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Climate change impacts on livestock in Gandaki River Basin of Nepal

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ABSTRACT

The livestock sector, integral part of mixed farming system of Nepal, is facing adverse impact of climate variability and extremities. A study was carried out to study the perception and impact of climate change on livestock in Gandaki river basin. A total of 551 samples from Dhading, Syangja and Kapilbastu districts were studied through household survey using purposive random sampling with structured questionnaires. Descriptive statistics; percentage, frequency and standard deviation were used to analyze the data. The results revealed that less than half (39%) livestock holders found to be heard about climate change. More specially, 83 percent of them could define the climate change more correctly. Radio and television were observed as the major sources (79%) of information to have climatic knowledge. The result further suggested that drought, extreme rain, hailstorm and floods were major events with increased frequency of occurrence in last five years. Majority of respondent experienced sensitivity of changing precipitation and temperature to livestock production. We found that problem of managing animal feed and pasture (49%), outbreak of internal, animal disorder and external parasites (38%), were the major impacts on livestock of change in precipitation while heat stress and low productivity of livestock were noticeable impacts of change in temperature. Similarly, two third farmers observed negative effects of changing climatic pattern in human derived from livestock human interaction. Awareness campaign on climate change is recommended among livestock holders for climate information there by allowing them to increase their resilience and adaptive capacity.

Keywords: Flood, precipitation, feed, pasture, resilience

INTRODUCTION

Livestock is an integral part of the mixed farming system and socio-economical life in the country; and contributes nearly 26 percent to the total Agricultural Gross Domestic Product (MOAD, 2012). Livestock systems vary along the elevation gradient, from buffalo dominated in the low elevations of the Terai to Chauri and Yaks in the Mountain region. While not definite, it would seem that livestock in Nepal is at par with livestock

systems in other developing countries; and is changing rapidly in response to many external and internal drivers including climate change, which is seen as a negative impact (Thornton *et al.,* 2007).

Climate change is already being felt and its effects are expected to continue and to increase and rural communities are increasingly vulnerable to climate induced hazards (Gurung and Bhandari, 2008). Due to the fragile ecosystem, which is very sensitive to even slight changes in natural climate, weaker geological situation and complex topography, Nepal is in fourth vulnerable position with regard to climate change (Maplecroft, 2011). The Intergovernmental Panel on Climate Change (IPCC, 2007) suggests that within the agricultural sector livestock are among the most climate sensitive economic areas. Studies on livestock and climate change revealed that climate change adversely affects the animal health and livestock production. The effects of climate change on the health of livestock and poultry are reported by many studies (Harvell et al., 2002; Baylis and Githeko, 2006). The limited herbaceous production, heat stress from higher temperature, and limited water intake due to the decrease in rainfall could cause reduced milk yields in animals and an increased incidence of some diseases. In some areas, climate change may also cause new transmission models; these effects will be felt mostly by developing countries because of lack of resources, knowledge, veterinarian extension services and research technology development (FAO, 2008). Heat stress on animals reduces the rate of animal feed intake and causes poor performance growth (Rowlinson, 2008).An increase in extreme climate events, such as droughts and floods, is anticipated more constraint to profitable livestock production (Christensen *et al*., 2007).Gandaki River Basin, where the research was conducted, is particularly vulnerable because it lies in the Himalayas' rain shadow and relies on river flows from mountain snow and ice cover for water supplies (Manandhar*et al*., 2012). However, appropriate mechanisms for coping and adapting to adverse effects in the livestock sector are weak or lacking. With this back drop this research focused to analyze the perception to climate change, its effects on livestock production to make the necessary policy recommendations.

MATERIALS AND METHODS

Study Area

The Gandaki River Basin (GRB), Nepal spreads from 27.21'45" to $28^0$36'36" degree north longitude to $83^0$08'00"- $84^0$53'00" degree east latitude and elevation ranging from about 144 Masl to 8167 Masl (DDC, 2002). It covers the areas in the Mountain zone (Mustang, Manang, Gorakha, Rasuwa Districts), Hill zone (Myagdi, Kaski, Tanahun, Lamjung, Syangja, Parbat, Dhading, Nuwakot, Makawanpur, Baglung, Gulmi, Palpa), and the valley Terai zone (Nawalparasi, Chitwan, Kapilvastu). The average temperature of this area ranges from -9 ^{o}C in Mustang to 42.5^{o}C in Chitwan. Average annual rainfall is 26.58 mms in mustang to 2500 mm in Chitwan. This research based on three Districts namely; Dhading, Syangja and Kapilbastu (Figure 1). These Districts were selected purposively as livelihood of the most of the people has been hinged on the agriculture and livestock sector (DADO, 2012; DLSO, 2011a; DLSO, 2011b).

Figure 1. Map of Nepal showing study Districts: Dhading, Syangja and Kapilbastu

A total of 551 randomly sampled household were considered for the survey from these districts. Sampling distribution is shown in the Table 1.

Table 1. Sampling distribution by districts

District	Sample size
Dhading	193
Syangja	178
Kapilbastu	180
Total	551

The primary data were collected through household survey using pretested structured questionnaire via face to face interview on January 2014.

2.2 Data management and analysis

The data were analyzed using descriptive; T statistics, Chi2 test, F statistics was applied to test the significance of these variables Data management and analysis was done by using computer software package, which are Statistical Package for Social Science (SPSS 16 version) and Microsoft Excel. Prioritization of major climatic hazards was rated using preference ranking scaling technique consisting four point scales. The points consists of strongly agree, somewhat agree, agree, least agree and disagree using score of 1.00, 0.75, 0.50, 0.25 and 0, respectively using following formula:

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

Where, Iprob = Index value for intensity of problem,
$\sum$ *= Summation,*
Si = Scale value of ith intensity
fi = Frequency of ith response,
N = Total number of respondents

RESULTS AND DISCUSSIONS

3.1 Climate Change in GRB: Past

Higher anomalies in both temperature and precipitation were observed on the dominant area in recent decades (1980s, 1990s and 2000s) compared to the long term average (1971-2009) (Figure 2&3). The result revealed that increasing trend in percentage of warm days and nights whereas the cool nights and cool days were found to be decreasing. In addition, very wet days and extremely wet days are increasing. We observed positive trend of consecutive dry days (CDD) (Figure 4 & 5).

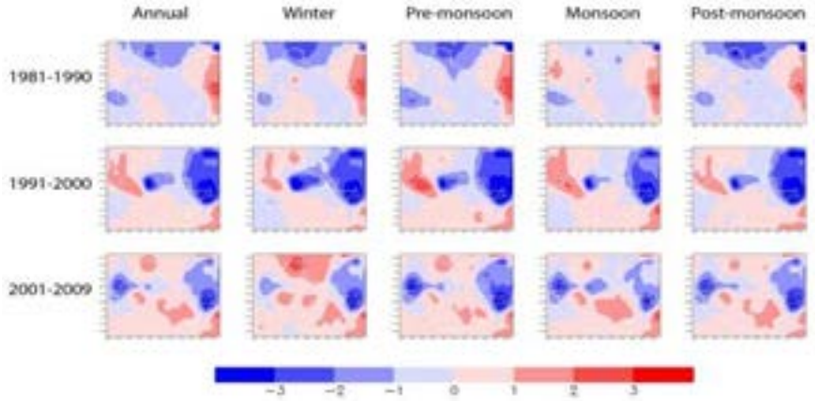

Figure 2.Temperature anomaly (^{o}c) of each decade compare to long term average1971-2009

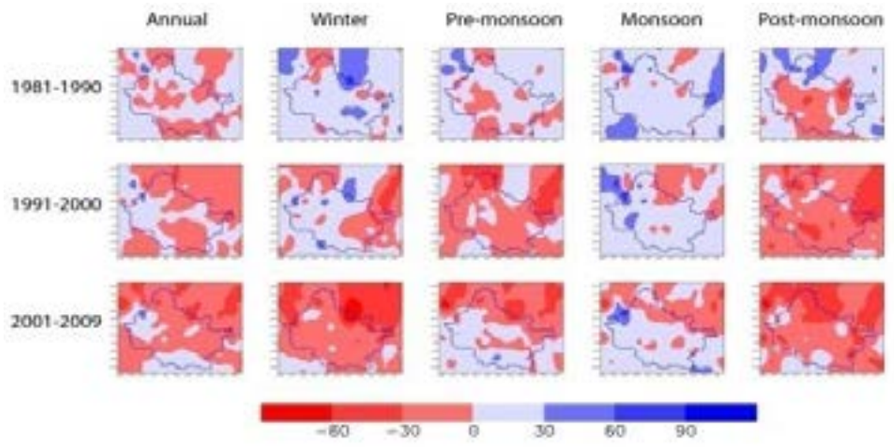

Figure 3. Precipitation anomaly (%) of each decade compare to long term average of 1971-2009

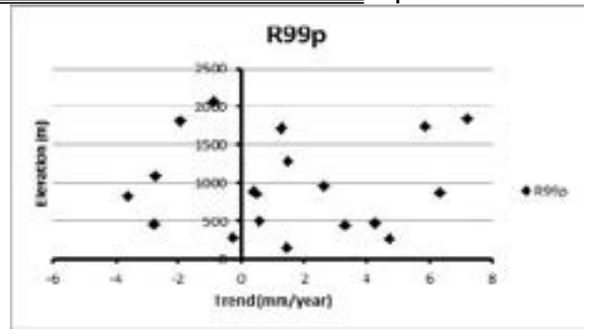

Figure 4.Trend of very wet days

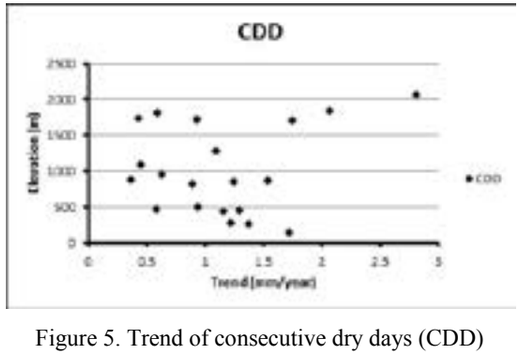

Figure 5. Trend of consecutive dry days (CDD)

3.2 Knowledge on climate change

It was found that less than half of sampled responded had knowledge on climate change as they had heard about the change on climatic parameters directly or indirectly. Livestock farmers from Kapilbastu (44%) were relatively more aware in climatic issue than Dhanding (33%) and Syangja (43%), this might be due to easy access to source of information and road. More specially, 83% of them could define the climate change more correctly (Figure7).

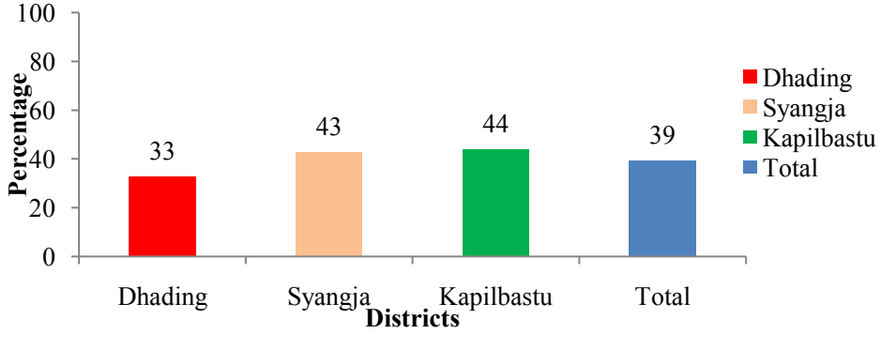

Figure 6. Percentage of livestock keepers having heard about climate change

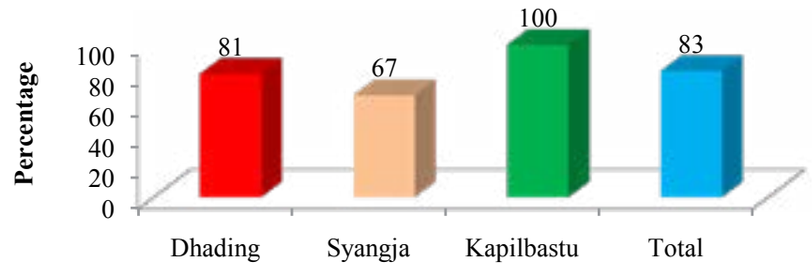

Figure 7- Clarity on Knowledge about climate change

Result showed that mass media communication through radio and television were most prominent sources of information and communication regarding to have knowledge on climate change (Table 2). It was ranked first all three districts. Farmers perceived TV and radio as an effective source of information as they could get more information staying at home. According to them, these were both entertaining and informative with the visualization effect from TV. A perusal of Table revealed that government agencies were least effective source of communication to the farmers. They said that it was only the extension agent, as a Governmental agency who could listen their problems and could take initiatives to solve their problems.Teachers were the somewhat credible source of information.

Table 2. Source of information used by livestock keepers in the GRB

Source of Communication	Dhading	Syangja	Kapilbastu	Total
Radio/TV	55 (87.30)	64 (83.12)	50 (67.57)	169 (78.97)
Teacher	5 (7.94)	7 (9.09)	14 (18.92)	26 (12.15)
Newspaper	3 (4.76)	4 (5.19)	2 (2.70)	9 (4.21)
Staff of NGO	0 (0.00)	2 (2.60)	4 (5.41)	6 (2.80)
Government office	0 (0.00)	0 (0.00)	3 (4.05)	3 (1.40)

Figure in the parenthesis indicates percentage
Source: Field Survey, 2014

3.3 Major climatic hazards or extremities

The result further suggested that extreme hot and drought, extreme cold, landslide and hailstorm and floods were major events with increased frequency of occurrence in last five years which were identified by the group discussion and based on literature. The value obtained from the preference ranking scale show that extreme hot and drought were the major extreme events in Kapilbastu (0.896). Similarly, landslide was major hazards in the warm temperate (0.629) and cool temperate (0.613) respectively (Table 3).

Table 3. Perception of respondents towards climatic hazards and events

Climatic hazards	Districts					
	Kapilbastu		Syangja		Dhading	
Floods	0.33	III	0.479	II	0.325	II
Landslide	0.000		0.508	I	0.529	I
Extreme hot and drought	0.896	I	0.021	V	0.04	IV
Extreme cold	0.388	II	0.450	III	0.300	III
Extreme rain	0.233	IV	0.151	IV	0.010	V

Source: Field Survey, 2014

3.4 Climate change impact on livestock production and performance

We found that problem of managing animal feed and pasture (49%), outbreak of internal, animal disorder and external parasites (38%), were the major impacts on livestock of change in precipitation while heat stress and low productivity of livestock were noticeable impacts of change in temperature. Managing feed and pasture was the major in both Dhading (61.14%) and Syangja (50.00), while outbreak of animal disease, disorder (49.78%) and incidence of animal external parasite (44.12%) was found as the major problem in Kapilbastu (Table 4).

Table 4. Climate change impact on livestock production due to change in precipitation

Problem	Kapilbastu	Syangja	Dhading	Total
Managing feed and pasture	63(35.00)	89(50.00)	118(61.14)	270(49.00)
Outbreak of animal disease	90(49.78)	60(33.98)	59(30.56)	209(37.93)
Incidence of external parasite	79(44.12)	68(38.32)	50(25.95)	198(35.93)
Water scarcity	39(21.67)	62(34.83)	66(30.49)	186(30.49)

Figure in the parenthesis indicates percentage
Source: Field Survey, 2014

Table 7. Effect of climate change on livestock performance

Major effects	Dhading	Syagja	Kapilbastu	Total
Reduction in milk	47 (24.35)	43 (24.16)	35 (19.44)	125 (22.69)
Infertility	25 (12.95)	34 (19.10)	56 (31.11)	115 (20.87)
Reduction in feed intake	25 (12.95)	30 (16.85)	53 (29.44)	108 (19.60)
Decline in meat production	32 (16.58)	17 (9.55)	21(11.67)	70 (12.70)
Decline in egg production	9 (4.66)	6 (3.37)	23 (12.78)	38 (6.90)

Figures in the parentheses indicate percentage
Source: Field Survey, 2014

Changing climatic situation might directly or indirectly affect the animal performance. Reduction in milk production and shortened lactation period (23%) was found as the major climatic induced problem in the GRB followed by infertility. Furthermore, infertility (31%) and reduction in feed intake (29%) were observed as the major effects of

climate change in Kapilbastu due to heat stress and increased temperature. About 20% respondents opined that climate change had an effect on livestock feed intake. Likewise 13% respondents observed the declined in the meat production and 7% observed the declined in the egg production (Table 5).

CONCLUSION

Climate change is one of the challenges to environment-human security and poses threat to the livelihood of people who rely more in the agriculture and livestock sector since these sectors are more susceptible to the climate induced disasters and calamities. Survey results confirmed that perception of climate change by the farmers in the study sites was in line with findings of other researchers around the world. Farmers were able to recognize that temperature had increased and precipitation had been dwindled. Landslide, floods, extreme hot, and glacial retreat in the high hill were major hazards and extremities. Major climate induced impact on livestock production were incidence of diseases and external parasites in animal, loss of forages and fodders, heat stress, water scarcity, infertility, decline in the milk yield and lactation period. The public extension service needs to train and employ qualified local smallholder farmers to fill the extension gap. Information is a very critical variable in farming operations and thus, cannot be overlooked but lacking in the survey sites. Awareness campaign on climate change is recommended among livestock holders for climate change information. Moreover, the research results in this study would serve the livestock research and development related authorities for formulate the action plan for adaptation of climate change in livestock sector in the rural areas.

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Response of heat treated mustard cake feeding on growth performance of growing female goats in fodder-based basal diet

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ABSTRACT

Growth comparison of goats fed with treated and none treated mustard cake is not evaluated so far in Nepal. Therefore, an experiment was carried out on eighteen growing female goats (50% Jamunapari 6, 50% Barberi 6 and Khari goats 6) at the Agriculture Research Station (Goat), Bandipur, Tanahun for 90 days after an adaptation period of 7 days. Female goats of average seven months age having body weight 9 kg were allocated into three groups having six animals (2 from each breed) in each group by using Complete Randomized Design (CRD). For T2 and T3 concentrate mixture were composed by using procured feed ingredients with 16 percent crude protein level while T1 was fed with commercial feed. Experimental animals of T1 group was provided forest mixed fodder (adlib) + commercial concentrate mixture @ 1.5 percent of body weight, T2 group was provided forest mixed fodder (adlib) + treated mustard cake included concentrate mixture @ 1.5 percent of body weight whereas T3 was provided forest mixed fodder (adlib) + untreated mustard cake @ 1.5 percent of body weight. Experiment revealed that the highest feed intake was observed in T1 (174.45 g/day) followed by T2 (165.86 g/day) and T3 (163.44 g/day) whereas fodder intake was found to be higher in T2 (2501.9 g/day) followed by T1 (2481.7 g /day) and T3 (2438.8 g/day). Both feed and fodder intake was highly significant (P<0.001) among diet groups and breeds. In addition, highest FCR was found in T1 (17.14:1kg) followed by T2 (16.03:1 kg) and T3 (13.19:1kg). Similarly, the initial body weight of experimental animals was 9.67 kg, 9.75 kg and 8.92 kg which reached 14.45 kg, 14.873 kg and 14.95 kg by the end of experiment for T1, T2 and T3, respectively. Both initial and final body weights were no significant among diet groups and breeds. Likewise, the total weight gain was highest in T3 (6.03 kg) followed by T2 (5.08 kg) and T1 (4.78 kg) with average daily gain 67.04 g, 56.48 g and 53.15 g for T3, T2 and T1, respectively.

Key words: Bypass protein feeding, fodder, body weight, breeds

INTRODUCTION

Goat has been rearing since the time immemorial. Generally, goat farming means rearing goats for the purpose of harvesting milk, meat and fiber. At present, goat farming has become a profitable business with a very low investment because of its multi functional utility. It keeps a great contribution to the economy and nutrition of a country. Goat has been considered as poor man's cow (mini cow) of poor people because of its immense contribution in rural economy and national income. Goat products like milk and meat are not only nutritious and easily digestible but also a great source of regular income for the poor, landless and marginal farmers. Being a small sized animal it can be easily maintained by women and children (www.rosal-feedmills.com) . Neopane and Pokharel (2008) reported that most of the farmers of western hills of Nepal are rearing Khari goats, crossbreds of Khari x Jamunapari and Khari and Barberi. Goat population of Nepal is estimated to be 9.19 million. Out of 9.19 million, goat population of western hills is 1.13 million which account 12.32 *percent* of total goat population that producing 5284 mt meat per annum (10% of total goat meat production) (MoAD, 2012).

Oil seeds cakes and meals are the residues remaining after removal of the greater part of the oil from oil seeds. The residues are rich in protein and most are valuable feeds for farm animals. Most oil seeds are of tropical origin, they include groundnut, cottonseed, soya bean, mustard, sesame etc (Bajjlieh, 2002). Mustard seeds contain about 30–35% oil and 34–39 *percent* crude protein. Mustard cake has a good balance of essential amino acids and relatively high methionine content. Cheaper than other meal or cake, it is used in the feeding of cattle and buffaloes, but information is scanty on its feeding in sheep and goats (Anil Kumar *et. al.,* 2002). The protein content in diets of ruminant animals is essential for growth and production requirements. Possibility that reasonable portions of high quality protein of feedstuffs may be degraded in the rumen, which negatively affects utilization of the feed. In this context, there are several methods for protection of dietary protein from degradation in the rumen (EL-Shabrawy, 1996). The heat treatment is known one of the methods to increase the protection of the proteins. During the process of manufacturing oil seed meals, they are subjected to different degree of heating which partly explains differences in the degree of protection. Through heating of protein supplement causes denaturation of protein; it provides effective protection against microbial fermentation in the rumen. Heat treatment of protein meal at 125- 150^0 C for 2-4 hours improves the bypass protein. The main benefit of "*bypass*" protein is that the original amino acids in the protein meal are absorbed in the small intestine instead of converted into microbial protein in the rumen, thereby providing a different balance of essential amino acids for better animal nutrition hence, production (Schroeder, 1997).

Growth comparison of goats fed with heat treated and none treated mustard cake is not evaluated so far in Nepal. Hence, a study was carried out to compare the growth performance of growing female goats fed with heat-treated and none treated mustard cake mixed concentrate mixture at Agriculture Research Station (Goat), Bandipur, Tanahun.

METHODOLOGY

Experimental animal

This experiment was carried out on eighteen growing female goats (50% Jamunapari 6, 50% Barberi 6 and Khari goats 6) at Agriculture Research Station (Goat), Bandipur, Tanahun from 25 August to 22 November 2013 (070/5/9 to 070/8/7). Female goats of

average 7 months old with average body weight of 9 kg were allocated into three groups having six animals (50% Jamunapari 2, 50% Barberi 2 and Khari 2) in each group by using Complete Randomized Design (CRD). They were drenched with Fenbendazole @ 5 mg/kg body weight against internal parasites before assigning in experiment.

Concentrate mixture composition

Feed ingredients maize, mustard cake, rice bran, minerals and salt were procured from Khowpa Feed Industry, Bhaktapur. For T2 and T3 concentrate mixture were composed by using procured feed ingredients with 16 *percent* crude protein level that has been presented in Table 1 while for T1 commercial compound feed was used made by Pancharatna Feed Industry, Narayangadh, Chitwan.

Table 1. Composition of concentrate mixture

S/n	Ingredients	Part	Crude Protein, %
1	Maize	47	4.13
2	Mustard cake	31	10.12
3	Rice bran	20	1.76
4	Mineral mixture	1	0
5	Salt	1	0
Total		100	16.01

Heat treatment of mustard cake

The drying of forage is known to increase the protection of the proteins. Through heating of protein supplement causes denaturation of protein; it provides effective protection against microbial fermentation in the rumen. Heat treatment was done by using hot air oven at temperature 125- 150^0C for 2-4 hours as suggested by Suresh, *et al* (2009).

Experimental diet of the animals

The dry matter requirement of goats was calculated based on 5 kg per 100 kg body weight. Following diets were formulated to the experimental animals (Table 2).

Table 2. Experimental diets of the animals

Treatment	Experimental diet
1	Forest mixed fodder (adlib) + commercial concentrate mixture @ 1.5% of body weight
2	Forest mixed fodder (adlib) + heat treated mustard cake included concentrate mixture @ 1.5% of body weight
3	Forest mixed fodder (adlib) + untreated mustard cake included concentrate mixture @ 1.5% of body weight

Feeding regime

Concentrate mixture and *adlib* amount of fodder was provided to the experimental animals individually in plastic vessel. Concentrate mixture was provided once a day in the morning whereas fodder twice a day (morning and evening). Quantity of concentrate mixture and fodder given daily to the animals was weighed daily and refusal was weighed in next morning. Experimental animal had free access to drinking water.

Chemical analysis

The samples of feed ingredients, prepared concentrate mixture and forest mixed fodder were sent to the Animal Nutrition Division, Khumaltar, Lalitpur for proximate analysis. Representative samples were analyzed for dry matter (DM), crude protein (CP), crude fibre (CF), ether extract (EE) and total ash contents (TA). The DM was determined by oven drying at 100°C for 24 hrs. Crude protein of the samples was determined using the Kjeldahl method. Ether extract was determined using Soxhlet apparatus. Ash content was determined by ashing at 550°C in a muffle furnace for 16 hrs (AOAC, 1980). Crude fibre of the samples was determined using the Van Soest method (Goering, H.K. and Van Soest, 1970).

Observation recording

The trial period consisted 90 days after an adaptation period of 7 days. Total feed intake by the goats was recorded daily for all experimental period. The body weight gain of individual animals was measured fortnightly in the morning before feeding.

Data analysis

Data of feed intake and body weight gain were analyzed by **"*One Way Annova*"** test for every measurement using computer statistical package Minitab 2003, versions 13.20.

RESULTS AND DISCUSSION

Chemical composition of feedstuffs

The result of chemical analysis has been given in Table 3 and crude protein content of prepared concentrate mixture was verified in laboratory that is presented in Table 4.

Feed intake

Average feed and fodder intake of experimental animals is presented in Table 5. The highest feed intake was observed in T1 (174.45 g/day) followed by T2 (165.86 g/day) and T3 (163.44 g/day) whereas fodder intake was found to be higher in T2 (2501.9 g/day) followed by T1 (2481.7 g /day) and T3 (2438.8 g/day). Both feed and fodder intake was highly significant ($P<0.001$) among diet groups and breeds. Consequently average dry matter intake per day was also noted higher for T1 followed by T2 and T3 (910.4 g, 905.1

g and 884.2 g, respectively) which resulted higher DMI for T1 followed by T2 and T3 (81.94, 81.45 and 79.57 kg, respectively). Similarly, highest FCR was found in T1 (17.14:1kg) followed by T2 (16.03:1 kg) and T3 (13.19:1kg). In case of average daily crude protein intake, highest was measured for T2 (103.25 g/day) followed by T3 (100.3 g/day) and T1 (98.16g/day)

Table 3. Chemical composition of different feed ingredients (% DM basis)

Ingredient	DM	OM	TA	CP	CF	EE
Maize	87.69	97.97	2.03	8.92	2.34	4.48
Rice bran	87.85	89.5	10.5	11.52	4.83	5.1
Mustard cake	87.27	90.5	9.5	35.52	9.19	NA
Mixed forest fodder	30	88.23	11.77	10.3	NA	NA

Table 4. Chemical composition of prepared concentrate mixture (% DM basis)

Particular	DM	OM	TA	CP	CF
Treated mustard cake included concentrate mixture	93.15	88.12	11.78	16.79	8.57
Untreated mustard cake included concentrate mixture	93.34	87.33	12.67	16.35	7.13
Commercial feed	93.4	86.72	13.28	12.99	6.79

Table 5. Feed intake of experimental animals/day/animal

Feedstuffs	Mean ± SD		
	T1	T2	T3
Feed intake, g	174.45±38.17	165.86±34.53	163.44±44.55
Fodder intake, g	2491.7±248.1	2501.9±254.6	2438.8±292.96
Dry matter intake/day, g	910.4±95.6	905.1±100.4	884.2±120.2
Crude protein intake/day, g	98.16±10.55	103.25±12.11	100.3±14.58
Total dry matter intake (DMI), kg	81.94	81.45	79.57
Total crude protein intake, kg	8.83	9.29	9.02
Feed conversion ratio (FCR)	17.14:1	16.03:1	13.19

Growth performance

Average growth performance of experimental animals is presented in Table 6. The initial body weight of experimental animals was 9.67 kg, 9.75 kg and 8.92 kg which reached 14.45 kg, 14.873 kg and 14.95 kg by the end of experiment (90 days) for T1, T2 and T3, respectively. Both initial and final body weights were no significant among diet groups and breeds, however, in 0, 15 and 30 days weight was significantly (P>0.01) differed among breeds. Further significant effect of breed was not observed. The total weight gain was highest in T3 (6.03kg) followed by T2 (5.08 kg) and T1 (4.78 kg) with average daily gain 67.04 g, 56.48 g and 53.15 g for T3, T2 and T1, respectively.

Table 6. Growth performance of goats

Parameter	Mean ± SD		
	T1	T2	T3
Initial body weight, kg	9.67±2.31	9.75±1.54	8.92±2.67
Initial metabolic weight, kg	5.48	5.51	5.16
Final body weight, kg	14.45±2.08	14.83±1.53	14.95±3.51
Final metabolic weight, kg	7.41	7.55	7.6
Total weight gain, kg	4.78±1.78	5.08±1.35	6.03±1.32
Average daily gain, g	53.15±14.24	56.48±15.08	67.04±14.68

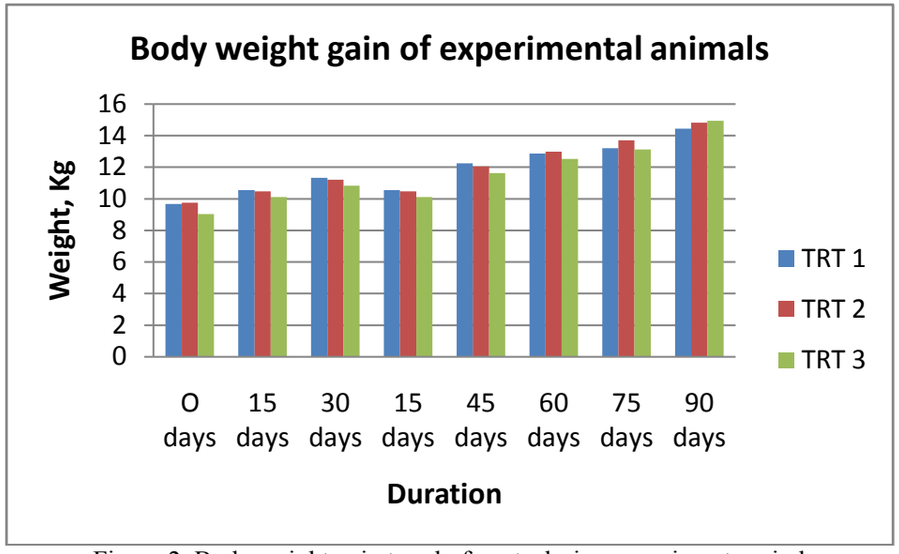

Figure 2. Body weight gain trend of goats during experiment period

CONCLUSION

Our experiment revealed that there was a no significant effect of heat-treated mustard cake on total body weight gain of goats, however, feed and fodder intake was highly significant (P<0.001) among diet groups and breeds. The heat treatment of mustard cake did not enhance the bypass of protein from rumen. Therefore, it is suggested that mustard cake can be incorporated in goat diet without heat treatments.

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Seedling tubers evaluation of true potato seed families for commercial potato production in Nepal

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ABSTRACT

True potato seed (TPS) is a tiny tomato like botanical seed of potato (Solanum tuberosum L.). Production of TPS is an alternative technology that is scientifically sound, technically feasible and economically viable. Good alternative for production of high quality planting materials free of major potato disease. To identify high yielding and suitable TPS families and find out better agronomic practices, many studies were carried out in the country during last several years. The experiments were conducted during 2011/012 to 2012/013 at Khumaltar (1360 masl) and Nepalgunj (181masl) conditions, to see the performance of seedling tubers (F_1C_1) of TPS families for commercial potato production. The families were evaluated and compared with well adopted commercial variety Kufri jyoti, Janakdev, Lal Gulab, Kufri Sindhuri and Perricoli in randomized complete block design (RCBD) with three replications. Results showed that TPS families LT 8 x TPS-13, LT 8 x TPS-67 and C96H-13.29×TPS-13 were found best at Khumaltar, Lalitpur (central mid hill). Families C96H 02.4 x C99HT2-32.17, C96H 02.7 x TPS 13 and HPS 7/67 were best at Nepalgunj (mid western terai). However, check clone Kufri Jyoti produced higher tuber yield at central hill condition, it might be due to well established, vigor and recommended cultivar of mid hill. While yield of Janakdev and Lalgulab is lower as compared to TPS lines. Total tuber numbers and yield among the families were significantly different at all the locations. These TPS families were high yielder over other families and late blight disease (Phytophthora infestans) build up was very low (resistant/ tolerance) as compared to check varieties in western terai condition, while all the TPS families were resistant/tolerance to late blight disease at Khumaltar, Lalitpur. All selected TPS families are promising and being tested in farmer's field. It is concluded from the study that cultivar Kufri Jyoti has higher tuber yield as compared to TPS lines in central hill Khumaltar and Pericolli produced slightly higher or equal tuber yield than TPS families in western terai condition. TPS families performed overall better performance and can be used as an alternate technology for potato production and through TPS technology disease free potato tubers can be produced on commercial basis.

Key words: *Solanum tuberosum*, technology, disease, varieties, tuber yield

INTRODUCTION

Commercial use of True Potato Seed, stemmed first in China around 60s and now a days the research on TPS is being conducted more than two dozen countries of the world including China, Sri Lanaka, Nepal, Rwanda, Egypt, Samoa, Philippines, India, Indonesia, Bangladhes, Thailand, Vietnam, Korea, Chile, etc. Research on TPS in about

34 countries is at experimental station level (Jackson, 1987). Preliminary work on TPS in Nepal was initiated in 1978 but several research works carried out after 1985 AD in this field (Ghimire et al., 2011). In Nepal potato cultivation through TPS is under practice at irrigated condition from plain to high hills. It is an alternative technology to generate planting material at low cost. The technology has advantage over conventional potato seed for minimum transmission of viruses and other pathogens. True Potato Seed has been found tolerant to most common Late blight (*Phytophthora infestans*) disease. Initial seed cost of this technique in seedling production is nominal. Transport and storage of TPS is generally easy and inexpensive. Management, size of land use and other inputs required for this technology are very low in comparison of economic return from seedling tubers. Longer growing season is one of the factors of low productivity in TPS families. Fruscionate et al. (1987) found large differences among the TPS families for yield, tuber uniformity and plant vigour. Martinetti (1987) advocated that TPS technology is the possible way of solving disease problem, storage, transport and high cost of production. Sinung-Basuki (1988) reported after evaluation of hybrid families that Atzimta DTO-28, Serana X DTO-28 and Atzimba X R–128.6 are good hybrid TPS families. Macaso et al. (1988) reported that TPS families are essential and can be utilized in commercial crop production after producing mini tubers. Nandekar et al. (1995) observed the highest number of tubers in DPS –25/13 and also found that growing potato through TPS is highly profitable in comparison to seed tubers. Malathy and Jayawardene (1999) released two hybrid TPS progenies (Atzimba X 260/398 and SE-II X 260/39B) named as Manike and Lakshemi, respectively in 1992 for general cultivation in Sri Lanka, having high yield and tolerant to late blight. Iqbal and Khan (2003) reported that there is great potential in TPS families and can successfully be adapted for commercial crop production after nursery raising.

In Nepal, potato production from TPS derived tuberlets is practically viable and highest tuber yield is also obtained from above 5 g sized seedling tubers as compared to TPS seedlings and clonal seed tubers of Desiree (Adhikari and Girish, 2004). Nepal has achieved remarkable success in the areas of TPS research, production and utilization. Of the total potato area, around 12 percent area is estimated to be covered by TPS and its derived planting materials in Nepal (NPDP, 2011). In Nepal, this technology is old but still tested on large scale. Presently TPS hybrid families have been evaluated at some research stations located in different parts of the country. Preliminary trials are being conducted to produce seedling tubers on nursery beds. Keeping in view the importance of TPS technology and to overcome the shortage of pathogen free seed production this study was conducted. The main objective of this study was to see the performance of seedling tubers (F_1C_1) of TPS families for commercial potato production and compare with well adopted commercial variety in western Terai (plain) and central hill condition of Nepal.

MATERIALS AND METHODS

During 2011/012- 2012/013 twelve TPS tuberlets (F_1C_1) from previous year's nursery bed trials namely C96H-02.7x TPS – 13, C96H-13.29x TPS – 13, C96H-02.4x C98HT-64.8, C96H-02.4x C99HT -2-32.17, C96H-02.4x C99HT-2-58.1, C98HT-200.14xC99HT-2-58.1, LT 8x TPS-13, LT 8 xTPS-67, MF II x TPS – 67, TPS 7 x TPS -

67, HPS II/67 and HPS 7/67 were kept in cold store. Twenty five days before planting, the tuberlets of 5-40 g size were taken out from the cold store and kept in diffused light for sprouting. The crop was planted at Hattiban Research Farm, Khumaltar, Lalitpur and Regional Agriculture Research Station, Nepalgunj, Banke. The basic seed tubers (25-50 g size) of Kufri Jyoti, Janak Dev, Lal Gulab, Kufri Sindhuri and Pericolli were planted as check for comparison. Planting distance for all the treatments was kept 60 cm between rows and 25 cm between plants. Pre-planting application of NPK was applied in lines at the rate of 100:100:60 kg/ha. The fertilizers were covered with well-decomposed FYM @ 20 t/ha. Treatments were laid down in randomized complete block designed with three replications. The experimental plot size was 3 m x 2.4 m (7.2 m^2). No any fungicide was sprayed. Irrigation was applied at 40 days, while earthling up was done at 50 days of planting. Other management practices were followed as per NPRP recommendation. Ground cover, plant uniformity (1-5 scale), number of stems per plant and plant height reading were taken at 75 days after planting (DAP) and late blight infection at 60 and 80 DAP. All the TPS families and check were dehaulmed at 100 days and harvested on June and February at Khumaltar and Nepalgunj, respectively. Total tuber number and tuber yield per plot in three grades (<25, 25-50 and >50 g) were recorded at harvest. The data was analyzed as suggested by GENSTAT package.

RESULTS AND DISCUSSION

Central hill: At Khumaltar, Lalitpur (2011/012), the emergence count was not significantly different among TPS tuber lets. Percent of ground coverage was highest (83.33) on both C96H-02.4 x C98HT-64.8 and MF II× TPS-67, but the lowest (71.67) was recorded in the family TPS 7 × TPS-67. The plant uniformity was good in most of the genotypes which was ranged from 4 to5 in 1-5 scale (Table 1).Maximum plant height (97.0 cm) was recorded in C96H-02.4x C99HT -2-32.17 and the lowest (67.80 cm) in check variety Kufri Jyoti. Ground coverage, plant uniformity, plant height and number of stems per plant differences among the families were statistically significant. All the TPS families were resistant/tolerance to late blight disease. Maximum number of tuber per plot (526.0) was recorded in Kufri jyoti followed by LT 8 x TPS-67 (460.0) and highest yield (26.83 kg/plot) were in check variety Kufri jyoti followed by LT 8 x TPS-13 (18.57 kg/plot) and C96H-13.29x TPS – 13 (16.60 kg/plot) . Family C98HT-200.14 x C99HT-2-58.1 produced the minimum tubers (212.0) and yields (9.10 kg/plot). Both tuber number and yield per plot were statistically significant. During 2012/013, results showed that the plant emergence count was highest (48) in TPS 7×TPS-67 and MFII×TPS-67 among TPS tuber lets. In overall observations, germination was good. Percent of ground coverage was highest (86.67) on check variety Kufri Jyoti followed by TPS family LT8×TPS-67(85), but the lowest (71.67) was recorded in the family C98HT-200.14×C99HT-2-58.1. The plant uniformity remained 3 to 4 (1-5 scale) in most of the tested genotypes. All the genotypes tested were found resistant to late blight disease in the testing site. Number of stems per plant and plant height among the families were statistically significant (Table 2). Tallest plants (73.53 cm) were measured in C96H-02.7×TPS-13 followed by C96H-02.4×C98HT-64.8 (71.73 cm) and shortest (42.13 cm) in check variety Kufri Jyoti. Tuber number and weight among the genotypes were highly significant. The tuber number per plot ranged from 238.7 to 581.0 (From Table 2). Maximum number of tuber per plot

(581.0) was recorded in genotype LT 8×TPS-67 followed by TPS 7 x TPS-67 (530.0), whereas minimum number of tuber (238.7) was measured in family C96H-02.4× C99HT-2-32.17. In contrast, the total weight per plot was highest (22.43 kg) in check variety Kufri jyoti followed by LT 8 x TPS-67 (19.57 kg) and C96H-13.29×TPS-13(18.43 kg/plot). Both number of tubers and yield per plot were highly significant among the genotypes.

Table 1. Plant and yield characters in TPS F_1C_1 generation of potato at Khumaltar, Hattiban (2011/12)

TPS Family	Emergence Count (30days)	Ground coverage %	Plant Uniformity (1-5)	Stem/plant (No.)	Plant height (cm)	Tuber no./plot	Tuber yield (kg) /plot
C96H-02.7x TPS	41.33	76.67	4.3	2.1	81.67	340	14.20
C96H-13.29x	41.67	75.00	4.3	2.5	86.13	322	16.60
C96H-02.4x	42.33	83.33	5.0	2.3	71.40	381	15.10
C96H-02.4x	42.67	75.00	4.0	2.3	97.00	272	11.83
C96H-02.4x	40.33	78.33	4.3	2.1	96.00	336	16.40
C98HT-	40.67	75.00	3.3	3.0	81.80	212	9.10
LT 8x TPS-13	42.00	81.67	5.0	2.5	93.13	454	18.57
LT 8 xTPS-67	38.67	76.67	4.7	2.5	74.73	460	14.90
MF II x TPS - 67	42.00	83.33	5.0	2.3	92.40	408	15.33
TPS 7 x TPS -67	43.00	71.67	3.3	3.0	78.40	406	11.57
HPS II/67	40.33	78.33	4.7	2.4	83.67	329	12.60
HPS 7/67	39.33	76.67	4.0	3.0	79.40	432	12.63
Janak Dev	42.00	81.67	4.0	3.5	74.33	321	15.73
Kufri Jyoti	42.67	73.33	4.0	3.0	67.80	526	26.83
F-test	ns	**	*	**	**	**	**
LSD(0.05)	4.189	5.315	0.9447	0.4104	8.978	118.3	5.675
CV %	6.0	4.1	13.1	9.5	6.5	19.0	22.4

Note: **,* Significant at 1% and 5% level, respectively. ns = Not significantly different

Mid Western Terai: At RARS, Nepalgunj (2011/012), more than 75 percent emergence count was recorded in different genotypes (Table 3).It was found statistically significant. Percent of ground coverage (80.0) was significantly highest on TPS 7 x TPS 67 followed by Lalgulab (76.7), but the lowest (53.3) was recorded in the familiy C96H 13.29 x TPS 13. Highest plant uniformity (4.0) was observed on LT 8 x TPS 13 and Lalgulab. Maximum number of stems per plant (2.4) was in LT 8 x TPS 67 and minimum (1.3) on C98HT 200.14 x C99HT 2-58.1. Plant height differences among the TPS families were statistically significant (Table 3). Plants of Lal Gulab were tallest (67.3 cm) followed by

LT 8 × TPS-13 (65.3 cm). The shortest (42.3 cm) was on HPS7/67. Variation in plant height may be due to growth behavior of TPS family.

Table 2 Plant and yield characters in TPS F_1C_1 generation of potato at Khumaltar, Hattiban (2012/13)

TPS Family	Emergence count (30days)	Ground coverage (%)	Plant Uniformity (1-5)	Stem/plant (No.)	Plant height (cm)	Tuber no./plot	Tuber yield (kg) /plot
C96H-02.7× TPS-13	46.33	78.33	3.3	2.9	73.53	309.7	11.73
C96H-13.29×TPS-13	47.00	80.00	4.0	3.1	63.40	424.7	18.43
C96H-02.4×C98HT-64.8	46.67	80.00	3.6	3.3	71.73	464.7	16.87
C96H-02.4× C99HT-2-32.17	47.00	75.00	3.0	2.9	66.87	238.7	10.37
C96H-02.4×C99HT-2-58.1	46.67	73.33	3.3	3.2	64.87	328.7	11.57
C98HT-200.14× C99HT-2-	47.00	71.67	3.3	3.6	57.53	357.3	10.30
LT 8×TPS-13	45.67	78.33	4.0	3.8	60.73	400.7	15.60
LT 8×TPS-67	47.00	85.00	4.0	4.5	56.67	581.0	19.57
MF II×TPS-67	48.00	78.33	3.3	4.8	57.20	441.3	16.40
TPS 7×TPS-67	48.00	81.67	3.6	4.6	50.00	530.0	15.37
HPS II/67	47.33	75.00	3.0	3.9	52.27	366.3	11.80
HPS 7/67	47.67	75.00	3.3	3.7	45.40	476.0	13.57
Janakdev	47.33	83.33	4.0	3.2	67.47	318.3	16.93
Kufri Jyoti	47.33	86.67	5.0	4.9	42.13	469.0	22.43
F-test	ns	*	ns	**	**	**	**
LSD(0.05)	2.120	6.554	1.151	0.8571	6.342	100.933	4.013
CV %	2.7	5.0	18.8	13.5	6.4	14.8	15.9

Note: **,* Significant at 1% and 5% level, respectively. ns= Not significantly different

The data revealed that late blight incidence in the scale 1-9 indicated that the crop raised through different families was lower which was ranged from 0.33 to 2.67 at 60 days after planting but, it was increased from 1.67 to 8 at 80 days after planting. Results showed that the check variety Lal Gulab was more susceptible to late blight disease than other TPS progenies. Maximum tubers number (811.0) and yield (15.50 kg /plot) was recorded in Lalgulab and C96H 02.4 x C99HT2-32.17 respectively, but family C98HT 200.14 x C99HT 2-58.1 produced minimum tubers (156.3) and yield (6.93 kg/plot). The tuber number and yield per plot were found highly significant among the families. During 2012/013, most of the genotypes showed plant emergence count below 40 at 30 days after planting (Table 4). The ground coverage (60%) was highest on C96H-02.4 x C99HT-2-32.17 followed by HPS 7/67 (58.3%).Plant uniformity (1-5 scale) was remained 2 in most of the families. Maximum number of stems per plant (5.4) was in both check variety Kufri Sindhuri and Pericolli.

Table 3. Plant and yield characters in TPS F_1C_1 generation of potato at Nepalgunj (2011/12)

TPS Family	Emergence count (30days)	Ground coverage (%)	Plant Uniformity (1-5)	Stem/ plant (No)	Plant height (cm)	LB (60days)	LB (80 days)	Tuber no./ plot	Tuber yield (kg) /plot)
TPS 7 x TPS 67	42.67	80.0	3.3	1.8	56.0	1.67	4.67	433.0	10.87
MF II× TPS 67	35.67	63.3	3.0	1.7	53.3	0.33	4.0	336.7	11.90
C96H 02.4 x C99HT 64.8	38.00	63.3	3.3	2.0	58.7	0.67	4.0	246.3	14.37
C96H 13.29 x TPS 13	33.67	53.3	2.7	1.7	47.3	1.67	6.67	265.0	9.87
C96H 02.4 x C99HT2-32.17	40.67	60.0	3.7	1.5	58.7	0.67	2.67	270.0	15.50
LT 8 x TPS 13	45.33	65.0	4.0	2.0	65.3	1.67	5.0	288.7	13.47
LT 8 x TPS 67	41.67	71.7	3.7	2.4	57.7	1.33	6.0	330.7	11.60
HPS II/67	41.67	73.3	3.3	2.0	52.3	1.33	5.67	334.3	12.50
C98HT 200.14 x C99HT 2-58.1	31.00	43.3	2.7	1.3	54.7	1.0	3.33	156.3	6.93
C96H 02.4 x C99HT 2-58.1	30.67	48.3	2.0	1.4	47.0	1.0	1.67	259.3	12.73
C96H 02.7 x TPS 13	38.67	58.3	3.3	2.1	54.7	0.33	2.67	320.7	14.63
HPS 7/67	37.00	73.3	3.3	1.7	42.3	1.33	6.33	448.0	12.00
Lal Gulab	46.00	76.7	4.0	2.3	67.3	2.67	8.0	811.0	12.73
F-test	*	**	*	*	**	**	**	**	**
LSD(0.05)	7.708	10.63	1.006	0.608	10.89	1.140	1.776	51.05	2.981
CV %	11.8	9.9	18.3	19.5	11.7	59.9	22.6	8.8	14.5

Note: **,* Significant at 1% and 5% level, respectively. ns = Not significantly different. LB =Late blight. Late blight incidence rating: 1= no symptoms, 2= up to 5% affected, 3= 5-15 % affected, 4= 15-35% affected, 5= 35-65% affected, 6= 65-85% affected, 7= 85-95% affected, 8=85-95%affected and 9= dead.

Plants of C96H-02.7×TPS-13 were tallest (50.4 cm) followed by C96H-02.4 x C99HT-2-32.17 (50.1 cm). The shortest (30.7 cm) plants were on TPS 7×TPS-67. Ground coverage, plant uniformity, number of stems per plant and plant height differences among the families were highly significant. Late blight incidence recorded in the scales indicated the disease build up in the TPS families was low at 60 days after planting (Table 4). The infection was ranged from 1.0 to 3.0 and 1.6 to 6.0 at 60 and 80 days after planting in 1-9 scale respectively. The check variety pericolli was found more susceptible (6) to late blight disease than other tested genotypes in field condition. Maximum number of tubers (476.0) and yield (20.0 kg /plot) was recorded in Kufri Sindhuri and Pericolli respectively, but family LT 8×TPS-13 produced minimum tubers (187.0).The tuber number and yield per plot were found statistically significant.

Table 4. Plant and yield characters in TPS F_1C_1 generation of potato at Nepalgunj (2012/13)

TPS Family	Emergence count (30days)	Ground coverage (%)	Plant Uniformity (1-5)	Stems/ plant (No)	Plant height (cm)	LB (60days)	LB (80dys)	Tuber no./ plot	Tuber yield (kg) /plot)
TPS 7×TPS67	47.0	45.0	2.0	2.3	30.7	1.0	2.6	324.3	14.57
MFII×TPS-67	36.7	41.6	2.0	2.2	31.3	1.33	2.6	266.0	11.37
C96H-02.4× C98HT-64.8	37.3	40.0	2.0	2.1	39.1	1.67	3.6	199.3	12.23
C96H-13.29× TPS-13	35.0	36.6	2.0	2.1	34.7	1.0	2.0	207.7	12.77
C96H-02.4× C99HT-2-	36.3	60.0	1.0	2.3	50.1	1.3	3.3	278.7	16.77
LT 8×TPS-13	30.0	38.3	2.0	2.2	38.3	1.33	3.0	187.0	11.50
LT 8×TPS-67	35.0	45.0	2.0	2.5	37.5	1.0	1.6	264.3	13.43
HPS II/67	37.7	41.6	1.3	2.0	33.2	1.67	2.3	264.3	12.43
C98HT-200.14× C99 HT-2-58.1	29.3	36.6	2.3	2.1	40.4	1.0	2.0	198.0	11.27
C96H-02.4×C99HT-	32.0	51.6	2.0	2.0	45.2	1.3	3.6	222.0	13.57
C96H-02.7× TPS-13	39.3	45.0	1.6	2.2	50.4	2.0	4.0	259.7	16.03
HPS 7/67	39.3	58.3	1.0	2.4	38.2	1.0	2.6	354.7	17.13
Kufri Sindhuri	45.7	48.3	1.6	5.4	38.4	1.3	2.3	476.0	18.40
Pericolli	46.0	40.0	3.3	5.4	48.5	3.0	6.0	386.3	20.00
F-test	ns	**	**	**	**	ns	**	**	**
LSD(0.05)	12.86	9.596	0.7037	0.8772	7.390	1.178	1.588	74.19	4.347
CV %	20.4	12.7	22.3	19.4	11.1	49.1	31.5	15.9	18.0

Note: **,* Significant at 1% and 5% level, respectively. ns = Not significantly different. LB= Late blight. Late blight incidence rating: 1= no symptoms, 2= up to 5% affected, 3= 5-15 % affected, 4= 15-35% affected, 5= 35-65% affected, 6=65-85% affected, 7= 85-95% affected, 8=85-95%affected and 9= dead.

