate change is expected to have a significant impact on global tea production (ITC, 2014). The changes in temperatures and rainfall not only altere the taste, aroma, and potential health benefits of the popular beverage but also the lives of farmers who grow tea for a living. According to Hazarika (2011) from the 100 years of tea research, environmental impact is likely to take a serious threat in large areas especially old tea bushes. Field monitoring and light trap, which has often been used in the ecological studies of insect pests in agro-ecosystems are highly useful to alert regarding pest activity among farmers that may be effectively utilized to schedule different pest-management operations. Available recent technology can help development of super clone with most of the attributes which would sustain for long time, at least 40-50 years. Therefore, integrated approach of tea garden management following good practices and quality tea production is necessary to sustain this commodity and compete quality tea produce in the international market.

CONCLUSIONS

Important tea insect pests and mites have been recorded in tea garden in different ecological domains of eastern Nepal. In fact, sustainable tea cultivation mainly relies increasingly on alternatives to conventional chemical insecticides including farmers' indigenous practices for pest management with bioagents' conservation that are environment-friendly, resilience to climate and reduce the amount of pesticide in tea garden and residues in made tea. It is important to maintain a good balance between technological innovation and its applicability to tea industry and main focus should be for the solutions to ecological imbalance being caused by biotic and abiotic factors, and Tea-IPM takes care of all the concerned issues to sustain tea production in Nepal.

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