CONCLUSION

TPS families LT 8 x TPS-13, LT 8 x TPS-67 and C96H-13.29×TPS-13 were found best at Khumaltar, Lalitpur (central mid hill). Families C96H 02.4 x C99HT2-32.17, C96H 02.7 x TPS 13 and HPS 7/67 were best at Nepalgunj (Mid western terai). Total tuber numbers and yield among the families were significantly different at all the locations. These TPS families were high yielder over other families and late blight disease build up was very low (resistant/ tolerance) as compared to check varieties in mid western terai condition, while all the TPS families were resistant/tolerance to late blight disease at central hill Khumaltar, Lalitpur. All selected TPS families are promising and being tested in farmer's field. However, check clone Kufri Jyoti produced higher tuber yield at central hill condition than TPS families, it might be due to well established, vigor and recommended cultivar of mid hill. While yield of Janakdev and Lalgulab is lower as compared to TPS lines. It is concluded from the study that cultivar Kufri Jyoti has higher tuber yield as compared to TPS lines in central hill Khumaltar and Pericolli produced slightly higher or equal tuber yield than TPS families in western terai condition. TPS families performed overall better performance and can be used as an alternate technology for potato production and through TPS technology disease free potato tubers can be produced on commercial basis.

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Replacement effects of soybean meal with different levels of sunflower meal with or without enzyme on performance of Cobb-500 broilers

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ABSTRACT

The experiment was carried out at Livestock Farm of Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan from 1st November, 2012 to 12th December, 2012. The aim of the study was to find out the replacement effects of soybean meal with different levels of sunflower meal with or without enzyme on growth, feed intake, feed efficiency, carcass characteristics and economics of Cobb-500 broilers. Three hundreds, day-old straight run Cobb-500 broiler chicks were brooded in an electric battery-brooder for a period of seven days, where pre-experimental diet was offered. On eighth day, chicks having uniform body weight were randomly allocated into five dietary treatments; T_1 (0% SFM), T_2 (25% SBM replacement with SFM without enzyme), T_3 (25% SBM replacement with SFM + enzyme), T_4 (35% SBM replacement with SFM without enzyme) and T_5 (35% SBM replacement with SFM + enzyme); with four replications (15 chicks in each). The diets were made isoproteinous and isocaloric. Starter and finisher diets were fed from 2-4 weeks and 5-6 weeks respectively. The chicks were offered ad libitum treatment diets and clean drinking water. The desired data were recorded weekly, which included live weight, weight gain, feed consumption, and feed efficiency of broiler birds. The obtained data were subjected to statistical analysis under completely randomized design as per the methods of MSTAT. Weekly feed consumption of the bird (g bird^{-1}) was found statistically similar ($P>0.05$) for all weeks of experiment (0-6 weeks). Total feed consumption (g bird^{-1}) was also found statistically similar ($P>0.05$). The results of weekly body weight gain were found statistically similar ($P>0.05$) for first and second weeks of experiment. But, weekly body weight gain was found significantly different ($P<0.05$) in third, fourth, fifth and sixth weeks. In third week highest weekly body weight gain was found in T_1 and the lowest in T_4. Similarly, in fourth week, highest weekly body weight gain was found in T_5 and the lowest in T_4. In fifth week, highest weekly body weight gain was found in T_5 and the lowest in T_4. In the same context, weekly body weight gain in sixth week was found highest in T_2 and lowest in T_1. The results showed significantly highest ($P<0.01$) final live weight in T_5 which was followed by T_3, T_1, T_2 and the lowest weight was found in T_4 .Dressing percent, giblet weight and other carcass characteristics were also found statistically similar ($P>0.05$). The gross expenditure bird^{-1} was increased with the higher level of soybean meal. However, income bird^{-1} increased with the lower level of soybean meal with enzyme supplementation. It is therefore, concluded that up to 35% soybean meal can be replaced with SFM with enzyme (Microzyme) in broiler starter and finisher diets without adverse effect on growth performance of Cobb-500 broilers.

Keywords: Feeding, growth, carcass characteristics, electric battery brooder, live weight,

INTRODUCTION

Poultry keeping has been an important source of income to many households of Nepal. There is growing awareness of nutritive value of meat and eggs among people. Poultry products (meat and egg) are a good source of protein with high biological value. Therefore, poultry keeping is becoming an important business enterprise in both urban and rural areas of Nepal (Bhurtel and Shah, 2002). Chicken contributes about 6.5% of total meat production in the country and 98 percent of the total egg production (MoAC, 2008/09).

Soybean meal is a fundamental and most commonly used protein feed of broilers diet. It contains 40-48 percent of crude protein (Ravindran and Blair, 1992; Adhikari, 2008; Khanal, 2009). It is particularly rich in lysine. The amino acid availability in soybean meal is also higher than those for other oil seeds meals (Acherne and Kennelly, 1982). However, the soybean meal is most suitable protein source in poultry diets. The availability of soybean meal for animal feed used in Asia is low (APO, 1990). Moreover, absolute amount of the soybean meal utilized by the Nepalese feed industry is imported from other countries, especially from India (Lohani and Amatya, 2000). Furthermore, soybean meal used as protein source for feeding animals and birds cost high price in the international markets, and also directly competes for human food (Gifford, 1971). The productivity of soybean in the tropical climate i.e. Asia is low due to lack of suitable high yielding cultivars and sub-standard agronomic practices. Besides, soybean also contains several anti-nutritional factors including protease inhibitors, a goitrogenic factor, and an estrogenic compound (Liener, 1980). Sunflower meal is also a good source protein source for poultry, provided that some of its nutritional characteristics are taken into account (Senkoylu and Dale, 1999). Sunflower meal contains 32 percent crude protein, 1-2 percent fat, 21-29 percent fiber, 6 percent ash, 1.14 percent lysine, 2.46 percent arginine, 0.55 percent cystine, 1.75 percent valine, 1.38 percent isoleucine, 0.68 percent methionine, 0.35 percent threonine and 1.13 percent tryptophan (NSA, 2008). It is easily available feed ingredients and good source of protein and B-group vitamins (NSA, 2008).

Many commercial enzymes are being used to accelerate the growth of broiler chickens fed on maize-soybean based diets (Wyatt *et al.,* 1997; Zenella *et al.,* 1999; Saleh *et al.,* 2003; 2004; Karki, 2007; Adhikari, 2008). Microzyme one of the commonly used commercial enzymes, which contents several enzymes, viz *Lactobacillus acidophilus, Saccharomyces cervisiae,* amylase, protease, lipase, cellulase, phytase, β-glucanase, pectinase and xylanase. The effect of enzyme supplementation on the performance of broiler fed diets improves weight gain, feed efficiency, carcass yield and reduces the per unit production cost (Sapkota and Ranjan, 1994; Adam, 2000; Karki, 2007, Adhikari, 2008). Feed cost is the major contributing factor of the poultry enterprises. High feed cost and lesser availability of conventional ingredients necessitates the continuous and intensive efforts to seek alternate agro-industrial by products which can replace soybean at cheaper rate without reducing its performance. Taking into consideration of aforementioned problems, an experiment was designed to find out the effect of sunflower meal substituted for soybean meal with or without enzyme on the performance of broiler chicken.

MATERIALS AND METHODS

This study was carried out at Livestock Farm of Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan from 1st November, 2012 to 12th December, 2012. The objective of the study was to find out the replacement effects of soybean meal with different levels of sunflower meal with or without enzyme on growth, feed intake, feed efficiency, carcass characteristics and economics of Cobb-500 broilers.

Experimental design

A total of three hundreds broiler chicks were used for experiment. Day old chicks were group brooded using an electric battery brooder for 7 days, and were fed on pre-experimental standard starter ration before the actual experiment began. Eight-day-old chicks were allocated randomly to five different treatments with four replications (15 chicks in each). The experiment was designed in a completely randomized design (CRD).

Experimental diet and shed management

Broilers were fed isoproteinous and isocaloric starter and finisher diets. The dietary treatments were T_1 (0% SFM), T_2 (25% SBM replacement with SFM without enzyme), T_3 (25% SBM replacement with SFM + enzyme), T_4 (35% SBM replacement with SFM without enzyme) and T_5 (35% SBM replacement with SFM + enzyme). The experimental birds were fed (*ad-libitum*) an experimental ration according to their treatment.

The broilers were raised up to 6th week of age. The experimental birds were kept on a deep litter system in separate pens. The pens were thoroughly cleaned, white washed and disinfected before putting the experimental chicks. All the birds were provided similar management conditions like floor space, temperature, relative humidity, ventilation and light. The birds were vaccinated according to broilers vaccination schedule.

Observation measurement

The data of weekly average body weight, weight gain and feed consumption were recorded and utilized to calculate feed efficiency for first to sixth week of broiler's age. Feed cost of different experimental diets was calculated. At the end of six weeks of experimental period, one bird from each replication was slaughtered. The weight of each carcass was recorded and dressing percentage was calculated on the basis of dressed meat. After evisceration, the heart, liver and gizzard of the slaughtered birds were taken out and weighed for their absolute weight. The data thus obtained were used for the calculation of: (a) dressing percentage (Dress weight of bird/Live weight of bird)×100); and (b) relative weight of heart, liver and gizzard. After evisceration, relative weights (g) [(weight of organ/live body weight) x 100] of various internal organs such as liver, heart, gizzard of the slaughtered bird were recorded.

Data analysis

The data collected regarding weight gain, feed consumption, feed conversion ratio, dressing percentage and relative weights of heart, gizzard and liver were subjected to the analysis of variance (ANOVA) technique in completely randomized design. The differences in the treatment means were compared by the Duncan's Multiple Range Tests using computer program MSTAT-C basic version 1.3 (1975).

RESULTS AND DISCUSSION

Weekly feed intake

The data revealed that the weekly feed intake and total feed intake of the bird (g $bird^{-1}$) was found statistically similar (P>0.05) on first week of experiment. Similar trend was observed in the second, third, fourth, fifth and sixth weeks (Table 1).

Table 1. Response of Cobb 500 broilers fed different levels of sunflower meal (SFM) with or without enzyme on weekly feed intake (g $bird^{-1}week^{-1}$) in different weeks

Treatments	Period (week) and feed intake (g)						Total Feed intake (g)	FCR
	1	2	3	4	5	6		
T_1 = 0% SBM replacement without enzyme	133.45	280.00	479.11	758.34	993.29	1301.10	3945.29	1.84
T_2 = 25% SBM replacement without enzyme	128.93	283.50	491.46	780.07	995.58	1299.40	3978.94	1.79
T_3 = 25% SBM replacement with enzyme	126.67	283.50	501.40	792.28	994.23	1271.98	3970.06	1.79
T_4= 35% SBM replacement without enzyme	136.06	278.00	495.83	778.08	989.59	1294.70	3972.26	1.85
T_5 = 35% SBM replacement with enzyme	128.93	278.25	496.47	801.58	996.82	1297.82	3999.87	1.76
P	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns
CV %	3.82	2.27	7.59	4.48	0.40	2.00	10.21	3.63
LSD	-	-	-	-	-	-	-	
SEm±	1.27	1.38	2.25	7.73	0.96	5.68	3.01	0.13

SBM: Soybean meal, SFM: Sunflower meal, LSD=least significance difference at 5%, CV=coefficient of variation, WOE=without enzyme, E=enzyme, SEm± = standard error of mean

The feed intake slightly increased in second, third and fourth weeks of experiment, however, it tremendously increased in fifth and sixth weeks. It might be due to higher body weight gain in the later weeks. The data did not show any difference (P>0.05) among the feed conversion ratio of the birds of different treatment groups. Pinheiro *et al.* (2002) did not observe any effect on feed intake with or no SFM diets. Sah (2002) also reported that substituting SBM with SFM did not alter the feed consumption significantly. The result is in agreement with Morris (1968) and Vieira *et al.* (1992) who found that over-consumption of energy in SFM rations could indicate another nutrient was deficient. Similarly, the enzyme did not alter the feed intake of the birds in each week. Testing of different microbial enzymes in another study (EI-Sherif *et al.*, 1997), however, did not indicate any difference between the treatments and the control diet to which no enzyme was added.

Weekly body weight

The results of weekly body weight gain were found statistically similar (P>0.05) for first and second weeks of experiment. Almost similar body weight gain was observed in each treatment. But, weekly body weight gain was found significantly different (P<0.05) in third week. The highest body weight gain was found in T_1 (416.26 g) followed by T_3 (416.11 g), T_5 (409.67 g), T_2 (372.85 g) and the lowest body weight was found in T_4 (343.54 g). Similarly, weekly body weight gain was found significantly different (P<0.01) in fourth week. The highest body weight was found in T_5 (514.37 g) followed by T_1 (473.42 g), T_3 (428.25 g), T_2 (415.65 g) and the lowest body weight was found in T_4 (346.05 g). Similarly, weekly body weight gain was also found significantly different (P<0.01) in fifth week. The highest body weight was found in T_5 (695.97 g) followed by T_3 (584.17 g), T_2 (571.19 g), T_1 (530.97 g) and the lowest body weight was found in T_4 (508.08 g). In the same context, weekly body weight gain was found significantly different (P<0.01) in sixth week of experiment. The highest and the lowest body weight were found in T_2 (402.27 g) and T_1 (361.39 g) respectively. The weight gain for other treatments were found almost similar i.e. T_3 (377.67 g), T_4 (375.04 g), T_5 (372.50 g). Similarly, significantly (P<0.01) highest final live weight (2196.00g) was found in T_5 which was followed by T_3 (2176.00 g), T_1 (2170.25 g), T_2 (2139.20 g) and the lowest weight was found in T_4 (2134.29 g).

Analysis of variance (ANOVA) showed that the body weight gain of the birds at lower level of replacement without enzyme had yielded higher body weight gain than higher level of replacement in almost every week (0-35% SBM replacement levels). But the body weight gain was found higher body weight gain in treatments having diet supplemented with enzyme. This might be due to digestion of non-starch polysaccharides (NSPs) by the addition of enzyme.

The findings were supported by Rajesh *et al*. (2006), Connel (1981), Adhikari (2008) and Khanal (2009). Performance of broilers can be affected on SFM diets at higher levels due to abundant quantities of NSP's like cellulose, hemicelluloses, pectins, β-glucans, arabinoxylans and β-galactosides (Rajest *et al.,* 2006). High levels of fiber also reduce the time of food passage throughout the digestive system (Connel, 1981). Adhikari (2008)

and Khanal (2009) reported that enzyme increases the digestion of NSP's so significantly improve the weight gain (P<0.01).

Table 2. Response of Cobb 500 broilers fed different levels of sunflower meal (SFM) with or without enzyme on weekly body weight gain (g bird^{-1}week^{-1}) in different weeks

Treatments	Period (Week) and body weight gain (g)						Final live weight (g)
	1	2	3	4	5	6	
T1 = 0% SBM replacement WOE	104.59	241.62	416.26a	473.42ab	530.97bc	361.39b	2170.25ab
T2 = 25% SBM replacement WOE	101.99	235.00	372.85ab	415.65b	571.19bc	402.27a	2139.20bc
T3 = 25% SBM replacement with E	92.46	235.86	416.11a	428.25b	584.17b	377.67ab	2176.00a
T4= 35% SBM replacement WOE	89.67	267.09	343.54b	346.05c	508.08c	375.04ab	2134.29c
T5 = 35% SBM replacement with E	97.75	232.82	409.67a	514.37a	695.97a	372.50ab	2196.00a
P	Ns	Ns	0.0240*	0.0007**	0.0003**	0.000**	0.005 **
CV	11.97	11.32	8.43	9.72	7.72	1.23	1.00
LSD	-	-	49.76	63.83	67.29	467.74	32.60
SEm±	2.65	6.18	9.34	15.50	17.34	7.51	6.85

Mean in column with different superscripts differ significantly by LSD (P<0.05). SBM: Soybean meal, SFM: Sunflower meal, LSD=least significance difference at 5%, CV=coefficient of variation, WOE=without enzyme, E=enzyme, * = Significant at 0.05 level of significance, ** = Significant at 0.01 level of significance; SEm± = standard error of mean

Carcass characteristics

Statistical analysis of the data did not show any difference (P>0.05) between the dressing percentages of the birds of different treatment groups (Table 3). The relative weight of gizzard, liver, heart and giblet were also found statistically similar (P>0.05) for all the treatment groups (Table 3).

Almost similar result was obtained by Wagan (2001), Sah (2002), Adhikari (2008) and Khanal (2009) who reported a non-significant effect on broiler dressing percentage, relative weight of giblet (heart, liver and empty gizzard) due to inclusion of different levels of sunflower meal with or without enzyme in broiler diet.

Table 3. The mean dressing percentage, relative weight of giblet (gizzard, liver and heart) of Cobb-500 broilers fed different levels of SFM with or without enzyme from 1 to 6 weeks of age

Treatments	Dressed %	Gizzard Weight%	Liver weight%	Heart weight%	Giblet weight%
T1 = 0% SBM replacement with SFM without enzyme	77.51	2.17	2.49	0.81	5.47
T2 = 25% SBM replacement with SFM without enzyme	75.23	2.27	2.07	0.64	4.98
T3 = 25% SBM replacement with SFM + enzyme	77.53	2.13	2.60	0.82	5.55
T4= 35% SBM replacement with SFM without enzyme	76.55	2.44	2.35	0.71	5.50
T5 = 35% SBM replacement with SFM + enzyme	76.91	2.68	2.35	0.73	5.76
P	Ns	Ns	Ns	Ns	Ns
CV %	4.15	14.61	12.90	12.89	10.98
LSD	-	-	-	-	-
SEm±	0.81	0.08	0.07	0.02	0.09

Mean in column with different superscripts differ significantly by LSD (P<0.05). SBM: Soybean meal, SFM: Sunflower meal, LSD=least significance difference at 5%, CV=coefficient of variation, WOE=without enzyme, E=enzyme, * = Significant at 0.05 level of significance; SEm± = standard error of mean

Benefit cost (B: C) ratio

The benefit cost ratio is presented in Table 4. The gross expenditure bird^{-1} had increased with the higher level of soybean meal. It was found highest in T_1 (0% SBM replacement with SFM without enzyme; NRs 235.82) followed by T_5 (NRs 235.72), T_3 (NRs 234.62), T_2 (NRs 233.94), and the lowest B:C was in T_4 (NRs 233.74) per bird. And income bird^{-1} increased with the lower level of soybean meal with enzyme supplementation. Highest income NRs 332.70 was obtained from T_5 (35% SBM replacement with SFM + enzyme) followed by T_3 (NRs 329.80), T_1 (NRs 328.80), T_2 (NRs 324.15) and the lowest income was obtained from T_4 (NRs 323.40). Likewise, the net surplus and change in surplus due to feed change were also found highest in T_5 (35% SBM replacement with SFM + enzyme; NRs 96.98 and +4) and followed by T_3 (NRs 95.18 and +2.2), T_2 (NRs 90.21 and -2.77) and the lowest was found in T_4 (NRs 89.66 and -3.32). Similarly, the benefit cost ratio (B: C) was observed highest in T_5 (1.41) and followed by T_3 (1.40), T_1 (1.39), T_2 (1.39). And the lowest B: C was observed in T_4 (1.38).

Rajesh *et al.* (2006) reported that replacement of soybean meal by SFM at 0 percent. 33 percent, 66 percent and 100 percent with or without enzyme had shown the cost of production per kg live weight over feed cost of 19.57, 18.59, 18.63, 18.02, 19.14, 18.44, 19.13 and 19.07 (in Indian Rupees) which was significantly different (P<0.05). The author further reported that inclusion of SFM with 33 percent and 66 percent soybean replacement with enzymes decreased the cost of production significantly (P<0.05) by 8 percent and 5.7 percent, respectively.

Table 4. Mean benefit cost (B: C) ratio of Cobb-500 broilers fed different levels of sunflower meal with or without enzyme from 1-6 weeks of age

Treatments	Gross expenditure (Rs)	Gross income (Rs)	Net surplus (Rs)	Net surplus over basal ration(Rs.)	Benefit cost (B:C) ratio
T_1 = 0% SBM replacement WOE	235.82	328.80	92.98	0.00	1.39
T_2 = 25% SBM replacement WOE	233.94	324.15	90.21	-2.77	1.39
T_3 = 25% SBM replacement with E	234.62	329.80	95.18	+2.20	1.40
T_4= 35% SBM replacement WOE	233.74	32380	89.66	-3.32	1.38
T_5 = 35% SBM replacement with E	235.72	332.70	96.98	4.00	1.41

Note: Gross expenditure includes cost of feed, chicks, vaccines, litter material, disinfectants, labor cost, water, electricity, vehicle and medicine.

CONCLUSION

The results from the experiment concluded that up to 35 percent soybean meal can be replaced with sunflower meal (SFM) with enzyme (Microzyme) in broiler starter and finisher diets without adverse effect on growth performance of Cobb-500 broilers.

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Effects of tillage and planting geometry on the performance of maize hybrids

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ABSTRACT

An experiment was conducted during the spring season of 2013 at Rampur, Chitwan. The experiment was laid-out in a strip plot design with three replications having 12 treatments, and consisted of two tillage treatments: no tillage and conventional, two genotypes: Rampur Hybrid-2 and RML-32/RML-17, and three planting geometries: D1=75 X 25cm, D2=70 X 25cm and D3= 60 X 25cm. between rows and between plants, respectively. Higher NDVI values of 0.747 were recorded in NT over the CT with 0.657. Rampur hybrid-2 had the lowest value of NDVI with 0.747 and the highest was found in RML-32/RML-17 with 0.757. CT had the highest plant height of 167.88 cm as against 167.17 cm in NT. Similarly, the highest plant height of 169.91cm was recorded in RML-32/RML-17 over 165.14 cm in Rampur hybrid-2. The highest number of cobs (73,177 ha^{-1}) was recorded at G3. A higher number of 27.3 kernels per row in NT was recorded over the 25.8 in CT. RML-32/RML-17 produced the highest test weight of 363.94g over the Rampur hybrid-2 with 362.17g. Significantly higher grain yield of 9.24 Mg ha^{-1} in planting geometry of D3. The experiments need to be further tested with higher plant population densities in Nepalese hybrids.

Key words: *Zea mays* L., plant height, kernels, cobs, test weight, yield

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops grown during the summer season in Nepal. It is the second most important staple crops after rice both in terms of area and production. Its area, production and productivity in Nepal is 849635 ha 1999010 Mg and 2353 Mg ha^{-1} (MOAD, 2013), respectively. It contributes 3.15% to national GDP and 9.5% to agricultural GDP (MOAD, 2013). Maize occupies about 40.6% area of the total food crops in the hills and 26.05% in the country. It shares about 25.69% of total edible food production in Nepal (NMRP, 2011). Despite the many efforts made, the productivity of maize is almost stagnant or slightly decreasing (MOAD, 2012 and MOAD, 2013). The overall demand for maize driven by increased demand for human consumption and livestock feed is expected to grow by 4% to 6 % per year over the next 20 years (Paudyal *et al*., 2001). Thus, Nepal will have to resort to maize imports in the future if productivity is not increased substantially.Harvesting extremely low cobs due to lower plant stand per unit area is the major causes of poor yield of maize in Nepal. Very recently one maize hybrid Rampur Hybrid-2 has been released for general cultivation and another RML-32/RML-17 is under consideration for release in Nepal. Maize hybrids differ in their response to plant density (Xue *et al*., 2002). As maize does not have

tillering capacity to adjust to variation in plant stand, optimum plant population for grain production is important. Agronomic practices such as plant population are known to effect crop environment, which influences yield and yield components. Optimum population levels should be maintained to exploit maximum natural resources such as nutrient, sunlight, soil moisture and to ensure satisfactory yield. Many studies have been conducted with the aim of determining the optimum plant density for maize within and outside the country. Unfortunately, there is no single robust recommendation, because the optimum plant density varies depending on environmental factors such as crop establishment methods i.e. tillage, soil fertility, moisture supply, genotype (Gonzalo *et al*., 2006), planting date, planting pattern, plant population and harvest time. The differential response to plant density in maize cultivars has been reported by Xu *et al*. (2002).

Nepal has developed some promising hybrids for the Terai and foot hills and it is necessary to test, verify and promote them under no till condition, since conservation agriculture has been emerging as the inevitable technology to save labor cost, conserve moisture and increase yields thereby sustaining productivity. The aim of this study is to determine the effects of crop establishment methods in combination with differential plant densities on yield and yield components of maize hybrids in Nepal.

MATERIALS AND METHODS

Experimental site

A field experiment was conducted during spring season (February to June) of 2013 in National Maize Research Program (NMRP) farm, Rampur, Chitwan, Nepal. The experimental site is 10 km far in South-West direction from headquarter of Chitwan district, Bharatpur. It is located at 270 37'North latitude and 840 25' East longitudes with an elevation of 256 meter above mean sea level. Experimental soil was sandy- loam in texture with 2.47% of organic matter, 0.13% of total nitrogen, 51.0 and 109.5 kg ha^{-1} respectively of available phosphorus and potassium.

The experimental site falls under the subtropical humid climate belt of Nepal which is characterized by three different seasons that prevail in the experimental site: cool winter (November to February), hot spring (March to May), and distinct rainy monsoon season (June to October).The maximum temperature during crop period (spring season) was 36.32°C. The minimum temperature was 5.87°C. The crop received a total of 1064.4 mm of rainfall and the highest rainfall of 624.8 mm was received in June and the highest of 72.4 mm per day was received on 20th of May.

Experimental setup

The experimental was planted during winter season of 2013 and the field was laid out in strip plot design with three replications and 12 treatments. Maize crop was planted on 12th of February, 2013 and harvested on 27th of June, 2013. The vertical factor was tillage with no tillage (NT) and conventional tillage (CT) and the horizontal factor were genotypes (Rampur Hybrid-2 and RML-32/RML-17) and in split planting geometries

(75cm X 25cm =53,333 plants ha^{-1}, 70cm X 25cm=57,142 plants ha^{-1} and 60cm X 25cm= 66,666 plants ha^{-1}). The individual plot size was having 7 rows of 5 meter long as prescribed by the treatments. The three central rows were used as net plot rows for biometric and agronomical data recording and the remaining 2 rows leaving the two border rows at either side were used for biometrical and phenological observations.

The crop was fertilized with 120:60:40 kg NPK ha^{-1}. Fifty % of the N along with full P and K was applied during seeding and remaining N was splitted into 2 and first half was applied at V7 stage and and the remaining N at pre-tasseling stageof maize. Rest of the crop management operations were done as per the treatment. Weather parameters were recorded from the NMRP's meteorological station. Soil texture, bulk density, organic matter content, pH, N, P and K were analyzed using the prescribed laboratory procedures.

Plant height and normalized difference vegetation index (NDVI) was measured at pre-tasseling stage of the crop for each treatment. An active hand-held sensor NTech's GreenSeeker™ was used for this study to determine NDVI using the equation 1 below:

(1) NDVI = (Near Infrared Band Reflectance – Red)/ (Near Infrared Band Reflectance + Red)

GreenSeeker® calculates NDVI using red and NIR light. Red light is absorbed by plant chlorophyll as an energy source during photosynthesis. Therefore, healthy plants absorb more red light and reflect larger amounts of NIR than those that are unhealthy. NDVI is an excellent indicator of biomass (amount of living plant tissue), and is used in conjunction with growing degree days greater than zero (GDD>0) or days from planting to accurately project yield potential.

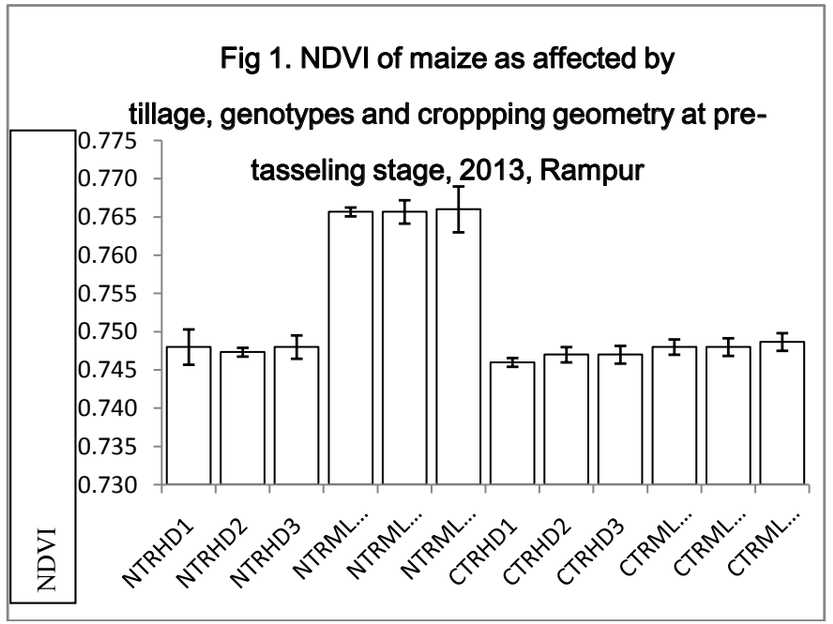
No of cobs ha-1, no of kernel rows cob-1, no of kernels rows -1, test weight (g) and grain yield (Mg ha^{-1}) were measured. The collected data was processed by MS Excel and analyzed by using ANOVA method of strip-split plot design.

RESULTS AND DISCUSSION

Normalized Difference Vegetation Index (NDVI) of maize

NDVI shows the vigor and healthiness of the plant. It varied significantly due to tillage and genotypes however did not due to planting geometry. Significantly higher value of NDVI (0.747) was recorded in NT as against the (0.657) in CT. It might be due to the availability of plant nutrients especially N fertilizers applied near to planting rows during spring season, since the N leaching during this season is less likely to occur due to low rainfall as compared to summer. Rampur hybrid-2 had the lowest value of NDVI with 0.747 and the highest was found in RML-32/RML-17 with 0.757. Similarly, interaction effect of tillage and genotype was also found and RML-32/RML-17 outperformed over Rampur Hybrid-2 in either of the tillage methods (Fig 1). Regression analysis (Fig 3)

revealed that the contribution of NDVI for grain yield was 98.6 %, indicating one of the best in-season yield predicting parameters in maize (Karki, 2013).

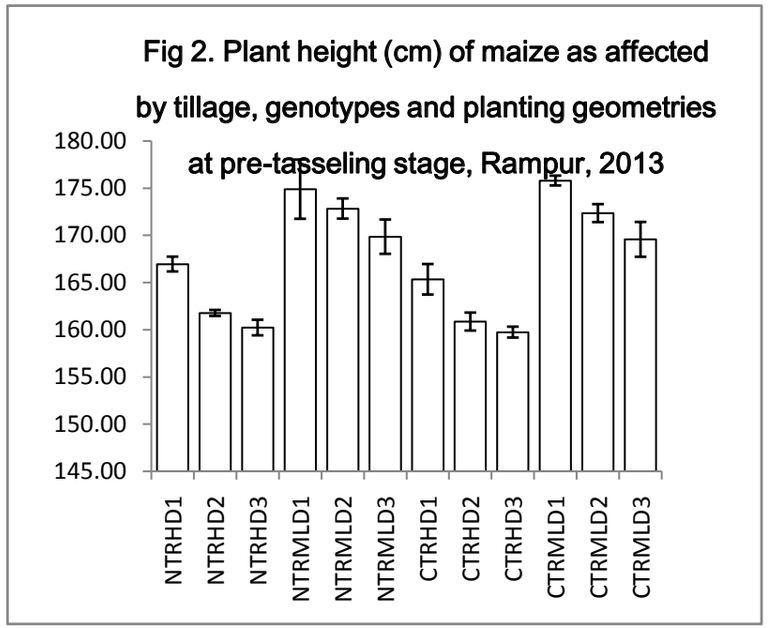


Note:NT: No tillage, CT: Conventional tillage, RH: Rampur Hybrid -2, RML: RML-32/RML-17, D1: 60x25cm, D2: 70x25cm and D3:75x25cm. ANOVA revealed the significant effect of tillage, genotype, tillage x spacing and tillage x genotype x spacing on plant height of maize.

Plant height of maize

Significant effects of tillage, genotype, tillage x spacing and tillage x genotype x spacing on plant height of maize was observed. Conventional tillage had the highest plant height of 167.88 cm as against 167.17 cm in NT. Similarly, the highest plant height of 169.91cm was recorded in RML-32/RML-17 over 165.14 cm in Rampur hybrid-2. Plant population densities did not affect the plant height of maize; however the height was increased with increasing densities. It was also affected by tillage x plant spacing and tillage x genotype x spacing and was higher in CT with higher plant densities and CT with RML-32/RML-17 having higher plant densities (Fig 2). NDVI and plant height of maize at pre-tasseling stage was positively correlated (R^2=0.21). Similarly, the plant height also affected the grain yield of maize (R^2=0.23).The trend line shows the increment of NDVI with increase in plant height (Figure 3a and 3b). Plant density significantly increased the plant height in maize hybrids. Data regarding the effect of maize hybrids and plant density on plant height are given in Table 2. In general, the maximum plant height (205.96 cm) was obtained with the highest plant density (12 plants m-2), while the least value (193.8) was

recorded at the lowest plant density (8 plants m-2). Similar results have been reported by Zhang *et al.* (2006) and Mobasser *et al.* (2007).



Note: NT: No tillage, CT: Conventional tillage, RH: Rampur Hybrid -2, RML: RML-32/RML-17, D1: 60x25cm, D2: 70x25cm and D3:75x25cm. ANOVA revealed the significant effect of tillage, genotype and tillage x genotype on NDVI of maize.

Crop maturity

Crop duration was affected significantly by tillage, genotypes and planting geometry. Irrespective of genotypes and planting geometry, crop from NT matured earlier at 130.72days than CT at 133.83 days. Similar was the findings of Araus *et al*. (2008). As far as genotypes are concerned, Rampur hybrid-2 took 131.78 days, whereas RML-32/RML-17 took 132.78 days. Wider spaced crop matured earlier than the closed spaced and the crop planted at planting geometry of 75cm between rows (RR) and 25cm between plants (PP) matured earlier at 130.83 days followed by RR of 70cm and PP of 25cm with 132.42 days. The longest duration of 133.58 days was recorded in RR of 60 cm and PP of 25cm (Table 1). Similar results were found by Amanullah *et al*. (2009) and reported that physiological maturity was delayed in those plots maintained at higher plant density. This suggests that dense planting might have slightly slowed down the rate of plant development because of more competition in dense population (Hamidand Nasab, 2001).

Number of cobs ha^{-1}

Number of cobs per hectare was influenced by tillage, and a significantly higher number of cobs (64962 ha^{-1}) were recorded in NT compared to 62120 ha^{-1} in CT. Similarly, cobs per hectare was also influenced by planting geometry and a higher number cobs were (64942 ha^{-1}) recorded at the planting geometry of 60cm between rows and 25cm between plants and the lowest of 62077 ha^{-1} in planting geometry of 75 cm between rows and 25cm between plants and was statistically at par with (63603 ha^{-1}) in the planting geometry of 70cm between rows and 25cm between plants (Table 1). There was a positive correlation of number of cobs and grain yields with R^2 value of 56.3% (Fig 4).

Number of kernel rows cob^{-1}

Number of kernel rows cob^{-1} did not vary due to tillage, genotypes and planting geometry. Both the methods of tillage (NT and CT) produced the similar number of kernel rows in a cob. It might be due to the similar availability of soil moisture, nutrients and solar radiation for photosynthesis. However, the rows were more in conventionally tilled plot and planting geometry of 75cm between rows and 25cm between plants. The two hybrids Rampur Hybrid-2 and RML-32/RML-17 were having the same number of kernel rows in a cob (Table 1).

Number of kernels row^{-1}

Difference due to genotypic and planting geometry was not evident for the number of kernels rows -1. However, significantly the highest number of kernels per row was recorded at the planting geometry of 60cm between rows and 25cm between plants. Tillage methods affected it and were higher of 27.3 rows in NT as against the 25.8 in CT (Table 1). Similar findings were also reported by Sornpoon and Jayasuriya (2013), where they did not found any difference in number of kernels per row of maize.

Test weight (g)

Except genotypic difference, no difference was observed due to tillage and planting geometry on the test weight (1000 grains weight) of maize kernels.. RML-32/RML-17 produced the highest test weight of 363.94g over the Rampur hybrid-2 with 362.17g. However, NT had higher test weight to CT. Similarly, slightly a higher test weight was observed in wider spaced planting than closely spaced.

Grain yield (Mg ha^{-1})

Like the other parameters, grain yield of maize was not significantly affected by tillage. Genotypic differences among both the released hybrid (Rampur Hybrid-2) and pre-released hybrid (RML-32/RML-17) were not observed during the spring season at Rampur. Since, similar grain yields were harvested from NT and CT, NT saved significant costs in production. Small holder farmers in Indonesia are realizing 25 percent savings in labour, 65 percent savings in land preparation costs, 28 percent savings in

irrigation water per cropping cycle and 2-3 weeks time saving for land preparation due adoption of conservation tillage (FAO, 2012).Change in microenvironment of soil is generally adjusted in NT by its overall strength and Iqbal *et al.* (2013) reported that on average, the NT had 63% higher soil strength than CT.

Table 1. Grain yield and related parameters of two hybrids Rampur Hybrid-2 and RML-32/RML-17 under various tillage methods and planting geometries in Rampur, during winter, 2013

Treatments	No of cobs ha^{-1}	No of kernel rows cob^{-1}	No of kernels $rows^{-1}$	Test weight (g)	Grain yield (Kg ha^{-1})	Maturity days
Tillage						
Conventional tillage	62120	14	25.8	362.5	8.35	133.83
No tillage	64962	13.7	27.3	363.61	8.36	130.72
F-test	*	NS	*	NS	NS	**
$LSD_{0.05}$	1831.1	-	1.06	-	-	0.48
Genotype						
Rampur Hybrid-2	64205	13.8	26.4	362.17	8.32	131.78
RML-32/RML-17	62876	13.8	26.7	363.94	8.39	132.78
F-test	NS	NS	NS	*	NS	**
$LSD_{0.05}$	-	-	-	1.61	-	0.48
Planting geometry						
60X25 cm^2	64942	13.8	26.1	362.5	9.24	133.58
70X25 cm^2	63603	13.8	26.5	363.08	7.95	132.42
75X25 cm^2	62077	14.6	27.1	363.58	7.88	130.83
F-test	*	NS	NS	NS	**	**
$LSD_{0.05}$	2242.7	-	-	-	0.72	0.59
CV,%	4.2	3.2	5.8	3.6	8.3	2.5
Grand mean	63541	13.9	26.6	363.06	10.36	132.28

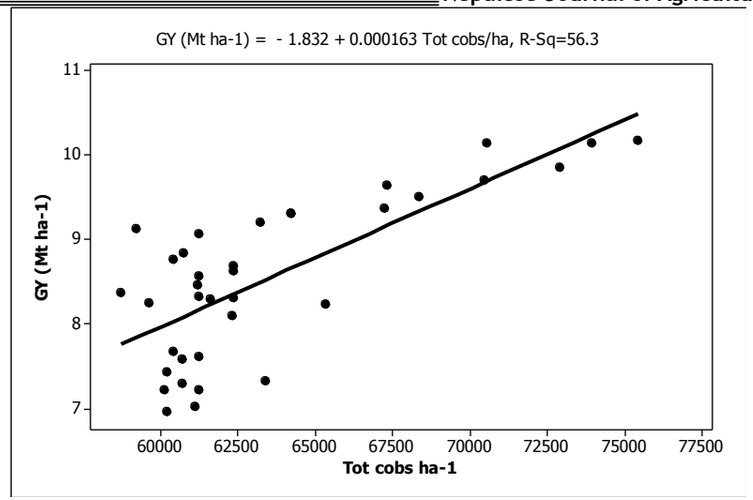


Figure 3. Correlation between total number of cobs and grain yields of maize, Rampur, 2013

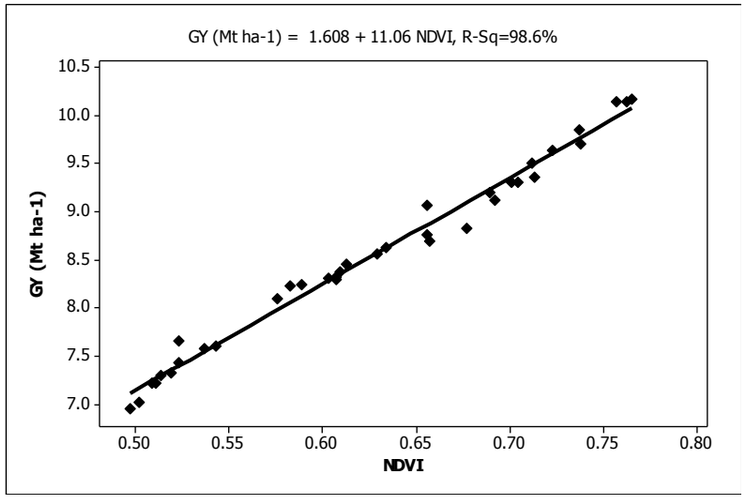


Figure 4. Correlation between total number of cobs and grain yields of maize, Rampur, 2013

The variation in grain yield was evident due to cropping geometry and was significantly higher (9.24 Mg ha^{-1}) in planting geometry of 60cm between rows and 25cm between plants (Table 1). It is mainly due to the higher number of cobs per hectare in planting geometry of 60cm between rows and 25cm between plants.

Many researchers have depicted that the dwarf maize hybrids perform better up to 90,000 plants in a hectare. Population of maize for maximum economic grain yield varies from 30,000 to over 90,000pl.ha^{-1}, depending on water availability, soil fertility, maturity

rating, planting date and row spacing. Xue *et al*. (2002) reported that grain yield increased with increasing plant density from 54000-94000 plants ha^{-1}, but decreased after 97000 plants ha^{-1}.Our findings are also in agreement with observations made by many researchers Mobasser *et al*. (2007).

CONCLUSION

There was a strong positive correlation of NDVI and grain yield of maize (R^2=98.6%). Rampur hybrid-2 had the lowest value of NDVI with 0.747 and the highest was found in RML-32/RML-17 with 0.757.Conventional tillage had the highest plant height of 167.88 cm as against 167.17 cm in NT. Similarly, the highest plant height of 169.91cm was recorded in RML-32/RML-17 over 165.14 cm in Rampur hybrid-2. Number of cobs per hectare was influenced by tillage, and significantly higher number of cobs (64962 ha^{-1}) was recorded in NT compared to 62120 ha^{-1} in CT. A higher number cobs were (64942 ha^{-1}) recorded at the planting geometry of 60cm between rows and 25cm between plants. Number of kernel rows cob^{-1} did not vary due to tillage, genotypes and planting geometry. A higher number of 27.3 kernels per row in NT was recorded as against the 25.8 in CT. RML-32/RML-17 produced the highest test weight of 363.94g over the Rampur hybrid-2 with 362.17g. Grain yield was not affected by tillage and genotypes. Significantly higher grain yield of 9.24 Mg ha^{-1} in planting geometry of 60cm between rows and 25cm between plants. The experiments need to be further tested with further higher plant population densities of Nepalese hybrids.

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Socio-economic aspects of ginger producers in the Western Hills of Nepal

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ABSTRACTS

This study was done to know the socioeconomic aspect of ginger producer farmer of Palpa district in March 2012. Information was collected through semi-structured questionnaire from 240 respondents of four village development committee of Palpa. Study revealed that younger farmers were attracted to ginger farming. Majority of the members of ginger grower family had primary education (31.77 %). Economically active population in the study population was 65.2 percent. Rice, wheat, maize, ginger, legume and vegetables were major crops grown over there. For the ginger farming, a total of 60.3 percent labor supply (human and animal) was made by their families. Average livestock standard unit holding by the study population was of 5.45LSU. Lack of quality planting materials, pest management problem and lack of technical knowhow was the major problem of ginger farming in the study areas.

Key words: Economically active population, labor supply, livestock standard unit

INTRODUCTION

Ginger (rhizome) is the underground modified stem of the plant (*ZingiberOfficinale*Rosc) of' family Zingiberaceae. It is one of the high valued cash crops and an exportable commodity in Nepal. Agriculture perspective plan has emphasized economic growth through agricultural productivity, crop diversification and commercialization of high value agricultural commodities (APPROSC & JMA, 1995). Nepali ginger is famous for medicinal purpose. Besides medicine it is widely used in cooking, baking, meat processing and soft drink manufacturing industries. Ginger cultivated in Nepal produced 161,171 mt fresh ginger with average productivity of 11.51 mt/ha, (MOAC, 2008). It is cultivated in more than 70 districts of Nepal. Likewise, nearly 70 percent ginger is grown in the mid-hills, while about 20 percent is grown in Terai. Among mid-hill districts, Palpa is one of the major ginger producing districts in western region. About 20 percent ginger is used as propagation materials and domestic consumption for household use and the remaining 80 percent is exported (Sharma, 2009). But report of MEDEP (2003) shows 60 percent of the total national production is exported, remaining 40 percent is locally used as seed, spice and medicinal purpose. India shares the main market of exported ginger (99% of total export). Major portion of export from Nepal is in fresh form and other form of export is in dried (slice, flakes and Sutho). Trade of ginger in Indian market is not fair. Many tariff and non-tariff barriers have created technical difficulty for Nepalese exporters to India. Major outlet for export of western region ginger is from Bhairawa customs. Due to fair marketing problem, export trend from Bhairawa customs has

drastically decreased since 2009. The export of dried and fresh ginger from Bhairawa customs was 701 and 4919 mt, respectively in the year 2010 (RPQO, 2011). The aim of this study was to be familiar with the general characteristics of ginger growing farmers and related problems and constraints. This study would be useful to the policy makers, planners and implementers of ginger production and marketing.

METHODOLOGY

On the basis of research objectives, Palpa (fig.1) is the best representative district for western region because of,

- Palpa is potential district in ginger cultivation in western part of Nepal.
- Fewer studies are happening in western region on ginger production and marketing.
- Among the 65 VDCs forty six VDCs are highly potential for production.
- Commercial production practices have been adopted over here.
- Variation by spatial phenomenon is high in four homogeneous ginger production areas.
- It is outlet for the movement of product to other district and to export also.

Four homogeneous areas were chosen, randomly on the basis of presence of primary ginger cooperatives, access and remoteness of areas within district, famous for rhizome seed production, geographical coverage of the district, and Presence of ginger processing practices. These four VDCs were Mujhung, Bhairabsthan, Kanigaun and Siluwa.

To grab maximum variable related to ginger industry, socio-economic data were collected using semi structured questionnaire after. A set of interview schedule was prepared for primary data to be collected from the community and secondary data were used reviewing different publication. Sixty samples were selected randomly from each four VDCs totaling 240 samples.

Sum, average, percentage, ratio like general form of analysis was done to conclude the socioeconomic attributes of the respondent and respondents' household characteristic. To calculate Livestock holding, it was converted by using LSU standards used by CBS (2003) and Eurostat (2013). Data analysis was done by using computer software packages like SPSS and MS-EXCEL.

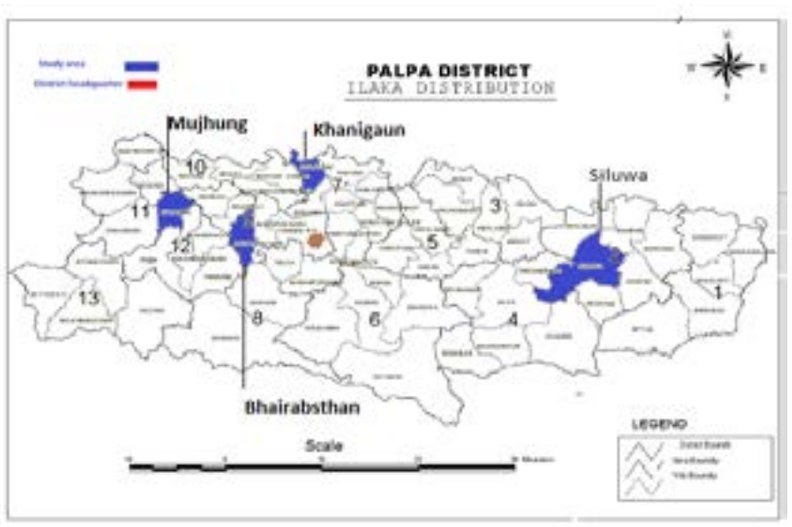
RESULTS AND DISCUSSION

Socioeconomic feature

This section illustrates general description of the study areas and the socio-economic characteristic of the respondents and families. These are mainly family size, education, labor availability, land holding, livestock units and crop area in different farming areas.

1. General introduction of study area

Palpa district represents the mid hill ecological region of Nepal. It is located in western part of Nepal and has spread out west to east. Area of the district is 1366 km^2 with altitude ranging from 157 to 1936 msl (DDC, 2010).



Total land under cultivation is 36567 ha (DADO, 2010). Ginger is mainly grown intercropped with maize. Total households, population and family size of the district are 59291, 261180 and 4.41, respectively (CBS, 2012). Siluwa and Mujhung are the two extreme side of Palpa. Bhairabsthan and Khanigaun are located in mid part of district and are famous for commercial farming and seed production respectively.

2. Characteristics of the respondents

2.1. Age distribution of respondents

The result shows that the average age of the respondent involved in ginger farming among the four VDCs is 43.77 years with the range of 20 to 71.25 years. Percentage of household head by age group (40-49 years) in Plapa is 21.42 percent (CBS, 2012). From the results it can be said that ginger farming has attracted to younger grower. Related development agencies should target to such age group to get maximum output from their program. Detail of the age distribution of respondents is given in Table 1.

Table 1. Distribution of respondents by age

Age structure	Age of respondents				
	Bhairabsthan	Khanigan	Mujhug	Siluwa	Mean
Min	16	21	25	18	20
Max	70	71	75	69	71.25
Mean age	43.38	44.43	48.13	39.15	43.77

Source: Field Survey, 2012

2.2. Gender of respondents

Gender involvement in ginger farming shows that, out of 240 respondents, 118 (49.17%) were female and 122 (50.8%) males. Female headed household is far higher in Palpa compared to national level of 26.6 percent (CBS, 2012b). Female headed household comparing by VDCs, the ratio between male and female respondents is more or less same. Detail of the gender distribution of respondents is presented in Table 2.

Table 2. Distribution of respondents by gender

characteristics	Number of respondents				
	Bhairabsthan	Khanigaun	Mujhung	Siluwa	Total
Female	28 (46.67)	30 (50)	27 (45)	33 (55)	118 (49.17)
Male	32 (53.33)	30 (50)	33 (55)	27 (45)	122 (50.83)

Source: Field Survey, 2012; Figures in parenthesis indicate the percentage.

2.3. Ethnicity of respondents

In this study, ethnic group of the respondents were categorized into three groups namely, Indigenous/Janjati, Brahmin/Chhetri and occupational cast. These three categories are the commonly accepted categories to classify the people in Nepal. Brahmin/Chhetri was found to be the dominating caste in all VDCs for ginger cultivation. In total sampled respondents, Brahmin/Chhetri, Janjati and Occupational class were 49.55 percent, 43.35.11 percent and 7.1 percent, respectively. VDC wise, involvement of Janjati and Occupational community was found maximum in Siluwa (71.7 %) and Khanigaun (13.3%) respectively (Table 3).

Table 3. Distribution of respondents by ethnicity

Ethnicity	Number of respondents				
	Bhairabsthan	Khanigaun	Mujhung	Siluwa	Total
Janjati	27 (45.0)	19 (31.7)	15 (25.0)	43 (71.7)	104 (43.35)
Brahmin/Chhetri	29 (48.3)	33 (55.0)	41 (68.3)	16 (26.6)	119 (49.55)
Occupational cast	4 (6.7)	8 (13.3)	4 (6.7)	1 (1.7)	17 (7.10)
Total	60 (100)	60 (100)	60 (100)	60 (100)	240 (100)

Source: Field Survey, 2012; Figures in parenthesis indicate the percentage.

2.4. Education status of respondents

The education level of the respondent was classified into six categories. Illiterate refers to those who cannot read, write and having no formal as well as informal education. Literate refers to those who can read and write but didn't have any school education except informal education. Those who have attained the school education up to five classes were grouped in primary, up to school education (10 classes) were grouped in secondary, who have attained the proficiency certificate level or 12 years of formal education (up to 12 classes) were referred as certificate and those who have attained further higher degree were grouped in university category (Table 4).

Table 4. Distribution of respondents by educational status

Education level	Number of respondents				
	Bhairabsthan	Khanigaun	Mujhung	Siluwa	Total
Illiterate	6 (10)	17 (28.3)	18 (30)	9 (15)	50 (20.82)
Literate	10 (16.7)	15 (25)	9 (15)	14 (23.3)	48 (20)
Primary	22 (36.7)	9 (15)	9 (15)	20 (33.3)	60 (25)
Secondary	16 (26.7)	14 (23.3)	17 (28.3)	12 (20)	59 (24.6)
Certificate	3 (5)	4 (6.7)	2 (3.3)	5 (8.3)	14 (5.83)
University	3 (5)	1 (1.7)	5 (8.3)	0 (0)	9 (3.75)
Total	60 (100)	60 (100)	60 (100)	60 (100)	240 (100)

Source: Field Survey, 2012; Figures in parenthesis indicate the percentage.

In general there is direct relation between poverty and education. Poverty declines progressively, as the level of education attainment by a household head increases. Majority of the ginger cultivating respondents were primary educated (25%) followed by secondary (24.6%). There is the estimates of CBS (2005) that if an illiterate household head attends primary school, the probability of this household being in poverty declines

by 47 percent and 29 percent in urban and rural areas respectively. This statement is supports to the farmer of Palpa. Respondents having education above SLC in the study population was 9.58 Percent which is near to national average 10.2 percent (CBS, 2012).

2.5. Occupation of respondents

Agriculture was the major occupation (89.6%) in study site. It was followed by business (10%). Respondents engaged in trade and study activities each showed same status (2.9%). On the other hand, the percent of the respondents involved in industry was only 0.4 percent (Table 5).In our research areas, occupation in agriculture was found more than the national average.

Table 5. Distribution of respondents by occupation in study sites

Occupation	Number of respondents				
	Bhairabsthan	Khanigaun	Mujhung	Siluwa	Total
Agriculture	53(88.3)	55 (91.7)	54 (90)	53 (88.3)	215 (89.6)
Trade	1 (1.7)	2 (3.3)	1 (1.7)	3 (5)	7 (2.9)
Industry	1 (1.7)	0 (0)	0 (0)	0 (0)	1 (0.4)
Service	2 (3.3)	1 (1.7)	4 (6.7)	3 (5)	10 (4.2)
Student	3 (5)	2 (3.3)	1 (1.7)	1 (1.7)	7 (2.9)
Total	60 (100)	60 (100)	60 (100)	60 (100)	240 (100)

Source: Field Survey, 2012; Figures in parenthesis indicate the percentage.

3. Respondent household characteristics

The respondents' household characteristics, such as population, gender distribution, family size, economically active population, education, occupations, livestock holding, land holding, crop situations are thoroughly discussed hereunder.

3.1. Population distribution

Sex ratio is the number of males per 100 females. In our study we found sex ratio having 108 in an average. In total, male population of the sample household was relatively higher (52.08%) than female population (47.92%) (Table 6).

The results show that average family size is 5.49 in study population. It is highest in Siluwa (6.18) and lowest in Mujhung (4.63). According to CBS (2012) the average household size in Palpa and Nepal is 4.41 and 4.88, respectively.

High level of family size in rural areas is the indication of low level of education and awareness in family planning. It is because of low level of resource use and living

standard with increasing demand for food. This statement magnetizes to the places of high family size and poverty situation. Households with 7 or more members have the highest incidence of poverty (CBS, 2005). It implies that poverty in Palpa is relatively lesser.

Table 6. Population distribution in the sampled households by study site

Category	VDCs				
	Bhairabsthan	Khanigaun	Mujhung	Siluwa	Total
Total Population	309	361	278	371	1319
Male	166	182	142	19 7	687(52.08)
Female	143	179	136	174	632 (47.92)
Family size	5.15[a]	6.02[b]	4.63[a]	6.18[b]	5.49
Male per household	2.77	3.03	2.37	3.28	2.86
Female per household	2.38	2.99	2.46	2.9	2.63

Source: Field Survey, 2012; Figures in parenthesis indicate the percentage.
Note: Identical letters on family size are not significantly different between the groups at 0.05 level of probability, according to the Mann-Whitney test.

The average number of male and female per household was 2.86 and 2.63 respectively. Among the four VDCs, male per household was the highest in Siluwa (3.28), while for female it was highest in Mujhung (2.99).

3.2. Age group distribution of the sample households

To categories the age, CBS methods was applied as I) below 5 years, II) from 5 to 14 years, III) from 15 to 59 years and IV) 60 or above years. The population age group from 15 to 59 was considered as economically active population (Table 7). National figure for active population shows 54.2 percent (CBS, 2011a), whereas within the research areas, it found 65.2 percent. Among the four VDCs economically active population were highest in Bhairabsthan (70.87%) and the lowest in Khanigaun (59.00%).

3.3. Educational status of family members

From the study, it was found that the largest population of sampled households was in the primary level education (31.77%) (Table 8) followed by secondary level education (26.35%). Among the four VDCs, primary education was the highest in Siluwa (37.76%) and the lowest in Mujhung (23.95%). In case of secondary education, more or less same situation was found in all VDCs.

Table 7. Age group distribution of the sample households

Age category	VDCs				
(years)	Bhairabsthan	Khanigaun	Mujhung	Siluwa	Total
<5	15	31	15	40	101
	(4.85)	(8.59)	(5.4)	(10.78)	(7.66)
5-14	43	75	42	63	223
	(13.92)	(20.78)	(15.11)	(16.98)	(16.91)
15-59	219	213	185	243	860
	(70.87)	(59)	(66.55)	(65.5)	(65.2)
60 or above	32	42	36	25	135
	(10.36)	(11.63)	(12.95)	(6.74)	(10.24)
Total	309	361	278	371	1319
	(100)	(100)	(100)	(100)	(100)

Source: Field Survey, 2012; Age category CBS (2011a); Figures in parentheses indicate the percentage.

Table 8. Educational status of family members

Education level	Household member				
	Bhairabsthan	Khanigaun	Mujhung	Siluwa	Total
Illiterate	18 (6.12)	66 (20.00)	44 (16.73)	38 (11.48)	166 (13.63)
Literate	43 (14.63)	33 (10.00)	46 (17.49)	44 (13.29)	166 (13.63)
Primary	105 (35.71)	94 (28.48)	63 (23.95)	125 (37.76)	387 (31.77)
Secondary	75 (25.51)	90 (27.27)	70 (26.62)	86 (25.98)	321 (26.35)
Certificate	36 (12.24)	26 (7.88)	30 (11.41)	35 (10.57)	127 (10.43)
University	17 (5.78)	21 (6.36)	10 (3.8)	3 (0.91)	51 (4.19)
Total	294 (100)	330 (100)	263 (100)	331 (100)	1218 (100)

Source: Field Survey, 2012; Figures in parenthesis indicate the percentage.

3.4. Occupational status of sample household

Agriculture is the self-employed sector in Nepal. Share of wage employment in agriculture is only 3 percent, while that in non-agriculture is 13 percent (CBS, 2011b). Active population engage in agriculture has decreased over the years coming down to 65.6 percent in the year 2012 (AICC, 2013). Out of 65.2 percent active populations in study sites nearly half of the population (50.57%) was self-employed in agriculture (Table 7 and 9). Foreign employment in Nepal is becoming a major source of earnings. Outcome shows that 7.25 percent (1921494) of total population are living out of country (CBS, 2012a) and in study areas 5.83 percent populations are in foreign employment which is near to national average.

Table 9. Occupational status of sampled households

Occupation	Household member				
	Bhairabsthan	Khani gaun	Mujhung	Siluwa	Total
Agriculture	157 (53.40)	155 (46.97)	138 (52.47)	166 (50.15)	616 (50.57)
Trade	3 (1.02)	3 (0.91)	2 (0.76)	8 (2.42)	16 (1.31)
Industry	3 (1.02)	0 (0.00)	0 (0.00)	0 (0.00)	3 (0.25)
Service	13 (4.42)	9 (2.73)	9 (3.42)	16 (4.83)	47 (3.86)
Student	106 (36.05)	134 (40.61)	97 (36.88)	128 (38.67)	465 (38.18)
Foreign employment	12 (4.08)	29 (8.79)	17 (6.46)	13 (3.93)	71 (5.83)
Total	294 (100)	330 (100)	263 (100)	331 (100)	1218 (100)

Source: Field Survey, 2012; Figures in parenthesis indicate the percentage.

3.5. Land availability

Livelihood of rural farmer is dependent on the quality and quantity of Land. Irrigated land in study areas is 31.51percent only while in national level, it is 53 percent of total agricultural land (CBS, 2011b). Total land of household is highest in Bhairabsthan but agriculture land owned is substantially higher in Siluwa (Table 10). Average size of agriculture land holding in study areas was 12.44 Ropani. This figure is slightly lower to national average of 13.72 Ropani (CBS, 2011b).

3.6. Major Crops in the study area

Maize based farming system is dominant in Palpa. Area per sampled household is 9.28 Ropani (Table 11). Ginger is main cash crop, cultivated in Bari land (sloppy land) intercropping with maize. In the study site the average ginger areas is 1.36 Ropani.

Bhairabsthan has largest areas among four sites (2.18 Ropani/household). In Nepal 216289 mt ginger is produced from 19081 hac of land (FAOSTAT, 20013).

Table10. Land holding characteristics of sample household

Land characteristics	Areas (Ropani) per household				
	Bhairabsthan	Khanigaun	Mujhung	Siluwa	Total
Total land	28.21	11.88	13.55	19.7	18.34
Agriculture land	14.15	8.25	9.45	17.9	12.44
Irrigated land	2.61	2.56	2.54	7.96	3.92
Un-irrigated (Bari land)	11.54	5.69	6.91	9.94	8.52
Grass land	14.06	3.63	4.1	1.8	5.9

Source: Field Survey, 2012; Figures in parenthesis indicate the percentage.

Table11. Major crops in the study area

Crops	Areas (Ropani)				Total
	Bhairabsthan	Khanigaun	Mujhung	Siluwa	
Rice	2.42	2.57	2.54	8.99	4.13
Wheat	1.93	1.54	1.92	1.52	1.73
Maize	12.21	5.77	6.42	12.73	9.28
Vegetable	1.19	0.21	1.13	0.67	0.80
Ginger	2.18	1.57	1.05	0.64	1.36
Legume	2.39	3.01	0.48	4.32	2.55

Source: Field Survey, 2012

3.7. Livestock holding of sampled household

Nepalese agriculture is of integrated farming system of crops and livestock. Livestock standard unit or livestock unit (LSU) is the way of comparing animals on the basis of nutritional requirement of grazing animal. It assists calculating stocking density also. Average LSU was found 5.45 in the study areas (Table 12). Similar type of outcomes (6.1 LSU) was reported in mid hill of Nepal (Luni et al. 2011). Agriculture and holding and LSU found positively related (Table 10).

Table12. Livestock holding of sampled households

VDCs	Livestock holdings (LSU) per household		
	Average	Maximum	Minimum
Bhairabsthan	5.28	18.01	1
Khanigaun	4.26	9.98	1.16
Mujhung	5.49	18.93	1.76
Siluwa	6.79	21.16	1
Total	5.45	17.02	1.23

Source: Field Survey, 2012, LSU=1(cow/buffalo) + 0.33(sheep/goat) + 0.3(pig/swine) + 0.1(poultry), (CBS, 2003), (Eurostat, 2013)

3.8. Household Labor supply (human and animal)

Ginger farming in Nepal is very labor intensive. These labor cost is mainly for land preparation, plough, plantation, FYM application, mulch collection weeding, harvesting and post harvest activities. Due to youth exodus labor availability in the village is becoming difficult. it's share to ginger cost of production is 35 percent (USAID, 2011). High share of labor cost making ginger farming less competitive due to increasing wage rate. There is high scope of ginger farming in the areas where labor availability is higher. In the study areas average own human and animal labor supply is 83.55 % and 37.0 %, respectively (Table 13).

Table13. Livestock holding of sampled household

Study area	Own labor use %		Total
	Human	Animal	
Bhairabsthan	72.6	32.5	52.5
Khanigaun	88.8	29.2	59.0
Mujhung	88.6	37.5	63.0
Siluwa	84.2	48.8	66.5
Total	83.55	37.0	60.3

Source: Field Survey, 2012

3.9. Problems of ginger cultivation

Producers are facing several production related problems like input supply, technical knowhow and pest management. In the study areas 35 percent farmers responded that they are facing problem of unavailability of quality planting materials. Rhizome as planting materials, share is highest on cost of production which goes up to 46 percent of total cost (USAID, 2011). So it is the major determinant of profit margins. The next most felt problem was the pest management. Some respondents reported that their crop was totally destroyed by the diseases rhizome rot and leaf spot in the field as well as in stored condition.

Table 14. Problems of ginger cultivation

Problems	Bhairabsthan	Khanigaun	Mujhung	Siluwa	Total	Rank
Lack of manure and mulch	6 (10)	9 (11.7)	6 (10)	3 (5)	24 (10.0)	V
Lack of quality planting materials	34 (56.7)	13 (21.7)	13 (21.7)	24 (40)	84 (35.0)	I
Poor rural infrastructure	2 (3.3)	6 (10)	4 (6.7)	14 (23.3)	26 (10.8)	IV
Lack of technical knowledge and skills	8 (13.3	13 (21.7)	7 (11.7)	8 (13.3)	36 (15.0)	III
Problem of pest management	10 (16.7)	19 (31.7)	30 (50)	11 (18.3)	70 (29.2)	II

CONCLUSION

Facts and figure obtained from the study are very important to improve the areas of socio-economic and gender policy analysis. Higher female farmers' involvement on cash crop like ginger farming indicates that women's economic empowerment is in improvement. Education of majority of the respondent and household member was found of primary level education. Agriculture in the study population was only 50.57 percent indicating the movement of people from agriculture to non-agriculture sector. Average agriculture land holding size per household in study areas was 12.18 Ropani of which only 31.51 percent land was irrigated.

As ginger is intercropped with maize there is high scope of expanding ginger farming if price and market is favorable. Livestock holding is supportive for ginger farming as it provides organic manure. More land owning farmer has more livestock unit and family size too. Larger family size has provided larger humane labor in ginger faming except Mujhung. Lack of quality planting materials and technical knowhow and pest management was the main problems of ginger cultivation.

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Evaluation of fungicides against Stemphylium blight (*Stemphylium botryosum* Walr) of Lentil (*Lens culinaris* Medikus)

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ABSTRACT

Stemphylium blight caused by Stemphylium botryosum Walr is one of the major diseases of lentil (Lens culinaris Medik) in Nepal. Experiments were carried out to evaluate five different fungicides against lentil stemphylium blight at Grain Legumes Research Program, Rampur, Chitwan, Nepal during two winter seasons of 2011/12 and 2012/13 using CRD in laboratory, and RCBD in field condition. All tested fungicides at lower doses also inhibited radial mycelial growth of S. botryosum significantly at different concentrations under in vitro test. Fungicides Krilaxyl and Blitox-50 had positive response in checking the growth of pathogen completely even in the lowest dose (500 ppm) while SAAF had better results with the increase in concentrations. The mycelial growth inhibition percent of SAAF, Mancozeb and Bavistin at 2000 ppm were 68.7, 55.9 and 47.1, respectively. Results of field experiment revealed that all fungicides had significant effect on disease severity and crop yield compared the control. The highest percent yield increase (PYI) was obtained from Mancozeb treated treatment (40.20%) followed by Krilaxyl (22.46%) and SAAF (21.63%) over the control. During 2012/13, in field condition at Rampur, all tested fungicides had significant effect on percent disease index (PDI), yield and hundred seed weight (HSWt) as compared to control. The lowest PDI was observed in the Krilaxyl (36.00%) followed by Mancozeb (37.35%), and the highest PDI was recorded in control (72.00%). The highest crop yield was recorded from the plot treated with Krilaxyl (1008.00 Kg/ha) followed by Mancozeb (914.30 Kg/ha) and SAAF (853.80 Kg/ha). Over years, among the fungicides, the performance of Krilaxyl was noted as the most effective fungicide followed by mancozeb to manage stemphylium blight under both in-vitro and in-vivo.

Key words: Disease severity, grain legumes, yield increase, PDI, crop yield

INTRODUCTION

Lentil (*Lens culinaris* Medik) is the most important and highly commercialized pulse among the grain legumes in terms of area (206522 ha), production (226931 t) and productivity (1099 kg/ha) which shares almost 62 percent of total area and 65 percent of total production of pulses and rates the highest consumer preference in Nepal (MOAD, 2013). The national lentil yield level, at present, is far below than potential yield. There are various biotic and abiotic yield limiting factors in lentil of which diseases and poor crop management are important ones. Lentil plants are affected by wide range of pathogen with fungal diseases being the most important. Among the diseases, Stemphylium blight caused by *Stemphylium botryosum* Walr is becoming a serious threat to lentil cultivation. *Stemphylium botryosum* causes leaf blight on lentil that can result in large scale defoliation of plants. Stemphylium blight disease of lentil has been reported in Bangladesh, Egypt, Syria and the USA (Bayaa and Erksine, 1998). It was first reported during 1993 in Nepal and has become widespread throughout major lentil growing areas of the country (Bayaa *et al*., 1998). Preliminary studies in Bangladesh and India estimated yield losses of 62 percent and total crop failure have been reported in some cases where the disease defoliated the crop in the early pod setting stage (Bakr, 1991; Erksine and Sarker, 1997). In recent years, *Stemphylium* has been observed increasingly in lentil fields in Banke, Bardiya, Rupandehi, Chitwan, Nepalgunj, Makwanpur, Bara, Parsa and Rautahat districts of Nepal (Joshi, 2006). Control of plant diseases becomes most successful and economical when management approaches involving several methods are employed including chemical means, cultural practices and use of resistance host. In view of the above facts, the present research work was undertaken with the objective of evaluation of fungicides against stemphylium blight of lentil both under *in-vitro* and *in-vivo* condition.

MATERIALS AND METHODS

Both laboratory and field experiments were conducted to study on efficacy of fungicides against stemphylium blight of lentil at Grain Legumes Research Program, Rampur, Chitwan, Nepal. Accordingly, lab works were done with the objective to calculate the growth of pathogen at different concentration of fungicides by poisoned food technique. Five different market available fungicides SAAF (Carbendazim 12%+ mancozeb 63% WP), Krilaxyl (Metalaxyl 8%+ Mancozeb 64% WP), Bavistin (Carbendazim 50% WP), Blitox-50 (Copper oxychloride 50% WP), and Dithane M-45 (Mancozeb 75% WP) were used to test their efficacy on the growth of *S. botryosum* Walr at the concentrations of 500, 1000, 1500 and 2000 ppm. Different quantities of tested fungicides were added to flask separately containing commercially available Potato Dextrose Agar (PDA) medium before its solidification to achieve the proposed concentrations, then rotate gently to ensure equal distribution of the fungicidal concentration and poured into sterilized petridishes. Strepto-penicillin (Bistrepen-V) (250 mg per liter) was added to the medium at the time of pouring to prevent bacterial contamination. There were 5 experimental setups consisting of SAAF, Krilaxyl, Bavistin, Blitox-50, and Dithane M-45 ammended PDA plates. Each experiment included 5 treatments; fungicides amended PDA at 500, 1000, 1500 and 2000 ppm concentration levels and controls (only PDA). Three plates was considered as one experimental unit and replicated 3 times. Each experiment was carried out in completely randomized design (CRD).

Four millimetre diameter of *S botryosum* Walr of one week old culture was cut by cork borer and picked up with the help of inoculating needle and placed onto the center of the

PDA plate amended with fungicide as upside down for better contact of pathogen to the media. The plates were incubated at incubator at 30^0C for up to 25 days.

The colony diameter (cm) of the pathogen was determined by measuring the average radial growth on different incubation dates. Average radial growth was recorded by using a measuring scale from the lower view of the petri-plates. Mycelial growth inhibition percent was calculated by following formula.

Mycelial growth inhibition (%) = [(dc-dt) / dc] × 100
Where dc = average diameter of fungal colony in the control
dt = average diameter of fungal colony in the treatment group

In-vivo test (Experiment under field condition)

The experiment was conducted under natural epiphytotic condition following Randomized Complete Block design. The unit plot size was 4m x 1.5m with 25 cm row to row spacing. A susceptible lentil variety Shital was sown in November 23rd of lentil season 2011/12 and 2012/13. There were altogether six treatments of the experiment comprising five different fungicides i.e. Dithane M-45 (Mancozeb), Krilaxyl, Bavistin, Blitox-50 and SAAF at the concentration of 2 g/l of water for each treatment and control. All treatments were replicated four times. First spray was given just after the appearance of disease symptom during the initiation of flowering period of crop i.e. 60-70 days after sowing. Three sprays were given at an interval of 15 days. Disease severity data was recorded before every spray using 1-9 scoring scale from 25 randomly tagged plants/plot (Morrall and Mckenzie, 1974).

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

Similarly Percent Disease Index (PDI) was computed on the basis of recorded data according to the formula (Wheeler, 1969) and calculation was based on the final data record at 15 days after the last spray. Percent Disease Control (PDC) was calculated on the basis of the formula developed by Shivankar and Wangikar, (1993).

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

1- 90% or more = very good
2- 80-89% = good
3- 70-79% = acceptable
4- 60-69% = poor

5- Less than 60% = very poor

Data was recorded on yield and yield attributes after necessary sun drying. Yield increase over the control was calculated. The temperature, relative humidity and rainfall were measured during experiment period (Figure 1).

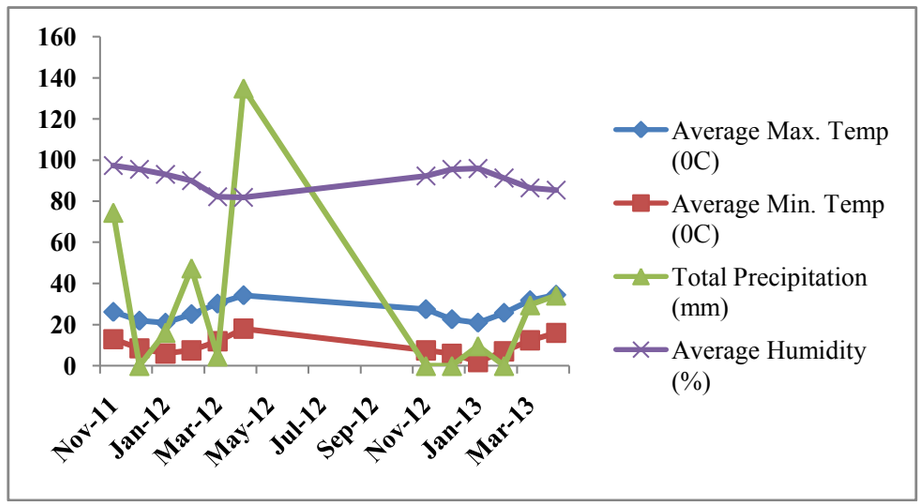

Figure 1. Weather data of lentil season 2011/12 and 2012/13 at Rampur Chitwan Nepal

All data were analyzed statistically using MSTAT-C. Analysis of variance was done. Treatment means were compared using Duncan's Multiple Range Test (DMRT) at one and five% levels of significance. All percent data was subjected to arcsine transformation before statistical analysis.

RESULTS AND DISCUSSION

In-vitro test

Effect of fungicides on mycelial growth inhibition percent

All fungicides even at a lowest dose also inhibited radial mycelial growth of the pathogen significantly over the control at different concentrations. Krilaxyl and Blitox-50 were able to check the growth of pathogen completely even in the lowest dose (500 ppm). With the increase in concentration, the mean colony diameter of the pathogen in the plate amended with SAAF, Mancozeb and Bavistin was significantly lower than the diameter recorded at control plate (Table 1). The highest mycelial growth inhibition percent was noticed on Krilaxyl and Blitox-50 followed by SAAF and Mancozeb (Table 2).

Table 1. Effect of different fungicides incorporated PDA on the growth of *S. botryosum* in 17th day of incubation period at 30 ^{0}C temperature on incubator during 2011/12

Treatments/fungicides used	Mean colony diameter of the pathogen (cm)				
	SAAF	Krilaxyl	Bavistin	Blitox-50	Mancozeb
500 ppm on PDA	4.57 ^{b†}	0.40 ^{b}	5.40 ^{b}	1.27 ^{b}	5.17 ^{c}
1000 ppm on PDA	3.33 ^{c}	0.40 ^{b}	4.40 ^{b}	0.40 ^{c}	6.40 ^{b}
1500 ppm on PDA	3.47 ^{c}	0.40 ^{b}	4.33 ^{b}	0.40 ^{c}	3.83 ^{d}
2000 ppm on PDA	2.60 ^{c}	0.40 ^{b}	4.40 ^{b}	0.40 ^{c}	3.67 ^{d}
Control	8.33 ^{a}	8.33 ^{a}	8.33 ^{a}	8.50 ^{a}	8.33 ^{a}
F-Test	**	**	**	**	**
LSD (≤0.01)	0.87	0.34	1.17	0.48	1.10
CV%	7.53	6.50	8.43	8.49	7.76

† Means of 3 replication. Means in column with same superscript is not significantly different by LSD $_{(P<0.01)}$. PDA- Potato Dextrose Agar, ppm- parts per million

Table 2. Percent inhibition of *S. botryosum* by different fungicides incorporated PDA over control at 30^{0}C temperature on incubator during 2011/12

Treatments	Mycelial growth inhibition percent				
	SAAF	Krilaxyl	Bavistin	Blitox-50	Mancozeb
500 ppm on PDA	45.14	95.19	35.17	85.06	37.93
1000 ppm on PDA	60.02	95.19	47.18	95.19	23.17
1500 ppm on PDA	58.34	95.19	48.02	95.19	54.02
2000 ppm on PDA	68.79	95.19	47.18	95.19	55.94
Control	-	-	-	-	-

From the in-vitro test of fungicides, radial mycelia growth inhibited significantly over the control. All the fungicides retarded radial colony growth of *Stemphylium botryosum* and no growth was observed in case of Krilaxyl and Blitox-50 ammended PDA plate even at lower concentration also. The maximum growth was noted in control petriplates followed by bavistin at lower concentration (500 ppm). Although there is no any literature regarding the support of Krilaxyl and Blitox-50 to control Stemphylium blight of lentil, Huq (2003) reported that Rovral 50 WP was the most effective fungicides among the others and there was no growth recorded at higher concentration (2000 ppm). Hosen et al. (2009) evaluated six fungicides and found that Rovral 50 WP from the iprodione group was the best fungicide followed by mancozeb and tilt in respect of reducing the radial colony growth of S. botryosum among the others at a lower concentration (500 ppm).

In-vivo test

Experiment under field condition at Rampur during 2011/12

All fungicides had significant (P≤0.05) effect on crop yield and percent disease index (PDI) over control. The higher crop yield was recorded from the treatment with Mancozeb (338.30 kg/ha) as compared to control (241.30 kg/ha). The lower PDI was found in the treatment with Blitox-50 (45.99%) followed by Krilaxyl (47.55%) (Table 3).

Experiment during 2012/13

During the research period (2012/13) also trends of disease control and crop yield were similar. All fungicides had significant effect over the control in reducing the disease. Among fungicides tested Krilaxyl @ 2g/lt of water remained most effective fungicides in terms of percent disease control (50%) and crop yield (1008 kg/ha) followed by Mancozeb compared to control. The lower PDI was obtained from the plot treated with Krilaxyl (36.0%) and Mancozeb (37.3%) compared to control (72.0%) (Table 4).

Table 3. Effect of fungicides on disease severity and yield of lentil at Rampur, Chitwan during 2011/12

Treatments (Conc^n: 2 gm/lt)	Percent Disease Index (PDI)	Percent Disease Control (PDC)	Grain Yield (kg/ha)	% Yield Increase
SAAF	53.77^{b†} (47.18)	28.40	293.50 ^{b}	21.63
Krilaxyl	47.55 ^{c} (43.59)	36.68	295.50 ^{b}	22.46
Bavistin	52.44 ^{b} (46.41)	30.17	269.30 ^{bc}	11.60
Blitox-50	45.99 ^{c} (42.72)	38.76	257.00 ^{c}	6.51
Mancozeb	54.21 ^{b} (47.42)	27.82	338.30 ^{a}	40.20
Control	75.10 ^{a} (60.08)	-	241.30 ^{c}	-
F-test	**		**	
LSD (≤0.05)	1.49		33.79	
CV%	2.07		7.94	

† Means of 4 replication. Means in column with same superscript is not significantly different by DMRT (P<0.05). Mean in parenthesis is of arcsine transformed data.

Management of plant disease successfully achieved through application of chemical fungicides. All the tested fungicides reduced the disease score and noticeable increased plant growth parameters and yield of lentil in comparison to treated with control plot. The yield of lentil was enhanced sharply through the application of fungicides. The lowest disease score was achieved in plots sprayed with krilaxyl followed by mancozeb and highest in control plot preceded by Blitox-50 and bavistin treated plot. The highest grain yield of lentil was recorded from the krilaxyl treated plot followed by mancozeb treated plot and lowest in the control pots. Bakr and Ahmed (1992) reported that disease score was lowest in plots treated with Rovral 50 WP @ 0.2% and it is indicating the highest disease reducing capability then rest of other fungicides and also found that plots sprayed with Rovral produced the highest seed yield followed by other fungicides tested while the

lowest yield was recorded in control plots. Sardar (2005) reported that the lowest disease was obtained from the Rovral 80 WP with Tilit 250 EC treated plots.

Table 4. Effect of fungicides on disease severity and yield performance of lentil at Rampur, Chitwan during 2012/13

Treatments (Conc^{n} :2 gm/lt)	EPS (%)	DS (1-9 scale)	PDI	FPS (%)	YIELD (kg/ha)	HSWT (gm)	PDC %	% YI
SAAF	87.50 †	.00 ^{bcd}	51.97 ^{c}	81.25 ^{ab}	853.80 ^{c}	1.74 ^{a}	27.82	45.03
Krilaxyl	90.00	.00 ^{d}	36.00 ^{d}	85.00 ^{a}	1008.00 ^{a}	1.75^{a}	50.00	71.22
Bavistin	87.50	.00 ^{b}	57.15 ^{b}	80.00 ^{ab}	822.50 ^{d}	1.56 ^{c}	20.63	39.71
Blitox-50	87.50	.50 ^{bc}	51.53 ^{c}	78.75 ^{b}	805.80 ^{d}	1.64 ^{bc}	28.43	36.88
Mancozeb	87.50	.50 ^{cd}	37.35 ^{d}	81.25 ^{ab}	914.30 ^{b}	1.73 ^{ab}	48.13	55.31
Control	81.25	.00 ^{a}	72.00 ^{a}	70.00 ^{c}	588.70 ^{e}	1.24 ^{d}	-	-
F-Test	NS	*	**	*	**	**		
LSD (≤0.05)	6.44	1.93	2.66	5.07	19.81	0.09		
CV%	4.92	25.65	3.46	4.24	1.58	3.77		

† Means of 4 replication. Means in column with same superscript is not significantly different by DMRT $_{(P<0.05)}$. EPS – Early Plant Stand per plot, DS – Disease severity, PDI-Percent Disease Index, FPS – Final Plant Stand/plot, YIELD- Grain yield, HSWT-Hundred Seed Weight, PDC- Percent Disease Control, YI- Yield Increase, NS-Not significant, *- Significant, ** - Highly significant .

From the findings of other researcher Rovral 50 WP was the most effective fungicide in reducing the disease score and increasing the yield of lentil. Rovral was the Bayer company product from the Iprodione group. Stemphylium blight disease was relatively new emerging disease in Nepal and very few researches have been done to cope up with this disease. Some noticeable research works were undertaken at Bangladesh to manage Stemphylium blight which was their major yield reducing factor of lentil. Rovral was easily available in Bangladesh but it was rarely found in Nepalese or even in Indian markets. Rovral 50 WP was little bit expensive than other market available fungicides. Krilaxyl and Mancozeb were popular as well as market access fungicides in Nepal and also relatively safer and economically affordable for Nepalese farmers. The present research work also showed that Krilaxyl (Metalaxyl 8% + Mancozeb 64% WP) was the most effective fungicide in controlling the disease severity and increase yield of lentil. The findings of this experiment was partially agrees with Johnston (1986) who reported that many schedules for vegetable crops tests involved low rate of fungicide. The broad spectrum fungicide e.g. Mancozeb early in the season followed by a phycomycete-specific fungicide e.g. metalaxyl plus mancozeb. Control of early blight on potatoes was

better when metalaxyl plus mancozeb was substituted for mancozeb (Dithane M-45) in the middle of the growing season rather than early or late. Because of the systemic activity of the phycomycete-specific fungicides, normally a 14-day schedule was followed. The idea of selection of Krilaxyl as the treatment for lentil Stemphylium blight management experiment was basically from its easy market access and also farmer preferred fungicide to control several other fungal crop diseases. Moreover the major ingredient of Krilaxyl was Mancozeb 64% WP. Gharti et al. (2008) also found that 2-3 sprays of Mancozeb 75 WP @2.5 g/lt or Carbendazim 50 WP @2g/lt also have been found effective to control lentil Stemphylium blight.

CONCLUSION

The findings of two consecutive years data showed that management of plant disease successfully achieved through application of chemical fungicides. It was noted that the yield of lentil was enhanced sharply through the application of fungicides. It is clear that Percent Disease Index (PDI) was less in fungicide sprayed plots compared to that of control. The lowest disease score and highest grain yield was achieved in treatments sprayed with Krilaxyl followed by Mancozeb. Control through chemical means showed Krilaxyl as the most effective fungicide when tested in-viro and in-vivo. Thus, it is recommended to spray the fungicide Krilaxyl @ 2g/lt or Mancozeb 75 WP @ 2g/lt thrice at an interval of 15 days from the day of first appearance of disease in the field with respect to disease control and yield increment of lentil.

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Factors influencing local innovation in ecological agriculture in the central development region of Nepal

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ABSTRACT

The study was carried out to assessing the influencing factors of local innovation in ecological agriculture in the Central Development Region, Nepal during the year 2011. Thirty individuals were selected randomly to collect information through semi structured questionnaire. The analysis showed that majority of the local innovation was innovated by janajati ethnic group, energetic adult group and medium to small size family. Educational level of innovators doesn't correlate with innovation and two third of innovations have been scaled out beyond the village. The utility and relevancy of the local innovations found higher in farmer community. Likewise, when local innovators face some problems, scarcity/stress, feel complex, no solution of problems and tought work were the remarkable situations of getting stimuli to innovate. Hence, family/community problems, existing unfavorable situation, scarcity, personal ego and interest were the major driving forces of local innovation.

Key Words: Natural resource management, scarcity, stress, knowledge transformation, livelihoods

INTRODUCTION

Nepal is predominantly an agricultural country with about two third of the total economically active population engaged in agriculture (Koirala, 2004). Agriculture is the mainstay of Nepalese economy and hence government has accorded the highest priority in five year plans (Sharma, 2004). The agrarian economy is subsistence oriented: in both hill and terai (lowland) regions, very little agricultural income is realized in cash (World Bank, 1991). Farming systems and crop production in Nepal vary across the agro-ecological regions of plain, hills and mountains (Pandey & Pandey, 2011). There is no other way to develop the nation without developing agriculture. Agriculture extension system adopted in the country has to play a vital role to uplift farmer's status and eventually country's economic level (Sharma, 2003).

Many approaches to 'get agriculture moving' have been adopted and discarded over the past several decades (Davidson, 2003). Training and Visit System (T&V), Integrated Rural Development approach, TUKI (Multiple Progressive Farmers) approach, Farming

Systems Research and Extension approach, and Block Production Program were made in the past to reform and strengthen agricultural extension system (Sharma, 2003).

Local innovation in agriculture and natural resource management (NRM) is the process through which individuals or groups discover or develop new and better ways of managing resources, building on and expanding their existing knowledge base (Waters-Bayer *et al.,* 2004). PROLINNOVA (Promoting Local Innovation) is an NGO-initiated program to build a global learning network to promote local innovations in ecologically-oriented agriculture and natural resource management. PROLINNOVA Nepal aims at developing and institutionalizing partnership and methodologies that promote processes of local innovation in environmentally sound use of natural resources. It is an initiative undertaken in partnership between several Nepal-based organizations (Waters-Bayer *et al.,* 2004). The objectives of this paper are:

- To identify local innovations (socio-institutional as well as technological) and innovators in the study area
- To find out if there is a gender bias in innovation and draw out the differences between men and women innovators, and
- To explore and analyze different governing factors that stimulates to innovate in individual, group and organizational level in the field of agriculture and natural resource management.

MATERIALS AND METHODS

The selected districts for this study were Dolakha, Sindhupalchok and Chitwan districts of Central development region of Nepal. The Central Development Region (CDR), one of the five development regions of Nepal, spans all three eco zones – mountain, hill and plains. It consists of 3 zones and 19 districts. The area of CDR is 27,410 square kilometer. The CDR is home of various ethnic communities for example Newar, Tamang and Thami, Tharu, Jirel, Chepang and its inhabitants represent different religions, including Hinduism, Buddhism and Islam. The Human Development Index (HDI) of the CDR according to NHDR-2009 is 0.531 is higher than the national average of 0.509. The HDI also varies greatly across the eco-zones (mountain: 0.454, plain: 0.478, hill: 0.6023).

The population for this study was the documented local innovators of the study area. Out of the total population of 65 local innovators, 30 respondents were selected for the study to get the required size of the sample by using systematic random sampling procedures. Primary data were collected through questionnaires, interviews, etc from the concerned local innovators where as secondary data were collected from PROLINNOVA-Nepal partner organizations, government offices and other relevant sources. The information collected from the field were coded and entered into MS Excel. The excel data file were exported to Statistical Package for Social Science (SPSS) and analyzed using both descriptive tools like percentage, frequency, mean, standard deviation, etc.

RESULTS AND DISCUSSION

Demographic characteristics of local innovators in the study area

Ethnic group

Table 1 summarizes the ethnic group of local innovators in the study areas. Most of the local innovators (56.67 %) were Janajati ethnic group followed by Brahmin Chhetri (43.33 %).

Table 1. Distribution of local innovators by ethnic groups

S.N.	Ethnic groups	Count	Percent
1	Janajati	17	56.67
2	Brahmin / Chhetri	13	43.33
Total		30	100

Source: Field survey, 2011

Janajati is the largest ethnic group involved in innovation followed by B/C. The above findings are in line with LI-BIRD (2009) that many of these innovations are localized in particular geographical areas and/or with certain ethnic groups. Nepal has a cultural mosaic comprising different caste and ethnic groups. They have depended mainly on biological resources for livelihood purposes since time immemorial and possess incredible indigenous knowledge (IK), skill and practices system (Maden *et al.*, 2008).

Age category

Figure 1 revealed that majorities (60 %) of the local innovators were 41-55 years age category followed by >55 year (26.67 %) and 25-40 year (13.33 %). There was no involvement of < 25 year age category peoples in local innovation process. All female local innovators falls in 41-55 year age category.

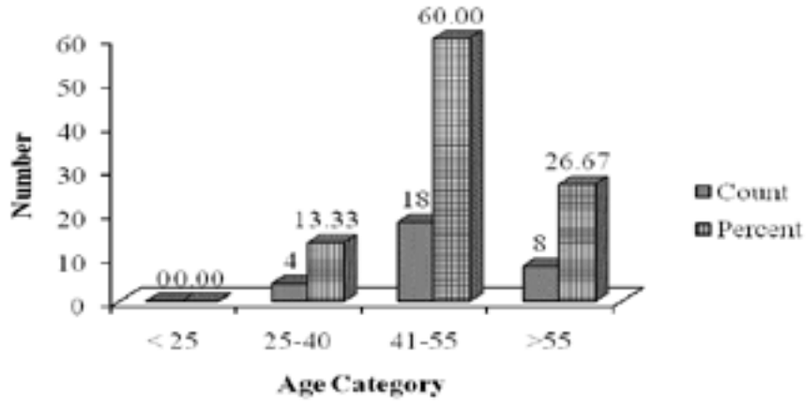

Figure 1. Involvement of local innovators by age category

Here, the majority of the local innovators fall in the age group 41 – 55 years who are relatively experienced people of the community. The above findings are in line with

Critchley *et al.* (1999) who reported that the average age of farmer innovators involved in the PFI programs is 44 years. Nielsen (2001) stated that the level of innovation was lower among older heads of household, but the drop was marked only among farmers in their late 60s. The peak in innovativeness was found among farmers in the age bracket of 35-40 years. The level of innovation appears to be fairly constant through most of the productive life of farmers and that they become less innovative only when they become quite old.

Educational level

Present reveals that 36.67 percent local innovators were literate without formal education and 36.67 percent attained secondary education, while 26.67 percent attained up to higher education (Table 2).

Table 2. Distribution of local innovators by their educational level

S.N.	Educational level of local innovators	Count	Percent
1	Literate without formal education	11	36.67
2	Secondary level education	11	36.67
3	Higher level education	8	26.67
Total		30	100

Source: Field survey, 2011

The level of formal education does not appear to be a determining factor with respect to farmer's creativity and propensity to innovate. In Ethiopia, Yohannes found that there was no significant correlation between the level of formal education and the innovativeness of farmers (Reij & Waters-Bayer, 2001). Under the common characteristics of local innovators, creativity and formal education are not correlated (Reij & Waters-Bayer, 2005). Therefore, innovativeness of the local innovators does not affected by the level of education.

Local innovation

Types of local innovation

Majority of local innovations were improved traditional (53.33 %) and new (23.33 %) while other were improved imported (20 %) and traditional (3.33 %) type of innovations. None of the innovation was of imported type (Figure 2). The findings are in line with Wettasinha *et al.* (2006) who reported that local innovations may be of traditional innovations, traditional but modified innovations, new innovations directly transferred from another location, innovations brought from outside but modified or value added in the local context and altogether new innovations.

Feature of local innovation

For the identification of the major characteristic feature of local innovations the information was collected from respondents. The major characteristic features are presented in Figure 3.

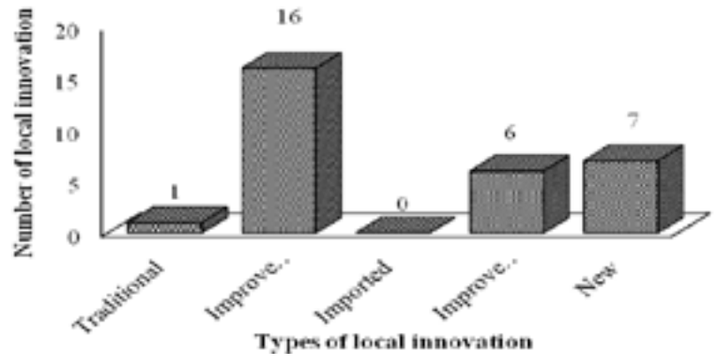

Figure 2. Types of local innovation in the study area

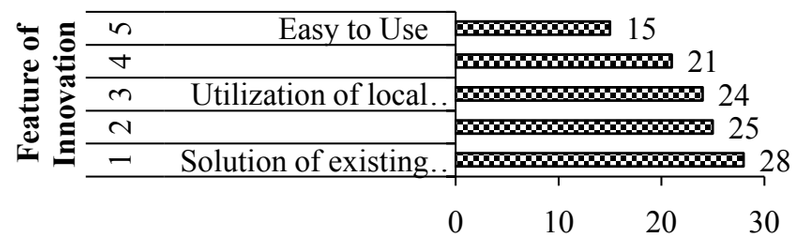

Figure 3. Major characteristic features of local innovation

Figure 3 revealed that the solution of existing problems were prominent (93.33 %) feature of local innovations followed by adoptable to local environment (83.33 %) and utilization of local resources (80.00 %). Likewise, cost effective (70.00 %) and easy to use (50.00 %) are other important features of local innovations. The farmer innovation is all about new ways of doing agriculture and that newness entails values, which may bring about positive changes in quantity, quality, sustainability, varity, simplicity, cost effectiveness, timeliness etc (Assefa, 2005).

Extent of coverage

Figure 4 revealed that almost all of the local innovations were extended in different scales. However, 70 percent of local innovations were extends beyond the village and 30 % were confined only in village. However, the effectiveness of local innovation was reflected through its area of coverage. Farming community has developed a number of valuable innovations, and have proved potential through the application of these innovations in fellow farmer's fields also (ICAR, 2010). Farmers were taking the lead not only in local research but also in sharing the results of their experiments and

investigations, from farmer to farmer. The recently improved from traditional type of local innovations was confined within village territory.

Figure 4. Extent of coverage of local innovation

Channels of knowledge transformation

Figure 5 revealed that the transfer of expertise, knowledge, learning and skills from local innovators to farming community was basically through friends, relatives and neighbors (26.67 %) followed by organizational help (23.33 %) and use of media (16.67 %). Likewise, group meetings, training and workshop and accessible publicity materials (10.00 %) are other channels of knowledge transformation adopted by local innovators. Figure 5 has outlined the channels of knowledge transformation.

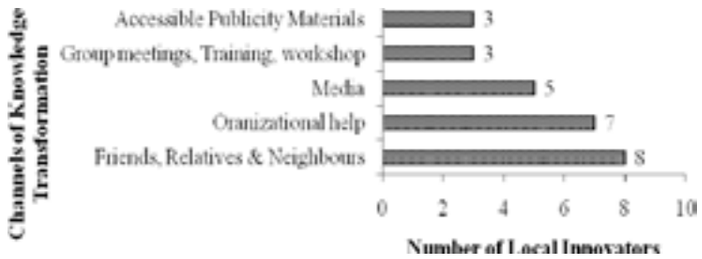

Figure 5. Knowledge transformation channels from local innovators to other farmers

Vivekanandan (1993) stated that conducting village level workshops and group discussion with farmers, publishing newsletters in local language for the exclusive communication of traditional farm technologies and travelling to interior regions were some of the effective means of disseminating AIK. In the network mechanism, successful farmers developed innovations that were diffused by interpersonal and community communication networks (Minh *et al.,* 2011).

Major benefits from local innovation

All of the local innovations have some sorts of benefits due to which they are used and adopted by farming community. Utilization of local resources, environment friendly, sustainable productivity of the farm, entrepreneurship development, and help in livelihood were the major benefits from local innovations. Similarly, exciting and interesting working environment, business survival, new revenue streams, advantage of

opportunity, competitive, market leadership and efficiency in work were the benefits experienced from institutional innovations.

Figure 6. Major benefits felt by farmers from institutional innovation

Over the centuries, rural people in many parts of the world have successfully resolved serious agronomic, economic, institutional, environmental and technological problems, through their own ingenuity, innovations and learning processes. These successes form part of a country's knowledge capital; if recognized and shared, they can inspire and enable rural communities in other parts of the country or in other regions to overcome similar constraints (SARD, 2007). Going beyond the technologies generated by the research institutions, drawing innovations and reinventions by the farmers for widening basket of the demand-driven technologies to suit various agroclimatic conditions is crucial to have quantum jump in agricultural production (ICAR, 2010).

Support in livelihood of local innovators

Figure 7 revealed that 46 percent of the local innovators get social support and 27 % get economic and economic plus social support in their livelihood from local innovations. Box 1 illustrates how a local innovation helps to earn livelihood of a farmer innovator.

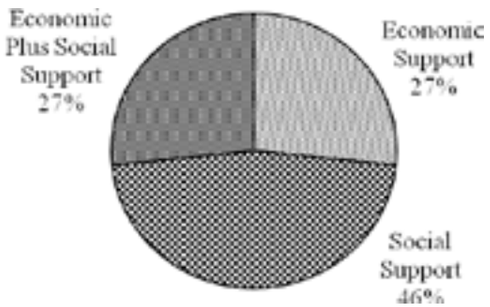

Figure 7. Support in livelihood of local innovators from their innovation

Box 1. Livelihood from local innovation: An example from Jagat Bahadur Shrestha of Dolakha district, Central Nepal
Red colored True Potato Seed (TPS) has been developed by Jagat Bahadur Shrestha by crossing red colored variety followed by repeated selection process based on shape, quantity, color, taste and keeping quality of seed in different agro ecological zones. Existing TPS varieties are white in color. Farmers as well as consumers are demanding red colored TPS. TPS developed by Jagat Shrestha has been found highly adaptive, high yielder, good cooking quality as well as tasty, virus free and with desired shape and size. Red color of potato tuber is the specialty of this innovation. This innovative product provided an appropriate solution for the aspiring farmers of the country to produce potato by using red colored TPS with low cost. The annual income of Jagat is nearly about NRs 2 million from his potato farmimg.

Outputs of joint research on the simplest of innovations have been readily taken up by other farmers, leading to positive livelihood impacts (PROLINNOVA, 2010). Farmers and natural resource users often find novel ways of using natural resources to address challenges and improve their livelihoods (Letty & Waters-Bayer, 2010).

Gender and innovation

Women participation in local innovation development and promotion

Figure 8 shows the women participation percentage in local innovation development and promotion process innovated by male innovators. Majority (66.67 %) of the women participation was of 20 to 50 percent followed by less than 20 percent participation (33.33 %).

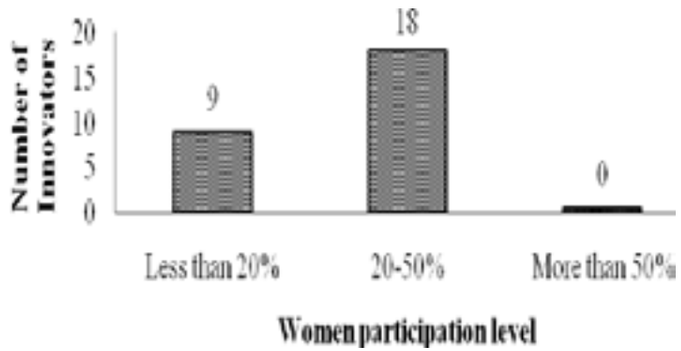

Figure 8. Women participation in local innovation development and promotion
Average women participation %: 19.81
Standard deviation: 9.66

The participation of women ranges from 5-50 percent. They played an often invisible but nevertheless important role in local innovation development and promotion. The less participation may due to some personal conflict and family problems. However, their contribution is rarely recognized at all. The social norms and traditional values of

Nepalese society are still major hindering factors to recognize, accept and promote leadership of women in Nepal (Ghale, 2008).

Women participation by ethnic groups of local innovators

The women participation by ethnic group had slightly positive relationship (r=0.13), i.e., women participation increases with increase in Janajati ethnic group.

Table 3. Distribution of women participation by ethnic groups of local innovators

Ethnic group	Women participation percentage		Total
	<20	20-50	
Brahmin Chhetri (B/C)	4(14.81)	6(22.22)	10(37.04)
Janajati	5(18.52)	12(44.44)	17(62.96)
Total	9(33.33)	18(66.67)	27(100.00)

Socio-economic stigmas acting against the participation of women are especially prevalent among certain ethnic groups and castes; within Nepal, Tibeto-Burmese communities are much more gender-egalitarian than orthodox Hindu Indo-Aryans (Rusten & Gold, 1991).

Women participation by level of education of local innovators

The women participation by level of education had slightly negative relationship (r= -0.18), i.e., women participation decreases with increase in level of education of local innovators.

Table 4. Distribution of women participation by level of education of local innovators.

Education Level	Women Participation Percentage		Total
	<20	20-50	
Literate without formal education	3(11.11)	6(22.22)	9(33.33)
Secondary level education	1(3.70)	10(37.04))	11(40.74))
College level education	5(18.52)	2(7.41))	7(25.93)
Total	9(33.33)	18(66.67)	27(100.00)

Specific personal characteristics

Figure 9 shows the specific personal characteristics of local innovators. Optimistic followed by willing to take risk, high will power, priority to farming agenda and continuous learning attitude were the major specific personal characteristics of local innovators.

Thus, Zigta sees himself as a hard working and forward looking man, and as someone who has been blessed with certain aptitudes. He is known as a man for whom laziness is next to sin. If he is convinced of an idea, no amount of difficulties and hard work will prevent him from trying to realize it. His perseverance and conviction that he is right drive him on, even when others think it is impossible (Zigta & Waters-Bayer, 2001).

Figure 9. Major characteristics of local innovators

Household decision making process

Figure 10 shows the household decision making process of local innovators. Majority of local innovators (60 %) take self decision followed by participatory decision making (30 %) and discussion/idea sharing (10 %).

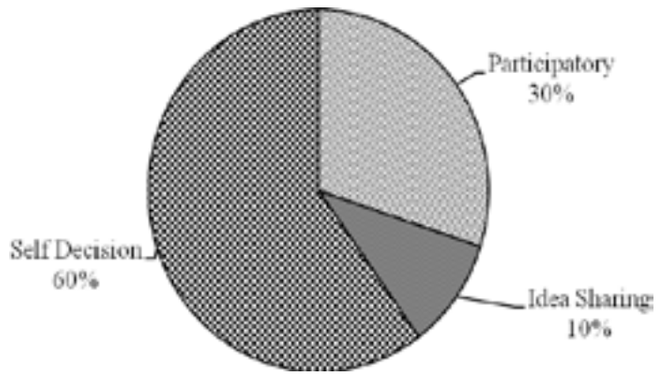

Figure 10. Household decision making process of local innovators.

Sambodo (2007) stated that, farmers' decision rules can be distinguished according to their perceptions and attitudes, to their belief that they have the power to deal with problems and opportunities, as well as to the extent of socio-cultural influences. Ojha (1989) stated that, the joint farming system is common in Nepal; many women are farm partners (joint decision taken, usually with husbands; majority of time spent on farming activities) or female farm workers (active in farming activities, but less decision aking power). It was found that the majority of the local innovators made their decision without consultation with household members. Generally they do not discuss and take advice prior to innovation. A few of them only discuss and share the idea with household members.

Drivers of local innovation

The main drivers that stimulate innovation were family/community problem closely followed by existing unfavorable situation, scarcity, curious habit of the person and personal ego and interest.

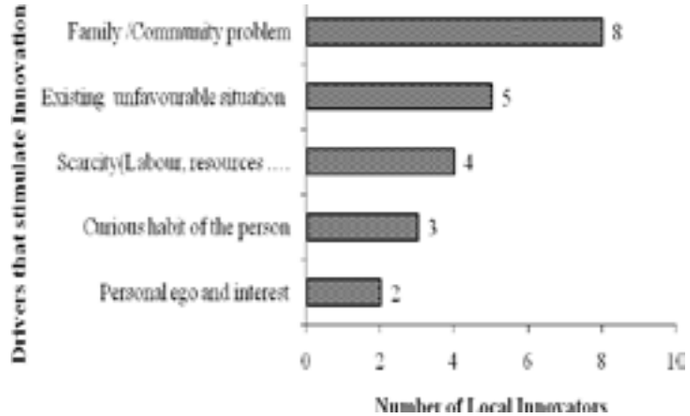

Figure 11. Drivers of local innovation

Drivers of innovation can be political, economic, social and technological. In some cases, crisis brings about a sense of urgency among actors and embodies a driver of change (Rand *et al.,* 2009). According to various sources, innovators tend to be curious, proud and willing to take risks, and they pick up ideas from here and there (CDCS, 1997); they respond to recognition (Gupta, 1998); they have latent skills and enthusiasm (Segeross *et al.,* 1996), and are triggered to innovate by various factors including problem solving and accidental or even playful discoveries (Roling *et al.,* 1997).

Relevance of local innovation

Figure 13 revealed that majority (60 %) of the local innovations were very relevant followed by relevant (40.00 %). None of the innovations was reported as not so relevant.

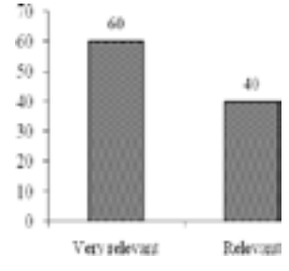

Figure 13. Response of Community towards the relevancy of local innovation

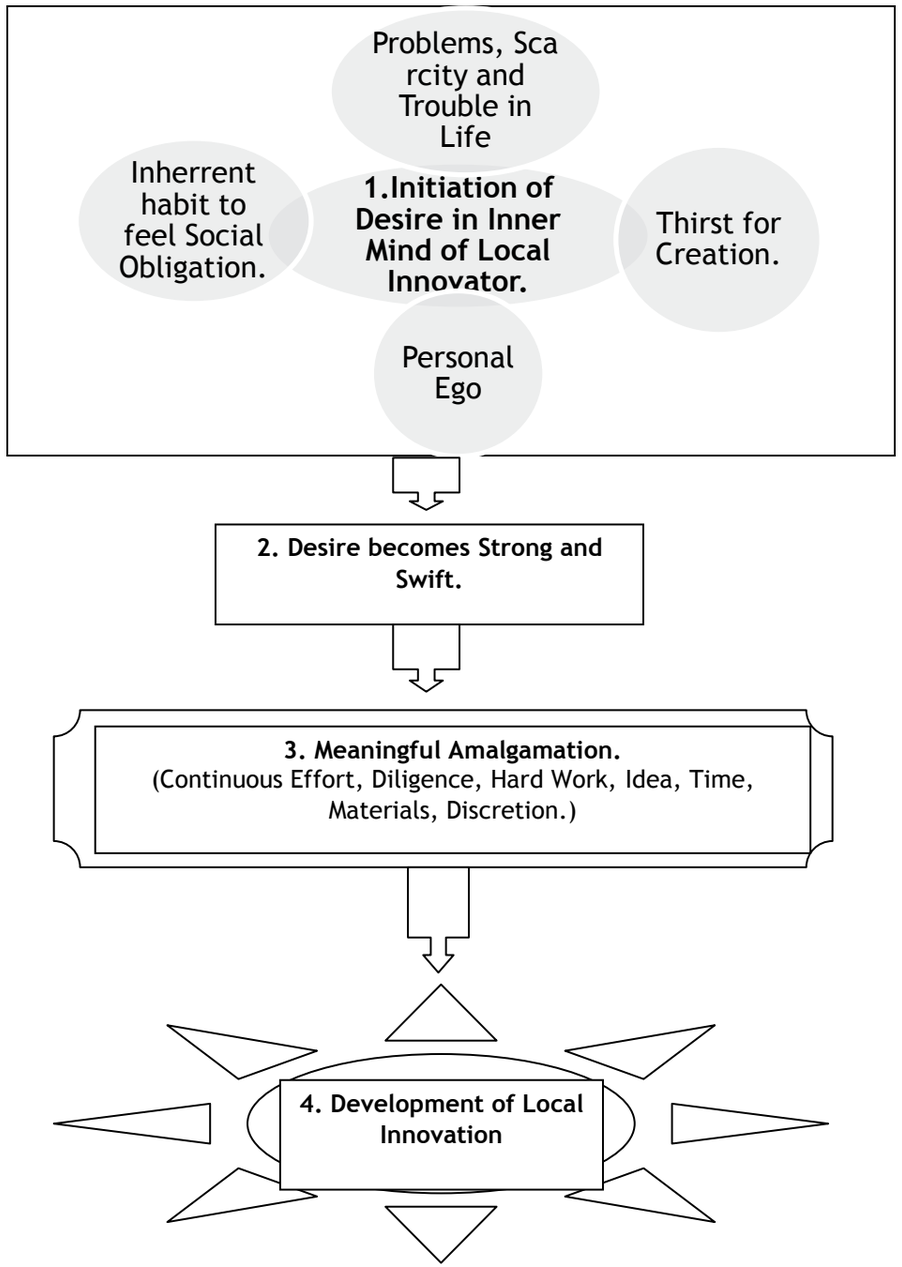

Figure 12. Local Innovation Development Process.

Indigenous innovations can help find the best solutions for local problems. By utilizing the indigenous knowledge and existing resources available, and in turn also generating new employment opportunities, indigenous innovations help foster self confidence and self-respect amongst the community. This eventually leads to economic growth and social change in the community. Therefore the local innovations has higher relevancy in community. Indigenous innovations encourage local self-reliance, decentralization of decision- making and fair access to natural resources. As these solutions emerge from the local context, they will be more likely to be accepted by the community (Mehta & Punekar, 2008). Local innovations and indigenous knowledge systems are far more appropriate to most rural situations than external technologies because they have developed within the given set of circumstances (Letty & van Veldhuizen, 2006).

Factors that reduce innovativeness

The major innovation killers were existing social beliefs, attitude and practices (23.33 %) followed by modern concept and life style (16.67 %), social attachment (13.33 %), extra busy on livelihood maintenance (6.67 %) and lack of networking (6.67 %).

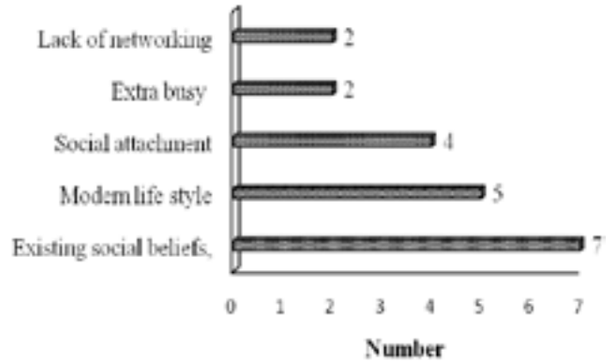

Figure 14. Major inhibiting factors that reduce innovativeness of local innovators.

Figure 14 revealed that the innovativeness of local innovators was affected by several factors in which they operate. The existing social beliefs,attitude and practice, modern concept and life style, social attachment, extra busy on livelihood maintenance and lack of networking are the major inhibiting factors of innovation that reduce innovativeness of local innovators. Innovation at the local level is happening less rapidly that it could, because the key actors are not working closely with each other. If many different actors have the opportunity to bring in their ideas and skills, innovation processes can be speeded up. However, if certain actors – particularly the farmers – feel that their capacities and potential contributions are not being valued by others, they are less likely to want to work together with them, less likely to enter into genuine collaboration. Recognizing the innovativeness of farmers creates fertile ground for their collaboration with other actors in innovation systems (Waters-Bayer et al., 2006). Attitudes and practices are a major obstacle to innovation (World Bank, 2006).

CONCLUSION

The study has been conducted to assess the influencing factors of local innovation in ecological agriculture and natural resource management (EA/NRM) in three different ecological belts; Chitwan in the terai, Sindhupalchowk in the mid hill and Dolakha in the high hill region of the central Nepal. For the collection of primary data, thirty individual local innovators and twelve institutional innovators were identified and interviewed randomly. Semi-structured questionnaires, focus group discussion and participatory rural appraisal were applied. Majority of the local innovators were relatively experienced people of the community having the age group of 41-55 years. The ethnic group Janajati appears to be more innovative ethnic group than B/C. Higher percentages of local innovators were found male. The level of formal education does not appear to be a determining factor with respect to farmer's creativity and propensity to experiment. Majority of the local innovators were medium size household.

Most of the local innovators were rural inhabitants and located in terai region. The important features of local innovations were: solution of existing problems, adoptable to local environment and utilization of local resources. Utilization of local resources, environment friendly, sustainable productivity of the farm, entrepreneurship development and help in livelihood were the major benefits from individual local innovations.

The specific personal characteristics of local innovators were optimistic, willing to take risk, high will power, priority to farming agenda and continuous learning attiitude. Likewise, regarding the household decision making process, most of the local innovators have tendency to take self decision. The main drivers that stimulate innovation were to solve family/community problems, existing unfavorable situation, scarcity, curious habit of the person and personal ego. The common threats to the innovativeness of local innovation were the existing social beliefs, attitude and value system, modern concept and life style, social attachment, busy on livelihood maintenance and lack of networking.

The local community peoples are utilizing their technical and institutional potentialities related to ecological agriculture and NRM and were taking the lead in sharing their success stories and local experimental results to attack on the root cause of rural poverty and multiple challenges (climate change, reduced crop productivity, social beliefs and culture) that helps to accelerate our overall agriculture system towards sustainable advancement.

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Major insect pests and diseases of cucurbits and their management under bio-intensive farming in Udayapur district

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ABSTRACT

The study was carried-out from May to August 2013 on the topic major insect pests and diseases of cucurbits and their management practices under BIFS. Samples of 60 households were taken randomly from Triyuga municipality (Chaukibari and Uttraitole) and Hadiya VDC to identify the crop pests and diseases and their management practices in cucurbits adopted by farmers. Fruit fly and Red Pumpkin beetles were the most important insect of cucurbits except in bitter gourd. Epilachna beetle was found most in the bitter gourd to be attracted mostly by mealy bug. Similarly Powdery mildew and the Downey mildew, Cucurbit Mosaic Virus were the most common diseases. Local farmers were largely aware about the major insect pests of the cucurbitaceous crops. It was found that farmers were aware of the botanical pesticides and its preparation method. Application of the botanical pesticides and other indigenous materials like cattle urine and wood ash were the most common pest management tool adopted by the farmers. A field study using the different traps against fruit flies in pumpkin was conducted in Hadiya, 6. Four treatments with four replications were used in the experiment. The treatments were: a) Cue lure with Malathion (1ml), b) Molasses with Malathion (1ml), c) Pumpkin with Malathion (1ml), and d) last one was untreated control. All the treatments were replicated for 4 times. Among all treatments Cue-lure treatment trapped the maximum number of fruit flies as compared to other treatments. It was found more effective in fruit flies management in the study area.

Key word: Fruit flies, red pumpkin beetle, mealy bug, powdery mildew, pest management,

INTRODUCTION

Cucurbits are warm weather crops which are grown during spring, summer and autumn seasons. Among the vegetables, the cucurbitaceous crops form one of the largest groups with their wide adaptation from arid climates to the humid tropics. In Asia, about 23 edible major and minor cucurbits are grown and consumed. Even with the gradual increase in production and consumption, the production of cucurbits is plagued by the occurrence of diseases and insect pests, inadequate availability of quality seeds, lack of maintenance of genetic varieties and naturally occurring biodiversities, and the lack of knowledge on the international standard of quality production and postharvest handling (Nath and Velu, 2006).

Vegetable producers around the world rely heavily on the use of chemical pesticides to ensure pest control. Although pesticides do not directly contribute to agricultural yields, there is evidence to suggest that intensive use of pesticides has significantly increased agricultural production (Brethour & Weersink, 2001).There is no doubt that the pesticides pose risk to human health, and the environment (Travisi et al., 2006). With the growing trend of commercial vegetable production in Nepal, the use of pesticides on vegetable crops has increased dramatically in recent years (Maharjan et al., 2004). Due to misuse and over use of chemical pesticides, not the economic condition of the farmer is scaling up but many harmful effects on human beings and the environment is being scaled up (Thapa, 2003). Most of the farmers are not aware of the chemical hazards, lack knowledge to the right use of pesticides and safety measures. In the Nepalese context, chemical pesticides are not only hazardous but also highly persistent in nature (Neupane, 2003). They leave long term effects, such as effect in soil, environment, human health, ground water contamination, pesticide resistance, pest resurgence and other ecological impacts but these impacts are being neglected by the farmers (Thapa and G.C., 2000). The major insect pests are Fruit fly, Red pumpkin beetle, Flea beetle, spotted beetle, Green stinky bug; and the major diseases are Bacterial wilt, Downey mildew, Cucumber mosaic virus and Anthracnose etc (Marwaha et al., 1998; Neupane, 2002). Red pumpkin beetle (*Raphidopalpa foveicollis*) is a very destructive pest of cucurbitaceous vegetable crops. Red and blue pumpkin beetles defoliate the cucurbit leaves and can cause severe damage in the early stage of the crop. Two species of fruit flies namely *Bactrocera cucurbitae* and *Bactrocera tauare* are important vegetable pests. Adult flies lay eggs inside the developing fruit or flower and developing larvae cause fruit rotting (Neupane, 2002). Striped cucumber beetle, *Acalymma vittatum* Fab. (Coleoptera: Chrysomelidae) feeds almost exclusively on cucurbits and is considered the most important pest of cucurbits in the United States (Gould, 1944). The spotted cucumber beetle, *Diabroticaundecim punctata howardi* (Barber) (Coleoptera: Chrysomelidae), also known as the southern 8 corn rootworm, has a wide host range of over 200 plants (Radin and Drummond, 1994). Both are particularly damaging to cucurbits in four ways: feeding on seedlings, feeding on roots, damage flower and foliage and transmission of Erwinia tracheiphila E.F.Sm., the pathogen responsible for bacterial wilt (Isley, 1927; and 1929).

According to Pradhan (1977) relative susceptibility of pumpkin (*Cucurbit moschata*), bottlegourd (*Lagenaria siceraria charandita L.*) to *Cucumber luffa cylindrical roem*, bittergourd (*Mimordica charandita L),* cucumber (*Cucumis sativus)* and tomato (*Lycopersicon esculentum* mill) to *Daucus cucurbitae* coq. was studied in the field and laboratory conditions where the fruit fly was most attracted to both the flowers and fruit of pumpkin and bottlegourd. Flea beetle is also one the major insect pests of the cucurbit crops. Flea beetles cause the greatest damage by feeding on cotyledons, stems, and foliage. Some flea beetles are considered general feeders, though many species attack only one plant or closely related kinds of plants (Metcalf and Metcalf, 1993). Nearly 250 species are of economic importance, and are distributed widely in temperate, sub-tropical, and tropical regions of the world (Christenson and Foote, 1960). The extent of losses varies from 30 to 100 percent, depending on the cucurbit species and the season. Fruit infestation by melon fruit fly in bitter gourd has been reported to vary from 41 to 89 percent (Gupta and Verma, 1992). The cucurbit fruit fly has been reported to infest 95 percent of bitter

gourd fruits in Papua New Guinea, and 90 percent in snakegourd and 60 to 87 percent pumpkin fruits in Solomon Islands (Hollingsworth and Allwood, 2002). Fruit flies (*Dacus cucurbitae*) are widely distributed throughout the world. It attacks almost all the members of Cucurbitaceae.

According to Rajbhandari and Gautam, 1998) bio-intensive farming system (BIFS) is an alternative concept and system approach based on holistic system of sustainable management of natural resources in a given agro-ecosystem with specific cultural and knowledge base. As a result of BIFS programme of WOREC the members of farming communities and local Women's Groups (WGs) at Nuwakot have become aware of pesticides that has been helping farming communities to attain high economic and technological self reliance reducing their economic shocks in chemical fertilizer and improved crop varieties (Rajbhandari, 2000). This study was conducted to assess the magnitude of pest occurrence/ damage and farmers' practices of pest management under BIFS in Udayapur district.

MATERIALS AND METHODS

The study was conducted from 15 May to 14 August, 2013. Purposively the study was conducted in the site where BIFS program was implemented for a long time. For this study, Uttraitole Eco-village, Chaukibari Eco-village in Triyuga Municipality, and Hadiya Eco-village in Hadiya VDC were selected. This study consisted of survey and field-based experimentation.

Survey

Twenty households in each location were randomly selected for household survey. Study was based on the primary data collected during the survey and secondary data collected through various published resources. A total of 60 households growing cruciferous vegetables were selected randomly for survey and interviewed with the help of semi-structured questionnaire. Different photographs were used to identify particular pest or disease during interview with the farmers. Field observation was done in various model demonstration farms (MDF) in the study sites.

Experimentation

Pumpkin cultivar, i.e. Rohini was used for and experiment in farmer's field at Hadiya, VDC, ward number 6, Udayapur. The field experiment was done employing Randomized Complete Block Design (RCBD) with four treatments (T1= 1 ml Cue-lure + 1 ml Malathion; T2= 1 ml Molasses + 1 ml Malathion; T3= Half cut pumpkin fruit + 1 ml Malathion and T4= control) and four replications for the fruit fly management on pumpkin with the same growth stages in the same environment. Treatments were installed randomly in each plot after 35 days of planting. Each experiment plot size was 7 sq. m. and altogether there were 16 plots in the field. The pheromone traps, and molasses traps were kept at the height of half meter from soil surface whereas the pumpkin fruit set was kept on the ground level. The traps were recharged every week.

The data were recorded by monitoring and counting the number of fruit flies trapped at plastic bottle and pumpkin set. The first monitoring operation was done after the plants were planted and traps were installed. Data recording was done on weekly basis till 12 weeks. The primary data obtained from household survey were analyzed by using the software SPSS and MS excel.The result obtained from field experimentation was analyzed using Anova under SPSS Package. Post hoc analysis was done using Tukey HSD.

RESULTS AND DISCUSSION

Survey results

Status of damage

According to the respondents most of damages (66.66%) was caused by the insect pests in their field rather than by diseases (28.33%) and both (Figure 1).

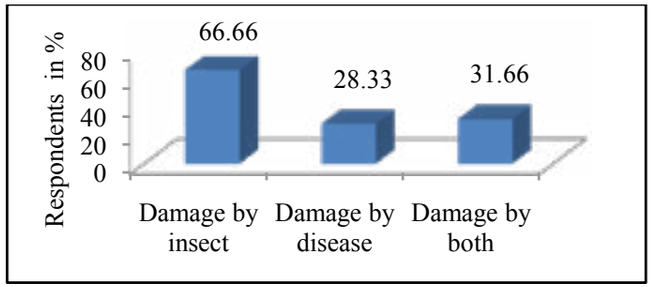

Figure 1. Percentage distribution of damages caused by insect pests, diseases and both

Damage by both insect pests and diseases was 31.66 percent. In the field observation almost all the cucurbitaceous crop plants were found damaged variously by various insect pests (Table 1) and diseases (Table 2).

Major insect pests of cucurbits

Insect pests like Fruit fly, Red pumpkin beetle, spotted beetle, banded blister beetle, Mealy bug, Aphids were more prominent in the cucurbit plants and caused damages from 20 to 100 percent (Table 1). It was observed that more than 50 percent loss or sometimes even more damage of the criciferous fruits was due to pests. Almost all respondents reported that Fruit fly and Red pumpkin beetle caused 100 percent fruit damages mostly in the pumpkin, cucumber and bitter gourd. Stink bug damaged 95 percent of the fruits, and spotted beetle caused more than 88 percent damage. Cut worm and Aphids caused more than 26 percent damages and the other pests like Mealy bug, Soybean hairy caterpillar, Banded blister beetle caused damaged from 20 to 21 percent.

Table 1. Major insect pests of cucurbits identified in the study area
(all pictures were taken by Jyoti K..C. on the field, 2013)

Common name	Scientific name	Percent	Frequency
Fruiit fly 	*Bactrocera cucurbitaceae*	100	60
Red PumpkinBeetle 	*Aulacophora foveicollis*	100	60
Cucurbit stink bug 	*Megymenum brevicorne*	95.00	57
Spotted beetle 	*Epilachna vigintioctopunctata*	88.33	53
Cutworm 	*Agrotis ipsilon*	36.67	22
Aphid 	*Aphiss gossypii*	26. 67	16
Mealy bug 	*Pseudoccoccus sp.*	21.67	13
Soybean hairy caterpillar 	*Spilartctia casignata*	20.00	12
Banded blister beetle 	*Zonabris phalerata*	21.67	13

White grub beetle 	*Phylophaga spp*	15.00	9

Major diseases of cucurbits

Comparing the insect pest damages with diseases in the field, disease damages were less in the study area (Table 2). Powdery mildew (*Sphaerotheca fuliginea)* and Downey mildew (*Pseudoperonospora cubensis)* were the major diseases identified with 60 percent damage. Other diseases with less than 13 percent damages included cucumber mosaic virus (*Cucumber green mottle mosaic virus),* damping off *(Pythium spp)* and root rot *(Fusarium oxysporiium).*

Table 2. Occurrence of major diseases of cucurbits in study sites, 2013

Name of the disease	Scientific name	Percentage	Frequency
Powdery mildew	*Sphaerotheca fuliginea*	100	60
Downey mildew	*Pseudoperonospora cubensis*	100	60
Cucumber mosaic virus	*Cucumber green mottle mosaic virus*	21.78	13
Root rot	*Fusarium oxysporiium*	8.33	5
Damping off	*Pythium spp*	13.33	8

Pest management practices of local farmers

In the focused group discussion farmers informed that they followed traditional farming system (56.66%); therefore trend of use of botanical pesticides, chemical pesticides, mechanical pesticides, and attractant was not so common. Above 43 percent of the farmers used chemical pesticides. Mostly they used Malathion, Endosulfan, and Dichlorovos (nuvan). After involvement in several trainings, farmers applied several approaches like botanical, mechanical, as well as attractants for insect pest management. Usually botanical pesticides were prepared by using locally available plant resources mixing with cattle urine. Further dilution with water was done with different ratios- usually 1:4. Botanical pesticide preparation and usage varied with different farmers. In the mechanical method, farmers used to do hand picking, pruning, burning of debris- mostly in vegetable crops. Above 81 percent of respondent farmers used botanical pesticides for pest management (Figure 2).

In FGDs, they reported that they did not use any chemical pesticides in vegetables but some of them used chemical pesticides in the rice field if the pest occurrence was high (above 30%). Some of the farmers used attractant pheromone trap (methyl eugenol) to manage fruit fly in pumpkins.

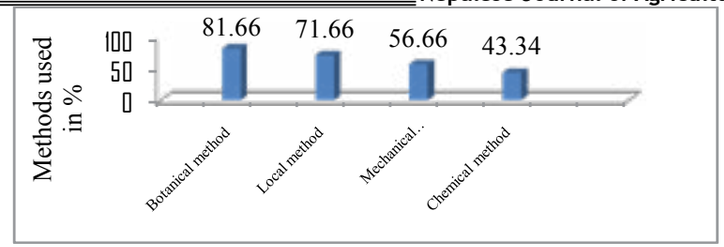

Figure 2. Methods applied for pest management

Effect of botanical pesticides on cucurbits pest management

The study found that people used different methods where majority of the respondents used botanicals for the pest management. They used different resources like wood ash in garlic and onion; alkaline (soap) water, cattle urine for the aphids. More than 81 percent farmers prepared and used botanical pesticides for the insect pest and disease management.

Farmer's experiences on the effect of botanical pesticides showed that botanical pesticides worked as the repellent. Fifty seven percent of the respondents reported that there was reduction in the insect pest occurrence while 34 percent of the respondents reported that there was not substantial change in pest (fruit fly) occurrence (Figure 5). Nine percent of the respondents did not use botanical pesticides as they were unaware about its benefits. Responding to the reasons why they were not using it they told that prepring botanical pesticides required more time; and they could not manage with their time.

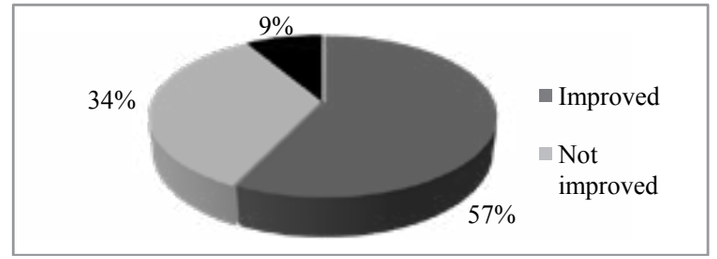

Figure 3. Effect of botanical pesticides on cucurbits pest management

Botanicals and indigenous materials used by farmers

The rural community has been using different botanical pesticides to manage insect pests. It has been found there are 324 plant species available in Nepal having pesticide properties (Neupane, 2000). From the focused group discussion, plants that were used by farmers in the study sites having the pesticides property are given below with the plant parts used (Table 3). Farming community preferred those botanicals as they were readily available around the surroundings. Preparation method of botanical pesticide cum fertilizer by local farmers is summarized in Table 4.

Table 3. List of commonly used resources for the botanical treatments

S.N	List of the natural plant resource used for treatments			
	Nepali name	English name	Scientific name	Parts used
1	Neem	Neem	*Azadirachta indica*	Leaf
2	Surti	Tobacco	*Nicotina tabaccum*	Leaf, seed
3	Bojho	Sweet flag	*Acoras calamus*	Rhizome
4	Titepati	Mugwort	*Artemisia spp*	Leaves
5	Asuro	Malabur nut	*Justicia adhatoda*	Leaves
6	Banmara	Micania micrantha	*Ageratina adenophora*	Leaves,Stem,
7	Bakaino	Chinaberry	*Melia azadarch*	Leaves, seeds
8	Khursani	Chilli	*Capsicum annum*	Fruits
9	Timur	Nepali pepper	*Xanthoxylum spp*	Fruits
10	Sisnu	Stinging neetle	*Urtia dioca*	Leaves, stem
11	Mewa	Papaya	*Carica pupaya*	Leaf fruits
12	Sayapatri	Marigold	*Tagettes spp*	Flower
13	Sajiwan	Physic nut	*Jatropha curcus*	Seed,leaf,stem
14	Tulsi	Tulsi	*Ocimum sanctum*	Leaf
15	Kapoor	Camphor	*Cinnamomum camphora*	Leaf

Pheromone traps

Pheromone traps are powerful chemical attractants emitted by female insects. These chemicals are detected by the males, assisting them in locating unfertilized females for mating. Pheromones of many species have been identified and are synthetically produced for use in insect pest management programs. It is the tool which is eco-friendly and is more efficient as it does not harm other organism and the environment. According to the respondents in the FGDs almost all the farmers had used pheromone in the previous season because they were supported by the organizations (WOREC and DADO). They also shared that it worked better for the fruit fly trap and wanted to install but due to high cost, unavailability and sensitivity to bad weather they were unable to install. However, 25 percent of the respondents were still using the pheromone that was provided by organisations.

Table 4. Preparation methods of some common botanical pesticides by farmers

Botanicals/Materials used	Preparation method
Neem,Sisno,Cow urine	Neem leaf (water soaked for 24 hr) and dilute @1:4 in water
	Sisnoo (soaked in cattle urine whole night) and dilute @1:8 in water
Tobacco, Neem, Cow urine, Wood ash	Tobacco leaf (soaked in water whole night) and dilute @1:4 in water
	Neem powder paste and seed powder (soaked in water for 24 hr and dilute @1:8 in water)
	Cow urine +Water (dilute 1:4)
Geetimal	Neem leaf + Asuro + Banmara + Bakaino + Sisnoo + garlic soaked in cattle urine for 20 days to get degraded then the dilute sprayed by farmers with various ratios 1:3,1:4,1:5. Mostly used dilution ratio with water was 1:3 mostly this were used for the red pumpkin beetle and aphids

Results of field experiment

These days, economic yield of cucurbitaceous crops are greatly in danger by numerous insect pests, among them fruit fly is considered as most problematic insect pest in pumpkin and cucumber. The main objective of this study on fruit fly is establishing which control method is effective and getting the information to farmers who can use it a primary concern. Fruit fly were ranked by farmers as their common and destructive pest problem perhaps it damage in the flowering to fruiting stage, reduce quality and quantity in yield in cucurbits in Udayapur including cucumber pumpkin and mango fruits. Fruit fly feeds on the cucurbit by damaging fruits and foliage.

The mean number of fruit fly trapped in cue-lure, molasses and the cut pumpkin trap were found 209, 63 and 35.50, respectively (Table 5). The highest number of fruit fly trapping was found more in cue lure than the other two treatments molasses and number of male fruit flies trapped found respectively in cue lure but both male and female were found attract comparing in other two treatments. In the molasses treatment there were on an average 63 fruit fly and in the cut pumpkin set there were lesser number (35.5) of fruit fly trapped. The stage of mid flowering to start of fruit setting both male n female fruit flies seemed more active. Female fruit flies prefer to lay egg in unopened flowers and tender fruits. On the comparison of the mean, the result shows that cue-lure has greater efficiency to control and monitoring of the fruit flies than that of the molasses and pumpkin set. But molasses were found effective in controlling the both male and female fruit flies where as the pumpkin set got least effective rather than others because effectiveness of malathion last over only 2-3 days. In fact the pumpkin set gets dry and shrimp in and less number of fruit flies were attracted.

Table 5. Effectiveness of different treatments for the management of fruit flies in Hadiya 6, Udayapur, 2013

Treatment	Mean ± SE
Pheromone	209±15.26
Molasses	63±3.37
Pumpkin	35.50±4.19
One way ANOVA (between groups)	
F value	100.244**
Tukey HSD	
Pheromone and molasses	146.50**
Pheromone and pumpkin	174.00**
Molasses and pumpkin	ns
** p value < 0.000 level of significance, ns = non significant	

CONCLUSION

There were many insect pests of cucurbits as Fruit flies, Red pumpkin beetle, Bug and diseases like Powdery mildew, Downey mildew. On Fruit flies farmers are facing great challenge to manage them. Maximum farmers of BIFS practiced eco friendly technique by using the indigenous natural botanical resources that were found around the surroundings for the management of the insect pest as we all know that there are variety of control method of cucurbit insect pest and diseases but after this study it was found that maximum number of farmers were more aware of the impact of chemical pesticides and were replacing with the use of botanical pesticides moving toward BIFS to ensure the higher crop yield.

The field experiment revealed that the sex pheromone, cue lure trap is relatively more effective and successful in trapping the number of fruit flies, managing the highest number of fruit flies without any harmful effects to the environment and human health.

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Growth, yield formation, fruit quality and economics of tomato production under IPM package vs. conventional practice in Surkhet district

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ABSTRACT

The present study was conducted in four locations of Surkhet district viz. Chhinchu-7, Sanoharre, Mehalkuna-6, Satmule, Dasaratpur-4, Goramare, Sahare-5, Baghkhor and Gadhi -5 and 6, Baelkada from June to September 2014. The experiment had two treatments viz. IPM practice and Farmer's conventional practice. Data on plant growth and yield were recorded every week. Higher plant height was observed in the IPM practice in each week (91.04 cm on 45 Days after transplanting which was in increasing trend. The plants subjected to IPM practice showed early flowering (average 27 DAT) and fruiting (7 DAF). Number of fruit per cluster was found to be higher in IPM practice field (n=8.6) as compare of Farmers practice field (n=7). Sample weight of the fruit collected from IPM practice was found higher (49.54 g) as compared to Farmer's practice (43.07g). Organoleptic test revealed that tomato fruits obtained from IPM practice were tastier than those from Farmer's practice and the ripen fruit from IPM practice had attractive color dark red than that of dull yellow color fruits produced in the Farmer's practice. On an average B:C ratio of IPM was found higher (1.67) than that of conventional practices (1.2). On an average per unit cost of cultivation of tomato in IPM practice was found less as compared to conventional practice. Analysis of gross return showed that it was higher in IPM practice (33%) than in conventional practice.

Key Words: Organoleptic test, *Trichoderma viride, Pseudomonas fluorescens, Metarhizium ssp, Bacillus thuringensis,* Sex Pheromone Traps

INTRODUCTION

Tomato (*Lycopersicon esculentum L.*) is one of the major commercial vegetable crops which is widely grown both in the plains and hills of Nepal. In the hills, tomato has been produced successfully in two growing seasons: spring and rainy. Rainy season tomato production is quite remunerative to the hill farmers as the supply from Terai is constrained due to high temperature, low fruit set, flowering and wilt. At present tomato ranks third, next to potato and sweet potatoes in terms of global vegetable production (FAO, 2002). Tomato is the major income generating vegetable in Nepal in terms of production and cultivated area. Tomato is one of the most important vegetable crops grown in Nepal and occupies more than 10,000 ha with an average production of 72,000 tones (Shrestha and Ghimire, 1996). The cultivation of this crop is very popular at an altitude of 1000-1800 m above mean sea level. As a measure for plant protection in

Nepal, pesticide has becoming one of the important weapons for several years. In this course, over use, mis-use and haphazard use which have been creating numerous problems for living beings including environment. Pesticide problems have been reported to in many non-target organisms such as fishes, wild life, natural enemies, and residue has been detected in food grains, fresh vegetables and milk. Pesticide misuse and overuse causes harmful effects on non-target organisms and adding extra burden to Nepalese society in terms of pesticide related health expenses, environment pollution, crop losses due to pest resurgence and spending extra costs both to farmer and country as whole (Thapa, 2003). Because of this situation, chemical pesticides are seen one of the important culprits for environmental mishaps and their uses has been viewed very suspiciously. Despite of the bitter reality of the hazards associated with the pesticides in Nepal, there is not much use of active ingredients (a.i.) as compared to other Asian countries on the per hectare basis. Until now, it has been reportedly mentioned that, Nepal consumes on an average 142 g/ha of pesticides. However, the application of pesticides in cotton (2560 g/ha), tea (2100 g/ha) and vegetables (1400g/ha) appears excessive and without the consideration of applicators (farmers) and consumers. In this scenario, the concerned stakeholders have to play a very proactive role in their judicious uses through various means. The increasing focus Integrated Pest management has to be supported with the development of alternative means of pest control, which could be utilization of botanical and bio-pesticides as well as the use of indigenous knowledge and technology (IKT) of the farmers. Brenner (1991) has pointed out the benefits from IPM quantifying the costs of pesticide treatment and crop losses due to pests for 40 major U.S. agricultural crops. Dr. David Pimentel and his associates at Cornell University examined U.S. Department of agriculture (USDA) data on current crop losses, reviewed crop loss data from experiments and consulted pest control specialists. By implementing available biological, cultural and environmental pest control strategies, Pimentel concluded that the use of insecticides, fungicides and herbicides could be reduced by 50 percent without reduction in yield. The additional cost of alternative controls ranged from a reduction of US $ 10 per hectare to an increase of US $ 15 per hectare (Brenner, 1991). IPM increased the crop yield while reducing the input costs (e.g. through reduction in the quantity of less hazardous pesticide use), provides additional income to farmers. It is more than just managing pests. Growing a healthy crop is an important factor in reducing pest attack. Use of pest resistant crop varieties, quality seedling, fertilizer management and plant spacing all have effect on pest attack. IPM is considered a proven tool for increasing food production and thus food security, whilst preserving the environment (Parasar *et al.,* 1999). This study was conducted to assess impact of IPM package on the growth, yield and quality of tomato and economic analysis in Surkhet district.

MATERIALS AND METHODS

Five VDCs namely Chhinchu-3, Sanoharre; Mehalkuna-6, Saatmule; Dasaratpur-4, Goramare; Sahare-5, Baghkhor; and Gadhi-5 and 6, Bayelkanda of Surkhet Districtwere selected for this study. The experiment was laid out as RCBD with 6 replications in each location (5). Thus the total number of replication was 30. Two treatments with various components were used in this study (Table 1). The field was prepared as per requirement for commercial tomato production. In Sanoharre, tomatoes were grown under plastic

house and rest of other locations, tomatoes were grown in open field conditions. In the IPM practice, compost, bio fertilizers: Neturiya @300 kg/ha, Agri- Zinc @10 kg/ha were used. Similarly, Bio-pesticide: *Trichoderma*, *Metarhizium* and *Pseudomonas* @5g/lit water were drenched at the time of transplanting but in the treatment Farmer's practice only compost was used.

Table 1. Treatments and their components

S.N.	Treatment 1(IPM Package)	Treatment 2 (Farmer's Practice)
1	Bio-Fertilizers: Compost, Neturia etc.(Nursery and Main Field)	Chemical Fertilizers, Compost
2	Bio-Pesticides: *Trichoderma viride, Pseudomonas fluorescens, Metarhizium ssp, Bacillus thuringensis*. (Nursery and Main Field)	Chemical Pesticides
3	Use of Nylon Net, Plastic Tray with coco pit (Nursery)	-
4	Yellow sticky traps, Delta tarp, Sex Pheromone Traps: Heli Lure, Spodo Lure etc.(Main Field)	-
5	Rouging Virus infected plants. (Nursery and Main Field)	

In this study hybrid variety Srijana was used. Tomato seeds were sown in the plastic tray with the media (coco peat + compost) with 10 g *Trichoderma*, *Metarhizium* and *Pseudomonas* in the IPM practice while seed were sown in well prepared nursery with compost in farmers practice. Seedlings were transplanted at the spacing of 60 cm× 45 cm in well prepared field in both treatments. The experimental plots of equal size (50 meter square) were prepared and 10 plants per plot were randomly selected for each treatment. The observations and measurements in respect to plant height (cm), days of 50% flowering, days of 50% fruiting, Number of cluster per plant, fruit weight (g), yield per plant and plot were recorded in the field. Yield per hectare was computed from the yield per plot. The observations on fruit colour were recorded at the time of harvesting. After each harvest, the individual fruit color was recorded and then ranked based on the varietal color. Organoleptic test was conducted after harvesting. After harvest, 5 tomatoes from T1 and 5 tomatoes from T2 were given to 30 people and their views were recorded for further analysis.

Cost Benefit analysis was done after calculating the total cost and gross return from tomato production. Total variable costs and total fixed costs were considered in total cost of production. The value of return from the tomato cultivation was calculated based on the direct use value of tomato fruits and by products accrued at the local level. The benefit-cost analysis was carried out by using following formula.

$$B/C \quad ratio \quad = \quad \frac{Total \quad return}{Total \quad \cos t}$$

Gross return = Price per unit of the produced crop X Total quantity produced by adoption of respective practices

Total cost=Total variable cost + Total fixed cost

RESULTS AND DISCUSSION

Plant growth

The average plant height of the tomato plant was higher in the IPM practice as compared to the Farmer practice (Figure 1). It should be noted that the plant height in both treatments increased with time (1st week to 6th week after transplantation). But plant height in Farmer's practice lagged behind the IPM practice after 1st week.

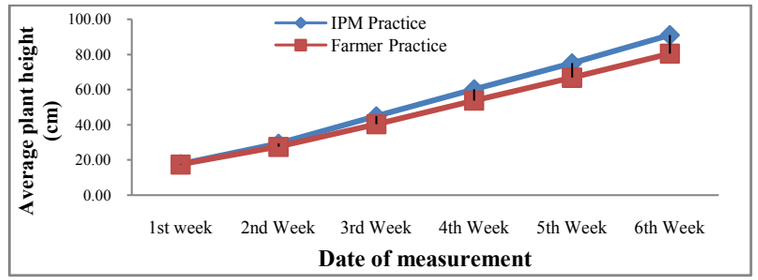

Figure 1. Dynamics of tomato plant height (cm) in each treatment

Yield formation

Yield formation in crop plants is a complex eco-physiological phenomenon determined by genotype, environment and their interactions (Rajbhandari, 1988). Impact of these interactions and factors is reflected in the yield attributing traits. In this study, attempt is made to measure and analyse such yield attributing traits as number of fruits per cluster and sample fruit weight. Phenological phages (flowering, fruiting and maturity) were relatively late in the farmers practice than the IPM practice (Table 2).

Table 2. Phenology of tomato in IPM and farmers practice

Treatments	50% flowering	50% fruiting	1st harvesting
IPM Practice	27 $\pm$ 0.58	34$\pm$ 0.62	56 $\pm$ 1.03
Farmer's Practice	29 $\pm$ 0.82	37 $\pm$ 0.91	60 $\pm$ 1.07

The average fruit per cluster in IPM practice was 8.6 where as in the farmer's practice that was 7.The result showing the higher number of the tomato fruits per cluster in the IPM may be due to higher number of the flowers, fertility percent and early flowering in IPM field. Other reasons may be the effect of the good growing condition of soil, effect of bio-fertilizer, bio-pesticide, essential amount of micro nutrient and lesser competition with pest. Because all of factors absent in farmer's practice.

The sample weight of the tomato fruits obtained from the IPM field differed significantly that obtained from the Farmers field. In reference with Table 4, the sample weight of the

fruit cultivated in the IPM practice was 49.50 g where as that in the farmer's practice it was 43.07 g.

Table 3. Average number of fruits per cluster in different location

Treatments	Mean ±SE
IPM Practice (T1)	8.6 ± 0.22
Farmer's Practice (T2)	7 ± 0.31

Table 4. Average weight of tomato per treatment

Treatments	Fruit wight Mean± SE	
	kg/plot	kg/ha
IPM practice (T1)	183.6 ± 14.40	36,720 ± 2,880.89
Farmer's practice (T2)	150.6 ± 13.98	30,120 ± 2,795.44

Table 5. Yield of tomato per plot and hectare in each treatments and location (kg)

Treatments	Mean ±SE
IPM practice (T1)	49.54 ± 2.02
Farmer's practice (T2)	43.07 ± 1.77

Tomato fruit quality

30 respondents participated in the quality test of tomato grown under IPM Practice and Farmers practice. Eighty percent of the respondents reported that tomato from IPM field were more tasty than those from conventional fields. Rest of the respondents (20 percent) remarks that tomato from IPM and farmer's fields were almost similar in taste. In the visual assessment of tomato color at ripening stage, tomatoes from IPM practice had attractive dark colour characteristic to the variety than tomatoes from Farmer's practice had dull yellowish red colour.

Economic analysis

Both the variable and fixed cost incurred to produce tomato was considered as the cost of cultivation. Cost of cultivation includes the cost of inputs (seed, fertilizers, manures, irrigation, pesticides, and insecticides); machineries and labors used from land preparation to harvesting of the crop. On an average total cost of production of tomato by adopting IPM was found NRs 9,53,600 per hectare and by adopting Farmer's practice it was found to the NRs 10,25,2000 per hectare(Table 6). Thus, the study revealed that IPM practice had saved cost of cultivation NRs 71,600 per hectare.

The gross return is the monetary value of total product. The study revealed that on an average the return from tomato cultivation by adopting IPM practices was higher (NRs 15,91,240 per ha)than Farmers practice (NRs 13,00,760 per ha) (Table 7).

Table 6. Cost of cultivation of IPM and conventional practices

Cost of cultivation (NRs) per hectare		
Treatments	IPM Practice	Farmers practice
Average	953600 ± 54888.12	1025200 ± 57476.73

Probably, it may be due to higher yield and less cost of cultivation in IPM practice. The yield in Farmers practice was observed lower than IPM practices, which was probably due to better cultivation practices, nutrients and pest management inputs used in IPM practices.

Table 7. Return of IPM and conventional practices

Returns(NRS) per hectare			
Treatments	IPM Practice	Farmers practice	Additional (%) return
Average	1591240 ± 72019.31	1300760 ± 76183.70	22 ± 1.70

Conclusively, return was found higher (22 percent) in IPM practice than the Farmers practice across the study sites. The study revealed that on an average B/C ratio was higher in the IPM practice (1.67) as compared to the conventional practices of tomato (1.27) (Table 8). Thus by adopting IPM technology conventional farmers can make additional recovery of 22 percent.

Table 8. B/C ratio (NRs/ha) of IPM and conventional practices

Treatments	IPM practice	Farmer's practice
Average	1.67 ± 0.05	1.27 ± 0.03

CONCLUSION

IPM is an important approach to save cost of cultivation, increase yield, minimize hazard to health and environment. Therefore it is gaining popularity among farmers in Surkhet district. This study analyzing growth, development and yield performance of tomato (Cv. Srijana) in the IPM and farmer's conventional practices revealed differences between these practice in terms of phenology, growth parameters, yield attributing character, yield, quality and economic returns in favour of IPM.

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Practices of vegetables production under poly-house condition: perceptions of farmers of Bhaktapur district

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ABSTRACT

Ahousehold survey was carried out during 5th June – 7th July 2013 A.D to assess the practices of the vegetable production under poly-house in Bhaktapur district of Nepal. Altogether 100 farmers were randomly but purposively selected from Mdhyapur Thimi Municipality, Duwakot and Bageshwori VDCs of the district for interview. The average size of the poly-house for vegetable cultivation was found to be 180 m^3 (15.73 m × 4.81 m × 2.38 m). Different verities, transplanting time, spacing, and plastic types as used by farmer of study sites were noted along with irrigation methods and water resources. Reconstruction of structure and replacement of plastics were performed almost every 2 years. Major advantages and disadvantages were ranked by index values. The impact on yield (73%), easier weed management (73%) and easy to perform intercultural operations (66%) were perceived by farmers as positive impact of plastic cover. However, farmers also reported difficulties in insect pest management (59 %) and soil fertility maintenance (47%) under poly-house condition. Technological packages, specific trainings and entrepreneurships activities need to be developed and exercised for further promotion of vegetables farming.

Key Words: Varieties, Capsicum, Cauliflower, Cucumber, Tomato, weed management, pest management

INTRODUCTION

Being rich in agro-biodiversity and agro-climatic variation the country has great opportunities to produce different crops round the year. Among different crop species vegetable crops have vital role not only in food and nutritional security but also in cash generation for livelihood improvement of the rural people. As the population of the nation is increasing rapidly, challenges for ensuring nutritional and food security in forthcoming future looks more serious. In this context, commercial vegetable production with scientific technique could be an important tool to contribute for both food and nutritional security as well as for employment and income generation. Similarly, vegetable crops have an important role in national economy. According to Ministry of Agricultural Development (MoAD), 2013; vegetable crops contributed 3.45 percent to National GDP and 9.71 percent to agricultural GDP of the country in 2011/12. Potato, tomato, cauliflower, leafy vegetables, capsicum, onion, carrot, radish and cucurbits are major vegetable crops cultivated in Nepal. The total production of vegetable crops in 2011/12 was 3298816 Mt from 245037 ha of land with an average yield of 13463 Kg per ha (AICC, 2013). Nepal could not meet vegetables requirement of the nation from the existing production system due to climatic adversities and insufficient inputs; and thus, seeking alternative ways for year round production of vegetables. Recently, vegetable

production under plastic cover has emerged as optional technique to produce vegetables even in adverse climatic conditions; and is gaining popularity among small farmers not only in rural but also in urban and peri-urban areas of the country. Production of vegetables under poly-house in different districts of Nepal has shown that certain vegetable crops can be grown round the year to produce uniform and high quality vegetables. Productivity of such vegetables is also higher under poly-house than on open field condition. Polyhouse technology can be adapted from Terai to mountain regions to modify the environment, but its structure should be different based on the season and altitude of the particular location (Regmi, 2005). Most of the poly-house technologies are developed for the production of fresh tomato and other vegetable crops in mid hills (1000-1400 masl) of the country. It is reported that poly-house technology enables various crops to mature 5 to 20 days earlier than normal, increases the yield by 30 to 50 percent and increases output value by 40 to 50percent. It also prolongs harvesting period of vegetables by 40 to 60 days. Furthermore, it helps to keep down weeds and protects the fruits from rot (Hessayan, 1991). It has positive effect on mangiing diseases, insects, weeds, soil moisture etc. The use of poly-house in tomato and cucumber production in the hills of Nepal has become imperative particularly for production of vegetables in commercial scale (Budhathoki *et a*l, 2004). Most of the poly-house technologies are developed for the production of fresh tomato and other vegetable crops in mid hills (1000-1400 masl) of the country. Considering these aspects, this study was undertaken to assess the perceptions of farmers toward practices of vegetable production under poly-house condition in Bhaktapur district of Nepal.

MATERIALS AND METHODS

This study was conducted during May – July, 2013. Two VDCs: Duwakot and Bageshwori; and one municipality- Madhyapur Thimi - of Bhaktapur District of Nepal were selected purposively for this study. Vegetable producers under plastic cover were the target population for this study. Primary data were collected through household survey with semi-structured pretested questionnaire among randomly selected 100 respondents (30 from Madhyapur Thimi municipality, 35 respondents from Duwakot VDC and 35 respondents from Bageshwori VDC). A focus group discussion with a checklist was conducted by assembling 11 experienced farmers, recognized by local Farmers' Group and DADO, Bhaktapur. Descriptive statistics like mean, percentage and frequency were analyzed with the help of Microsoft Excel 2007. Scaling technique developed by Miah (1993) was used to determine intensity of advantages and disadvantages of poly-house as perceived by the farmers.

RESULTS AND DISCUSSION

Uses of poly-house for growing vegetables

Size of plastic cover

Average size of plastic cover was calculated by assessing average length, width and height of plastic cover. On an average the size of the plastic cover was found 180 m^3 (15.73 m × 4.81 m × 2.38 m). But the size was varying from place to place due to

availability of space, shape and size of land area used for vegetable cultivation and also due to economic conditions of farmers. The average size of plastic cover was found 173.67 m^3 in Bageshwori VDC and (165.02 m^3) in Madhyapur Thimi Municipality.

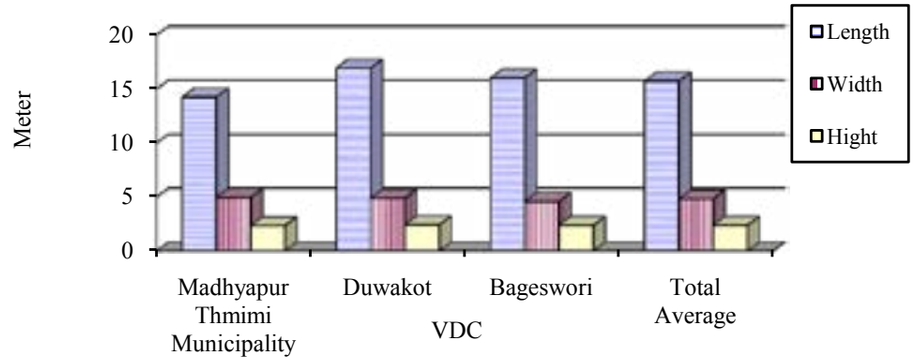

Figure 1 Size of plastic cover in m^3 by VDC/ Municipality

Activities poly-house

Almost all farmers performed weeding, top dressing with nitrogenous fertilizers, pruning, irrigation, and replacement of plastics. Whereas the farmers performing reconstruction of plastic cover, application of insecticides and fungicide regularly was found slightly lower. In case of reconstruction of plastic cover, insecticide and fungicide application; only 1 %, about 2 % and only about 6 % farmers respectively were found not performed reconstruction of plastic cover, insecticides and fungicides application regularly under plastic cover. The percentage of farmers who practiced pinching, application of micro nutrients and use of hormones were 88 %, 86 % and 80 %, respectively. Farmers who measured temperature inside the plastic cover regularly were quite low (2 %) as compared to that of other activities.

Type of plastic used

Mainly two types of plastic polythene and Silpaulin were used by farmers for construction of plastic cover.

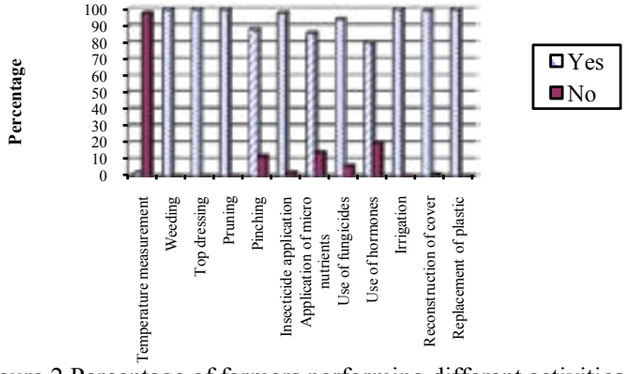

Figure 2 Percentage of farmers performing different activities

Among 100 respondents' farmers, 54 % used polythene and 46 % used Silpaulin. The preferences to polythene could be its lower cost but those who had information on government subsidies on expensive Silpaulin have used it.

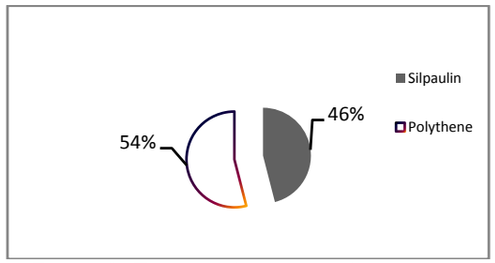

Figure 3. Type of plastic used by farmers

Replacement of plastic

Average year for replacement of plastic was calculated and it was found 1.86 years. However, the duration of plastic replacement depend on the type and quality of plastics used.

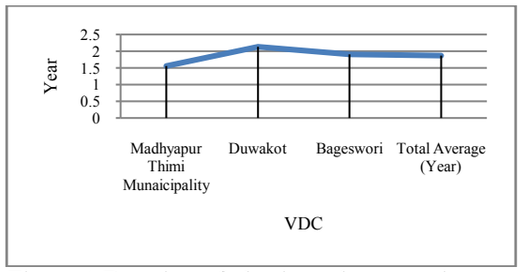

Figure 4 Duration of plastic replacement in year

Perceptions of Farmers towards Plastic cover

Impact of plastic cover

Among 100 respondents 73 percent perceived that plastic cover has positive impact there by increasing the yield. But, 18 % of the farmers found no change in production level in open field condition. Some (9%) farmers found a decreased yield under plastic cover which might be due to lack of appropriate techniques inputs and management factors used in plastic cover. Respondent farmers (73 %) said it was easy to manage weeds while 66% farmers felt the intercultural operations were easy under plastic cover but some (22%) experienced difficulties (Table1). Analysis of perceptions of farmers regarding advantages of vegetable production under plastic cover (Table1) shows that easy technique for off season vegetable production, increasing in production, helps to increase income during off season, easy to cultivate vegetable under plastic cover and easy to cultivate vegetable production often adverse climatic condition are the most important advantages of vegetable farming under plastic cover across the study sites.

Table 1. Perceptions of farmers on impact of plastic cover (%)

Impact of plastic cover	Increasing/Easy	Normal	Decreasing/Difficulties
Production	73	18	9
Soil fertility maintenance	23	30	47
Insect pest and disease management	33	8	59
Weed management	73	5	22
Intercultural operations	66	12	22

Easy technique for off season vegetable production was the first most advantage of plastic cover. However, farmers of the study sites were perceived that plastic cover is easier for organic farming as the least advantages.

Table 2. Advantages of plastic cover perceived by farmers

Advantages	Index	Rank
Increasing in production	0.518	II
Easy techniques for off season production	0.523	I
Helps to increase income during off season	0.251	III
Easier for organic farming	0.123	IX
Suitable for farmers having small land holding	0.156	VIII
Easier management of insects and disease	0.170	VII
Increased productivity than open field farming	0.174	VI
Easy to cultivate vegetables round the year	0.184	IV
Easy to cultivate vegetable crops often adverse climatic condition	0.183	V

However difficult to manage soil fertility was perceived as the most serious disadvantage of the plastic cover (Table 2) farmers also found higher occurrence of diseases under plastic cover followed by marketing of producers.

Table 3. Disadvantages of vegetable farming under plastic cover perceived by farmers

Disadvantages	Index	Rank
Higher infestation of weeds	0.170	VIII
Difficult to manage soil fertility	0.436	I
Difficult to prepare field	0.186	V
Initial cost of vegetable production may increase	0.208	IV
Higher occurrence of disease	0.277	II
More labor required	0.171	VII
Difficult to construct plastic cover	0.178	VI
Marketing problem	0.226	III
Difficulties to select vegetable crops for cultivation under plastic cover	0.139	IX

Hence, it can be said that both the advantage (Table 2) and disadvantage (Table 3) must be considered as perceived by the farmers of study areas.

CONCLUSION AND SUGGESTIONS

Vegetable cultivation under plastic cover is an important alternative technique for year round production of vegetables which is gaining popularity among the farmers of the Bhaktapur, Nepal. Plastic cover not only provides opportunity for vegetable production but also creates avenue to fetch higher cash returns during off-season there by helping in livelihood improvement of the rural people. Tomato, cauliflower, cucumber and capsicum were four major vegetable crops cultivated under plastic cover in this district and tomato occupied large share under plastic cover. Plastic cover technology is of recant one which started only about 11.12 years ago and gaining popularity in short period. In spites of being an effective and efficient tool for higher production more net returns, the concerned agencies should provide scientific knowledge and trainings to the farmers to manage technical, managerial and entrepreneurship parts of vegetable farming under plastic cover so as to promote and expand this technology within and outside Bhaktapur district.

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Indicators of agricultural and socio-economic transformations in promising eco-villages in Dang

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ABSTRACT

Eco-village addresses the social, cultural, ecological and techno-economic discrepancies and instabilities through sustainable community based structures, practices and concepts from holistic right based perspectives. This study was conducted in Dang district during June to September 2014 to assess the changes in the livelihood of local people in Paddha, Urahari and Hekuli villages undergoing transformation. A total of 90 households were selected for the study from three eco-villages namely: Paddha, Urahari and Hekuli. Random sampling method was followed for selecting samples from the study areas. In all three eco-villages most of the people were Janjaati. About 81 percent of respondents spoke Chaudhari (Tharu). Out of total respondents 93 percent of the respondents were literate with 58 percent and 31 percent of the respondents having primary and secondary level education respectively. Only 3 percent of the respondents had higher secondary level education and 1 percent of the respondents had university level education. It was found that 90 percent of the respondents were engaged in agriculture. Rests of the respondents were engaged in wages, foreign employment and in other services. The major changes of eco-village in the study areas were awareness of sanitation and hygiene in the eco-village, construction of improved shed, use of improved cooking stove, involvement in groups, use of energy sources (bio gas) was found in increasing trend as compared to previous conditions. The changes in access to health services, women's decision making power was found increasing. Almost all households were found engaged in bio-intensive vegetable farming, use of IPM approach and organic recycling. Changes in food security and livelihoods situations were remarkable.

Key words: Eco-village, livelihood, bio-intensive farming, food security, health, sanitation, energy

INTRODUCTION

Hunger, poverty, discrimination, exploitation, violence and misuse of resources are the major problems and challenges that humanity has been facing today. Over exploitation or misuse of natural resources, misuse of chemical inputs on the farm lands, green house farming have created a number of challenges that has threatened life of biological organisms including human beings as well as existence of planet Earth (Rajbhandari, 2011). Eco-village is a full featured human settlement where human activities are integrated into the natural world in a sustainable way for longer future period. It is one of the approaches which will be able to improve the livelihood situation of marginalized

communities in a sustainable way. Livelihood of majority of the rural people in Nepal is based on agriculture. In order to address the issues of food security and livelihood or income generation, the small or marginalized farmers have less option. Eco-village approach includes promotion of the bio-intensive farming system and sustainable agriculture. Bio-intensive farming is a system that emphasizes biodiversity, recycling of nutrients, synergy among crops, animals, soils, and other biological components, and regeneration and conservation of resources. In other words, the concept and approaches of BIF system is based on holistic system of sustainable management of natural resources in a given agro-ecosystem with specific cultural and knowledgebase (Rajbhandari & Gautam, 1998).

Eco-villages are intentional communities whose goal is to become more socially, economically and ecologically sustainable. An "intentional community" is a group of people who have chosen to live together with a common purpose while sharing responsibilities and resources to create a lifestyle that reflects their shared core values. Each of these groups places a high priority on fostering a sense of community, belonging and mutual support which is increasingly hard to find in mainstream Western society). The concept of eco-villages has emerged in response to natural eco-system deterioration and climate change. It is regarded as one kind of the broader concept of intentional communities, where people live together in communities that share common beliefs and intentions (Rajbhandari, 2013). Eco-villages are self-sustained ecologically-sustainable communities, where a small group of people (50-500) can live and develop naturally in a full-featured environment which is also ecologically-, economically- and socially-healthy People living in an eco-village share the responsibilities of the community, while enjoying the warmth of close relationships and a dense social network (Kasper, 2008). This study was conducted to analyze the changes in the livelihoods of local communities in the eco-villages undergoing transformation in Dang district.

MATERIALS AND METHODS

This study was conducted in three eco-villages of Dang districts viz. Paddha, Urahari and Hekuli. The study was conducted from 20 July to 19 September, 2014. Simple random sampling method was followed for selecting households from the study areas of the three eco-villages. Altogether 90 households were taken for this study. From each eco-village 30 randomly selected households were included in this study. Pre survey field visits was conducted to gather preliminary information regarding the demographic, socio-cultural, and topographical settings of the site. This information was used in preparing questionnaires and designing a sampling framework.

In this study, standard questionnaire developed by WOREC was used to gather primary information. Primary data were collected using other methods also such as focus group discussion and in-depth interviews. Two focus group discussions (FGD) were conducted in each eco-village to verify the collected data from household survey as well as to know about context and knowledge about the process of changes taking place in the eco-village. Secondary information were also used in this work from several literature such as books, journals, annual reports available at different institutions like HICAST, WOREC

Nepal, NARC and MoAD. The data were processed by using the computer program like SPSS, MS excel. The quantitative data were converted in standard units like land/area in hectare, weight in kg, volume in liters.

RESULTS AND DISCUSSION

General information

The study found that the majority of the respondents were between 31-40 years age group. Participation of women was more than men in household survey. This finding may be taken as an evidence of migration of male members to other location for income generation; and that women have been taking the responsibility of farming besides household choses. Gathered information revealed that in all three eco-villages most of population (above 90%) belonged to Tharu community. This indicates that in those eco-villages Tharu community had predominant culture, tradition and farm activities. Study also showed that 93 percent of the respondents were literate with 58 percent of the respondents having primary level education. Thirty one percent of the respondents having secondary level education, 3 percent of the respondents having higher secondary level education and only 1 percent of the respondents having university level education, only 7 percent of the respondents were found illiterate. It was found that 90 percent of the respondents were engaged in agriculture.

Sanitation and health situation

Health situation

The study indicated that 75 percent of the respondents were affected from different health problems such as fever, headache, diabetes, diarrhoea, heart problem, kidney stone, anaemia, jaundice, aasthma, stomach pain, and uterus prolepsis before eco-village. But after eco-village, 58 percent of the respondents were affected from different health problems. Respondents visit nearest health clinic, health post, Tulsipur, Nepalgunj, Kathmandu, etc. places for check up. Before eco-village, only 8 percent of the respondents gave birth to their baby at hospital but after eco-village, 35 percent gave birth to their baby at hospital and rest of them gave birth at home. All respondents told that they give vaccine to their child. This is all due to awareness programme related to women and child health launched by WOREC Nepal.

Household sanitation situation

After initiation of transformation process local communities have formed eco-clubs to raise awareness of people about health and sanitation. In every eco-village, weekly sanitation programme has been conducted in the leadership of local leader. People were becoming aware about maintaining sanitation in communities. For this, bamboo baskets were used as dust bins on road sideToilet is the foremost important thing, which must be in every house for maintaining the hygiene and sanitation of home as well as community. Before eco-village most of the households did not have toilet. But after initiation of that programme all (100%) respondents had toilet.

Household with drinking water facility

Safe drinking water is the need of every people to remain healthy. This study showed that, 63 percent of the respondents had drinking water facility at their own home and 37 percent of the respondents had to fetch drinking water from others home and from public well.

Improved cooking stove (ICS)

Improved cook stove (ICS) is a device that is designed to consume less fuel and save cooking time, convenient in cooking process and creates smokeless environment in the kitchen or reduction in the volume of smoke produced during cooking against the traditional stove. That is very important for the health of the women engaged in cooking. Study showed that 32 percent of the respondents had ICS before eco village programme and it increased to 68 percent after eco village programme.

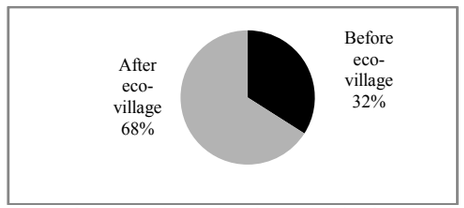

Figure 1. Percentage of respondents having ICS before and after eco-village

Improved cattle shed

Keeping in view converting the village into model eco-village, the model eco-village should also have improved sheds. Livestock is an integral part of Nepalese agriculture. Shed of the livestock determines the production also. Improved sheds also improve the health of animal; and it is easy to collect urine and helps to improve the soil productivity and finally increase crop productivity. This study showed that 34 percent of the respondents had improved shed before eco village programme and it increased to 66 percent after eco village programme (Figure 2).

Socio-political transformation

Collective empowerment

WOREC has taken animation and collective empowerment as an entry point for its community development initiative (WOREC, 2006). In the study areas, maximum number of people were involved in various types of groups such as women's group, child group, farmer's group, eco club, youth club, farmer's cooperative. Before eco-village programme only 46 percent of the people were found involved in group but after eco-village initiative 83 percent of the respondents were found involved in groups.

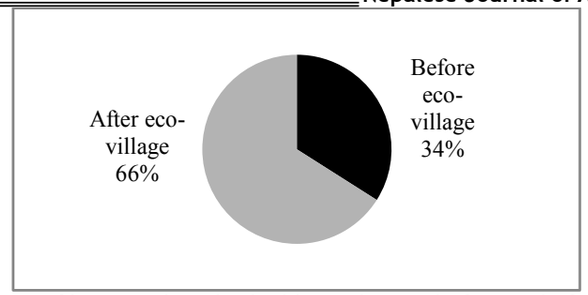

Figure 2. Status of improved cattle shed in study area before and after eco-village

Empowerment of women

Mobility

Before eco-village, only 68 percent of the women could travel to market, temple or distant place alone but after eco-village initiation, this has been increased to 95 percent. This change has challenged the traditional patriarchal norms and values in respect to women's mobility and freedom.

Decision making process

In traditional patriarchal society all decision (politics) in regard to income and expenditure has been made by the "Gharmuli" (or "Gardhuriya" in Tharu). This system deprived women's participation in decision making although they formed the major contributors in household income. This norm needs to be changed. In the course of this study it was found that, before eco-village programme 35 percent of the women could sell goat, hen, vegetables and grains with their own decision but after eco-village programme, it increased to 65 percent. In all eco-villages, women and men both make collective decision about household expenditure and income. This should be taken as a good start of equality in socio-political aspect of household.

Health status of women

Study showed that, before eco-village programme, 34 percent of the women had suffered from various diseases such as fever, headache, stomach pain, joint pain, heart problem, etc. But after eco-village programme, only 20 percent of the women was suffering from such diseases. It is due to the awareness and support programme organized by WOREC Nepal.

Changes in social behavior

After transformation intoeco-village, different kinds of changes were observed and experienced in all three (Paddha, Urahari and Hekuli) villages. Maximum change was seen in terms of sanitation and hygiene. Other changes included schooling of children, reduction of discrimination against male and female children, women's participation in meeting and other programmes, substantial decline on violence against women, on health

situation of women and child, increased women's involvement in leadership development, involvement of maximum number of people in meetings, etc.

Agricultural transformation

This study revealed that, before the eco villages only 25 percent of the respondents were aware about negative effect of chemical pesticides so the substantial number of respondents were using chemical pesticides but after transformative programme about 90 percent of respondents were aware about negative impact of chemical pesticides and farmers had startedcultivation of vegetables using localy made bio-products like Jhol mal (liquid botanical / organic fertilizer), compost, botanical pesticides ased on various botanicals like nem, tite paati, asuro, bakaino etc. These findings are at par to those reported by Nepal et al (2014) for Baireni ecovillage in Udayapur.

CONCLUSION

Eco-village is one of the approaches for sustainable livelihood and progressive socio-economic transformation without harming environment, eco-system and bio-diversity. The major changes of eco-village in the study areas included awareness and engagement of the people on management of sanitation and hygiene, construction of improved sheds, use of improved cooking stove, formation and strengthening of groups, use of alternative energy sources (bio-gas, LPG) and adopting bio-intensive farming practices. Besides these, the changes in access to health services, access to education, women's role in resources management was found encouraging.

The impact of transformative process on the targeted communities was seen in environment, livelihoods, and food / nutritional security. On the basis of the study, it was concluded that eco-village approach had visible and measurable positive ecological, socio-economic and technological changes in the study areas.

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Comparison of fungal and microbial biomass of three soils under different land use systems

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ABSTRACT

The study was undertaken to compare fungal and microbial biomass of three soils from different land use systems (i.e. garden, arable land and catch crop). Chloroform-fumigation extraction and adenosine 5'-triphophate (ATP) measurement were used to assess microbial biomass while determination of ergosterol concentration was done to assess living fungal biomass in the soils. Catch crop soil revealed to have considerably higher microbial activity and carbon turnover in the soil. The mean fungal biomass was significantly higher in the catch crop soil (1.68 µg g^{-1}) than garden (1.19 µg g^{-1}) and arable land (0.67 µg g^{-1}). The considerable high ergosterol: microbial biomass C ratio in the catch crop soil suggest that fungal part of microbial biomass was high in this soil compared to the rest which did not differ appreciably. The garden soil had significantly higher mean microbial biomass C of 765 µg g^{-1} soil as compared to arable land (345 µg g^{-1}) and catch crop (379 µg g^{-1}) soils. The average ATP concentration in the garden (6.7 nmol g^{-1} dry soil) and catch crop (6.6 nmol g^{-1} dry soil) soils were considerably larger than that of arable land soil (3.8 nmol g^{-1} dry soil). The variation in fungal and microbial biomass in the soils may be due to differences in microbial species assemblage, plant species and environmental conditions.

Key words: Garden, arable land, catch crop, ergosterol, ATP, plant species

INTRODUCTION

Knowledge on soil ecology is considered to be important for the sustainability of diverse ecosystems. Soil microbial community plays a key role in various ecosystems by regulating the dynamics of organic matter decomposition and plant nutrient availability (Joergensen and Olfs, 1998). Changes in soil microbial communities resulting on ecosystem management and global change can have substantial impacts on the ecosystems dynamics, and microbes respond sensitively to changes and environmental stress as they have intimate relations with their surroundings (Chen *et al.,* 2007). Understanding variations in fungal and microbial biomass in soils under different management types is an interest and focus of microbial ecology for sustainability of the ecosystems. Continual investigation of variation in microbial biomass is vital for monitoring nutrients deficiency over time (Joergensen, 1996). Several methods (such as fumigation-incubation (Jenkinson an Powlson, 1976), Substrate-induced respiration (Anderson and Domsch, 1978), adenosine 5'-triphophate (ATP) method (Jenkinson and Oades, 1979), fumigation-extraction (Vance *et al.,* 1987),) have been developed and widely used in quantifying microbial biomass in soil. The measurement of ergosterol concentration has been widely used to reflect living fungal biomass in soils (Stahl and

Pakin, 1996; Joergensen, 2000). However, differences in results exist, which may be due to variation in soil pH levels, microbial species, plant species, water content in soils, and different treatments in soil either inorganic or organic fertilizers applications. The objective of this paper is to compare fungal and microbial biomass as well as amount of organic & inorganic C in three soils (garden, arable land and catch crop) that are under different management systems. To meet this goal, different microbial methods, which include ergosterol measurement; chloroform-fumigation extraction and ATP method were used to measure living fungal biomass, microbial biomass C and ATP content respectively. Gas chromatography and basal respiration were used to measure amount of organic carbon (CO_2 efflux) in the soils while Scheibler-apparatus was used to measure inorganic carbon in the soils.

MATERIAL AND METHODS

Soil sampling and Preparation

Three soil samples from garden, arable land and catch crop in Witzenhausen, Germany were collected and taken to laboratory for analysis. First of all, the soils were weighed and sieved (2 mm) to remove roots and stones. Thereafter, soil samples were analyzed within 9 days for different soil and microbial properties.

Determination of soil water content, water holding capacity and pH

For each sample four replicates of wet soil were put in paper bags, weighed and recorded. The samples were oven dried at 105 ^{o}C for about 17 hours. Then soil samples were transferred into a desiccator filled with desiccant to cool the samples to room temperature. Thereafter, the samples dry soil weights were recorded. Three empty paper bags were weighed and the average was taken as representative weight of bags. This average weight of the empty bags before and after drying was subtracted from fresh and dry soil samples respectively. The percentage water content (% wc) and the dry soil matter (% dm) were calculated as shown in the formula below.

% wc = {(soil before drying (g) – soil after drying (g)) / soil after drying (g)} x 100
% dm = {soil after drying (g) / soil before drying (g)} x 100

For water holding capacity, four replicates of about 10 g of fresh soil from each sample were put in the labelled porous membrane glass tubes. The weight of the glass tubes and fresh soils were recorded, afterwards transferred into a water bath with about 1 cm water level. Water was added until the soil is almost completely covered. The tubes have porous membranes that allow infiltration and they were closed to avoid losses by evaporation. After 2-4 hours the tubes were taken out of the water and put into absorbent wet tissue paper. About 10 minutes was enough to let the spare water run-off onto paper. The weight of tubes with saturated soil was recorded, and then the tubes were put into oven at 105 ^{o}C for 24 hours. Thereafter, the tubes were handled like envelopes for water content determination as described before. The calculation for percentage water holding capacity (% whc) was computed by the formula shown below.

% whc = {(saturated soil (g) – soil after drying (g)) / soil after drying (g)} x 100

Soil pH was determined by pH glass electrodes. 25 ml of distilled water was filled to all four fresh soil replicates of about 10 g from each soil category. The suspensions were stirred with rod and then waited for about half an hour to allow deposition on the bottom of the beakers. Thereafter, the pH values were measure using pH glass electrodes after calibrating them.

Determination of inorganic carbon (carbonate) in soils

The determination of soil inorganic carbon was done using the *Scheibler-apparatus*. Four replicates of about 5 g each from the three soil samples were weighed and recorded. The soils were then treated with 15 ml HCl (in small beaker (40 ml)) after connecting to the *Scheibler-apparatus*. Shaking of the reaction-vessel was done carefully until HCl gets in contact with the soil. A range of 5-10 minutes was enough for the chemical reaction to be complete depending on the carbonate content of the soil. Released CO_2 was measured volumetrically. The apparatus was calibrated with pure 500 g $CaCO_3$ in the same way as for the soil samples.

Determination of fungal biomass using ergosterol

Four replicates of about 2 g each from the different studied fresh soils were put into brown flasks and 100 ml of distilled ethanol was added. The soils were then shaked for 30 minutes at 250 rounds per minute using an agitator. Thereafter, the soil-ethanol suspension were filtered into a round bottom flasks using Buchner-funnel, a Whatman GF/A glass filter, a desiccator and a wet jet pump. The buchner-funnels were rinsed three times with 5 ml ethanol to wash all ergosterol from the filter into extract. Then the round bottom flasks were fixed with filtered solution to the rotary evaporator to evaporate all ethanol to nearly dryness using water bath with temperature less than 40^{o}C as ergosterol is not stable at higher temperature. The extracted compounds including ergosterol were precipitated to the walls of the round bottom flask followed by the addition of 3 ml methanol into the flask to receipt all the present ergosterol that is in flask. Flasks were then slightly shaked and repeat addition of methanol two more times. The methanol solutions were transferred into 10 ml balloons using a pipette where the balloons were filled up to 10 ml mark. An equivalent of the methanol solutions were then filtered again by pressing through a special filter into labelled plastic cups using syringe. Afterwards, aliquots were transferred into brown HPLC vials and then taken to HPLC for determination of ergosterol amount. The amounts (µg ml^{-1}) from HPLC were multiplied by 10 ml and divided by soil dry matter to get ergosterol values in µg ml^{-1} g^{-1}dry soil.

Determination of Basal respiration

Four replicates (from each soil samples) of about 50 g sieved soil at 40-50 % whc were put into 500 ml blue cap bottle. 5 ml of 0.5 M NaOH were pipetted into test tubes and placed inside each bottle. Four blanks with only NaOH were prepared too. Then, all the bottles were incubated for seven days at 22 ^{o}C. After 7 days of incubation the test tubes were taken out of bottles carefully using tweezers. The NaOH was transferred into beaker ready for titration. The test tubes were rinsed with distilled water and the rinse water added to the titration vessel. Titration was done to pH 8.3 in the presence of $BaCl_2$ (Anderson, 1982). 5 ml saturated $BaCl_2$ solution was added to precipitate the carbonate as

insoluble $BaCO_3$. Few drops of phenolphthalein were added as indicator. Then, the NaOH not reacted was brought to pH of 8.3 by adding 0.5 M HCl under magnetic stirring. The acid was added slowly to avoid any possible dissolution of the precipitated $BaCO_3$. Finally, the amount used to titrate NaOH in blanks and samples were recorded. The calculation for evolved CO_2-C was performed as given below.

CO2-C (µg g^{-1} soil) = ((B-S) x M x E/DW) *1000

Where, B and S represent amount of acid needed to titrate the NaOH in the blank and samples respectively, M is molarity of HCl, E is 6 g mol^{-1} equivalent weight of carbon to OH^- ions used in the titration reaction and DW is dry weight of the soil (g).

Determination of soil respiration using gas chromatograph

From the three soils we had four replicates of about 300 g of fresh soil which was weighed and put into preserving glass, which were closed carefully and tightly. At beginning of incubation period two gas samples were taken from the headspace and the CO_2-C concentration inside the headspace of the incubation glasses were measured at the gas chromatography immediately. During the incubation the glasses were kept into the chamber at 20^0C. At the end of the incubation period all gas samples from the headspace volume were taken and measured at gas chromatography immediately. Thereafter, the calculation for CO_2-C (ppmv) was done using the formula given below.

CO_2-C (µg C g^{-1} soil dm day^{-1}) = Cco_2 x (M_c/8.3145 x (T/p) x 1000) x ($V_{headspace}$/dm) x (24/Δt)

Where, Cco_2 is concentration of CO_2, M_c is molar mass of carbon (g mol^{-1}), T is temperature during incubation (^{o}K), p is atmospheric pressure, $V_{headspace}$ is volume of headspace (ml), dm is dry weight of incubated soil samples (g) and Δt is the time of soil incubation inside the closed incubation glasses.

Quantification of soil microbial biomass by determining Nihydrin-reactive N

The chloroform-fumigation extraction method was performed according to practical laboratory guide. About 10 g non-fumigated samples in 100 ml flasks were extracted with 40 ml 0.5 M K_2SO_4 for 30 minutes by oscillating shaking at 200 rev. min^{-1} and filtered through a folded filter paper. For fumigated treatment, glass vials containing the moist soil was placed into desiccator containing wet tissue paper and a vial of soda lime, beaker containing 25 ml ethanol-free $CHCl_3$ and a few boiling chips and desiccator evacuation was done when $CHCl_3$ had boiled vigorously for 2 minutes. The desiccator was incubated for 24 hours at 25 ^{o}C in the dark. After fumigation $CHCl_3$ was removed by repeated evacuation (6-folds) and extracted with 0.5 M K_2SO_4. The 0.5 M K_2SO_4 extract was stored at -15 ^{o}C prior to analysis of nihydrine-reactive N. The amount of nihydrine-reactive compounds from the soil microbial biomass during the CHCl3 fumigation and extraction by 0.5 M K_2SO_4 is closely related to the initial soil microbial biomass C and biomass content (Joergensen and Brookes, 1990). Standard solutions, K_2SO_4 soil extracts or blank (0.6 ml) and the citric acid buffer (1.4 ml) to 20 ml test tubes was added as per Joergensen and Brookes (1990). Nihydrin reagent was slowly added, mixed thoroughly and closed with loose aluminium lids. The test tubes were heated for 25 minutes in a vigorously boiling water bath, any precipitate formed during the addition of the reagents then dissolved. Thereafter, ethanol-to-water mixture (4 ml 50 % ethanol) was added and the solution was mixed thoroughly. The 96 well multi-plate was used, the solutions was

put in the plate 300 µl per well. The reading of the absorbance at 570 nm was obtained from the multi-plate reader in optical density (OD). Calculation of microbial Nihydrin-reactive N (B_{nin}) was done by subtracting N_{nin} extracted from non-fumigated soil from N_{nin} extracted from the fumigated soil. Microbial biomass C was calculated as per Joergensen (1996), Biomass = B_{nin} x 22 (soils pH-H_2O > 5.0).

Determination of soil adenylates nucleotide

Adenosine 5'-triphosphate (ATP) was extracted according to Jenkinson and Oades (1979). For each replicate, 2 soil samples each of 3 g dry weight was measured. One was placed in glass labelled A, and the other in B. Extractant A and B (each 25 ml) were added to glass labelled A and B, respectively. Immediately after adding the extractant to the first glass, sonification was done for 2 minutes at full power. Then, the glass was cooled in ice for at least 5 minutes. All the replicates were treated in the same way. The Whatman 40 filter paper was used to obtain 5-10 ml of filtrate and the extracts was stored at -15 ^{o}C. ATP standards were already prepared and it is important to use standards with concentrations above 10 ppm if working with substrate amended soil. Then, 10 µl sample/standards were pipetted into the eppis. The pipetting was done between 20 seconds from one replicate to the next. 50 µl of luciferin solution into vials and the samples left for one hour to react. Afterwards, the first 2 µl eppi was placed into the luminometer device. A button "measure fluorescence" was pressed and the data was transferred into excel. The sample name was recorded into the next column. The same process was applied for every subsequent replicates. Calculations were performed as per laboratory guide document provided.

Statistical Analysis

All data were analysed using the Graphpad Prism 5 software package. One-way ANOVA followed by Tukey Highly Significance Difference (HSD); *post-hoc* test was used to analyse for differences between the soil sample parameters. The data were first tested for normality using the Liliefors test. Correlation was estimated using the Pearson correlation coefficient test using the Microsoft Excel program.

RESULTS AND DISCUSSION

Soil Characteristics

Some properties of the soils are given in Table 1. Soil pH values in the garden and arable land soils were in the moderate alkaline range (7.5-8.5) while that of catch crops was within the neutral range (6.5-7.5) where both, the garden and arable land soil pH values were significantly higher than the catch crop soil. The garden soil had significantly higher water content and lower dry matter as compared to arable and catch crops soils, which did not differ appreciably in their values. The catch crop soil had significantly lower water holding capacity than garden and arable land soils.

Comparison of microbial biomass C, ergosterol and ATP content between soils

The Mean values of microbial biomass C, ergosterol content, ergosterol: microbial biomass C ratio (%), ATP contents and soil organic and inorganic carbon are presented in Table 2. The amount of organic carbon in the catch crop soil was significantly higher compared to garden and arable land. The inorganic carbon (CO_3-C) was significantly

lower in the catch crops than the other two soils, which had higher pH values. The microbial biomass C varied significantly between the soil samples ($F_{(2,9)} = 18.08$, $p = 0.0007$), the garden soil having higher microbial biomass compared to arable and catch crop soils.

Table 1. Properties of the three soils (n =4)

Characteristics	Garden	Arable land	Catch crop
% water content	24.9[a]	21.1[b]	21.1[b]
% dry matter	80.0[a]	82.6[b]	82.6[b]
% water holding capacity	58.9[a]	54.0[a]	45.8[b]
Soil pH level	8.2[a]	8.1[a]	6.9[b]

*different letters reveal significant difference between the mean values (Tukey test, $p < 0.05$)

The fungal biomass was significantly different ($F_{(2, 9)} = 167.8$, $p < 0.0001$) between the soil samples. The catch crop soil had considerably higher ergosterol content than the other two soils, while garden soil had significantly higher ergosterol content than arable land soil. The geometric mean of the ergosterol: microbial biomass C ratio percentage was 0.26 and increased in the order garden (0.16), arable land (0.19) and catch crop (0.44). The ATP contents range between 2.5-8.5 nmol ATP g^{-1} dry soil. The ATP content varied considerably between the soils ($F_{(2, 19)} = 20.64$, $p = 0.0001$). The mean soil ATP content in the garden and catch crop did not differ appreciably, but both had significantly higher ATP content than the arable land. For the three soils, the mean ergosterol contents were strongly correlated with mean soil basal respiration ($r = 0.96$) and ATP content ($r = 0.85$), all data pooled together. Additionally, for the three soils, there was fair close ($r = 0.71$) correlation between the mean ATP content and organic C.

Table 2. Mean respiration rate, microbial biomass C (% CV), ergosterol content (% CV), ergosterol: microbial biomass C ratio and ATP content (standard deviation) of the three soils

Soil	Evolved CO_2			Microbial biomass C (µg C g^{-1} dry soil)	Ergosterol (µg g^{-1} dry soil)	Ergosterol: Microbial biomass C ratio (%)	ATP content (nmol ATP g^{-1} dry soil)
	Basal respiration	Soil respiration by GC	Scheibler-apparatus				
Garden	27.1[a]	10.4[a]	1.3[a]	765[a] (13)	1.19[a] (0.25)	0.16	6.7±1.0[a]
Arable land	25.2[a]	8.9[a]	1.2[a]	346[b] (28)	0.67[b] (0.31)	0.19	3.8±0.9[b]
Catch crops	32.0[b]	24.0[b]	0.2[b]	379[b] (35)	1.68[c] (0.47)	0.44	6.6±1.0[a]

*different letters show significant difference between the mean values (Tukey test, $p < 0.05$, $n = 4$)

Soil characteristics

The soil water content and pH are imperative component that regulate microbial activity, community structure, diversity and response to substrate addition (Harris, 1981; Aciego Pietri and Brookes, 2008), also they influence the physiological status of microbes and

may limit their capacity to decompose certain compounds (Harris, 1981). The variation in these two parameters from the three analyzes soils indicate different microbial community among the soils which are significant different.

Ergosterol content and Microbial biomass in the soils

Ergosterol content is considered to reflect living fungal biomass in the soils (Stahl and Pakin, 1996; Joergensen, 2000), and its applicability has been convinced, among other things, by correlation with phospholipid fungal indicators (Klamer and Bååth, 2004). The large ergosterol concentrations in the soil show a strong fungal colonisation (Joergensen, 2000). The variation in ergosterol in the three analysed soils may be due to difference in fungal species within the soils (because different fungi species contain different amount of ergosterol), dissimilarity in environmental conditions (Djajakirana *et al.,* 1996) and differences in nutrient availability. The recorded mean ergosterol concentration from the three soils in this study ranged between 0.67-1.68 µg g^{-1} dry soils, which is within the range recorded by other authors, for instance, Djajakirana *et al.,* (1996) recorded ergosterol ranging between 0.75-12.94 µg g^{-1} while Lopez-Sangil *et al.,* (2011) found ergosterol to vary between 0.6-3.8 µg g^{-1} in the upper layer of Mediterranean grasslands. The fungal biomass is highly correlated with soil basal respiration (Rousk and Bååth, 2007). Unlike other methods, the analysis of ergosterol is not affected by the presence of roots in soil sample and can be detected by a variety of methods in solid substrates (Stahl and Pakin, 1996). Ergosterol has been used successfully used to differentiate between fungal and plant tissue (Joergensen, 2000).

Microbial biomass C is relative active organic carbon in soils and it is important for microbial growth. The amount of microbial biomass C in soil reflects the activity of microbes in it. The microbial biomass C varies between soils due to amount of C and N input applied. Higher the C and N input tend enhance the microbial activities and vice versa (Chirinda, *et al.,* 2008). Also, change in soil pH has considerable effect upon soil microbial biomass and microbial activity due to increasing extractable Al as soil pH decrease (Aciego and Brookes, 2008). The ergosterol: microbial biomass C ratio in soil represent fungal versus the whole microbial biomass (Djajakirana *et al.,* 1996). The considerable high ergosterol: microbial biomass C ratio in the catch crop soil suggest that fungal part of microbial biomass was high in this soil compared to the rest which did not differ appreciably. Djajakirana *et al.,* (1996) report the ergosterol: microbial biomass C ratio to have strong negative relationship with pH of soils. This explain why large ergosterol: microbial biomass C ratio (mean: 4.4 mg g^{-1}) was measured in catch crop soil, which had significantly lower pH value.

The quantification of ATP content provides a means of determining in situ microbial biomass in soil samples, and has been widely used for the determination of total microbial populations in soils (Jenkinson *et al.,* 1979). The ATP continent varied appreciably in the soils, possibly because of differences in the microbe species and perhaps due to differences in the metabolic state of the soil micro-organisms (Ross *et al.,* 1981). In the present study arable land had least ATP content, this concur with Jenkinson *et al.,* (1979) findings who reported arable land soils having least ATP content compared to grassland and forest soils. The mean ATP content in this study are within the average

range of 1.22-8.74 µg ATP g^{-1} oven dry soil recorded by Jenkinson *et al.,* (1979). The possible reason could be that large amounts of organic matter normally are found in soils with largest annual inputs of organic materials (Jenkinson and Rayner, 1977; Jenkinson *et al.,* 1979), these are the soils with most ATP content (Table 2). Soil ATP content is also closely correlated with other microbial indices, (*e.g.* C, N *e.t.c,*) and can be used as an independent estimate of soil microbial biomass content (Jenkinson *et al.,* 1979).

Soil respiration rate

Both basal respiration and soil respiration by gas chromatography revealed that the catch crop soil had higher amount of CO_2 released, which suggests that the catch crop have higher microbial activity and carbon turnover in the soil. The significant difference in soils organic carbon could be attributed with considerable differences in pH levels (Jingyun *et al.,* 1998; Aciego-Pietri and Brookes, 2008), high pH levels influence evolution of CO_2 in soil. The soil CO_2 release is related to the catabolic carbon turnover of cells to gin energy in the soil. The ratio of released CO_2 to microbial biomass (*i.e.* metabolic quotient) provides detailed information of on the metabolic status of the soil microbes. The metabolic quotient increases with decreasing availability of carbon in the organic compounds used by soil microbes (Anderson and Domsch, 1990). Other factors that affect metabolic quotient include quality substrate quality and environmental stress (Anderson and Domsch, 1990) and temperature (Pöhhacker and Zech, 1995). Jingyun *et al.,* (1998) report several factors that affect in one way or another soil respiration rate (see figure 1). The larger amount of inorganic carbon in garden and arable land soils could be influenced by their alkaline pH values. In our findings, the amount of fungal biomass could have influenced the respiration rate between the soils, as they were strongly correlated.

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Comparative analysis of organic and non-organic farms in South Asia

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ABSTRACT

Crop production measure is an important parameter to consider when addressing dual challenge of meeting global food demands and mitigating environmental damage. Most of the world's undernourished people suffering from chronic hunger are living in South Asia, which is the focus area of this study. 33 differet scientific studies contributed 104 complete sets of observations representing each on organic and non-organic farms. To analyze the difference in crop productivity between organic and non-organic farms, a meta-analysis was conducted with the estimation of effect size and by testing the statistical significance of relative organic yield over absolute non-organic yield. Based on the results of this study, average productivity of organic farms is approximately 5% less than non-organic, but the difference is statistically insignificant with substantial variation among different crop types (cereals, legumes and non-legumes, fruit crops and other cash crops). Organic yield for legumes and non-legumes was 0.7% and 6% less than non-organic, respectively. The productivity of organic farms compared to low- and high-input non-organic farms is found to be 13% and 8% less than non-organic farms, respectively. Similar yields between organic certified and default organic farms were found, as the yield gap is 3.5% for certified organic farms and 6% for default organic farms, respectively. The effect size estimate reflected that the magnitude of difference between the productivity of organic and non-organic farms is very small and statistically not significant among crop types, organic farm types and level of input in non-organic farms. So, future research should focus on promoting organic farming for sustainable organic production to address the issues of certification, marketing, soil fertility and plant protection, easing certification for smallholders, developing marketing networks, building soil fertility, conserving soil and water and conducting research on biological pest management, which helps to generate more knowledge and information capitalizing on the already available basis and resources for organic farming in South Asia.

Key words: Productivity, low-input, high-input, certified, default

INTRODUCTION

The agricultural sector faces the dual challenge of meeting global food demand and mitigating environmental challenges. It is estimated that 842 million people in the world are undernourished and most of the world's undernourished people suffering from chronic hunger are living in South Asia, followed by Sub Saharan Africa and East Asia (FAO, 2013). Average crop productivity is far lower in many developing countries in South Asia as compared to developed countries and one important consideration to address hunger

and poverty is to improve the crop productivity (FAO, 2002). The majority of agricultural land suffers from the deterioration of land, water and biodiversity that hinders the ability to achieve the goal of food security and poverty alleviation considering ecological and environmental sustainability (FAO, 2002). Organic farming is a system designed to produce crops with minimum damage to the ecosystem, nevertheless the performance of organic farming depends on site characteristics, management practices, crop types and growing practices (Seufert et al., 2012). The major issue in organic agriculture is whether organic agriculture can produce enough food to meet future global food demands (Ponti et al., 2012). In this debate, the central discussion is the crop production measures basically organic and inorganic farming practices.

Global organic agriculture land distribution shows that 55% of its total land is occupied by the agriculture sector, 43% under wild collection and remaining 2% from others (FIBL and IFOAM, 2014). The report on "The World of Organic Agriculture, Statistics and Emerging Trends" by FIBL and IFOAM (2014) states the global share of agricultural land under organic agriculture is 0.87% with 37.5 million ha (hectare) until 2012 including conversion areas. The leading countries in organic agriculture by area are Australia (12 million ha), Argentina (3.6 million ha) and the United States (2.2 million ha). Productivity of organic farms is 20 to 30% less than non-organic farms, as evident in cash crop focused production systems under most favorable climate and soil (FAO, 2012). The difference in land productivity between organic farming and non-organic farming is context specific and varies among countries. Overall, the evidence is limited, especially in many developing countries where data availability is poor (Nemes, 2009 and Seufert et al., 2012). Recent studies on yield gap by Ponti et al. (2012) and Seufert et al. (2012) reported that the organic yield is 20% and 25% less than non-organic however most of these studies were from developed countries. Whereas, Badgley et al. (2007) reported average organic yield is 32% higher than non-organic but majority of data used by Badgley were coming from gray literature and majority of data from organic farm represented high input system. Organic agriculture occupancy in most of the South Asian countries, compared to arable land, is below 1% except in Bhutan (1.21%). More specifically, organic agriculture over arable land in India, Nepal, Bangladesh, Sri Lanka and Pakistan is 0.28%, 0.12%, 0.07%, 0.75% and 0.09%, respectively (FIBL and IFOAM, 2014). It also reflects that, overall, the organic sector in Asia is in the early phase of its development. In this regard, identifying the difference in productivity of organic and inorganic farms is one of the important parameters to be considered to address the issue of food security and environmental concern.

MATERIALS AND METHODS

A comprehensive literature search was conducted in the internet database of Google, Google scholar, Scopus and Science direct for the review of organic and non-organic productivity in South Asia and collected information and data were imported into STATA for further analysis. As a criteria of selection, publications had to contain the data on productivity, particularly crop yield both on organic farming (either default or certified organic) and non-organic farming systems with standard deviation, standard error and sample size or sufficient data had to be reported to calculate mean yield,

standard deviation and standard error in the well-documented scientific studies like peer reviewed publications. Based on selection criteria, 33 scientific studies contributed data with 104 complete sets of observations representing each organic and non-organic farm. Meta analysis was used with random effect model to estimate mean effect size and its confidence interval in meta-analysis as it allows true effect to vary across the studies. Total heterogeneity was categorized between groups and within groups' variation, same as in Analysis of Variance (ANOVA) and estimates the Q statistic as a measure of heterogeneity and tested with P-value to determine whether it is statistically significant (Koricheva et al. 2013). The test of heterogeneity can be performed comparing the value of Chi square ($\chi 2$) statistics with respective degree of freedom and P-value. A significant value indicates effect sizes are more heterogeneous. The value of the Q statistic has low power as it depends directly upon the number of studies. So, alternative measure of heterogeneity that is inconsistency (I^2) and inflation of observed Q compared with what is achieved in the absence of heterogeneity (H^2) was used to measure heterogeneity (Koricheva et al. 2013).

We estimated effect size measures to determine the magnitude of a treatment effect over control effect across studies to summarize the findings from a specific area of research (Cohen, 1988). “Cohen's d” is commonly used to estimate the effect size (Becker, 2000).

$d = (M_1 - M_2)/ S_{pooled}$

Where
d = Cohen's d
M_1= Average productivity of organic farms
M_2 = Average productivity of non-organic farms
S_{pooled} = Overall standard deviation (organic and non-organic farms' yield)

In this analysis, organic farms' yield is allocated as treatment and non-organic farms' yield is allocated as control group. Various statistical tools like mean, standard deviation, range, and confidence interval are used to retrieve, select, and combine results across studies of “Productivity of Organic and Non-organic Farms in South Asia”. The data were analyzed and plotted using STATA to identify and visualize the difference of productivity of organic and non-organic farms.

RESULTS AND DISCUSSION

A comprehensive literature search yielded 33 scientific literature that dealt with crop productivity, that were from four different countries in South Asia; particularly from India, Nepal, Bangladesh and Pakistan. Out of these studies, only 14 studies contributed data for meta-analysis with 34 observations on average crop productivity that covered 15 different crops, including major cereals (rice, wheat, and maize), vegetables, legumes (soybean, cowpea, pigeon pea and chickpea), oilseed crop (sunflower) and fruits. The range of study years was from 1994 to 2012 and the years of publication ranged from 2003 to 2014.

Based on this study, overall data on productivity reflects that the organic yield is 5% less than the non-organic yield. Organic productivity range was 56% to 129% of the non-organic yield with the average organic proportion to non-organic yield for all crops of 95%, which also reflects similar yield performance. For cereals, the organic crop yield is 8% less than non-organic, ranging from 59 to 125% of non-organic production. Similarly, average organic productivity of fruits and vegetables was 6.5% less than non-organic farms ranging from a minimum of 85% to a maximum of 100% of non-organic production systems. In the case of other cash crops like cotton, sugarcane and sunflower; the average organic production was 96.9% of non-organic farms, which is 3.1% less than non-organic.

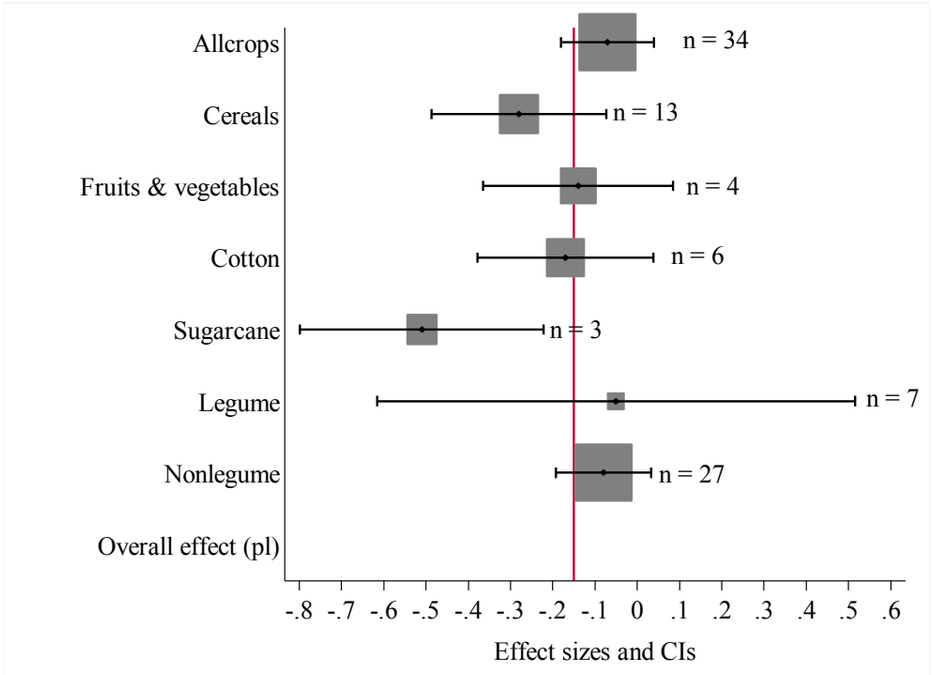

Figure 1. Effect size and confidence intervals among crop types

Effect size estimate at the 95% confidence interval among the crop types reflects that the effect size is lowest for sugarcane (−0.51), which shows approximately 33% non-overlap of organic mean cereal yield to non-organic. Effect size for cereals (−0.28), fruits and vegetables (−0.14) , cotton (−0.17) reflects small magnitude of difference between the productivity of organic and non-organic farms. The effect size for legume is −0.05 and for non-legume is −0.08 that indicates very small variation among organic and non-organic yield whose mean value lies approximately at the 50th percentile of non-organic yield.

Heterogeneity was measured with the Q statistic, degree of freedom and P-value among crop types.

	Value	df	P value
Cochrane Q	10.83	6	0.09

The P value is larger than 0.05 (α) at the 95% confidence interval, which shows statistical insignificant heterogeneity among the effect size of different crops.

Table 1. Variability in effect estimate among different crops

Estimate	Value	95% confidence interval	
I^2 (%)	28.5	0.00	69.25
H^2	1.40	0.60	3.25
tau^2	0.003	0.00	0.049

I^2 shows 28.5% variability among crop types in terms of effect size and h^2 shows small inflation of observed Q, which we could get in the absence of heterogeneity, tau^2 estimate (between group variance) is also very less (0.003) that indicated very low heterogeneity among the crop types. This study found that the organic productivity of legumes (−0.3%) was closer to non-organic than non-legumes (−6%). This finding is supported by many studies. The productivity of legume under an organic farming system was better than under a non-organic farming system (Ponti et al., 2012 and Seufert et al., 2012). The organic to non-organic yield difference is statistically insignificant for a leguminous crop, but the difference is significant for non-legumes (Seufert et al. 2012). Similarly, leguminous crops are also more efficient in utilizing nitrogen, as legumes do not depend on external sources of nitrogen like non-legumes. The extensive root system of legumes results in an increased crop yield when legume is in rotation with other crops (Ponti et al., 2012). The long-term experiment of Pimental et al. (2005) found that the organic soybean yield was similar to the non-organic system. Therefore, the improved leguminous crops' yield can be because of the nitrogen fixation by the leguminous crops, their extensive root system and efficiency in utilizing nitrogen, resulting in better yields than non-legumes.

Ponti et al. (2012) found an 11% yield gap in organic farms in Asia, which is quite close to the findings of this study and the slight difference in our findings might be because of the region specific analysis focusing on South Asia. The results of this study are also in accordance with the results of a 22-year long field research experiment conducted by Pimental et al. (2005). The findings of Seufert et al. (2012) state that organic yield in developed and developing countries is 20% and 43% less than non-organic, respectively, which is not supported by our findings because the majority of data used by Seufert et al. (2012) were from developed countries and very few data were from South Asia. This study also does not support the findings of Badgely et al. (2007), which report a higher organic yield than non-organic in developing countries (176%) over developed countries (92%).

The comparison between low- and high-input non-organic farms reflected substantial variation between low-input non-organic (+12.8%) and high-input non-organic (−8%) farms on the organic to non-organic yield ratio, although the difference was also statistically insignificant. A long-term research project of 22 years by Pimental et al. (2005) identified that organic farming is more advantageous in low-input agriculture, as organic matter and available nitrogen is higher in organic soils, and that promotes soil, water and biodiversity conservation. So, the variation in input level is also an important determinant for crop productivity between organic and non-organic farms and organic farms' productivity is found to be better when it is compared to low-input non-organic farming systems.

The study did not find a significant difference between the productivity of certified organic farms (−3.4%) and default organic (−5.9%), and observed a slightly higher relative yield in certified organic than default organic. The higher yield in certified organic farms might be because of the superior level of knowledge and management among certified organic farmers compared to non-certified organic farmers. Crop yield is influenced by crop types and management practices (Seufert et al. 2012 and Pimental et al., 2005). A similar yield of certified and default organic compared to non-organic farms could be the result of long and traditional organic farming technologies in smallholders default organic farms (Pimental et al., 2005). However, it is essential to support farmers during conversion to compensate yield loss.

CONCLUSION

The meta-analysis of the productivity of organic and non-organic farms revealed that overall average productivity of organic farms is only approximately 5% less than non-organic, but substantial variation has been identified among different crop types (cereals, legumes and non-legumes, fruit crops and other cash crops), although these differences are found to be statistically insignificant. The effect size estimate reflected that the magnitude of difference between the productivity of organic and non-organic farms in each category is small and statistically insignificant.

The findings of this study on organic and non-organic productivity reflect a similar performance, with substantial variation among crops and input level. This indicates that organic farming can equally contribute to food security issues among smallholders, as it does with non-organic farming in present context of South Asia. It is also important to protect and promote the best traditional practices and the crop lands, which are by default organic, and that can be easily converted into certified organic without a major adjustment of farming techniques. In farming communities, research and extension from both the public and private sector should be involved in agricultural sustainability. It should be clear that the productivity of organic farming is one parameter to consider. However, there are many aspects of sustainability measures to consider in organic farming research, such as the certification process, climate change mitigation, soil fertility maintenance and plant protection. Without addressing these issues, organic farming cannot be sustainable in the developing world. Therefore, future research should focus on addressing such issues for the promotion of organic farming, such as easing certification for small scale farmers, developing marketing networks, building soil

fertility, conserving soil and water, and conducting research on biological pest management, which respects the environment.

Although the study was able to find some yield gaps and associated factors relating to productivity, it is noticed that the number of studies and the datasets obtained are rather small because many studies had reported their results on crop yield with a one shot observation, which could not be included in this analysis. Also, for reliability of the study, data were only included from peer reviewed articles. Furthermore, this study could not disaggregate several other factors such as pest management, N-input and soil type due to the absence of suitable studies reporting such categories.

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Performance of teosinte (*Euchlaena mexicana*) as a promising summer-forage crop with respect to location and sowing dates considering the scenario of possible climate change in Nepal

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ABSTRACT

Green forage deficit, especially in summer season, is one of the most limiting factors for the commercial buffalo farming in Nepal. This is more aggravated because of the climate change. Considering this fact, Government of Nepal has recently been launching 'forage mission' as a five years program in 35 dairy pocket districts of Nepal. However, no specific research on summer forage has been carried out so far in the farmers' field conditions. To address the demand, an experiment on production potential of teosinte (Euchlaena mexicana), a promising summer-forage, under varying sowing dates and locations was conducted at three sites viz. Chitwan, Gorkha and Tanahun using Split Plot Design with three replications during April, 2013 to September, 2013. The result showed that the effect of location was significantly different (P<0.05) in tillers/plant, fresh biomass, dry weight as well as major chemical constituents (DM, CP and Ca content). In terms of sowing dates, 23rd April had significantly higher (P<0.05) number of tillers/plant, fresh biomass yield (113.8 t/ha), dry weight yield (13.36 t/ha) and the major chemical constituents at every harvest. The interaction of location and date of sowing was also found significant (P<0.05). Among the locations, sowing teosinte in Chitwan on 23rd April had significantly higher number of tillers/plant, fresh biomass yield (165.0 t/ha), dry weight yield (21.80 t/ha) as well as major chemical constituents at every harvesting. Sowing dates had significant effect (P<0.05) to tillers/plant with its positive contribution to the herbage mass production at each stage of growth of teosinte. These results provide very good message to consider the date of sowing in summer season along with the location to obtain the maximum biomass of teosinte that would be very supportive for the commercialization of buffalo farming in the context of climate change in Nepal.

Keywords: *Buffalo farming, herbage mass, limiting factors, biomass, commercialization*

INTRODUCTION

Insufficient feeds and fodder/forage supply, especially during dry season is one of the serious problems to the livestock grower (Devkota *et al.,* 2007). Green forage is important part of nutrition that reduces cost of production as well as supplies necessary nutrients. If ad libitum supply of good quality fodder is available, no extra concentrates are necessary up to 10 kg milk production in cows and 7 kg in buffaloes (Sastry *et al.*, 1986). Teosinte (*Euchlaena Mexicana* Schrad) is a tall and vigorously growing crop. It can tolerate moderate drought and temporary flooding caused by heavy monsoon showers. In case of multi-cut management, it can give four cuttings. Sowing date is the subject of most concern in the production of Teosinte as it requires a long hot growing season. Rise in temperature during growing period reduces production and nutrient composition of the fodder whereas delay in sowing has negative effect on biomass production and nutrient composition of Teosinte. An experiment was thus conducted with the general objective to evaluate herbage mass producing potentiality of teosinte to help develop a standard cultivation practices. Specific objectives were: to determine the fresh yield as well as dry matter production and productivity of teosinte, and to examine differences in biomass yield of teosinte in relation to variation in sowing dates considering location effect.

MATERIALS AND METHODS

Site description

Chitwan (Chanauli), Gorkha (Palungtar) and Tanahun (Dulegauda) districts of Nepal

Planting material: Local seeds of teosinte from AFU, Chitwan, Nepal.

Research Design:

Split Plot Design with RCBD for Factor A (location), and Factor B(sowing date)

Treatment details:

Main plot treatments:

1. Sowing at Chitwan district
2. Sowing at Gorkha district
3. Sowing at Tanahun district

The sub plot: Four dates of sowing teosinte

a) Sowing on 15th April (2 Baisakh)
b) Sowing on 23rd April (10 Baisakh)
c) Sowing on 1st May (18 Baisakh)
d) Sowing on 9th May (26 Baisakh)

Table 1. Soil properties at the time of sowing in the research sites

S.N.	Soil properties	Chitwan	Gorkha	Tanahun
1	Physical properties			
	Sand %	52.33	17.00	17.67
	Silt %	37.17	70.50	68.50
	Clay %	10.50	12.50	13.83
2	Chemical properties			
	Soil pH	5.50	7.97	7.89
	Soil organic matter %	2.97	2.02	2.08
	Total nitrogen (N) %	0.12	0.10	0.10
	Phosphorus (P_2O_5) %	347.55	180.32	80.08
	Potash (K_2O) %	493.95	123.99	117.13
3	Textural class	Loam	Sandy loam	Sandy loam

Manuring:

- 10 t Farm Yard Manure/ ha
- 6 doka per research sites; distributed evenly.

Fertilizer:

- 90:60 Kg NP/ ha
- DAP: 105 gram per plot of $8m^2$
- Urea: 116 gram per plot of $8m^2$

Seed rate: 40 kg/ha; 32 gm/plot

Harvesting:

- first cut- 50 days after sowing
- Second and third cut- at 30 days interval
- Harvesting was done in 1 sq. m area of each plot
- During harvesting, plants were cut 15 cm above the ground to ensure the tillering of teosinte.

RESULTS AND DISCUSSION

The mean monthly meteorological data (maximum and minimum temperature and total rainfall) during the experimental period of April 2013 to September 2013 was taken from the daily record of National Maize Research Program (NMRP) at Rampur, located about 4 km away from experimental site, for Chitwan; the daily record of weather sub-station

established in each site at Gorkha and Tanahun. Temperature (mean maximum and mean minimum) and total rainfall during the experiment period has been illustrated in Figure 1.

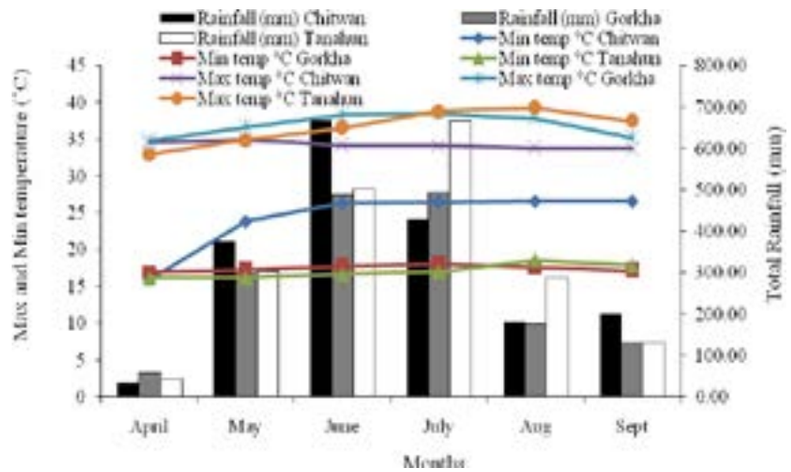

Figure 1. Total rainfall and status of temperature in the research sites

Table 2. Plant height of Teosinte as affected by date of sowing

Date of sowing	Plant height of Teosinte (cm)		
	15 DAS	30 DAS	45 DAS
T1= 15th April	21.41[b]	63.78[b]	101.7[b]
T2= 23 April	24.17[a]	69.94[a]	109.8[a]
T3= I st May	19.44[c]	57.80[c]	96.17[c]
T4= 9th May	18.32[d]	51.10[d]	90.21[d]
LSD	0.9131	3.166	4.040

Number of tillers per plant

The mean number of tillers of teosinte revealed that the number of tillers goes on decreasing on successive harvesting (Table 3) and the highest number of tillers was found on second date of sowing (23rd April) in Chitwan in all harvesting period (Table 3). No of tillers is one of the components that would contribute to the forage yield, but only increment in tiller number won't have direct impact to herbage mass until its dry matter also increases. Therefore, this result could be reflected with the seasonal factors, such as nature of establishment, growing habit, and also due to the effect of soil and climate.

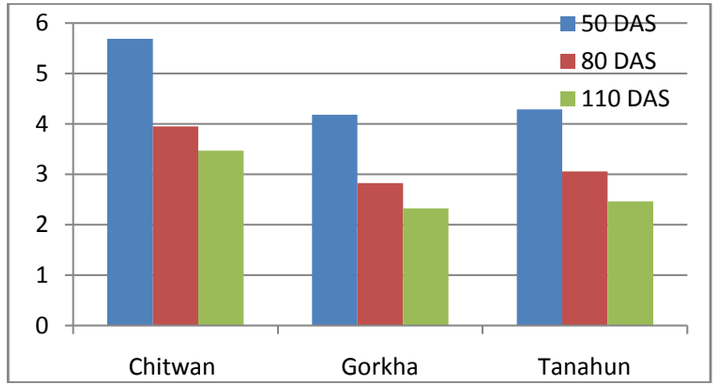

Figure 2. Number tiller/plant in terms of site performance

Table 3. Effect of interaction between location and date of sowing on number of tillers per plant of teosinte

Treatments	No of tillers of Teosinte		
	50 DAS	80 DAS	110 DAS
L1T1	5.683[b]	3.763[b]	3.367[b]
L1T2	7.067[a]	5.300[a]	4.720[a]
L1T3	5.243[bc]	3.593[bc]	2.967[cd]
L1T4	4.767[cdef]	3.130[cd]	2.813[cd]
L2T1	4.233[efgh]	2.897[dfg]	2.323[ef]
L2T2	4.897[cde]	3.210[cd]	2.747[cd]
L2T3	3.867[ghi]	2.807[def]	2.153[f]
L2T4	3.727[hi]	2.400[f]	2.070[f]
L3T1	4.487[defg]	3.137[cd]	2.613[de]
L3T2	5.000[cd]	3.620[bc]	3.077[bc]
L3T3	4.167[fghi]	2.930[de]	2.027[f]
L3T4	3.500[i]	2.533[ef]	1.987[f]
LSD	0.6509	0.4698	0.3719
CV (%)	8.05	8.34	7.91

Note: LSD= Least significant difference, CV= Coefficient of variation, DAS= Days after sowing, L1-L3= Location of sowing; L1=Chitwan, L2=Gorkha and L3-Tanahu, T1-T4= Date of sowing

Fresh biomass yield of teosinte

Effect of interaction between location and date of sowing on fresh biomass yield of teosinte

The effect of interaction between location and date of sowing was statistically significant ($P<0.05$) for fresh biomass yield of teosinte. At 50 DAS, the highest biomass yield was 84.33 t/ha that was obtained on Chitwan at 23rd April (L1T2) whereas the lowest biomass yield was 23.67 ton/ha that was obtained on Gorkha at 9th May (L2T4) (Table 4). Similarly, at 110 DAS, the highest biomass yield was 32.57 t/ha in Chitwan at 23rd April (L1T2) whereas the lowest biomass yield was 4.533 ton/ha that was obtained on Gorkha at 9th May (L2T4) (Table 40). In total fresh biomass yield of teosinte, the effect of interaction between location and date of sowing was statistically significant ($P<0.05$). Accordingly, the highest total biomass yield was 165.0 t/ha that was in Chitwan at 23rd April (L1T2) (Table 4).

Table 4. Effect of interaction between location and date of sowing on fresh biomass yield of teosinte

Treatments	Fresh Biomass yield of Teosinte (ton/ha)			Total
	50 DAS	80 DAS	110 DAS	
L1T1	72.67 ^{b}	40.40^{b}	28.50^{b}	141.6^{b}
L1T2	84.33^{a}	48.07^{a}	32.57^{a}	165.0^{a}
L1T3	52.33^{cd}	35.07^{c}	26.60^{b}	114.6^{c}
L1T4	44.17^{de}	33.77^{cd}	22.13^{c}	100.1^{de}
L2T1	31.33^{fg}	18.97^{gh}	8.867^{f}	59.17^{gh}
L2T2	37.33^{ef}	20.97^{g}	11.13^{ef}	69.43^{g}
L2T3	29.33^{fg}	16.87^{h}	7.800^{fg}	54.00^{hi}
L2T4	23.67^{g}	15.67^{h}	4.533^{g}	43.87^{i}
L3T1	51.50^{cd}	27.47^{ef}	14.63^{de}	93.60^{ef}
L3T2	58.67^{c}	30.80^{de}	17.50^{d}	107.0^{cd}
L3T3	49.00^{cd}	24.87^{f}	11.47^{ef}	85.33^{f}
L3T4	36.33^{ef}	18.93^{gh}	10.80^{f}	66.07^{g}
SEM	32.15	3.923	4.248	38.18
LSD	9.727	3.398	3.536	10.60
CV (%)	11.92	7.15	12.58	6.74

Note: SEM= Standard error of the mean, LSD= Least significant difference, CV= Coefficient of variation, DAS= Days after sowing, L1-L3= Location of sowing; L1=Chitwan, L2=Gorkha and L3-Tanahu , T1-T4= Date of sowing

The second sowing date was important in terms of producing higher cumulative fresh herbage mass whereas Chitwan had better performance. It could be due to the favorable climate (rainfall and temperature), less competitions as well as less weed infestation during second sowing date (23rd April) which could have favored for normal vegetative growth of teosinte than that of delayed sowing. Basically, plant subjected to water stress has reduced photosynthetic activity and reduced growth and active nutrient uptake (Baker, 1993). Delay of sowing and shortening of the growing cycle decreased the amount of radiation intercepted during the growing season and thus total fresh yield.

Dry weight yield of teosinte

Effect of interaction between location and date of sowing on dry weight yield of teosinte

The effect of interaction between location and date of sowing was statistically significant ($P<0.05$) for dry weight yield of teosinte. Accordingly, at 50 DAS, the highest dry weight was obtained when teosinte was sown in Chitwan on 23rd April (L1T2) whereas the lowest dry weight was obtained when sown in Gorkha on 9th May (L2T4) (Table 5). The similar results were found when teosinte was harvested at 80 DAS and 110 DAS (Table 5).

The effect of interaction between location and date of sowing on total dry weight yield of teosinte was statistically significant ($P<0.05$). The highest dry weight yield was 21.80 t/ha that was obtained when teosinte was sown in Chitwan on 23rd April (L1T2) whereas the lowest dry weight yield was 4.467 t/ha that was obtained when teosinte was sown in Gorkha on 9th May (L2T4) (Table 5).

The overall trend of dried weight of herbage mass revealed that the mean cumulative dried herbage mass was decreased as sowing date was early, as well as del;ayed to standard. Likewise, the dry weight of herbage mass was decreased at successive harvesting from 50 DAS to 110 DAS. Dry matter yield would be reduced if sowing is delayed until late summer. Delay of sowing and shortening of the growing cycle decreased the amount of radiation intercepted during the growing season and thus total fresh and dry yield. Thus, literatures suggest that early establishment; specific growing habit of plants, and favorable climate would be more responsible to have better herbage mass production if planted earlier.

Effect of interaction between location and date of sowing on CP content in teosinte

The effect of treatments on CP content in teosinte was statistically significant ($P<0.05$) for all harvesting. Accordingly, at 50 DAS, the highest CP content was 13.00% that was obtained when teosinte was sown in Chitwan on 23rd April (L1T2) whereas the lowest CP content was 7.536% that was obtained when teosinte was sown at Gorkha on 9th May (L2T4) (Table 6). At 110 DAS, the highest CP content was 9.8% when teosinte was sown in Chitwan on 23rd April (L1T2) whereas the lowest CP content was 7.079% and 7.046% that was obtained when teosinte was sown in Gorkha on 9th May (L2T4) and Tanahun on 9th May (L3T4) that remained statistically similar ($P>0.05$) (Table 6).
The overall trend showed that CP content of teosinte was decreased with subsequent harvests. That could be due to the fact that N content of the soil could have been depleted in each harvest, which could affect the nitrogen content, and consequently to the CP content of forage species. Similar result was also obtained on the experiment of forage grass and legume in the mixture under shade condition (Barshila, 2006).

Table 5. Effect of interaction between location and date of sowing on dry weight yield of teosinte

Treatments	Dry weight yield of Teosinte (ton/ha)			Total
	50 DAS	80 DAS	110 DAS	
L1T1	9.793^{b}	4.997^{b}	2.647^{b}	17.44^{b}
L1T2	12.58^{a}	5.957^{a}	3.267^{a}	21.80^{a}
L1T3	5.543^{c}	3.763^{c}	2.117^{c}	11.42^{c}
L1T4	4.570^{cd}	3.240^{cd}	1.830^{c}	9.460^{de}
L2T1	3.650^{de}	1.597^{gh}	0.893^{efg}	6.140^{hi}
L2T2	3.787^{de}	2.333^{efg}	1.197^{e}	7.317^{fgh}
L2T3	3.130^{de}	1.550^{gh}	0.570^{fg}	5.250^{ij}
L2T4	2.493^{e}	1.440^{h}	0.533^{g}	4.467^{j}
L3T1	4.167^{cde}	3.107^{cde}	1.283^{de}	8.557^{ef}
L3T2	5.600^{c}	3.667^{cd}	1.707^{cd}	10.97^{cd}
L3T3	3.873^{cde}	2.913^{def}	1.043^{ef}	7.830^{fg}
L3T4	3.180^{de}	2.243^{fgh}	0.817^{efg}	6.240^{ghi}
SEM	0.8340	0.1890	0.0650	0.792
LSD	1.5670	0.7458	0.4373	1.527
CV (%)	17.57	14.18	17.15	9.12

Note: SEM= Standard error of the mean, LSD= Least significant difference, CV= Coefficient of variation, DAS= Days after sowing, L1-L3= Location of sowing; , L1=Chitwan, L2=Gorkha and L3-Tanahu , T1-T4= Date of sowing

The result also revealed that the highest CP content was for second date of sowing. It might be due to the increment in crude protein concentration with later sowing than first date due to reduced maturity of the plants. The decrease in CP content in delayed sowing than second date might be associated with the growing condition of plant, such as water stagnation, temperature, rainfall and unfavorable growing condition.

Effect of interaction between location and date of sowing on Ca content in teosinte

The effect of treatment on Ca content in teosinte was significant for all harvesting. Accordingly, at 50 DAS, the highest Ca content was obtained when teosinte was sown in Chitwan on 23rd April (L1T2) and Tanahun on 23rd April (L3T2) that remained statistically similar (P>0.05). Likewise at 110 DAS, the highest Ca content was obtained when teosinte was sown in Chitwan on 15th April (L1T1) and Chitwan on 23rd April (L1T2) whereas the lowest Ca content was obtained when teosinte was sown at Chitwan on 1st May (L1T3) (Table 7).

Table 6. Effect of interaction between location and date of sowing on CP content in teosinte

Treatments	% CP content in Teosinte sample		
	50 DAS	80 DAS	110 DAS
L1T1	12.24^{ab}	9.880^{ab}	8.943^{b}
L1T2	13.00^{a}	10.57^{a}	9.802^{a}
L1T3	11.72^{bc}	9.413^{b}	8.343^{bcd}
L1T4	9.708^{defg}	8.107^{cd}	7.729^{de}
L2T1	8.854^{efg}	7.984^{cd}	7.609^{ef}
L2T2	9.718^{defg}	8.679^{c}	8.405^{bc}
L2T3	8.626^{g}	6.967^{ef}	7.079^{f}
L2T4	7.563^{h}	6.599^{f}	6.317^{g}
L3T1	9.928^{de}	8.650^{c}	7.552^{ef}
L3T2	10.83^{cd}	9.730^{b}	8.252^{cd}
L3T3	9.825^{def}	8.180^{cd}	7.145^{ef}
L3T4	8.742^{fg}	7.651^{de}	7.0466^{f}
SEM	0.3536	0.2449	0.1975
LSD	1.050	0.7278	0.5868
CV (%)	6.09	4.98	5.36

Note: SEM= Standard error of the mean, LSD= Least significant difference; L1-L3= Location of sowing; , L1=Chitwan, L2=Gorkha and L3-Tanahu CV= Coefficient of variation, DAS= Days after sowing

The overall result of Ca content in teosinte revealed that, it was not significant for location of sowing. However, the date of sowing has significant effect on Ca content in teosinte. The highest Ca content was found on second date of sowing (23rd April) and the value decreased when teosinte was sown earlier or later than that. The interaction of location and date of sowing was also significant for Ca content in teosinte.

Table 7. Effect of interaction between location and date of sowing on Ca content in teosinte

Treatments	% Ca content in Teosinte sample		
	50 DAS	80 DAS	110 DAS
L1T1	1.473^{ab}	1.526^{abc}	1.687^{a}
L1T2	1.584^{a}	2.002^{a}	1.693^{a}
L1T3	1.039^{bcd}	1.556^{abc}	0.954^{c}
L1T4	1.279^{abc}	1.089^{bc}	1.137^{bc}
L2T1	0.789^{d}	1.257^{bc}	1.092^{bc}
L2T2	1.116^{bcd}	1.526^{abc}	1.338^{abc}
L2T3	0.949^{cd}	0.913^{c}	1.171^{bc}
L2T4	0.940^{cd}	1.394^{abc}	1.176^{bc}
L3T1	1.068^{bcd}	1.516^{abc}	1.175^{bc}
L3T2	1.640^{a}	1.699^{ab}	1.475^{ab}
L3T3	1.271^{abc}	1.176^{bc}	1.080^{bc}
L3T4	1.033^{bcd}	1.397^{abc}	1.369^{abc}
SEM	0.1354	0.1889	0.1366
LSD	0.4023	0.5611	0.4059
CV (%)	19.91	23.03	18.56

Note: SEM= Standard error of the mean, LSD= Least significant difference, CV= Coefficient of variation, DAS= Days after sowing; L1-L3= Location of sowing; , L1=Chitwan, L2=Gorkha and L3-Tanahu

CONCLUSIONS

Location of sowing could significantly influence on morphological attributes, and thus to the productive performance, including chemical constituents of teosinte. Higher fresh and dried weight of teosinte from Chitwan sowing indicated higher degree of sensitivity of teosinte for sowing locations.

Date of sowing could significantly influence on morphological attribute, and thus to the productive performance, including chemical constituents of teosinte. Higher cumulative herbage mass from second sowing date (23rd April) indicated higher degree of sensitivity of teosinte for sowing dates.

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Production potentials of promising oat (*Avena sativa*) varieties in combination with legumes at farmers' field condition

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ABSTRACT

Winter fodder scarcity is one of the major problems in feeding management for ruminants in Nepal. Some of the improved fodders are introduced at farmers' level but appropriate technology is not yet established. Moreover there is a risk of fluctuation in the production potential of such fodder due to climatic variability across the location. Three trials were conducted across the three locations of Chitwan, Gorkha and Tanahu district of Nepal to estimate production potentials of two varieties of fodder oats (Avena sativa)in combination with field pea (Pisum sativum) and vetch (Visia sativa) . Six treatments were used; each replicated for four times in a RCBD. Fresh herbage mass and dried weight was estimated along with number of tiller per plant and determination of major chemical constituents. Findings revealed that highest dried matter yield (t/ha) was obtained in Gorkha and Chitwan district (7.0 t/ha) that varied significantly (P<0.001) with respect to the location whereas treatment differences remained statistically similar indicating similar performance of the varieties across the location. Likewise, except %CP there was significant variation in the % content of EE, ADF, NDF and ADL among the sites/location whereas such variation was statistically similar for treatment combination that fairly suggest the differences in quality of fodder as per their productive performance. Findings clearly suggests the need to consider niche specific variation while promoting improved cultivation practices of oats in combination with promising forage legumes. This could equally be linked to the climatic parameters such as total rainfall received, while making efforts in improvement in the quantity herbage harvest.

Keywords:, Vetch, field pea, Dried Weight, herbage mass, forage legumes,

INTRODUCTION

Winter feed deficit is one of the critical problems related to ruminant production in Nepal whereas quality feeding management considering leguminous as well as non-leguminous fodder cultivation (Upreti and Shrestha, 2006; Upreti and Upreti, 2013) is grossly lacking. Oats are considered most important cereal fodder crop grown in Nepal during the winter season. Oats are quick growing, palatable, succulent and nutritious (Suttie and

Reynolds, 2004) and form an excellent combination when fed along with other winter season grasses such as berseem, lucerne, pea, and vetch. They have many uses: a cereal, a feed grain (to feed horses, sheep and poultry), green or conserved fodder. In Nepal, fodder oats have been under testing since 1970s, but the two cultivars Kent and Swan were distributed to relatively large numbers of farmers, especially after 1980s. Usually oat is an erect annual with a fairly good tillering habit. It attains a height of 1-2 m. The panicles are lax and effuse. The inflorescence may be equilateral or unilateral. The main axis and lateral branches end in a single apical spikelet. The grain is long and slender or spindle shaped and usually covered with fine hair at the upper end. The leaves may have a length of 25 cm and more. Roots are fibrous (Relwani, 1979).

In spite of its advantages to grow as winter fodder- farmers have not been cultivating oats widely due to several factors associated with it. This necessitate establishing demonstration block of promising winter fodder cultivation at the farmers' field so that demonstration effect of cultivation practices and dry matter yield potential of fodder, such as oats (Relwani, 1979; Suttie and Reynolds, 2004), would help farmers in convincing towards opt of these practices. Better nutrition through low cost fodders would help farmers in reducing per unit milk production and way out the path towards their ability in adapting harsh condition that may prevail due to alteration in climatic parameters that are associated with feeding management in Nepal. Accordingly a field trial was conducted in three research sites of Gorkha, Tanahu and Chitwan with the objective to establish demonstration unit at farmers' field by using promising fodder oats and legumes, and to demonstrate cultivation practices and fodder yield potentials in terms of dry matter and chemical composition.

MATERIALS AND METHODS

Experimental site and duration
The field experiments were conducted at Farmers' field condition in three districts, viz: Gorkha, Tanahun and Chitwan during November 2012 to March 2013. Palungtar, Gorkha district is situated approximately 148 kilometer North of Dumre Bazar-lies in the Kathmandu-Pokhara Highway. Dulegauda, Tanahun district lies about 28 km west to Pokhara and represent inner flat plain valleys with the foot hills towards the North. Chanauli-Gunjanagar of Chitwan district represent sub-tropical inner Terai region of southern part of central part Nepal, situated between 83°48’ to 84°45’ east longitude to 27°21’ to 27°46’ north latitude, and is 228 meter above sea level.

Design: Randomized Complete Block Design; each treatment replicated for 4 times. Each treatment was sown using 6 meter square of area. All together there were 24 experimental units, each with 3× 2 meter square area.

Treatments:

a. Oats variety Kamadhenu (a)
b. Oats variety Netra (b)
c. Oats 'a' + winter vetch in combination
d. Oats 'a' + field pea in combination

e. Oats 'b' + winter vetch in combination
f. Oats 'b' + field pea in combination

Seed rate: Seed rate was used as -oats: @90 kg/ha; vetch @8-10 kg per ha in mixture with oats; pea-@30 kg per ha in mixture with oats was used.

Fertilizer: Organic manure was applied as @10 t Farm Yard Manure/ha. Nitrogen and phosphorus fertilizers were applied @120:40 kg/ha considering a double cut crop (80 kg nitrogen as basal and 40 kg nitrogen for top dressing after the first cut). Accordingly, DAP 52 g +Urea 84 g per plot of $6m^2$ was applied as basal dose, and urea was applied as 24 g per plot as top dressing.

Seeds were sown during first week of November (after rice harvest). Spacing was maintained as: Row to row: 25 cm; legumes in between rows in a continued fashion

Climate

The experiment sites lies in the subtropical humid climate zone of Nepal. The mean monthly meteorological data (maximum and minimum temperature and total rainfall) covering the experimental period was taken from the daily record of National Maize Research Program (NMRP) at Rampur, located about 300 m away from experimental site for Chitwan Chanauli site whereas similar information was obtained from Weather Station at Khairanitar, Tanahun as a nearby weather station for Gorkha and Tanahun site. Temperature and total rainfall during the experiment period has been illustrated in Figure 1.

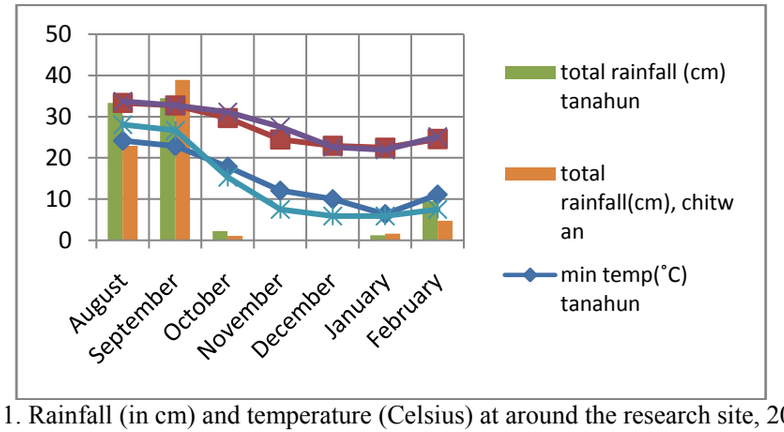

Figure 1. Rainfall (in cm) and temperature (Celsius) at around the research site, 2012/13

RESULTS AND DISCUSSION

Physico-chemical properties of soil

The chemical properties of experimental sites revealed that soil pH varied as per site. pH in the Chitwan was low which denotes the strongly acidic (5-5.5 strongly acidic) condition of soil whereas it was slightly alkali in the case of Tanahun and Gorkha. The

available organic matter % was medium in all sites so as the N content. On the other hand available phosphorus and potash in all the sites was medium to high. Available phosphorus was relatively low in the Tanahun whereas it was higher in the case of Tanahun followed by in the Gorkha (Table1).

Table1.The Physico-chemical characteristics of soil (0-15cm) at the experimental site in 2012

Site	pH	OM %	N%	P_2O_5 (Kg/ha)#	K_2O (Kg/ha)#	Physical properties			Remarks
Chitwan						% Sand	% Silt	% Clay	
	5.5	2.86	0.12	347.5	493.9	47	42.5	10.5	Loam
Tanahun	7.8	2	0.1	80.08	117.1	17	68.5	14.5	Silt Loam
Gorkha	8	2.6	0.12	268.9	126.2	17	70.5	12.5	Silt Loam

Note: # denotes available phosphorus and potash

Fresh and dried fodder yield

Table (2) presents fresh and respective dried yield of the treatments. Trends of fresh fodder yield (t/ha) was such that it increased from first to second harvest in general. Fresh fodder yield in Tanahun was the lowest whereas treatments variation was non-significant ($P>0.05$) whether they be mixed with vetch or peas or grown as oats alone (Table 2). Variation in fresh fodder yield could be attributed to the several factors including rainfall that was higher during September in Chitwan compared to the Tanahun and Gorkha. % OM and available P_2O_5 content in the Chitwan was also higher compared to the rest of the sites (Table 1). MOAC-DLS (2065/66BS) reported that general fresh yield of oats could be 30-50 t/ha that the results of this experiments matches well to the value reported. Pariyar (2002) had reported that results from the leasehold district in Nepal had yielded 25-31 t/ha of fresh herbage mass of oats grown in combination with vetch and pea. Findings from this experiment revealed possibility of further increment in the fresh yield to the value reported by Pariyar (2002) that could be varied as per district and local sites.

The trend in dried yield of treatments considering district variation was similar to that of fresh herbage mass yield (Table 2). Accordingly total dried yield of fodder varied significantly ($P<0.01$) to the districts whereas treatment combination remained statistically similar. Highest total dried yield was for Gorkha and Chitwan (7.6 t/ha) followed by Tanahun. In terms of treatments as well Netra (6.4 t/ha) alone or in combination with vetch had highest dried yield but the statistically it was similar ($P>0.05$) to the other treatments (Table 2). Detail of fresh weight of fodder as well as respective dried weight as per districts for different harvests has been presented in Table (3) and (4).

Table2. Fresh fodder yield and corresponding Dried yield by location and specie combination

Factors	Fresh fodder wt. (t ha^{-1})				Dried wt. (t ha^{-1})			
	I harvest	II harvest	III harvest	Total fresh fodder	I harvest	II harvest	III harvest	Total dried fodder
Locations								
Chitwan	13.92	27.29	-	41.41	1.91	5.12	-	7.03
Gorkha	10.79	12.96	17.67	41.42	2.07	2.07	3.53	7.68
Tanahun	17.38	10.71	-	28.08	2.08	1.65	-	3.73
F-prob	<0.001	<0.001	-	<0.01	NS	<0.001	-	<0.001
LSD	2.22	5.49	-	6.00	0.31	0.66	-	0.91
Species combinations								
Kamdhenu	12.42	18.75	17.54	37.00	1.79	3.11	3.34	6.01
Netra	13.29	18.67	17.54	37.79	1.95	3.23	3.66	6.41
Kamdhenu+Vetch	13.67	16.33	17.91	36.00	1.99	2.93	3.45	6.07
Kamdhenu+Pea	14.08	16.83	18.64	37.25	2.04	3..04	3.78	6.35
Netra+vetch	15.62	16.83	17.18	38.12	2.19	2.76	3.59	6.15
Netra+Pea	15.08	15.50	17.18	36.25	2.18	2.59	3.34	5.87
F-Prob	NS	NS	NS	NS	NS	NS	NS	NS
LSD	2.21	3.34	2.33	4.04	0.33	0.66	0.53	0.77

Table 3. Treatments combination and fresh weight of fodders, t ha^{-1}, using Split plot design

Factors	Chitwan			Gorkha				Tanahun		
Treatments	I Harvest	II Harvest	Total	I Harvest	II Harvest	III Harvest	Total	I Harvest	II Harvest	Total
Kamdhenu	12.38	31.25	43.62	9..00	11.75	17.50	38.25	15.88	13.25	29.12
Netra	14.00	30.50	44.50	10.50	13.00	17.50	41.00	15.38	12.50	27.87
Kamdhenu+Vetch	10.75	28.00	38.75	11.75	13.00	18.00	42.75	18.50	8.00	26.50
Kamdhenu+Pea	12.75	27.50	40.25	11.50	14.00	19.00	44.50	18.00	9.00	27.00
Netra+Vetch	17.38	25.25	42.62	11.50	13.50	17.00	42.00	18.00	11.75	29.75
Netra+Pea	16.25	24.25	40.50	10.50	12.50	17.00	40.00	18.50	9.75	28.25

First harvest: The interaction effects were not significant (p>0.05) with SEM=1.35, LSD=3.95, %CV= 19.2

Second harvest: The interaction effects were not significant (p>0.05) with SEM=2.44, LSD=7.08, %CV= 23.

Third harvest: The interaction effects were not significant (p>0.05) with SEM=1.34, LSD=4.04, %CV= 6.6

Total fresh biomass: The interaction effects were not significant (p>0.05) with SEM=2.84, LSD=8.17, %CV= 13.3

There was a visible difference in dried weight of different treatments of oats in combination with peas and vetch (Figure 2). Accordingly all the treatments had higher yield in Chitwan followed by in Gorkha and Tanahun. Lower yield of treatments in Tanahun was due to short cropping period in Tanahun where only two cuts was possible as farmers had to continue with other food crops after second harvest. Nevertheless the oat variety 'Netra' had relatively better performance than the other (Figure 2).

Table 4. Treatments combination and dried weight of fodders, t ha^{-1}, using Split plot design

Factors	Chitwan			Gorkha				Tanahun		
Treatments	I Harvest	II Harvest	Total	I Harvest	II Harvest	III Harvest	Total	I Harvest	II Harvest	Total
Kamdhenu	1.82	5.44	7.25	1.74	1.83	3.36	6.92	1.82	2.05	3.87
Netra	1.99	5.68	7.76	1.99	2.06	3.68	7.74	1.86	1.95	3..81
Kamdhenu+ Vetch	1.51	5.57	7.09	2.25	2.02	3.43	7.71	2.22	1.19	3.41
Kamdhenu+ Pea	1.74	5.11	6.85	2.14	2.45	3.84	8.43	2.23	1.56	3.79
Netra+Vetch	2.29	4.66	6.95	2.17	2.02	3.60	7.79	2.10	1.62	3.72
Netra+Pea	2.12	4.23	6.35	2.17	2.05	3.29	7.51	2.25	1.52	3.76

First harvest: The interaction effects were not significant (p>0.05) with SEM=1.35, LSD=3.95, %CV= 19.2

Second harvest: The interaction effects were not significant (p>0.05) with SEM=2.44, LSD=7.08, %CV= 23.

Third harvest: The interaction effects were not significant (p>0.05) with SEM=1.34, LSD=4.04, %CV= 6.6

Total fresh biomass: The interaction effects were not significant (p>0.05) with SEM=2.84, LSD=8.17, %CV= 13.3

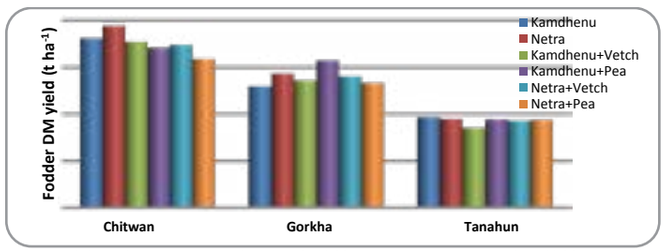

Figure 2. Fodder dry matter yield of different treatments in different locations

Chemical constituents

The nutrient composition of fodders at second harvest is presented in Tables 5 and 6. Dry matter content of fodder at Gorkha was significantly higher compared to Tanahun and Chitwan (p<0.001). There was no significant difference in crude protein (CP) content in all the three sites testes. Upreti and Upreti (2013) reported the CP value of oats in general as of 11.6%, whereas in this experiment the values in all the three sites tested was 5.9%. It could be due to its late stage of harvest.

Table 5. Chemical constituents as per treatments at second harvest

Factors	% chemical constituents							
	DM	CP	EE	T Ash	Ca	NDF	ADF	ADL
Locations								
Chitwan	93.06	5.70	3.10	13.18	0.80	64.87	52.22	7.06
Gorkha	95.91	5.97	4.58	10.92	0.89	66.33	55.90	12.14
Tanahun	95.28	5.03	3.15	13.59	0.99	53.64	41.53	5.03
F-prob	<0.001	NS	<0.001	<0.001	NS	<0.001	<0.001	<0.01
LSD	0.40	1.50	0.36	0.82	0.22	2.30	3.03	2.73
Species combinations								
Kamdhenu	94.52	5.44	3.60	12.28	0.78	61.32	49.24	6.47
Netra	94.59	4.46	3.72	12.53	1.06	63.33	53.04	10.57
Kamdhenu+Vetch	94.81	5.42	3.91	13.24	0.85	58.54	46.58	7.70
Kamdhenu+Pea	94.50	6.06	3.73	12.79	0.94	61.58	50.02	8.64
Netra+vetch	94.87	6.95	3.47	12.33	0.84	62.52	51.82	8.67
Netra+Pea	95.21	5.08	3.22	12.21	0.93	62.37	48.59	6.40
F-Prob	NS	<0.001	NS	NS	NS	NS	NS	NS
LSD	0.88	1.03	0.50	1.19	0.29	3.53	5.13	4.39

The ether extract (EE) content varied significantly from site to site ($p<0.001$) so as the total ash, NDF, ADF and ADL. There was no difference in Ca content amongst the three sites (Table 5). NDF, ADF and ADL values were similar to the values reported by Upreti and Upreti (2013) with slighter higher values in this experiment. ADL content in Gorkha was slightly higher than the other sites and also to the values reported by Upreti and Upreti (2013). ADL content in Gorkha could have been attributed to the lower rainfall in the sites and also due to relatively dryness in the site. These values as per treatment combination, however, were not statistically significant ($p>0.05$), except CP content whereas CP content of treatments varied statistically ($p<0.05$) and it was highest for Netra plus vetch (Table 5). Detail of % chemical constituents as per treatments combination and sites has been presented in Tables 6 (a, b).

Table 6a. Nutrient composition at second harvest (CP, EE, T Ash and Ca)

Fodder species/Locations	CP			EE			T Ash			Ca		
	Cht	Gkh	Tan	Cht	Gkh	Tan	Cht	Gkh	Tan	Cht	Gkh	Tan
Kamdhenu	2.94	7.82	5.55	2.74	4.82	3.26	12.82	11.74	12.29	0.81	0.91	0.62
Netra	3.01	5.94	4.44	3.26	5.22	2.69	13.18	9.69	14.72	0.98	1.14	1.06
Kamdhenu+Vetch	6.68	5.44	4.14	3.22	5.30	3.22	13.51	12.55	13.65	0.89	1.09	0.57
Kamdhenu+Pea	6.99	6.50	4.70	2.96	5.23	3.00	12.95	10.48	14.93	0.89	0.86	1.07
Netra+Vetch	7.53	6.84	6.47	3.18	3.61	3.62	13.85	10.55	12.61	0.56	0.67	1.28
Netra+Pea	7.03	4.31	4.90	3.27	3.29	3.09	12.80	10.50	13.32	0.68	0.72	1.39

Note: CP: The interaction effects were significant ($p<0.001$); SEM=0.72, LSD=2.07, %CV= 22.5

EE: The interaction effects were significant ($p<0.001$); SEM=0.31, LSD=0.87, %CV= 16.9

T Ash: The interaction effects were not significant ($p>0.05$); SEM=0.70, LSD=1.99, %CV= 11.5

Ca: The interaction effects were significant ($p<0.05$) SEM=0.17, LSD=0.49, %CV= 28.9

Table 6b. Chemical composition of major nutrients at second harvest (NDF, ADF and ADL)

Fodder species/Locations	NDF			ADF			ADL		
	Cht	Gkh	Tan	Cht	Gkh	Tan	Cht	Gkh	Tan
Kamdhenu	64.77	63.79	55.40	50.72	55.84	41.16	6.38	8.04	4.99
Netra	66.05	69.99	53.96	52.57	60.59	45.97	6.26	21.27	4.20
Kamdhenu+Vetch	62.98	61.91	50.70	49.82	49.94	39.99	6.02	13.19	3.89
Kamdhenu+Pea	65.27	65.28	54.19	56.19	50.82	43.06	6.45	12.08	7.40
Netra+Vetch	65.55	68.75	53.27	51.05	63.21	41.20	10.32	10.81	4.78
Netra+Pea	64.60	68.23	53.30	52.98	55.00	37.79	6.91	7.42	4.86

Note: NDF content: The interaction effects were not significant ($p>0.05$); SEM=2.07, LSD=5.87, %CV= 7.0; ADF: The interaction effects were not significant ($p>0.05$); SEM=2.98, LSD=8.46, %CV= 12.5;

ADL content: The interaction effects were not significant ($p>0.05$); SEM=2.56, LSD=7.27, %CV= 26.1

CONCLUSIONS

There is a need to consider niche specific variation while promoting improved cultivation practices of oats in combination with promising forage legumes. This could equally be linked to the climatic parameters such as total rainfall received while making efforts in improvement in the quantity herbage harvest.

The findings revealed lesser variation of the popular oats varieties - Netra and Kamadhenu whereas role of legumes was minimal in contributing to the total herbage mass. This fairly suggests the need to explore better performing legume species to be suited with oats in combination.

There were differences in quality of fodder in relation to the major chemical constituents that varied according to the sites. This also emphasizes the need to consider proper harvesting management to address the particular production scenario of a locality.

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Effect of packaging materials on fruit quality and shelf life of mandarin (*Citrus reticuleta* Blanco)

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ABSTRACT

The experiment was conducted to assess the effect of different packaging materials on postharvest losses and quality parameters of mandarin during storage at ambient condition (16 degree±2^{0}C). Observations on PLW%, decay loss%, fruit firmness, juice%, TSS content, TA%, TSS/acid ratio, vitamin C content, and organoleptic rating were recorded at weekly interval. Experiment revealed that the PLW and decay loss was increased significantly with the increase in storage period in different container. Among the different containers PLW (7.08%), decay loss(3.83%) was lesser in CFB boxes followed by wooden boxes. Fruit retained firmer (3.54 kg-force) with maximum juice recovery (46.37%) followed by wooden boxes than other containers or loosely form. Regarding the quality parameters, TSS was increased with the increase in storage whereas acidity and vitamin C were decreased. The quality attributes were found better in CFB boxes with lowest TSS (10.7^{0}Brix), higher in acidity (0.97%), organoleptic rating (4.51) and higher in vitamin C (26.74mg/100 ml) than other containers or loosely form.

Key words: Physiological weight loss, decay loss, juice recovery, postharvest shelf life, perishability

INTRODUCTION

Mandarin under the citrus is most valuable fruit crop for its economic and nutritious importance in Nepal. It is one of the lead exportable commodities among the fruit crops produced by the country. Nepal supplies the mandarin to its domestic market as well as exports to neighbouring countries. Nepal exports 625 tons of mandarin and sweet orange to India and China (Anon, 2013).The heavy loss during the transportation and marketing in and outside the country isfaced due to its high perishability and non-climacteric nature.Improper handling, overloading and dropping of the fruits during weighment are the main factors of losses during packaging (Bhattarai et al., 2013). Losses during fresh fruit handling range from 5-10 percent in most developed countries, but from 25-30 percent or more in developing and underdeveloped countries (Ladaniya, 2008). Postharvest losses of oranges varied from 6.30-7 percent depending upon the mode of transport, time and season (Madan and Ullasa, 1993)Mandarin showed and estimated loss of 20-25 percent in transportation from field to market and up to 25 percent loss in cellar store stored for a period of 90 days (PHLRD, 2005). A study conducted in Lumjung, Tanahun and Gorkha showed about 10 percent of loss during harvesting, 2-3 percent

postharvest loss from production point to collection and 5-7 percent was due to transportation (Bhandari *et al.*, 2002).

The package must protect the produce for mechanical damage and poor environmental condition during handling and distribution (Sinha, et. al., 2012). Generally, mandarin fruits in peak season are being transported loosely by trucks and jeeps to the markets which results heavy losses and poor quality and not acceptable by consumers. Ladaniya (2001) reported that transport to fruit to distant markets loosely in trucks results in 20-25 percent losses. The contained fruit nutrition in mandarin is more fragile and susceptible with packaging materials. Ascorbic acid is more susceptible to significant losses during postharvest handling and storage (Wilhelmina, 2005). Fruit spoilage has been associated with loss of functional compounds such as phenolic and ascorbic acid (Sanusi et al., 2008). Very little traders are used plastic crates, and bamboo baskets, however, wooden basket, and corrugated fibre box (CFB) are not practiced in use for transportation of mandarin. In developed country, wooden box and CFB box are extensively used for distant market to keep better quality and shelf life.Moreover, wooden and bamboo basketsare local products and can be used extensively by utilizing timber and bamboo easily. In the other hand, Nepal has started its exporting to neighbouring countries like Bangladesh, Thailand and Tibet which is very distant. Appropriate packaging protects the fruits from physiological, pathological and physical deterioration in the marketing channels and retains their attractiveness (Bose, 2001). The storage of fruits in proper packaging materials helps in curtailing the postharvest losses (Kaur et. al., 2013). The common practice of packing oranges in baskets and open truck van for distant markets by distributors should be discouraging (Faasema et. al., 2011). Hence, to reduce these heavy losses during the transportation, standard packaging containers would be beneficial. Thus, an appropriate packaging container is urgent to fetch attractive price by keeping firm with good quality during longer period. However, the evaluation of packaging materials is not performed yet.Keeping in view on above facts, the present investigations were undertaken to find out the ideal packaging material for transportation and storage of mandarin.

MATERIALS AND METHODS

This study was conducted at Khumaltar, Kathmandu in collaboration with Nepal Agricultural Research Council (NARC). Mandarin fruits of private orchard in Lamjung, with well-developed colour, and uniform in size were harvested with clipper keeping small pedicel. 10 kgof fruits were packed in each package viz., bamboo basket, wooden basket, plastic crates, wooden boxes, Corrugated Fibre Box (CFB) with newspapercutting as cushioning materials, and loosely kept on the floor in mini truck as a control. The weight loss, damage percentage, and total transportation losses were observedimmediately after transportation and healthy fruits were kept for storage for four weeks at ambient condition ($16^0C \pm 2^0C$). The experiment was laid out in Randomized Block Design (RBD) with five treatments and replicated four times. Weekly observations on physicochemical parameters i.e. weight loss, decay loss, firmness, juice percentage, TSS, acidity, ascorbic acid and organoleptic rating were recorded and analysed as

outlined by AOAC (2005). The data were tabulated in excel sheet and statistically analysed with the procedures described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

From the perusal of the data in the table the PLW (%) increased with the increasing trends of the storage period from 1st week (3.73%) to 4th (14.96%) week under the ambient condition (16 ± 2^0 C) and the increase was much more higher in the fruits kept in loose form than in containers. Among the containers the PLW% was significantly less in the fruits with CFB box (7.08%) followed by wooden box (8.58%) and much higher in the fruits with loose form (12.73%) during the storage. At the end of the storage, the PLW% was found highest in the fruits kept in loose form (19.9%) followed by plastic crate (14.97%), and found lowest in CFB box (11.55%).

Increase in PLW during the storage period might be due to loss of water from the fruit surface through the evaporation and transpiration. The rate of PLW is highest in loose form, and might be due to higher rate of evaporation due to open condition in the storage. These findings were in corroboration in the findings of Kaur et. al. (2011) in peer who reported the PLW increased during storage and much less PLW was found in CFB box. Sharma and Singh (2010) claimed that PLW was increased with the increase in storage period in apple. Jain and Chauhan (1993) observed that the PLW was lowest in CFB in Kinnow mandarin due to CFB packed fruits were not exposed to atmosphere directly and the evapotranspiration. Simila observation was recorded by Sidhu et.al. (2006) who noted minimum PLW in the pear fruits packed in CFB.

Table 1. PLW (%) and Decay loss (%) in mandarins kept in different packaging materials under ambient conditions

Packing material	Weeks after storage									
	PLW (%)					Decay loss (%)				
	1	2	3	4	Mean	1	2	3	4	Mean
Loose form	5.17	10.28	15.57	19.90	12.73	1.48	5.38	10.24	19.27	9.09
Bamboo basket	3.89	7.84	11.39	14.67	9.45	0.93	4.80	7.49	10.52	5.93
Wooden box	2.93	7.12	10.56	13.73	8.58	0.91	4.86	7.15	11.47	6.10
CFB box	2.56	5.70	8.50	11.55	7.08	0.00	3.38	5.03	6.91	3.83
Plastic crate	4.12	8.34	11.97	14.97	9.85	0.99	4.92	7.86	10.24	6.00
Mean	3.73	7.86	11.60	14.96		0.86	4.67	7.55	11.68	
$LSD_{0.05}$	Container(C)			0.57		Container(C)			2.20	
	Weeks (W)			0.51		Weeks (W)			1.97	
	Interaction (CxW)			1.14		Interaction (CxW)			NS	

The decay loss was significantly increased with the increase in storage period from 1st week (0.86%) to 4th week (11.68%) in mandarin under room temperature. The higher percentage of decay loss was observed in loose condition (9.09%) and lowest percentage was recorded in the fruits packed in CFB box (3.83%) as mentioned by Deka et. al.

(2008) who noticed that CFB boxes remained intact without any structural damage. At the end of the storage, decay loss was much less in the fruits with CFB box (6.91%) followed by plastic crate (10.24%) whereas higher decay loss was recorded in the fruits with loose form (19.27%). The less decay percentage in CFB box was might be due to lesser chances of the external environments and microbes and higher loss in loose form might be due to fruits open condition had higher chances of the infection with microbes. Many earlier workers have observed that fruits in open condition have higher decay loss than in closed containers. Sharma and Singh (2010) in apple, Kaur et al. (2011) in pear, Jain and Chauhan (1993) in Kinnow mandarin, and Sharma et al. (2009) in apples have reported that the decay loss decreased with time during storage. Yadav et al. (2005) claimed that minimum decay loss was observed in CFB in ber.

The firmness was sharply declined with increase in the storage period in mandarin and found 4.0 kg/force in 1st week to 2.72 kg/force in the end of the storage i.e. 4th week. The perusal in the table had showed the decline in fruit firmness was much higher in the fruits under loose form than those kept in the containers. Fruits were found better texture packed in CFB box (3.54 kg-force) followed by wooden box (3.43 kg-force), and lowest firmness was recorded in the fruits with loose form (2.96 kg-force). At the end of the storage, CFB box gave the highest firmness (3.14 kg-force) and found least firmness in the fruits in loose form (1.97 kg-force). In summary, CFB and wooden boxes were observed the best containers for mandarin storage. The decline firmness was might be due to loss of water from the fruits and became softer in the loose form and better CFB box and wooden box could be due to less oxidised and less water loss from the fruit surface. These results were in agreement with the results of Jain and Chauhan (1993) in kinnow mandarin, Barua et al. (1993) in mandarin, Sharma and Singh (2010) in apple, Sharma et al. (2009) in apple, Kaur et. al. (2013) in pear who claimed that firmness was declined with time during storage and found better firm packed in CFB and wooden boxes. Faasema et al. (2011) reported that the decrease could be due to the degradation of propectin by pectinatase.

Table 2. Firmness(kg/force) and Juice recovery (%) in mandarins kept in different packaging materials under ambient conditions

Packing material	Weeks after storage									
	Firmness (kg-force)					Juice recovery (%)				
	1	2	3	4	Mean	1	2	3	4	Mean
Loose form	3.95	3.39	2.55	1.95	2.96	45.89	43.53	40.93	36.89	41.81
Bamboo basket	3.99	3.56	3.16	2.82	3.38	47.85	45.80	44.00	42.03	44.92
Wooden box	4.01	3.57	3.23	2.91	3.43	48.15	45.92	44.40	42.92	45.35
CFB box	4.05	3.62	3.36	3.14	3.54	48.43	47.21	45.67	44.17	46.37
Plastic crate	3.99	3.45	3.05	2.77	3.32	47.10	45.05	43.99	41.18	44.33
Mean	4.00	3.52	3.07	2.72		47.48	45.50	43.80	41.44	
$LSD_{0.05}$	Container(C)			0.26		Container(C)			1.25	
	Weeks (W)			0.23		Weeks (W)			1.12	
	Interaction (CxW)			NS		Interaction (CxW)			NS	

The recovery of the juice percentage was significantly decreased with time in all treatments during the storage and ranged from 1st week (47.48%) to 4th week (41.44%). Among the container, CFB box had showed the highest percentage of juice (46.37%) followed by wooden box (45.35%) and least percentage of juice was observed in the fruits with loose form (36.89%). At the end of the storage, the CFB box gave the maximum juice content (44.17%) followed by wooden box (42.92%), whereas loose form and plastic crate recorded the less content of juice (36.89% and 41.18%) respectively. The lesser amount of juice content in loose form was might be due to higher oxidised with higher losses of moisture from the fruit. These findings are in consonance with the findings of Barua et al. (1993) in mandarin, Sharma et al.(2009) in apple, Sharma and Singh (2010) in apple, Faasema et al.(2011) in sweet orange, Jain and Chauhan (1993) in kinnow mandarin, and Kaur et al. (2013) in pear all reported that juice percentage was decreased during the storage.

Total soluble solids (TSS) increased with the increase in the storage period from 1st week (10.49^0 Brix) to 4th week (11.76^0 Brix). Among the containers, loose form (without container) showed the highest level of TSS (11.75^0 Brix) followed by bamboo basket (11.25^0 Brix) whereas lowest level of TSS was observed in the fruits with CFB box (10.71^0 Brix). At the end of the storage i.e. 4th week, loose form had recorded the highest TSS content (12.62^0 Brix) followed by bamboo basket (11.75^0 Brix), and it was observed significantly lowest in CFB box (10.71^0 Brix). The lowest percentage of the TSS in CFB might be due to less reduction of the moisture and nutrient contents. The faster declined the TSS in the fruit without container might be due to sharp dehydration and heavy loss of fruit moisture. The increase in total soluble solids with the advancement of storage might be due to increased hydrolysis of polysaccharides and concentration of juice due to dehydration.Consequently, the decrease in TSS is due to exhaustions of acids and the conversion of sugars to other organic products as substrate for respiration.These findings were in agreement with the findings of Jawandha et al. (2012) in kinnow mandarin, Mahajan and Singh (2014) in kinnow mandarin, Shaikh etal. (2003) in oranges, Faasema et al. (2011) in sweet orange, Sharma and Singh (2010) in apple, Sharma et al. (2009) in apple, Kaur et. al. (2013) in pear all reported that TSS increased during the storage. Ramesh and Pal (2006) reported that CFB box showed high retention of TSS and acidity in litchi.

Titrable acidity (TA) was decreased with the prolongation of storage and the decreased percentage was recorded from 1.07 in 1st week to 0.77 in 4th week of the storage. The decreased level of acids was might be due to use of acid as respiratory materials during the storage. According to Faaseem et al. (2011), the acidity of the fruits was decreased by disappearance of astringency is due to the use of the acids as respiratory materials. Likewise, among the containers, CFB box showed the highest percentage of the acidity (0.97) followed by wooden box (0.95) as against of loose form (0.8). At the end of the storage i.e. 4th week, the declined percentage of acidity was lesser in the fruits with CFB box (0.84) and higher in loose form (0.65). This means fruits under the loose form were less acidic then in different containers. CFB box and wooden box showed the lesser decline in acidity than other containers. The declined in acidity in loose form was might be due to faster in respiration and metabolic activities and lesser decline in acidity in CFB

and other containers was might be due to less consume of the fruit contents as respiratory materials. Sharma et al. (2010) in apple reported that the acidity was decreased with time during storage and due to inverse relation between acidity and sugars; it decreases as the TSS increases. Some previous worker; Bhusal, (2002), Bastakoti and Gautam (2007), Baral (2008) reported that the acidity was decreased with prolongation the storage. According to Rana (2006) organic acids are considered as a reserve source of energy to fruits as they utilized respiratory substances.

Table 3. TSS (^{0} Brix) and Acidity (%) in mandarins kept in different packaging materials under ambient conditions

Packing material	Weeks after storage									
	TSS (^{0} Brix)					TA (%)				
	1	2	3	4	Mean	1	2	3	4	Mean
Loose form	10.97	11.54	11.88	12.62	11.75	0.98	0.85	0.71	0.65	0.80
Bamboo basket	10.69	11.14	11.42	11.75	11.25	1.06	0.93	0.81	0.78	0.90
Wooden box	10.28	10.61	11.10	11.43	10.85	1.13	0.99	0.87	0.82	0.95
CFB box	10.15	10.56	10.90	11.24	10.71	1.15	1.00	0.88	0.84	0.97
Plastic crate	10.38	10.87	11.32	11.73	11.07	1.04	0.90	0.78	0.76	0.87
Mean	10.49	10.94	11.32	11.76		1.07	0.93	0.81	0.77	
LSD $_{0.05}$	Container(C)			0.24		Container(C)			0.06	
	Weeks (W)			0.21		Weeks (W)			0.05	
	Interaction (CxW)			NS		Interaction (CxW)			NS	

From the perusal of the data in table 4, organoleptic rating was significantly decreased with the increasing level of storage and the decreased trend was ranged from 4.75 in 1st week to 3.38 in 4th week. Irrespective packaging materials, CFB box showed the highest rating (4.51) followed by wooden box (4.31) as against loosely kept (3.4). The decreased trend on the organoleptic rating was might be due to decreased in fruit quality i.e. taste, colour, and appearance of the fruit during storage as mentioned byKaur et al. (2013) in pear and Sharm and Singh (2010) in apple. The higher organoleptic rating in CFB box wooden box than other containers and loosely from might be due to better retention of the quality parameters and less permeability of oxygen to the fruits during storage. In overall, the fruits were acceptable upto only 3rd week of the storage beyond this, loosely kept fruits were not acceptable as compared to fruits in containers. Similar observation was noted by Jain and Chauhan (1993) in kinnow mandarin and Faasema et al. (2011) in sweet orange claimed that sensory rating was decreased with time and best rating was recorded in CFB and wooden box.

The vitamin C was decreased with the advancement of the of the storage period in all treatments from 1st week (29.96 mg/100 ml) to 4th week (20.21 mg/100 ml). The decrease in vitamin C was faster in the fruits with loosely kept than kept in different container. Among the different container, vitamin C content was higher in the fruits kept in CFB box (26.74 mg/100ml) and wooden box (25.82 mg/100ml). At the end of the storage,

vitamin C was found maximum in the fruits with packed in CFB box (22.79 mg/100 ml) followed by wooden box ((21.34 mg/100 ml). The lesser amount of vitamin C in loosely kept fruits was might be due to faster rate of dehydration and degradation through the metabolic activities during respiration process as mentioned by Beltan et.al. (2009) who claimed higher level of oxygen reduced the vitamin C.Faasemaet. al. (2011) reported that high rate of transpiration and respiration reduced the ascorbic acid in sweet orange. The maximum level of vitamin C was recorded in the fruits with packed in CFB box could be less consumed oxygen and less in metabolic activities as kept inside the containers with ventilation hole. This finding is in agreement with findings of other earlier workers Sharma et al. (2009) in apple, Jain and Chauhan (1994), Sharma and Singh (2010) in apple, Bhusal (2002) in mandarin, Deka et al. (2008) in Khasi mandarin.

Table 4. Organoleptic rating (1-5) and Vitamin C content (mg/100 ml) in mandarins kept in different packaging materials under ambient conditions

Packing material	Weeks after storage									
	Organoleptic rating (1-5)					Vitamin C (mg/100 ml)				
	1	2	3	4	Mean	1	2	3	4	Mean
Loose form	4.49	3.83	3.09	2.20	3.40	28.32	24.23	20.18	17.38	22.53
Bamboo basket	4.70	4.33	3.98	3.50	4.13	30.05	25.97	22.21	19.59	24.46
Wooden box	4.88	4.48	4.13	3.76	4.31	30.94	27.24	23.79	21.34	25.82
CFB box	4.98	4.67	4.35	4.04	4.51	31.46	27.89	24.83	22.79	26.74
Plastic crate	4.68	4.32	3.95	3.42	4.09	29.03	25.27	22.13	19.94	24.1
Mean	4.75	4.33	3.90	3.38		29.96	26.12	22.63	20.21	
LSD $_{0.05}$	Container(C)			0.09		Container(C)			1.45	
	Weeks (W)			0.08		Weeks (W)			1.30	
	Interaction (CxW)			0.18		Interaction (CxW)			NS	

CONCLUSION

Among the different containers CFB boxes followed by wooden boxes is the proven a best packaging container to reduce postharvest losses and then to fetch highest market price. Fruit transported in CFB and wooden boxes retained firmer with maximum juice recovery with other internal quality. This investigation recommends that for distant transportation and storage CFB and wooden boxes will be the beneficial to keep superior quality of the fruits.

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Effect of maturity stages on fruit quality and postharvest shelf life of mandarin

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ABSTRACT

Mandarin is a perishable and non-climacteric fruit thus much consideration must be taken to maintain quality at an appropriate maturity stage when harvest. The experiment was carried out to determine the actual maturity stage based on peel color and its subsequent effect on storability. The fruits harvested at 100 percent green, 25 percent yellow, 50 percent yellow, 75 percent yellow, and 100 percent yellow color stage were evaluated during the storage period for four weeks at ambient condition. Among the maturity stages, 50 percent yellow skin colored fruits had the minimum PLW (7.75%), and decay loss (2.45%), higher in firmness (3.15 kg/force) and maximum juice recovery (46.84%) during the storage at ambient condition. Overripe and under ripe fruits showed inferior in quality with highest PLW and decay loss, minimum firmness, and lowest juice recovery percentage during the storage.

Keywords: Physico-chemical properties, physiological loss, decay loss, recovery, firmness, TSS

INTRODUCTION

Mandarin (*Citrus reticulata* Blanco) is predominant fruit crop getting popularity due to its superb eating quality and economic importance, thus the area under this crop is expanding rapidly in the rural periphery of Nepal.It is a major exportable commodity in the country and exports to India, China, Pakistan and Bangladesh. Annually, Nepal exports 625 tons of mandarin and sweet orange to India and China (Anon, 2013). Nepal stands 20th position in the production of mandarin around the world (FAO, 2012). It produces 146,721 tons of mandarin fruits annually across the country (CDP, 2013).

In general, the judging of maturity is performed by the external fruit color development and it is most common measure to assess maturity for harvesting the mandarin elsewhere. It is a non-climacteric fruit crop thus needs to mature on- tree before it harvesting (Ladaniya, 2008). In contrasting, it is bitter experiences that contractors or traders harvest the fruits while immature and green and dumping those in the market. This creates glutting situation and poor quality thereby harmful to public health. The loss in fruit weight is primarily caused by peel color development although it is a main indicator for judging maturity. The peel of the fruits plays an important role in regulating physiological loss (Bose, 2001). Farmers in the mid-hills of Nepal produce large amount of mandarins during November and December (Subedi, 2001) and considerable decrease

in the succeeding months and minimum quantity or no transaction of mandarin during May to September (Gurung, 2005). Rind quality is the critical factor affecting the external appearance and marketability of citrus fruits, especially for fresh consumption (Khalid et.al., 2011).In citrus fruits, juice content, TSS, and TA are the main internal quality parameters used all over the world (Antonucci et al., 2010). Fruit harvested at optimum stage retained maximum TSS: acid ratio and palatability rating during post-storage shelf life (Gupta and Jawandha, 2010). In the processing the fruit quality is very important and should be monitored closely. Processors of natural orange fruit juice should monitor closely the stage of maturity of the fruits they procure forprocessing (Alhassan and Adjei, 2014). Maturity stage of the mandarin fruit is found to be important factor for the storability and quality of fruits (Bastakoti and Gautam, 2007). Fruit harvested at 26-50 percent color stage showed the best performance in storage (Bhusal, 2002).

Maturity at harvest is the most important factor that determines storage life and fruit quality. Immature fruits are more subject to shriveling and mechanical damage, and one of the inferior flavor qualities when ripe. Over ripe fruits are likely to become soft and mealy with insipid flavor soon after harvest. Fruits picked too early or too late in their season are more susceptible to postharvest physiological disorders than fruits picked at the proper maturity (Kader,1999).The maturity standards provide acceptable levels for sugar-acid ratio, total soluble solids, and percentage juice content (Lacey, et. al., 2009). Various physico-chemical parameters of maturity were found influenced by agro-climatic conditions and the cultural practices and the maturity standards vary from region to region (Devkota*et. al.*, 1982).Winston and Cree (1954) also observed that consistent delay in the time of harvest beyond the point of maturity (8:1 TSS/acid ratio) resulted in reduced yield. Picking of the fruits at its proper stage of maturity is of paramount importance (Rajput and Haribabu, 2000).For the consumer, color is an important indicator of the eating quality (Moneruzzaman et. al., 2008). Among the maturity stages, good quality with long storability was found from the mandarins harvested during the turning stage (LARC, 1995/96).Physico-chemcial characteristic such as TSS, acidity, TSS/acid ratio and specific gravity as criteria for maturity (Surinder, 1986). Incase of mandarin, TSS: acid ratio is more reliable index than rind colour (Ladaniya, 2001).Ripening indices and grading of fruits are helpful to enhance shelf life and better marketing of fruits (Singh and Singhrot, 1994). Citrus fruits should be harvested when they are fully ripe and had developed their characteristics flavor and aroma (Bal and Chohan, 1987). Various distinctive maturity indices prevail amongst different varieties of citrus and thus it is imperative that indices of these changes need evaluation (Khokhar and Sharma, 1984).The present studies, therefore, conducted to find out the optimum time of maturity of mandarin in Nepal. Such standards may prove an efficient tool in the hands of growers to harvest and to regulate the produce in the market at appropriate time.

MATERIALS AND METHODS

The experiment was carried out in 2013 and 2014 at Lamjung district to determine the actual maturity stage based on peel color and its subsequent effect on storability. The fruits harvested at different peel color stages i.e. 100 percent green, 25 percent yellow, 50

percent yellow, 75 percent yellow, and 100 percent yellow as treatments and replicated four times. The randomly selected fruits with five different stage of maturity based on peel color were kept in normal room at $16^0C \pm 2^0C$and 65-70% RH for four weeks. The observation onphysico-chemical properties was recorded atweeklyinterval.The physical parameters like weight loss, and decay loss were recorded by top balance,juice content was measured with measuring cylinder by squeezing, TSS was measured was taken by hand refractometer, and chemical parameters i.e. Tritableacidity, and ascorbic acid were studied as per methods outlined in AOAC (2005). The data were tabulated in excel sheet and statistically analyzed with the procedures described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Physiological loss in weight (PLW)

Physiological loss in weight (PLW) was significantly affected in different stages of maturity and increased consistently with time during storage. The maximum weight loss was found in the fruits of 100 percent yellow fruits (17.38%) followed by 100 percent green fruits (16.05%) at the end of storage. The minimum weight loss (7.75%) was observed in the fruits with 50 percent yellow colored followed by 25 percent peel colored fruits (8.95%). The reduction in weight loss in the 50 percent yellow colored fruit might be due to less metabolic activities in the respiration process. The weight loss in the under ripe fruits (100% green) was might be due to immature and loss of the chlorophyllcontent and weak composition of the cells. Likewise, weight loss in the over ripe fruits (100% yellow) was might be due to dehydration and degradation of the cells and fast deterioration in the metabolic activities. This finding corroborates with the findings of Singh and Singhrot (1994) in lemon who claimed that full yellow lemon gave the highest weight loss.

The trends of weight loss were sharply accelerated in the first week (4.79%) then after it was observed to gradual declined to the end of the storage (14.99%). The higher losses at initial period were might be due to fast deterioration of the metabolic activities after immediately of harvest. The losses of the fruit weight and moisture content of the peel were mainly caused by fruit transpiration in which water moved out and resulted in wilted rind (Wills et al., 2007). These findings are inconformity with the findings of the Bastakoti and Gautam (2007), Bhusal (2002), Susanto et al. (2013) in mandarin, and Gupta and Jawandha (2010) in peach that reported weight loss was decreased with time during the storage.

Decay loss

The decay loss of the fruits was increased progressively with increase in storage in all the treatments. The decay loss was observed higher in the fruits of over matured and under matured fruits, i.e. 100 percent yellow and 100 percent green. The decay loss was found maximum (12.99%) in the fruits harvested at later stage of maturity, i.e. 100 percent yellow which wasfollowed by 100 percent green color stage (9.30%). The minimum percentage of decay loss was recorded with the fruits harvested at 50 percent yellow color

stage (5.03%) followed by 25 percent yellow colored stage (7.75%).The reduction in decay loss in the half ripe stage was might be due to less respiration for physiological process. This finding was in confirmity with the finding of the Bastakoti and Gautam (2007) and Bhusal (2002) in mandarin, Gupta and Jawandha (2010) in peach, Moneruzzaman (2008) in tomato. The higher decay loss in later harvested fruits might be occur due to increased respiration rate, metabolic activities and dissolution of cell wall which ultimately leads to softening and ripening of fruits.The main cause of mandarin decay under the storage was due to green mouldcaused by *Penicilliumdigitatum and* blue mould *(Peniciliumitalicum).* The finding revealed that 50 percent yellow color stage was the best stagefor extension of shelf life and internal quality of mandarin. The reduction in weight loss in early stage might be due to hard covering of the fruits which reduces the rate of various physiological processes and retained the internal quality of the fruits. These results werein consonance with the result of Undurraga et al. (2009) in lemon who reported the early stage of maturity was indicated lower decay losses during storage.

Table 1. PLW (%) and decay loss (%) in mandarin in different maturity stages under ambient condition (14-18^0 C and 65-70% RH)

Maturity stage	Weeks after storage									
	PLW %					Decay loss %				
	1	2	3	4	Mean	1	2	3	4	Mean
100 % green	4.94	8.48	11.06	16.05	10.13	0.00	2.08	7.11	9.30	4.62
25 % yellow	4.43	7.52	9.99	13.88	8.95	0.00	1.37	5.28	7.75	3.60
50 % yellow	3.93	6.43	8.45	12.17	7.75	0.00	1.25	3.54	5.03	2.45
75 % yellow	5.15	8.16	10.78	15.46	9.89	0.00	2.46	6.82	9.14	4.60
100 % yellow	5.51	9.13	12.05	17.38	11.02	0.00	2.50	9.31	12.99	6.20
Mean	4.79	7.94	10.47	14.99		0.00	1.93	6.41	8.84	
LSD $_{0.05}$	Maturity(M)			0.87		Maturity (M)			1.30	
	Weeks (W)			0.78		Weeks (W)			1.16	
	M x W			NS		M x W			2.59	

Firmness

Fruit firmness in all maturity stages was significantly affected in the maturity stages and consistently decreased with the advancement of the storage period. The firmness was ranged from 4.5 kg/force to the 2.7 kg/force during the entire storage period. The firmness was significantly higher (3.15 kg/force) in the fruit with 50 percent yellow which was close to 25 percent yellow (3.14 kg/force) during the storage. The firmness is

directly correlated to the weight loss. Higher firmness might be due to less loss of the fruit moisture and lesser firmness was might be due the moisture reduction and faster in catabolic activities in the fruits. At the initial stage, the firmness was observed significantly higher in the fruits harvested at deep green stage (5.45 kg/force) over the treatments but immediately after one week, it was found sharply decreased. In contrast, at the end of the storage, the firmness was recorded lesser in the 100 percent yellow colored stage (1.97 kg/force) whereas, it was recorded maximum firmness (3.15 kg/force) in the fruits harvested at 50 percent maturity stage. This finding was in consonance with the findings of Ramin and Tabatabaie (2003) in Persimmon fruits, Infante et al. (2008) in apricot, and Moneruzzaman et al. (2009) in tomato who stated that higher firmness was observed in the early stage of maturity and decreased during storage.

Table 2. Fruit firmness and juice recovery in mandarin as affected by maturity stage under ambient condition

Maturity stage	Weeks after storage									
	Firmness (kg/force)					Juice recovery %				
	1	2	3	4	Mean	1	2	3	4	Mean
100 % green	5.45	4.43	3.67	2.84	4.10	43.44	39.87	36.70	33.06	38.27
25 % yellow	4.70	4.29	3.73	3.14	3.97	46.72	44.02	41.55	38.98	42.82
50 % yellow	4.42	3.96	3.63	3.15	3.79	48.97	47.63	46.19	44.56	46.84
75 % yellow	4.05	3.48	3.01	2.39	3.23	49.73	46.93	44.90	42.34	45.97
100 % yellow	3.89	3.14	2.47	1.97	2.87	49.13	45.05	41.25	36.88	43.08
Mean	4.50	3.86	3.30	2.70		47.60	44.70	42.12	39.16	
LSD $_{0.05}$	Maturity(M)			0.87		Maturity (M)			1.46	
	Weeks (W)			0.78		Weeks (W)			1.30	
	M x W			NS		M x W			NS	

Juice content

Fruit juices count as good source of vitamin C in the diet and they also contains amounts of folate, potassium and polyphenols (AIJN, 2015).Juice content of the fruits consistently decreased gradually with the advancement of the storage period and decreasing trend was influenced significantly by different treatments.The mean juice recovery percentage was recorded maximum (46.82%) in the fruits with 50 percent yellow colored followed by 75 percent yellow colored fruits (45.97%) and minimum percentage was found in the fruits with 100 percent green (38.27%). Juice percentage was ranged from 47.60 percent in the first week and lowered as 39.16 percent at fourth week. The decreasing trend in the juice percentage was might be due to faster dehydration and degradation of metabolites. The juice content at initial was found higher in the fruits of 75 percent yellow skin color stage (49.73%) followed by 50 percent yellow color stage (49.13%) and 50 percent yellow color stage (48.97%) and lowest juice was found in the fruits with 100 percent green peel

color (43.44%).These findings were in agreements with the findings of Deka et al. (2006) in Khasi mandarin, Bastakoti and Gautam, (2007) and Bhusal (2002) in mandarin, and Teka (2013) in tomato that stated the juice is decreased with time in the storage. At the end of the storage, the maximum juice percentage was found in the fruits with 50 percent color stage (44.56%) as against 100 percent green stage (33.06%). The higher the juice percentage might be due to accumulation of the juice sacs and increased in the skin and peel size of the whole fruits. In the contrary, lesser juice content might be due to less accumulation of the total nutrition contents of the fruits.

TSS content

The total soluble solid (TSS) content of the fruits at harvest was found significantly affect in the maturity of the fruits. The TSS was observed the gradually increased with time of storage and it ranged from the 10.15 to 11.75 from the first week to fourth week during the storage. Among the maturity stage, the highest TSS was recorded in the fruits with 100 percent yellow colored stage (12.00) whereas lowest percent was observed in the fruits with 100 percent green color stage (9.75). It was indicated that the TSS was increased in irrespective of the treatments and with much higher in the later stage of the maturity. The increased in TSS was might be due to dehydration of the fruits in the later part of the storage. Deka et al. (2006) reported that the increased in TSS was found to be increased linearly to the fruits. The increased level of TSS in the beginning of storage may be due to conversion of starch into sugar. Bhular (1983) reported as TSS gave an indication of maturity of fruits and can be relied upon along with acidity.These findings were in inconsonance with the findings of the Bastakoti and Gautam (2007), Bhusal (2002) in mandarin, Undurraga et al. (2009) in Lemons, and Teka (2013) in tomato and reported that the TSS was increased during the storage.

TA percentage

The Titrable acidity (TA) was found significantly decreased with time during the storage in al maturity stages. The TA percentage was ranged 1.79 to 0.82 (full green to full yellow) in the first week and gave decreased result with weekly interval and showed the 0.94 to 0.53 (full green to full yellow) at the fourth week. TA percentage was found highest (1.35) in the fruits harvested with 100 percent green maturity whereas the lowest TA (0.67) was noticed in the fruits with 100 percent yellow peel color stage. The TA percentage was higher in the first week (1.2) and then gradually it was observed lowered down and reached at minimum level (0.71). These findings were in accordance with the findings of Roongruangsriet. al. (2013) in Tangerine, Bastakoti and Gautam (2007), Bhusal (2002) in mandarin, Undurraga et al. (2009) in Lemons, and Teka (2013) in tomato and reported that reported TA was decreased during the storage. The decreased trends TA in the fruits was might be due to conversion into sugars and their derivatives are used in respiration and responsible for this decreasing trend. Bhattarai and Gautam (2006) reported that the changes in total titrable acidity during storage was mainly due to the metabolic activities of living tissue during which depletion of organic acid takes place.

Table 3. TSS (^{0} Brix) and TA (%) in mandarin in different maturity stages under ambient condition

Maturity stage	Weeks after storage									
	TSS (^{0} Brix)					TA (%)				
	1	2	3	4	Mean	1	2	3	4	Mean
100 % green	8.95	9.49	10.07	10.51	9.75	1.79	1.49	1.16	0.94	1.35
25 % yellow	9.75	10.20	10.70	11.12	10.44	1.49	1.25	0.96	0.79	1.12
50 % yellow	10.27	10.72	11.25	11.76	11.00	1.01	0.86	0.75	0.68	0.83
75 % yellow	10.59	11.10	11.74	12.23	11.42	0.87	0.78	0.68	0.60	0.73
100 % yellow	11.17	11.61	12.06	13.15	12.00	0.82	0.72	0.62	0.53	0.67
Mean	10.15	10.62	11.16	11.75		1.2	1.02	0.83	0.71	
LSD $_{0.05}$	Maturity (M)			0.384		Maturity(M)			0.12	
	Weeks (W)			0.344		Weeks (W)			0.11	
	M x W			NS		M x W			0.24	

TSS acid ratio

The TSS acid ratio was found significantly decreased with the maturity and storage period. The highest TSS acid ratio was recorded in the fruits with 100 percent yellow colored (18.60) and lowest ratio was observed in the fruits with 100 percent green (8.40). TSS acid ratio was in increasing trends in all the treatments during storage and found 9.91 to 17.76 from first week to fourth week of storage period. TSS acid ratio ranged from 5.71 to 9.91 in the first week from full green to full yellow and found 11.23 to 24.92 at the end of the storage. This increasing trend in the TSS acidity ratio was reported by the earlier worker Obenland (2011) in mandarin, Bastakoti and Gautam (2007), Bhusal (2002) in mandarin, Undurraga et al. (2009) in lemon, Roongruangsri et al. (2013) in tangerine. Deka et al. (2006) reported that the increase in the ratio was due to higher TSS content with the corresponding acidity at different stage of maturity.

Vitamin C

Vitamin C content was found significantly different among the maturity stage and storage period. The trend of vitamin C was observed increased with full maturity and then showed gradually declined with time. The vitamin C was recorded highest in the first week (32.99 mg/100 ml) and lowest in the fourth week (23.31 mg/100 ml). Among the maturity stage, 25 percent maturity stage gained the maximum (30.42 mg/100 ml) vitamin C followed by 50 percent color stage (29.78 mg/100 ml) and minimum was recorded in the fruits with 100 percent yellow colored (24.63 mg/100 ml). These findings were inconsonance with the findings of the Beltran et al. (2008) in mandarin who reported decreased trends during the storage.Moneruzzaman et al. (2009) in tomato

reported that half ripe stage showed the best for vitamin C and TA. According to Lee and Kader (2000), the loss of vitamin C after harvest can be reduced by storing in reduced oxygen and declined during cold storage in almost citrus fruit such as mandarin, orange and grapefruit (Ladaniya, 2008). A decrease in ascorbic acid could be due to enzymatic loss of L-ascorbic acid where it is converted to 2-3- dioxy –L-gluconic acid (Mapson, 1970). The Experts Committee of the European Association of Citrus Juice Producers (AIJN) establishes a minimum level of vitamin C concentration (300 mg/L) in orange and mandarin orange juices that must be maintained throughout the shelf life of these products (AIJN 2005).

Table 4. TSS-Acid ratio and Vitamin C (mg/100 ml) in mandarin in different maturity stages under ambient condition (16-18^0 C, 65-70 RH)

Maturity stage	Weeks after storage									
	TSS/Acid ratio					Vitamin C (mg/100 ml)				
	1	2	3	4	Mean	1	2	3	4	Mean
100 % green	5.71	7.33	9.31	11.23	8.40	33.63	30.83	26.67	23.61	28.68
25 % yellow	7.38	9.06	11.59	14.42	10.61	35.32	32.09	29.02	25.26	30.42
50 % yellow	10.44	12.60	15.26	17.60	13.97	35.23	31.10	27.83	24.96	29.78
75 % yellow	12.34	14.49	17.49	20.63	16.24	32.02	29.37	26.38	22.87	27.66
100 % yellow	13.67	16.22	19.58	24.92	18.60	28.75	26.38	23.55	19.85	24.63
Mean	9.91	11.94	14.65	17.76		32.99	29.95	26.69	23.31	
$LSD_{0.05}$	Maturity (M)			1.42		Maturity (M)			2.05	
	Weeks (W)			1.27		Weeks (W)			1.84	
	M x W			NS		M x W			NS	

Organoleptic rating

The organoleptic rating was found significantly decreasing in trends in all maturity stage during the storage and ranged as 4.22 to 2.6 from first week to fourth week. Fruit appearance, freshness, and taste are the prerequisite for the organoleptic test. A group of expert panel was involved in the evaluation and overall acceptable fruits were found with 50 percent skin colored fruits (3.7) whereas 100 percent green fruits obtained lowest rank (3.00). At initial, the highest rating was observed in the fruits with the 50 percent maturity stages (4.82) followed by 75 percent yellow peel color (4.57) and 25 percent yellow peel color (4.2). At the end of the storage, the highest rating was observed in the fruits with 50 percent maturity stage (2.9) and lowest rating was noticed in the fruits with 100% green maturity stages (2.52).

These findings were in corroborates with the findings of the Marcilla et al. (2006) in citrus fruits who reported that the higher temperatures reduced the orange-like flavour

and increased the presence of off-flavors over storage; this had a negative impact on the sensorial quality of the fruit. According to Obenland et al. (2011) in mandarins many of these volatiles had aromas characteristic of citrus, their involvement in flavor loss during storage. The decreasing trend of the mandarins and other citrus was due to low oxygen-induced fermentation and correlates with the development of off-flavor.

Table 5. Organoleptic rating in mandarin in different stages of maturity under ambient condition (14-18^0 C, 65-70% RH)

Maturity stage	Weeks after storage				
	1	2	3	4	Mean
100 % green	3.42	3.19	2.88	2.52	3.00
25 % yellow	4.20	3.51	3.15	2.79	3.41
50 % yellow	4.82	3.81	3.28	2.90	3.70
75 % yellow	4.57	3.75	3.16	2.74	3.55
100 % yellow	4.10	3.34	2.83	2.11	3.10
Mean	4.22	3.52	3.06	2.61	
LSD, 0.05 for maturity				0.25	
LSD, 0.05 for weeks				0.23	
LSD, 0.05 for interaction				NS	

CONCLUSION

Fruits harvested at different maturity stage significantly effect to the subsequent transportation and storage behavior of the fruits. The fruits harvested at 25 to 50 percent yellow color stage was found the best stage for transportation and storage at that stage physiological loss in weight and decay loss was seemed minimal. Furthermore, the fruit quality was observed superior in this stage, hence, we recommend for harvesting at this stage of ripening. Over and under ripening stage are not suit for harvesting for effective marketing.

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Relationship of food security and traditional beverages

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ABSTRACT

This article is based on study in the buffer zone of National Park (PAs) where crop damage by wild animals is prominent with its impact on food security. The main objective of this study was to explore relationship of food security and traditional beverages like and raksi. The study was done in two protected areas of Nepal viz. Parsa Wildlife Reserve (PWR) and Shivapuri National Park (SNP). Beverage making (e.g. jand and raksi) is a common practice among poor and land less people as adoption strategies for alternative livelihood measures. It has threatened conservation sustainability and food security too. Food security of PAs is 56.6 % from agriculture and other sources of income. Agriculture contributes only 19.2%. In the past, PWR belonged to food surplus zone. But this study showed that only 76% of people have food security and only 12.2 % households have surplus food from agriculture. On the other hand, SNP has 26% of households with food security. Major causes of food insecurity are attributed to lower fertility of land, less access to irrigation facilities and wildlife depreciation. Food security is significantly different among indigenous group (Chaudhary, Danuwar, Uraw, Tamang, Majhi, Chepang and Bankariya) and others groups (Brahmin, Chhetri, Muslim, and Newar). Indigenous groups have 24% households food secure, while other groups have 51% households food secure. Therefore, people adopt alcohol making for income generation. It was found that jand had higher nutritional value than raksi.

Keywords: Protected areas, *jand, raksi*, nutritional security, livelihood

INTRODUCTION

Right to food security is the fundamental human right. I/NGO are involved in advocacy for safeguarding the right to food security. Nepal has signed international agreements relating to it. Poverty alleviation is related with the networks of food security. As such, networking at district and national level is required. Right to food security is related with social and economic activities, irrigation facilities, right against malnutrition, right to employment and gender issues. Government should seriously take up this issue. Therefore, coordination among the related institutions is imperative. Communities affected by natural calamities and disasters also do suffer more from food insecurity. Nepal has been facing food insecurity problem since 1990 AD (FAO, 2003). This is a dramatic change compared to the year 1981 when only 8 of the 75 districts faced food deficiency and 40 were surplus districts. Since the early 1990s, the status of Nepal has changed and instead of being exporter it has become net importer of food. Nearly, half of

Nepal's districts had deficiency in food. The situation is most serious for Peripheral Mountain of the middle hills (47%). The country is now a net food importer: the deficit reached 151000 MT (3.6% of requirements) in 1997 A.D. That indicates significantly negative trends. Total number of food insecure people is around 6.9 million (OCHA, 2008). In the past few decades, food deficit has been a serious problem in the hilly areas of Nepal. It has been the primary concern of people to go for forest clearance for production of food grains. At present, Nepal has 20 protected areas 12 buffer zones (www.dnpwc.org.np). It has contributed to conservation of bio-diversity. In this context, this study was carried out in two protected areas of Nepal to explore the relationship of food secutity and traditional beverages like *jand and raski* and assess their nutritional importance.

MATERIALS AND METHODS

Two buffer zones of PAs representing the Mid Hill and Terai regions buffer zones were selected for this study. In this selection, Parsa Wildlife Reserve (PWR) represented the case of Terai, which consisted of flat alluvial plain lands, and 4 sampled VDCs like Simara, Amlekhgung, Jitpur and Handikhola. Selected VDCs were based on their proximity to the forest, and inhabitants of indigenous group and the immigrants. Shivapuri National Park was identified to represent the case of mid hills with 3 adjoining VDCs like Jhor Mahankal, Sundrilijal and Shingla. In all of these total 7 VDCs, 22 settlements were sampled for study. The stratified random sampling technique was used covering 20 percent of the total households of buffer zone.

Collected samples of *Jand and Raksi* were brought from SNP by means of local transport by the researcher and kept in freeze. Next day the fresh samples were taken to the Food Research Lab**,** Department of Food Technology and Quality Control, Babar Mahal, Kathmandu, Nepal for analysis. Nutritive value was analysed on the basis of original sample. Proximate analysis was done by AOAC method and Ministry of Agriculture and Cooperatives, Laboratory Manual Food and Feed Ingredients. Protein was computed based on nitrogen content, which was analysed by Micro Kjeldahl Method. Fat was analysed by Solvent Extraction Method. Ash was determined by ignition in Muffle Furnace. Crude fiber was analysed by Acid and Alkali Hydrolysis followed by ashing. Carbohydrate was determined by using different methods (100 and sum of moisture, protein, fat, fibre and Ash). Moisture was determined as described in the AOAC Oven method. Crude fibre was determined by AOAC Oven method and total energy was derived from a theoretical calculation. Mineral such as calcium was determined by AAS Method (Titration Method). Iron and phosphrous wass analysed by spectrophotometer AOAC method. Vitamin C analysis was done by 2-6 dichlorophenol indophenols Dye Method.

RESULTS AND DISCUSSION

Food Security

It was found that 56.6% of household were food secure from agriculture and other sources of income and agriculture econtributes only 19.2%. The percentage of food security depends on agriculture, wildlife crop damage, irrigation facilities and income from other sources such as service, remittance and business.

Nepal Federation of Indigenous Nationalities has classified 59 indigenous groups or nationalities into 5 major categories (HRD, 2004). According to this categorization, *Majhis, Chepangs and Danuwars* belong to highly marginalized group whereas *Tharus, Dunuwars, and Tamang*s are marginalized group. *Magars, Rais and Gurungs* fall into disadvantaged group and *Bankariya* belong to endangered group. Food security has strong affinity with such indigenous communities in PAs which are also associated with inhabitants of endangered, highly marginalized and disadvantaged groups. About 54 percent of respondent households belonged to indigenous groups that include *Chaudhary, Danuwar, Uraw, Tamang, Majhi, Chepang and Bankariya.* 46 percent of other castes include *Brahmin, Chhetri, Muslim, and Newar,* who are basically immigrants from hills and other parts of the country.

It was found that indigenous groups have food security by 24 percent than that of other groups having food security by 51 percent (Figure 1). One way ANOVA test had found that there is a significant difference between indigenous and other groups in terms of food security (F= 2.376, df =144, p = 0.01). The result indicates that food security is still a pressing problem to both groups but was more challenging to indigenous communities in PAs.

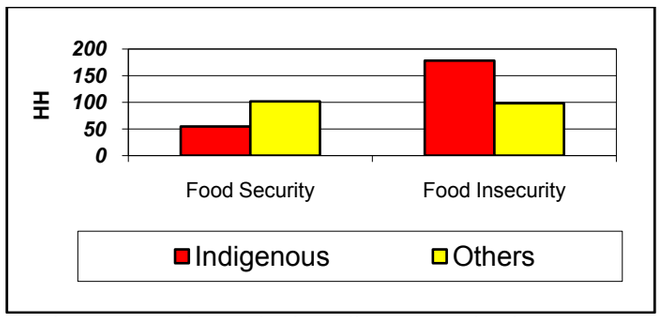

Figure 1. Food Security in Indigenous and Other groups

Overall protected areas have 56.6 percent of household food security contribution from agriculture and other sources of income and it implies a situation when food security is less. People are forced to explore alternative sources of income as alcohol making and fuel wood selling. However, alcohol making requires more fuel wood which is ultimate impact on forest degradation. Selling alcohol is an option to make alternative income in SNP *i.e.,* 33 percent. Almost all households are involved in selling alcohol in some hamlets of *Okherani* and *Mulkharkh* of Sundrijal VDC inside the Park. Mostly, *Tamang*

communities prepare alcohol (*Raksi*)[1] and supply this to business centers and nearby small restaurants in cities. This is one of the major busines in all households. Similarly, 4.5% households were involved in fuel wood selling in PWR. In some areas like *Pathaliya* settlement fuel wood selling occupies main occupation for livelihood. Both men and women are involved in fuel wood selling in *Pathailya* settlement. People helplessly sell *Sal* wood as fuel wood price to solve food security.

Table 1. Nature of work of PA's and BZ

SN	Profession	No of HH involved	Involved %	No of HH not involved	Not involved %
1.	Local alcohol making *(Raksi)*	66	15.2	367	84.8
2.	Fuel wood selling	16	3.7	417	96.3

Source: Field research data

Nutritive values of *Jand and Raksi*

Middle age and old age people mostly consume *Jand* and *Raksi* regularly as tea and snack among *Tamang* community of SNP. Chemical analysis of local *Raksi* and *Jand* is not available to date as secondary information. Chemical analysis of *Jand* and *Raksi* is given in table 2. From nutritional point of view *Jand* is better than *Raksi*. It containts protein (1.95%) and iron (1.5%). Analysis was done in two types of *Jand* collected from SNP. They were 6 and 8 days aging. Ethanol percentage was slightly higher in 8 days *Jand* than in 6 days. Their contents are slightly different from Nutritional composition of 6 days and 8 days' *Jand.* Ethanol, protein, total ash, acid insoluble ash and iron are a bit higher in 8 days *Jand*. It was slightly less in energy, calcium and phosphorus but significantly low in carbohydrate contents. People would offer *Jand* to lactating mother. Therefore, it was better to offer early aging *Jand* to lactating mother for better nutritional status (Table 2).

Table 2. Nutritive value of *jand and raksi*

SN	Ethanol	*Raksi*	Average (*Jand*)	6 days (*Jand*)	8 days (*Jand)*
1	Ethanol (%)	14.4	4.8	4.69	4.91
2	Moisture %		95.15	94.35	95.95
3	Protein %		1.95	1.8	2.1
4	Fat %		0.75	0.74	0.76
5	Total Ash %		0.59	0.48	0.7
6	Acid insoluble Ash %		0.34	0.26	0.42
7	Crude Fibre %		ND	ND	ND
8	Carbohydrate %		1.53	2.63	0.43
9	Energy (Kcal/100ml)		20.74	24.38	17.0
10	Calcium %		0.011	0.01	0.012
11	Phosphorus (mg/100ml)		0.011	0.01	0.011
12	Iron (mg/100g)		1.5	1.2	1.8

Source: Chemical analysis of Jand and Raksi from field areas

[1] *Raksi* is locally brewed alcohol by fermentation of cereals especilly of millet which contain alcohol 14 percent.

Alcohol making (*Raksi*) is one of the major issues in conservation of PAs and BZ. Average 15.2% (66 HHs) people are involved in this profession with higher rate of alcohol making. In general, the *Tamang* communities make alcohol but they do not disclose it. They do it during agriculture slack season where water and fuel wood are easily accessible. It can generate additional income for household expenditure such as oil, salt and school fees of children in education. It was found that there was an annual turnover of 2000 kg to 6000 kg of fuel wood to prepare *Raksi* in a household (table 3), which may impact on canopy cover and tree density. They have been reduced in the place where people make *Raksi,* which warns of a situation of forest degradation. *Raksi* is generally prepared by women. If forest degradation continues, it would adversely affect the availability of fuel wood and fodder, thus increasing the drudgery of women in fuelwood for household cooking purpose. Therefore, it is necesaty to provide alternative source of income and stop making *Raksi* specialy in protected areas.

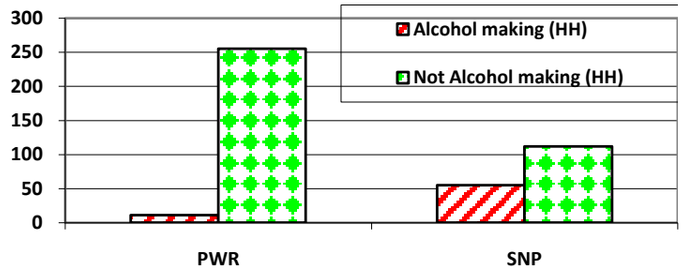

Figure 2. Alcohol making household as source of income

Table 3. Fuel wood need for alcohol (*Raksi)* making/year

SN	Fuel wood need for ***Raksi*** Making (Kg)	No of HHs	%	Remarks
1	Not involved	324	74.8	
2	100-2000	57	13.2	Only for ***Raksi*** making
3	2001-4000	29	6.7	”
4	4001-6000	7	1.6	”
5	>6000 kg	16	3.7	”
	Total	433	100.0	2000->6000kg fuel wood are necessary for ***Raksi*** making small scale job

Source: Field research data

CONCLUSION

This study showed that food security was one of the serious problems in PAs, which is not a good indicator for conservation of forest resources and biodiversity. Problems creep in due to food insecurity, low income, low nutritional status of a child and a mother, low literacy rate of women, high rate of teenage pregnancy and poor sanitation conditions, which are common features or the way of life in the area. Therefore, it is a big threat for biodiversity conservation.

It was found that *Jand* contains iron and other important nutrients more than *Raksi*. It contains 1.95% of protein. It is also found that *Jand* is a good source of iron (1.5 mg/100 g). It is found that *Jand* contains iron 1.5 mg/100gms and other important nutrients. It contains 1.95% of protein. Therefore, it is nutritionaly important in our diet and also zero percent waste.

The study showed that dependency is high on natural resources when alternative sources of income are not available such as fuelwood selling and alcohol making which have direct impact on the depletation of forest. Therefore, it is necessary to provide alternative sources of income at least to each household involved in fuel wood selling and alcohol making for food security through special intregrated conservation programme. Similarily, wildlife damage is a major cause of food insecurity. Hence, it is necessary to introduce unpatalable species cultivation such as NTFP and leguminous crop in the wildlife damage areas.

Similarly, restoration programmes for soil fertility are imperative. Introduction of a new agricultural system is supposed to be a solution. Improved fertilizer, seeds and irrigation facilities are needed for food security.

RECOMMEDATION

The right to food is the right of the people which needs to be assured by the state for food security at all times. The state is considered accountable for not being able to make policy decision at national level and develop mechanisms to solve the vital problem. Food security is one of the basic human rights.

Stop making *Raski* in protected areas and buffer zone which is sensitive areas of biodiversity conservation and food shortage areas. It can be soved by providing alternative income sources.

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Gender role and buffalo rearing decisions in Nepal

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ABSTRACT

Families not only divide works between members, but decisions are also divided between and are made by the members in the family. Men and women have different roles, responsibilities and participation in livestock management and livelihood activities. Such roles could be varied in agricultural activities including livestock rearing. This study examined gender roles and decisions among the buffalo producing farmers with the objective to assess the current scenario of livestock rearing, focusing to the buffalo production and to demonstrate whether such roles and decisions have been changed in the rural context. Data collection was completed into three steps: (i) base line study- carried out during 2012 with 30; 35 and 33 households from Chitwan, Gorkha and Tanahun, respectively. Baseline survey was broadly covered- demographic and socio-economic features; number of livestock raised; gender roles in buffalo production and management (ii) Focus Group Discussion (FGD) was carried out in the same three sites with three mixed group of men and women to strengthen the information. (iii) Additional survey was carried out in Chitwan (n=57) site only during 2014 to triangulate and or scrutinize the whole set of information. Findings clearly revealed that gender roles such as construction of shed, cleaning, grazing and feeding, breeding and veterinary health care are still traditionally done-either male or female alone dominating task that suggest the need to consider role specific planning while promoting scientific buffalo production and or enterprise development. Likewise, gender decision on buffalo rearing, for example-marketing and buffalo production activities (whether to keep buffalo, sale it and determine its number and other alike decisions) are found in favor of joint decision of male and female that firmly suggest the concept to consider such change in buffalo production paradigm while implementing gender based development planning.

Key Words: Household decision, planning, gender-based development, buffalo production

INTRODUCTION

Families not only divide works between members, but decisions are also divided between and are made by the members in the family (Devkota, 1999). This situation generates the concept of roles in the households. As work is divided into 'inside' and 'outside', decision can also be taken as major and other/ minor (Chhetri, 2007). Livestock is an important sector of Nepalese economy. It contributes about 30 Percent of agricultural Gross Domestic Product (GDP) in the country. Livestock has not only been a key source of household cash income for the rural people, but it has also been the main suppliers of

nutrients for growing field crops and users of crops by-products. Mixed farming systems are common in Nepal, where livestock are an integral part of agriculture along with crops, fruit and vegetables. Most households keep some livestock. The average number of livestock is comparable to the average household size (CBS, 2007). Men and women have different roles, responsibilities and participation in livestock management and livelihood activities. Such roles could be varied in agricultural activities including livestock rearing. Research findings reveals that gender roles are especially varied according to domain- reflecting either male or female members' domination in their involvement (Gurung *et al*., 2005; Devkota, 2010). Such domain specific involvement of both men and women are weak in terms of jointly done, but are visible in either men or women dominating task. Examples are found on these trends especially in the agricultural activities including livestock rearing (Bajracharya, 1994; Gurung *et al*., 2005; Devkota, 2010).

Gender roles refer to how men and women should act, think, and feel according to norms and traditions in a society (Groverman and Gurung, 2001). Roles are reflected in the tasks and responsibilities expected of men and women and identities associated with being male or female in a certain society. Gender roles and relations are not fixed. They are dynamic and changing as per the societal change (Devkota, 2010). Traditionally some livestock related roles and responsibilities were specific to women and men, but such specific task have been changed perhaps due to the formation of women groups and social mobilization efforts in the rural community. Thus livestock related decisions are more inclined towards jointly done for several agricultural works including livestock rearing (Gurung *et al*., 2005). Study findings have revealed that there has been change in the paradigm of gender decisions in favor of jointly done rather than male alone or female alone domination which used to be the case in the traditional agricultural practices. Thus it has been reflective scenario that- change in gender roles and decisions is seen in agricultural activities including livestock rearing whereas such change could vary in terms of its magnitude and dimension-male alone to joint, or female alone to joint. This could vary as per location, specific farming system, socio-economic status of the farmers and niche specific differences (Acharya and Bennet, 1981; Bajracharya, 1994; Devkota, 1999). Under this situation gender roles and decisions among the buffalo producing farmers were examined with the objective to assess the current scenario of livestock rearing, focusing to the buffalo production and to demonstrate whether such roles and decisions have been changed in the rural context.

MATERIALS AND METHODS

Improving nutrition and productivity of buffaloes (INPB) to adapt to impacts of climate change in Nepal is a USAID funded project, executed by Michigan State University in collaboration with AFU, NARC and DLS. The collaborative research has been going in relation to improve in overall productivity of buffalo through the technical intervention in the areas of feeds and feeding (forage crop cultivation, feeding); breeding, reproduction management and health management with the aim to conserve buffalo for the future so that they could be able to cope with the changing extreme climatic condition in the future.

This project has executed in three sites namely, Chitwan (Chanauli), Tanahun (Dulegaunda) and Gorkha (Palungtar) of Gandaki river basin.

Present study is mainly focused on gender related issues. In the project activities study of gender role in buffalo production was well envisaged starting from participant farmer selection to related research activities such as- in terms of gender involvement, and decision-making. Thus data collection procedure was completed into three steps: The first set of research work was done in relation to collect basic fact sheet about livestock in general and overall management of buffalo in particular. Accordingly, base line study was carried out during 2012. The study broadly covered- demographic and socio-economic features; number of livestock raised; gender roles in buffalo production and management focusing to the feed and feeding management, health management, marketing and overall household decisions. For this purpose 30 households in Chitwan, 35 households in the Gorkha, and 33 households in Tanahun were interviewed by covering all the participant farmers in the project.

The next set of research work was to verify the critical areas of gender related buffalo rearing activities. Accordingly, Focus Group Discussion (FGD) was conducted in the three research sites. For the focus group discussion- we the team of researchers reached to the participant farmer's hometown during May-June 2014 and requested to gathered at least all the participant farmers those included in our project (n=30 each). It was quite difficult to capture all the participating farmers due to their busy schedule of farm work, nevertheless about 20-25 participant farmers form each district were gathered for the FGD. Accordingly, we had conducted 3 FGD in three project sites of Gorkha, Tanahun and Chitwan, separately. A set of questions were prepared as checklist to be asked to the participants farmers that were systematically asked and the final response was tapped based on consensus through discussion. Firstly, we did a taping of all the information then obtained into a Nepali version. Finally, all the information tapped in Nepali language was systematically retranslated into the English version to draw the valuable and relevant information.

The third set of research work was done as of additional/ supplementary survey in 2014 to triangulate and or scrutinize the whole set of information collected from base line study so that concrete evidence would be possible to collect that would also reflect the time dimension of information which could also address the change scenario of gender roles and decision if any.

In this regard we were only confined to carry out additional study in the Chitwan district. There are some reasons of taking Chitwan as representative site for the supplementary study. One of the reasons of selecting Chitwan is due to the fact that all the residents of Chitwan are migratory population from all over the country that could broadly cover the sample frame of all three study sites as well. The next reason is such that respondents in the Chitwan are fairly educated and are advance in terms of access of information and resources for buffalo production compared with other districts. Thus we captured available households as respondents for this study purpose. Accordingly, 57 respondents were covered whereas both male and female adult members at the rate of two from each

participant household were picked up and interview was done separately to both male and female member of each house. When there are 30 participant households, theoretically there should have been 60 members altogether, but one woman was single whereas male were absent as migrant labour in two households thus total sample size became 57 in the study site. All the data from base line study and in-depth additional work were coded and statistically analyzed using SPSS. Descriptive analysis was done. Data were presented in tables and graph as per relevancies.

RESULTS AND DISCUSSION

Age and Family size

The mean age of the respondents were similar in all three study sites with the overall mean age of 47.8 years. Respondents in Tanahun were relatively younger compared to the other two sites (Table 1). Likewise the mean family size of all sites was also similar with the overall mean size of 6.1 per household. Compared to the other sites, Tanahun had a small family size (Table 1).

Table 1. Mean age and family size of the respondents

Age and family size	Tanahun (n=33)	Gorkha (n=35)	Chitwan (n=30)	Overall (n=98)
Age of the respondent	41.30 (12.39)	53.83 (9.58)	48.13 (12.34)	47.87 (12.49)
Size of the family	5.67 (1.84)	6.66 (2.40)	6.13 (2.25)	6.16 (2.20)

Source: Field Survey, 2012

Note: Figures in parentheses is standard deviation

Status of education

Respondent's level of literacy was visibly good in all three study sites as illiterate % in all three sites was below five percent. Proportion of just literate population was high in Chitwan whereas about one-third of them were having secondary level education in Tanahun and Gorkha. In all three sites, about 11-15% respondents also had college and university level education (Table 2).

Table 2. Level of education of the respondents

Level of education	Tanahun	Gorkha	Chitwan	Overall
Illiterate	1 (3.0)	1 (2.9)	-	2 (2.0)
Just literate	12 (36.4)	11 (31.4)	18 (60.1)	41 (41.8)
Primary level	-	1 (2.9)	-	1 (1.0)
Secondary level	11 (33.3)	12 (34.3)	4(13.3)	27 (27.6)
SLC	4 (12.1)	6 (17.1)	4(13.3)	14 (14.3)
College and university	5 (15.2)	4 (11.4)	4(13.3)	13 (13.3)
Total	33 (100)	35 (100)	30 (100)	98 (100)

Source: Field Survey, 2012

Note: Figures in parentheses indicate percentage of response

Status of livestock rearing

Major livestock species such as cattle and buffaloes were only considered as dominating species in the study sites. Their presence in the site was categorized as improved milch, dry and heifer. Findings revealed that number of improved adult milch cattle per household were high in Chitwan (2.5) whereas number of improved heifer per household was high (6) in Tanahun (Table 3).

Table 3. Status of livestock rearing per household in the study districts

Livestock number per household (mean)	Tanahun (n=33)	Gorkha (n=35)	Chitwan (n=30)	Overall (n=98)
Improved adult milch cattle	1 (0) (n=2)	1 (0) (n=2)	2.56 (3.99) (n=13)	2.18 (3.52) (n= 17)
Improved heifer cattle	6 (0) (n=1)	1 (0) (n=2)	2.73 (3.71) (n=11)	2.85 (3.55) (n= 14)
Improved adult milch buffalo	1.18 (0.39) (n=17)	1.50 (0.63) (n=28)	1.29 (1.04) (n=24)	1.35 (0.76) (n=69)
Improved adult dry buffalo	1 (0) (n=8)	1.24 (0.53) (n=21)	1.22 (0.44) (n=9)	1.18 (0.45) (n= 38)
Improved heifer buffalo	1 (0) (n=3)	1.50 (0.70) (n=2)	1.18 (0.50) (n=22)	1.19 (0.48) (n= 27)
Local adult milch buffalo	1 (0) (n=12)	1 (0) (n=8)	-	1 (0) (n= 20)

Source: Field Survey, 2012

Note: Figures in parentheses is standard deviation

Gender roles in buffalo production and marketing

(a) *Gender roles in shed, feeds and feeding management*

Gender roles on buffalo production are described with respect to the sheds, feeds and feeding management and also health and marketing management. Accordingly, construction related work was heavily dominated by male whereas cleaning of the shed and grazing activities was largely women's domain in all research sites (Table 4). Fodder collection work was dominated by the involvement of male in Tanahun whereas it was equally dominating for female in the case of Gorkha and somehow to the Chitwan. In general, nearly fifty percent of the respondents support the concept of male involvement in fodder collection that was nearly in the similar proportion for female (Table 4).

(b) *Gender roles in animal health management*

Animal health management was dominated by the involvement of male as reported by more than one-third of the respondents in Tanahun and Chitwan and slightly strong domination of male for such activity in the Gorkha. It was, however, a dominating role of female was seen for animal health care in Chitwan. About one-third of the respondents in Tanahun also reported that it is the case of the involvement of both male and female (Table 5).

Table 4 Gender roles in shed, feeds and feeding management in the study district

Roles and activities	Tanahun (n=33)	Gorkha (n=35)	Chitwan (n=30)	Overall (n=98)
Construction of buffalo shed				
Adult male	30 (90.0)	30 (85.7)	25 (83.3)	85 (86.8)
Adult female	1 (3.0)	4 (11.4)	2 (6.7)	7 (7.1)
Both adult	2 (7.0)	1 (2.9)	3 (10.0)	6 (6.1)
Cleaning of buffalo shed				
Adult male	5 (15.2)	7 (20.0)	6 (20.0)	18 (18.4)
Adult female	19 (57.6)	24 (68.6)	21 (70.0)	64 (65.3)
Both adult	9 (27.2)	4 (11.4)	3 (10.0)	16 (16.3)
Grazing and feeding				
Adult male	3 (9.1)	7 (20.0)	5 (16.7)	15 (15.3)
Adult female	22 (66.7)	24 (68.6)	22 (73.3)	68 (69.4)
Both adult	8 (24.2)	4 (11.4)	3 (10.0)	15 (15.3)
Fodder collection from fodder tree				
Adult male	18 (54.5)	15 (42.9)	14 (46.7)	47 (48.0)
Adult female	13 (39.4)	19 (54.2)	14 (46.7)	46 (46.9)
Both adult	2 (6.1)	1 (2.9)	2 (6.6)	5 (5.1)

Source: Field Survey, 2012

Note: Figures in parentheses indicate percentage of response

(c) *Gender roles in buffalo marketing activities*

Gender roles in buffalo marketing related activities, for example, buying of buffalo was thought to be equal responsibilities of either male, female alone and both male and female jointly observed in the Tanahun district.

It was learnt that more than fifty percent of the respondents in Gorkha reported that it was the job of male member alone for purchasing of buffalo. In contrast to the two districts, Chitwan has different scenario of gender involvement in buffalo marketing related activities. Accordingly, about $9/10^{th}$ of the respondents in Chitwan opined that buying of buffalo would be the major responsibility of male member alone in the family (Table 6).

Table 5 Gender roles in animal health management in the study district

Gender roles and activities	Tanahun (n=33)	Gorkha (n=35)	Chitwan (n=30)	Overall (n=98)
Caring of sick milch buffalo				
Adult male	12 (36.4)	15 (42.9)	11 (36.7)	38 (38.8)
Adult female	9 (27.2)	14 (40.0)	16 (53.3)	39 (39.8)
Both adult	12 (36.4)	6 (17.1)	3 (10.0)	21 (21.4)
Feeding medicine to the sick milch buffalo				
Adult male	16 (48.5)	24 (68.6)	24 (80.0)	64 (65.3)
Adult female	7 (21.2)	5 (14.3)	4 (13.3)	16 (16.3)
Both adult	10 (30.3)	6 (17.1)	2 (6.7)	18 (18.4)

Source: Field Survey, 2012

Note: Figures in parentheses indicate percentage of response

Table 6 Gender roles in marketing management of buffalo in the study district

Gender roles and activities	Tanahun (n=33)	Gorkha (n=35)	Chitwan (n=30)	Overall (n=98)
Buying of buffalo				
Adult male	11 (33.3)	20 (57.1)	27 (90.0)	58 (59.2)
Adult female	11 (33.3)	6 (17.1)	1 (3.3)	18 (18.4)
Both adult	11 (33.4)	9 (25.8)	2 (6.7)	22 (22.4)
Selling of buffalo				
Adult male	10 (30.3)	22 (62.9)	27 (90.0)	59 (60.2)
Adult female	13 (39.4)	5 (14.2)	1 (3.3)	19 (19.4)
Both adult	10 (33.3)	8 (22.9)	2 (6.7)	20 (20.4)
Involvement in selling of milk				
Adult male	8 (24.2)	20 (57.2)	27 (90.0)	55 (56.1)
Adult female	16 (48.5)	11 (31.4)	1 (3.3)	28 (28.6)
Both adult	9 (27.3)	4 (11.4)	2 (6.7)	15 (53.3)

Source: Field Survey, 2012

Note: Figures in parentheses indicate percentage of response

Gender division of labour in buffalo production

Table (7) presents the highlights of Focus Group Discussion (FGD) about gender division of labour in buffalo production in the three study sites of three districts. It was revealed that gender division of labour varied as per the study location whereas some of the

activities were observed similar in terms of gender involvement in all study sites. Cleaning of shed was male's domain in Gorkha and Tanahun, but both male and female would do this job in Chitwan. Likewise, fodder collection work would be done by both male and female in all sites, but selling milk would entirely the responsibility of male in all sites (Table 7).

Table 7 Gender division of labor in buffalo production across the study districts

Activities	Gender division of labour							
	Gorkha			Tanahun		Chitwan		
	Male	Female	Both	Male	Both	Male	Female	Both
Cleaning of shed	√			√				√
Feeding animals		√			√			√
Fodder collection			√		√			√
Milking	√				√	√		
Selling milk	√			√		√		
Selling animals	√				√	√		
Obtaining veterinary care	√				√		√	

Source: FGD, 2014

Gender roles in buffalo marketing decisions

Gender decisions on buffalo marketing was studied in relation to determining size of buffalo keeping, decide market place to buy buffalo and decide market place to sell buffalo. Accordingly, about $3/5^{th}$ of the respondents in Tanahun and Gorkha reported that determining size of buffalo was the role of both male and female whereas it was a dominating work of male in the case of Chitwan. In overall all, it was a dominating case for both male and female members considering all three study sites (Table 8).

In a similar reflection, it was revealed that nearly 70% of the respondents in the Tanahun and about 60% respondents in Gorkha reported that decide market place to buy buffalo was the role of male member whereas about 60% respondents in Chitwan district reported the task as of male dominating. Similar pattern of response was revealed in the case of decide market place to sell buffalo as well (Table 8).

Findings from the Focus Group Discussion

Gendered Daily Work Routine

The present study of Focus Group Discussion (FGD) has tried to get an idea of the activities of male and female do during one day in rural households. There are some similarities in daily work routine between and among the caste and ethnic groups across the districts. Usually, both male and female start their work at 5 to 5.30 is and ends at 6.30 am. However, wake up time varies from one household to another. For example, Mr. Pulananda Adhikari and his wife in Chitwan always wake up at 3 am in the morning that he has more number (60-70) of livestock. Generally, all family members get up between 4.30 to 5 am in the farming community.

Table 8 Gendered decisions on buffalo marketing in the study sites

Activities	Tanahun (n=33)	Gorkha (n=35)	Chitwan (n=30)	Overall (n=98)
Determining size of buffalo				
Adult male	5 (15.2)	8 (22.9)	17 (56.7)	30 (30.6)
Adult female	6 (18.2)	4 (11.4)	1 (3.3)	11 (11.2)
Both adult	22 (66.6)	23 (65.7)	12 (40.0)	57 (58.2)
Decide market place to buy buffalo				
Adult male	3 (9.1)	10 (28.6)	18 (60.0)	31 (31.6)
Adult female	7 (21.2)	5 (14.3)	1 (3.3)	13 (13.3)
Both adult	23 (69.7)	20 (57.1)	11 (36.7)	54 (55.1)
Decide market place to sell buffalo				
Adult male	4 (12.1)	13 (37.2)	19 (63.3)	36 (36.7)
Adult female	8 (24.2)	4 (11.4)	1 (3.3)	13 (13.3)
Both adult	21 (63.4)	18 (51.4)	10 (33.3)	49 (50.0)

Source: Field Survey, 2012

Note: Figures in parentheses indicate percentage of response

In Gorkha, farmers wake up at around 5 am and start to clean the shed, feed the animal and finish milking job within 6.30 am. Then after, they go for selling milk in the nearby cooperative. Woman, however, in all the districts usually keeps busy in kitchen affairs especially for cooking food, caring of elderly and child in the family. During the day time, mostly at around 2-3 pm they go for fodder and forages collection, watering the animal and often they clean the animal as well. Around 4 pm, they go for milking buffalo. Usually, evening meal is ready at around seven to eight pm. They have their food and males go to the bed little bit earlier than females. After cleaning and washing utensils, women go to bed at 9.30 to 10 p.m. Moreover, at present days all the family members enjoys watching Television together during night in all the districts.

In the Tanahun, farmers wake up quite early than in Gorkha. Accordingly, most of farmers at the rural household wake up at 4-5 am in the morning. They also involved in livestock care and management activities like in Gorkha in the early morning hours. The only difference in Tanahun than in the Gorkha is that due to lack of cooperatives in nearby area, they sell the surplus milk in the tea shop and to their fellow neighbors. Usually, neighbors visit their house and purchase milk according to their wish of contact. Some of them are involved in off-farm activities (Service and Business). During the day time, at 3 pm they go for collecting the fodder and forages, and involve in grazing and watering the animal. Mostly, women go for forages collection and men go for the fodder tree collection. After returning to the respective home, women remain engaged into their traditionally assigned duties of preparing meal, cleaning and washing utensils. Similar

scenario of gendered daily work routine was found in Chitwan as well. Enjoying with Television program is a means of relaxation for Tanahun farmer is also common at present days.

Farmers are not only engaged in farming and household affairs, equally they are religious people and regularly participate in different religious functions and activities in group and also make visit to the temple in all the study districts. In all study sites, we found that women usually participate and work together in neighborhood ritualistic function.

Gender division of labour in buffalo production

It was learnt that there were distinct gender division of labor found in buffalo production across the study districts of Palungtar of Gorkha; Dulegaunda of Tanahun and Chanauli of Chitwan districts. Cleaning of shed in Gorkha and Tanahun was done by male whereas such activity was performed by joint involvement of male and female in the case of Chitwan. In the past, the male member of the family in Tanahun did not practice collection of farm yard manure due to the traditional belief that male should not do that activities. Thus, cleaning of shed was the female's job in the past. This indicates that society is changing so as the traditional value is also inclined to change. There was a joint involvement of male and female in fodder collection in all the study districts.

Feeding animals across Tanahun and Chitwan was jointly done by male and female, whereas in Gorkha such activity was done by female alone. Similarly, milking animal, selling of milk and selling whole animal were done by male members in Gorkha and Chitwan while milking and selling milk were the domain of male alone in the Tanahun district. A contradiction in gender role was found in the case of obtaining veterinary care among the study districts. It was learnt that male alone were involved for obtaining veterinary care in Gorkha while female alone took such responsibility in Chitwan. However, both male and female jointly involved for such activity in Tanahun. This information clearly reflects the indication of rigidity in division of labour across the districts. However, flexibility in performing role was also found inclined towards change as per the availability of labour at the household level. These activities are practiced from ancient time. They have learnt to practice those activities from their ancestors and also thought that this is a source of raising household income.

Household Decision-Making Process

Decision-making is not a matter of debate at rural households of Nepal. Generally, decisions are made on the basis of consensus between husband and wife in the family. Minor decisions such as selling and buying small items are made by female in all the districts. Usually, male actively involved in the decisions of buying and selling of animals.

Although selling milk is the job of male members in all the study districts, female member (the mother) of the family often decides on amount of milk to keep for home consumption and for sell. After consuming the required amount of milk, female decides to sell the surplus amount of milk in the local market and to their neighbor. One of the participant farmers of Tanahun has larger amount of milk production thus sold in the

dairy nearby location. In Gorkha, the decision making power was found dominated by the male head (70%) of the family compared to the female (30%) member of the family. The household activities- livestock farming, management and feeding of livestock, are dominated by the female (70%) compared to the male (30%) member of the family. In the case of Tanahun, male members mostly attend social meeting because it is traditionally in practice that favors male.

It was also learned that male and female member jointly participate for making big decisions such as purchasing land, purchasing animal, spending time for social and religious ceremony etc, but for small and minor household decisions either male or female could have individual decision. In Chitwan, both male and female member exercise the power in taking decisions. In the absence of male member, however, female can make her own decision for minor activity, but for major household decisions she decides in consultation with the male members such as Father-in-Law, brother-in-Law or even her own father and brothers.

Challenges for livestock production

There was a similarities found in terms of challenges faced by the participant farmers of study districts. Accordingly, farmers of Gorkha district realized that the biggest challenges for the livestock production was problem of scientific shed due to lack of resource for construction followed by problem of proper management of farm yard manure. Similarly lack of sufficient supply of fodder and forages is another alarming problem for livestock production along with assurance of water availability to feed animals. Moreover, there is lack of strong policy in livestock farming. Similar types of challenges were faced by the farmers of Tanahun and Chitwan as of Gorkha. However, farmers of Chitwan have realized the fact that there is lack of proper grazing field on the top of other constraints and problems related to the livestock. Before launching the LCC INPB Project there was lack of knowledge to feed improved forages to the animals thus they forcefully fed weed to their animals in all the study districts. At present due to impact of project activities they have learnt to feed improved forage and balanced feeds to their animal. This is the lesson learned by the participating farmers in all the study districts.

Motivation towards buffalo production

Positive points

Buffalo milk content more fat percentage, thus buffalo milk is tastier than cow milk. More manure can be produced from buffalo and thus more useful in making soil fertile for agriculture purpose. Buffalo manure/dung is also good for Biogas Plant due to more dung production. Moreover, more than half of the cost of rearing can be incurred even after selling dry buffalo for meat purpose. Therefore, farmers are inclined to raise buffalo compared with the cow farming in all sites of the study districts.

Negative points

In spite of several advantages buffalo posses, buffaloes are considered large animal that requires more feeds and greater attention to rear. Often they are difficult to handle as

well. Thus some farmers are still thoughtful to raise buffalo due to burden of work and less profit.

Findings of supplementary work of Chitwan district

Gender role decisions on land use

About one-third of the respondents reported that men would decide on whether to plant fodder crops into their own farm whereas nearly half of the respondents thought that such decision would be taken by both men and women together. Similar response were also revealed for what fodder crops to plant and how much land to cultivate to grow fodder (Table 9).

Table 9 Gender roles in land use decision among the buffalo rearing farmers of Chitwan

Land use pattern	Gender roles in land use decisions (n-57)			
	Women	Men	Both separately	Both together
Whether to plant feed/ fodder crops into own farm?	6 (10.5)	19 (33.3)	4 (7.0)	28 (49.2)
What feed/fodder crops to plant/sow in own farm?	9 (15.8)	24 (42.1)	-	24 (42.1)
How much land to cultivate as feed/ fodder crops into own farm?	6 (10.5)	19 (33.3)	2 (3.5)	30 (52.7)

Source: Field Survey, 2014

Note: Figures in parentheses indicate percentage of response

Gender role decisions in buffalo production

It was revealed that men would decide on whether to keep buffalo for milk production as reported by about half of the respondents whereas similar proportion of the respondents also thought that such decision would be made by both men and women together. Similar trend of response was also found on the activities such as whether to sell buffaloes, or to select the appropriate breed of buffalo (Table 10).

Table 10 Gender roles in buffalo production decisions among farmers of Chitwan

Buffalo production activities	Gender roles in decisions on buffalo production (n=57)			
	Women	Men	Both separately	Both together
Whether to keep buffalo for milk production and/or farming?	8 (14.0)	26 (45.6)	-	23 (40.4)
Whether to sell buffalo?	9 (15.8)	25 (43.9)	1(1.8)	22 (38.5)
Selection of the breed	3 (5.3)	35 (61.4)	-	19 (33.3)

Source: Field Survey, 2014

Note: Figures in parentheses indicate percentage of response

Gender roles in feed management and animal nutrition

Gender roles in feed management and animal nutrition varied as per activities. For example, about one-third of the respondents reported that women as well as men would involve in planting feed crops whereas about one-fifth of the respondents reported that such involvement would be for both men and women but separately (Table 11).

Table 11 Gender involvement in feed management and animal nutrition related activities among farmers of Chitwan

Feed management and animal nutrition activities	Gender roles in feed management and animal nutrition			
	Women	Men	Both separately	Both together
Planting feed crops (n=57)	20 (35.1)	19 (33.3)	12 (21.1)	6 (10.5)
Tending to feed crops (n=57)	23 (40.4)	10 (17.5)	18 (31.6)	6 (10.5)
Harvesting feed crops (n=56)	25 (44.6)	8 (14.3)	17 (30.4)	6 (10.7)
Selection of purchased feed (n=55)	13 (26.3)	31 (56.4)	10 (18.2)	1 (1.8)
Feed preparation (n=57)	27 (47.4)	10 (17.5)	8 (14.0)	12 (21.1)
Feeding (n=57)	20 (35.1)	22 (38.6)	12 (21.1)	3 (5.3)
Administration of supplements (n=57)	7 (12.3)	45 (78.9)	5 (8.8)	-

Source: Field Survey, 2014

Note: Figures in parentheses indicate percentage of response

Women would be involved in tending feed crops as reported by 2/5th of the respondents whereas about 1/3rd of them reported that tending to feed crops would be done by men only. Feed preparation, on the other hand would be heavily done by women as reported by ½ of the respondents whereas about 1/5th of the respondents thought that it would be done by both men and women together (Table 11).

Gender roles in animal health management

Gender roles in animal health varied according to the activities. For example, about one-third of the respondents reported that diagnosis of diseases would be done singly by women, men, as well as by both but separately whereas more than 80% respondents reported that obtaining veterinary care and buying medicines for buffalo would largely done by men alone (Table 12).

Table 12 Gender roles in animal health management among farmers of Chitwan

Animal health related activities	Gender roles in animal health			
	Women	Men	Both separately	Both together
Diagnosis of diseases of buffaloes	18 (31.6)	24 (42.1)	15 (26.3)	-
Obtaining veterinary care for buffaloes	5 (8.8)	47 (82.5)	3 (5.3)	2 (3.5)
Buying medicine for buffaloes	4 (7.0)	51 (89.5)	2 (3.5)	-
Care of sick animal	10 (17.5)	20 (35.1)	8 (14.0)	19 (33.3)

Source: Field Survey, 2014

Note: Figures in parentheses indicate percentage of response

Gender roles in animal reproduction related activities

Information on gender roles for animal reproduction revealed that heat detection in buffalo would be done by women and men alone as reported by about one-third of the respondents whereas obtaining AI services and natural breeding related works would exclusively done by male alone (Table 13).

Table 13 Gender roles in animal reproduction related activities among farmers of Chitwan

Animal reproduction related activities	Gender roles in animal reproduction			
	Women	Men	Both separately	Both together
Heat detection	25 (43.9)	19 (33.3)	8 (14.0)	5 (8.8)
Obtaining AI services	3 (5.4)	52 (92.9)	1 (1.8)	-
Natural breeding	5 (8.8)	44 (77.2)	4 (7.0)	4 (7.0)

Source: Field Survey, 2014

Note: Figures in parentheses indicate percentage of response

Gender roles in milking and marketing activities

Findings revealed that milking would be equally done either by men, women or both separately as reported about by one-third of the respondents. Whereas selling milk, selling buffaloes and determining price of buffalo would be dominated by men as reported by about 3/5th of the respondents (Table 14).

Table 14 Gender roles in milking and marketing among farmers of Chitwan

Milking and marketing activities	Gender roles in milking and marketing			
	Women	Men	Both separately	Both together
Who milks the buffalo?	15 (26.3)	22 (38.6)	18 (31.6)	2 (3.5)
Who sells the milk?	9 (15.8)	35 (61.4)	13 (22.8)	-
Who sells the buffalo?	4 (7.0)	33 (57.9)	-	20 (35.1)
Who determines the price of buffalo?	4 (7.0)	34 (59.6)	1 (1.8)	18 (31.6)

Source: Field Survey, 2014

Note: Figures in parentheses indicate percentage of response

Gender concern in the use of assets and income

It was revealed that men would exclusively own the legal title of the land as well as the buffalo as revealed by the response in Chitwan district (Table 15). Regarding decision on spending money by selling milk, about 1/5th of the respondents reported that it would be decided by men or women alone whereas ½ of the respondents reported that it would be decided by both men and women together. Similar response was also obtained regarding who decides on how to spend the money from buffalo sales (Table 15)

Table 15 Gender concern in the assets and use of income among farmers of Chitwan

Activities	Gender concern in the use of assets and income (n=57)			
	Women	Men	Both separately	Both together
Assets				
Legal ownership of land	5 (8.8)	51(89.4)	NA	1 (1.8)
Legal ownership of buffalo	9 (15.8)	47 (82.5)	NA	1(1.8)
Use of income				
Who decides how to spend the money from milk sales?	11(19.3)	13 (22.8)	2 (3.5)	31(54.4)
Who decides how to spend the money from buffalo sales?	10 (17.5)	12 (21.1)	2 (3.5)	33 (57.9)

Source: Field Survey, 2014

Note: Figures in parentheses indicate percentage of response

Gender roles in livestock- focusing to the buffalo production

Gender division of tasks and responsibilities is not strict. Gender division of labour varies across regions (Bajracharya, 1994). Both men and women take part in livestock management. However, women generally contribute more labour inputs in areas of feeding concentrate and water, feeding fodder, grazing animals, collecting fodder from grassland or forest, cleaning of barns, milking, churning butter, sale of milk and its products than men in the rural household of Nepal (Devkota, 2010). Findings of this study well revealed that gender roles such as construction of shed, cleaning, grazing, feeding, breeding and veterinary health care are still traditionally done-either male or female alone dominating task. Gender division of labour in livestock farming in South-East Asia is indeed similar to that described in other regions. Men are principally responsible for taking care of large animals and women for small ruminants (Petheram and Basuno, 1986).

In general, women take care of animals and men decide to the major agenda of livestock rearing whereas livestock production overlap and influence each other due to changing paradigm of gender roles as well (Devkota, 2010). When men are absent at the household women carry out these tasks without hesitation and burden perhaps for the temporary adjustment in gender roles. In deed examples of women's involvement are provided from the different agro-ecological zones and context. It is important to make a distinction among the types of responsibility that women have over livestock related activities: ownership, control over decision-making, use rights and provision of labour. In most systems, women provide labour for the various tasks related to livestock, but may or may not control the process of decision-making. Women may be involved in production, but may or may not own the means of production such as livestock, land, water, etc. Nevertheless, it is important to understand about the pattern and practices on how gender role has been assigned in a given context-focusing to the activities that are heavily done, either-men dominating, women dominating, or done by both together at a time as and when it happens to perform based on their convenience. In the case where most of the livestock related works are traditionally done-either men alone, for example, feeding medicine, breeding, shed construction, or women dominating such as feeds and feeding

management, shed cleaning etc. that fairly suggest the need to consider role specific planning while promoting scientific buffalo production and or enterprise development.

Changing decision pattern of men and women in livestock production

The findings of this study clearly revealed changing in the pattern and context of household decision-making in relation to gender decision processes. It is hard to say that both external and internal factors could contribute to have such results as it was beyond the scope of this study, however, social and global environment and their direct as well as indirect impact might contribute even at the household level for such visible changes. Traditionally, most of the livestock related decisions used to be men dominated task such as selling, marketing, use of money after livestock sell whereas women alone would have to hold very minimum participation for such decisions perhaps due to strong social norms and cultural construct (Chhetri, 2007; Devkota, 2010). However, results clearly showed that the common prevalence of joint decisions of both men and women in livestock production and marketing decisions including decisions on selling of buffalo and determining size of buffalo rearing. Many recent changes in the economic and socio-political conditions could affect livestock management decisions - whether it should be done by men or women. "The deleterious impact on women of continuing processes, such as increasing monetization of the rural economy, privatization of land, and commercialization of agriculture could play vital role to have such scenario developed (Joekes and Pointing 1991). In terms of decision-making, the handling and marketing of milk mostly done by women; men make decisions about large animals in the African context as well. In India, men are largely the decision makers for livestock production, and are in charge of general herd management whereas decisions on the sale of animals are generally taken by both men and women (Rangnekar, 1991). Nevertheless, there are visible changes in such scenario across the country. Household level changes towards joint decisions including livestock rearing are also reported by earlier researchers in the Nepalese context (Devkota and Pyakuryal, 2006; Devkota, 2010).

Different logics are found regarding particular decision making process in livestock rearing. For example, it is often argued that gender division of labour and participation in decision-making processes are influenced by the value and uses of animals and their products. Accordingly, if the animals serve purposes that are within the domain of women's responsibilities, such as feeding the family, women will have greater influence on decisions regarding the animals. On the other hand, women participate less in decision-making regarding animals such as draft oxen that are mostly used by men for ploughing (Martins, 1990). Men are responsible for the general welfare of livestock, such as animal care, breeding and herd management. Such scenarios were, however, not strictly revealed in this study where a flat type of joint decisions on major livestock production and marketing were reported. Such cases, although have not been well studied under this research frame, but decision-making for livestock, specially to the buffalo rearing are shifting towards joint decisions of both male and female for major activities such as production and marketing decisions. Indeed a shift from the subsistence economy to commercial production could have affected women adversely, diminishing both their revenue from animal products and their status and decision-making authority. Such

context could have equally been developed due to several factors linked to the personal and social context, but such indication are important to consider for planning and executing development activities that are related to the buffalo rearing and management.

CONCLUSION

Number of mature buffalo per household in the study sites matches to the data of national survey thus buffalo should be considered as one of the prime livestock species whereas gender roles and decisions on buffalo rearing would have greater reflection to the other productive livestock species

It has been clearly revealed that gender roles such as construction of shed, cleaning, grazing and feeding, breeding and veterinary health care are still traditionally done-either male or female alone dominating task that suggest the need to consider role specific planning while promoting scientific buffalo production and or enterprise development.

Gender decision on buffalo rearing, on the other hand, for example-marketing and buffalo production activities (whether to keep buffalo, sale it and determine its number and other alike decisions) are found in favor of joint decision of male and female that firmly suggest the concept to consider such change in buffalo production paradigm while implementing gender based development planning.

ACKNOWLEDGEMENT

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Prevalence of fasciolosis in river basin area of Saptari district

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ABSTRACT

A study on prevalence of fasciola in cattle and buffalo of Dauribharauwa V.D.C in Koshi river basin area of Saptari district was conducted from January 2012 to May 2012. A total number of 125 faecal samples were collected and were examined for the presence of Fasciola by sedimentation method as described by Hansen and Perry (1993). The overall prevalence of Fasciola was 72.8%. The prevalence of Fasciola according to species was found to be 74.66% and 70% in cattle and buffalo respectively. The prevalence of Fasciola according to sex was found to be 81.81% in female whereas 69.04 % in male cattle. But it was found to be 56.25% in male whereas 76.47% in female buffalo. The prevalence of Fasciola according to age was found to be 40%, 76%, and 78.33% in group less than two year, two to five years, and above five years, respectively.

Key words: Cattle, buffalo, river basin, species, disease, climate

INTRODUCTION

Fasciolosis is the most important among such diseases which reduce the productivity of livestock in Nepal. More than 50% prevalence of the disease has been reported in cattle and buffaloes in different parts of the country (Joshi, 1988). Under Nepalese condition, the major risk period of the disease is from September to February.

Fasciolosis is a highly prevalent disease in the animal population in most of the districts of Nepal where the climate and farming practices favour the prevalence of the disease. Although a proper survey in different parts of the country has not been conducted to determine the prevalence of this disease, the number of positive faecal samples reported from the veterinary hospitals in the different parts of the country indicates its widespread occurrence and high prevalence rate within the country. The prevalence may be far higher than those reported by the district veterinary hospitals because of the incomplete coverage of the veterinary services and the diagnostic facilities in the District. In 1973, Singh, Basnyat, Eichenberger and Bommili (1973; cited by Mahato 1993) reported an infection rate of 50-90 percent in animals in areas below 1800 m and estimated an annual economic loss of Rs. 200 million due to this disease alone.

The disease is distributed in all parts of the country in all farm animals. The disease is a problem from the buffaloes of terai to the yaks of Himalayas (Joshi 1983). The disease is well recognized by Nepalese farmers and called by different local names like *namle, lew*, *galphulo, mate* in different regions of the country. The extent of the problem, as recognized by farmers, is reflected by the drug sale (60%) that is incurred for the treatment of fasciolosis.

MATERIALS AND METHODS

Site selection
The study was carried out in Duribharuwa VDC of Sapatri district from February to July. This is the rural river basin area, where livestock are raised in the densely human populated area. Various studies have not been carried out on prevalence of fasciola in different animal of species. The area of Saptari is 1363 Km2. Total Population 570,282 (2011) and having population density 420Km2.

Collection of samples
Fresh dung samples were collected in the morning from the rectum of the animal. In the cases where it was impossible to collect rectal samples, fresh faecal samples were collected from central part of faecal pit taking care not to contaminate any foreign materials with dung. A total of 125 faecal samples were collected from Duribaruwa VDC of Saptari district in which from cattle 75 and from buffalo 50 samples were collected. The collected samples were kept in the separate plastic sleeves and marked individually for their identification. The sleeve was tightened close to the dung so as to exclude air from the container. The laboratory work was performed at the District Livestock Services Office (DLSO) Saptari.

Examination of sample
The samples collected in the morning were examined in the same day. During the study, direct technique and standard sedimentation technique were employed. Animals with fasciola eggs in dung were considered positive for fasciolosis. Gross examination of the faecal sample was performed for consistency, color, and presence of segment of parasite/mucous/blood. Microscopical examination was performed for the detection of eggs of fasciola helminth parasites as described by Souls by (1978). A small quantity of dung were placed with a tooth pick on a slide, mixed with a drop of distilled water, spread out and examined directly.

RESULTS AND DISCUSSION

Gross examination of faecal sample
Consistency
The consistency of the faecal sample observed during the time of its collection was found to be of three different types: semi-solid, firm and slurry. The percentage of semi-solid type was found to be maximum (54.4%), followed by slurry type (40.8%) and firm (4.80%). The data is presented in Figure 1.

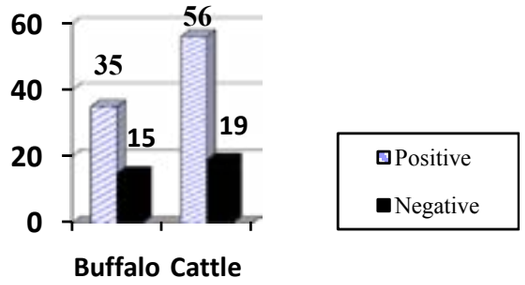

Figure 1. Consistency of collected faecal samples

The difference in consistency of the faecal materials may be due to the type of feed to the animals, habits, health condition and the presence of fasciolosis in the animal. The animal producing slurry type of dung may be infected with fasciola causes diarrhea in infected animal.

Dung colour

The colour of the dung material of cattle collected for the examination of fasciolosis was also noted at the time of its collection. Most of the samples were greenish black (85.60%), followed by yellowish brown (8%), yellowish green (4%) and greenish grey (2.40%). The data are presented in Figure 2.

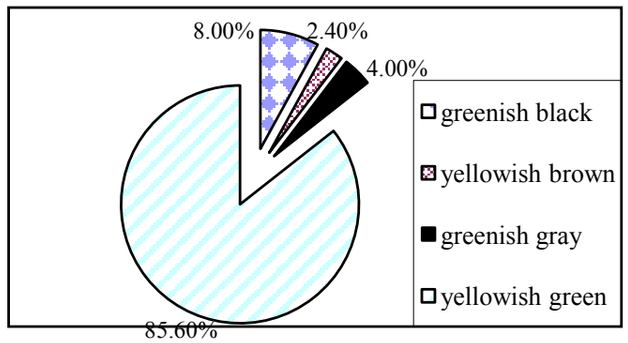

Figure 2. Colour of the collected faecal samples

The colour of dung is mainly due to the types of the feed to the animal, for example, greenish color of dung is indicative of feeding green grasses to the animal,

Faecal content

While examining the faecal materials grossly, segment of parasites, adult parasites were absent and the sample wasn't stained with the mucus or blood. There was presence of plenty of undigested fibres and pollen grains in all the samples. The presence of undigested fibres in plenty amount may be justified by the feeding habit of the cattle.

Cattle were fed plenty of roughages, i.e. straw which does not digest completely and undigested fibers can be seen in the dung.

Microscopic examination of faecal sample

Overall prevalence of Fasciola

The faecal samples were examined by sedimentation method. Of 125 samples, 91 (72.8%) were found to be positive and rest 34 (27.2%) were found negative (Figure 3).

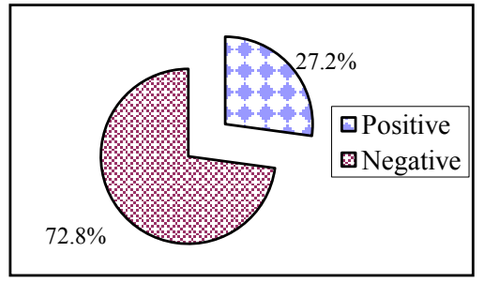

Figure 3**.** Prevalence of Fasciola in the study area

The findings of the current study is comparable to Jaiswal (2006) in which70.70% were positive for overall parasitic during study on fascioliasis in ruminants at Dhanusa district and slightly more than Buddhathoki (2008) in which 67. 77 % Fasciola is the positive in the dang district as this study area (river basine) is similar to Jaiswal and different to Buddhathoki.

Prevalence by species

A total samples 125 (75 cattle and 50 Buffaloes) dung samples were tested for presence of Fasciola out of 75 samples in cattle 56 (74.66%) samples were found positive where as 35 (70%) samples found positive in buffalo faecal sample.

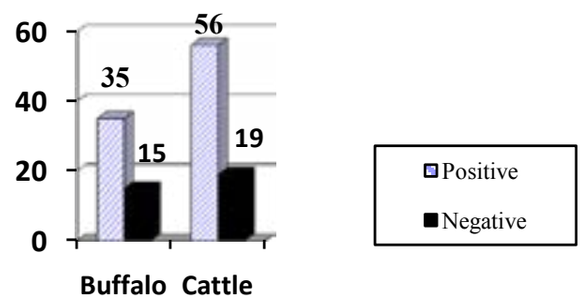

Figure 4. Prevalence of Fasciola according to species

Prevalence by sex

The prevalence of Fasciola was found to be 81.81 % (27/33) in female where as 69.04 % (29/42) in cow. But it was found to be 56.25% (9/16) in male where as 76.47% (26/34) in She buffalo.

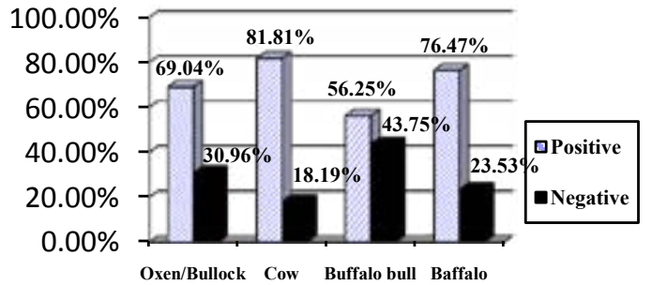

Figure 5. Prevalence of Fasciola with respect to sex

In both species (cattle and buffalo) females had higher prevalence compared to the males. The finding is comparable with the similar findings of Mahato (1993). The higher prevalence in female may be due to the fact that most of the male were sold when they attained marketing age and a higher proportion of these animals were generally young which were less susceptible to infection. Second reason may be due to female animals were mostly stall fed during pregnancy. These animals were provided with mainly rice straw which may have been infected with metacercaria and may have greater chance of getting infection.

Prevalence by age

For finding the prevalence of Fasciola according to age, the animals were divided into three groups (0-2 years, 2-5 years, ≥ 5 years). It was found that 6 (40%) out of 15 at 0-2 yrs of age both cattle and buffalo are positive while 38 (76%) out of 50 animals were positive between 2-5 yrs of age. Similarly 47 (78.33%) out of 60 cattle and buffalo were positive in more than 5 yrs of age (Table 1).

Table 1. Prevalence of fasciola with respect to age

Particulars	0-2 years	2-5 years	≥ 5 years	Total
Cattle Positive	4	23	29	56
Cattle Negative	5	6	8	19
Buffalo Positive	2	15	18	35
Buffalo Negative	4	6	5	15
Total	15	50	60	125

The findings indicate that the younger animal gets less infection than adult one. Liver fluke infection is more common in adult than young animal, for liver fluke infection, as the age of animal increase, the chance of infection is more.

The prevalence of Fasciola increased with increasing age. This could be due to longer exposure of older animals to infection and to carrying residual infection from previous years.

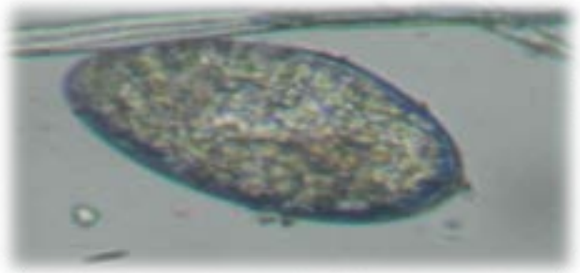

Figure 6. Eggs of Fasciola

CONCLUSIONS

A study on prevalence of Fasciola in cattle and buffalo of Dauribharauwa V.D.C established in Koshi river basin area of Saptari district was conducted from January 2012 to May 2012. A total number of 125 faecal samples were collected through random sampling technique. The Dung samples were examined for the presence of fasciola by sedimentation method as describe by Hansen and Perry (1993). The overall prevalence of fasciola was (72.8%). The prevalence of fasciola according to species was found to be 74.66% and 70% in cattle and buffalo respectively. The prevalence of fasciola according to sex was found to be 81.81% in female where as 69.04 % in male cattle. But it was found to be 56.25% in male where as 76.47% in female buffalo. The prevalence of fasciola according to age was found to be 40%, 76%, and 78.33% in group less than two year, two to five year, and above five year respectively

The faecal samples were examined for the presence of fasciolosis by sedimentation method. Out of 125 samples 72.80% (91/125) were found to be positive. In the Koshi river basin area of Duribharuwa VDC of Saptari district .The prevalence of fasciolosis was found to be 74.66 % and 70% in cattle and buffalo respectively. The prevalence of Fasciola was found to be 81.81% in cow where as 69.04 % in male cattle. But it was found to be 76.4% in female buffalo and 56.25% in male buffalo.

For finding the prevalence of Fasciola according to age, the animals were divided into three groups. It was found that 6, 38, and 47 animals were positive out of 15, 50 and 60 animals resulting 40%, 76% and 78.33% infection in group Less than two year, two to five year, and above five year respectively.

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Status of Pakhribas pig: constraint and prospects

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ABSTRACT

Pakhribas pigs are very popular in the Eastern hills of Nepal. This breed has been developed in the country by three way crossing of exotic breeds (Saddle Back, Fayuen and Tamworth) at Agricultural Research Station (ARS), Pakhribas (then PAC). It is much diversified and heterogeneous populations which remain largely unknown and under-studied in spite of real economic and public importance value that it seemed to represent mainly in Eastern region of Nepal. The present study envisaged the objectives of maintaining, valorization and development of the rustic and well adapted genetic substrate. In this respect, growth parameters, runt population, mortality and coat colour were measured. Result showed that the overall birth weight and weaning weight of Dhankuta and Sunsari districts are 0.93 kg and 9.6 kg respectively. Dhankuta was found to be better performing than Sunsari in body weights. The percentage of runt population in Sunsari and Dhankuta are 50.9 % and 49.6 % respectively. Mortality percentage is found to be the highest in case of Sunsari district (47.1 %) followed by Dhankuta (44.3%). As the coat colour performance of parent pig is 76 % black, 23% mixed and 1% white and the piglets showed that 50% population are mixed colour (black with white patches), 46 % pure black and 4 % pure white. There is a great variation in the growth performance, high piglet's mortality, higher runt population and higher mixed colour in piglets. The parity of birth is 4 to 5. So the parent inbreeding effect is lower than the piglets. Thus, they could represent a strong argument of development of mating plan of the nation to maintaining the existence breed of pig and to fulfill the public economy and public demand. Therefore an urgent programme of screening, evaluation and maintaining of the pig populations is to be conceived and applied.

Key words: Breed, traits, indigenous, exotic, phenotypes, inbreeding

INTRODUCTION

Livestock farming has been an indispensable part of socioeconomic life of the most of the Nepalese farmers. Livestock plays an important role in the farming systems and provide a source of animal protein and household cash income, and thus have a significant position in the national economy. APP predicts the share of livestock in AGDP to reach at 45% from current level at the end of 12th plan period (2014/15). The agriculture sector dominates the economy of Nepal; about 65.7% people depend on agriculture for their livelihood (MoAD, 2013). Livestock is an integral and important component of Nepalese farming system. Agriculture contributes about 33% to the total gross domestic production

(GDP) whereas livestock contributes about 28% of the total agricultural gross domestic production, which has been envisaged to increase at 45% by 2015 (Poudel *et. al*, 2009). At national level, the annual population growth rate is 0.38% in cattle, 3.33% in buffalo, 3.72% in goat, 1.99% in pigs and 7.77% in poultry in the year 2011/012 (DLS, Livestock Statistics of Nepal, 2011/012). The total population of cattle is 7.2 millions, buffaloes 5.1 millions, sheep 0.8 millions, goat 9.5 millions, pig 1.1 millions, and poultry 45.17 million (MoAD, 2013).

Pig production as commercial enterprises in Nepal started since last five and half decades and is now it becomes one of the main national agricultural industries. There is a growing awareness of the nutritive value of pig meat among the people out of ethnic group. Therefore, pig farming is becoming an important business enterprise in both rural and urban areas of the country which alleviate the poverty of poor farmer (Joshi *et al*., 2002).

The net meat production during the year 2012/13 was 2, 95,167 metric ton out of which the distribution from pig was 6.4% (MOAD, 2013). Although commercial pig farming is growing in the urban area of the country, the percentage of indigenous pig still exceeds in the country. 80% of the total pig population of the country comprises the indigenous stock and the exotic origin represents 19 % of the total pig population (Rasali *et al.*, 1998). Indigenous pig under scavenging systems plays a vital role in rural economy to poor people. There are three indigenous breed of pig in country that has been identified so far. They are Hurrah, Chwanche and Bampudke (Shrestha, 1995; Neopane, 2004). Amongst these breeds, Chwanche constitutes a major proportion of the population and are located in hills (Shrestha, 1996). Apart from these breeds there are large white Yorkshire, Landrace, Hampshire, Berkshire, Saddle back, Fayuen, Tamworth and Duroc as introduced breed. The most popular breed developed in the country is Pakhribas Pigs. In the mid 1970's; Pakhribas Agriculture Centre (PAC) introduced exotic pigs (Yorkshire, Saddle black, Fayuen, and Tamworth). Out of these, Saddle back, Fayuen and Tamworth had triple cross in developing a new breed, Pakhribas Pig (Aryal, 1992; Shrestha 2000; Neopane, 2005; Neopane and Kadel, 2008). This black pig is the most commonly found in eastern region of Nepal. Pakhribas pigs are located in the eastern part of Nepal. They have a wide range of adaptability from tropical to temperate region. The crossbreed black pigs were produced at Pakhribas Agriculture Centre (PAC) to meet the demand of local community. There are two types of black pig -one with convex back and another with concave back. It is a pork type and preferred by the farmer of eastern region. The sow is prolific and good mother. Mature boar weighs about 350 kg and the sow weighs 250-300 kg. It is widely used for cross breed (Aryal *et al.,* 1992; Ghimire and Aryal, 1999). Pakhribas Agriculture Center (PAC) introduced exotic pig (Saddle back, Fayuen, and Tamworth) for producing Black Pakhribas Pig characterized by large body size, prolificacy, good mothering ability and hardiness (Shrestha, 1998). The Black Pakhribas Pigs have great contribution from early eighties to late 1980s. But the local community feels that there are several problems with this breeds having low litter size, prone to diseases and high mortality. Similarly, the researcher feel that black pig produced at Pakhribas Agriculture center (PAC) are highly inbred and as a result prolificacy has been deteriorated with less number of piglets born, high piglet mortality and comparatively having slow growth rate. With this context, this study is undertaken

for suggesting mitigating these challenges and constraints. This would be helpful in genetic improvement for regenerating more prolific and vigor black pig. So regeneration of black Pakhribas pig needs special attention owing to its economic and public importance. Segregation of genes is an important constraints factor for maintaining black Pakhribas pig and for this genes must be stabilized.

MATERIALS AND METHOD

The study was conducted in the eastern region of Nepal especially in two districts, Dhankuta and Sunsari from September to November 2014. Two sites were selected according to the agro-ecological zone of the Eastern Development Region of the country for the questionnaire survey and the method chosen was random. Dhankuta and Sunsari districts were selected for mid hill and terai region respectively. A total of 65 farms were selected randomly for the study; 35 from Sunsari and 30 from Dhankuta. The respondents for the questionnaire survey were randomly selected. A total of 1226 animals were used for this study.

Sample collection, processing and data analysis

The primary data was collected through, key informant interview, questionnaire survey, formal and informal discussion and direct observations. To develop further idea of the study site, informal discussion and interview with key informant was done. Commercial pig farms were taken as the key informants. The interview was focused on the effect of inbreeding on growth trait, reproductive traits, health traits and phenotypic traits. Among the districts, Sunsari, and Dhankuta sites were chosen randomly. The questionnaire survey was focused on the pigs reared in the area; major phenotypic character shown by dam; piglet's mortality, and growth pattern and diseases prevalence. All the quantitative data were entered in the Statistical Package for Social Science (SPSS, 2007). Microsoft-Word; Microsoft-Excel and SPSS programs were used for data processing, analysis and interpretation of the information collected through questionnaire survey and interview. The results were then represented in the form of tables, graphs, charts and pictorial devices. The information obtained from the questionnaire was analyzed by using SPSS software. Temperature data was analyzed by using Microsoft Excel for trend analysis and regression.

RESULTS AND DISCUSSION

This section presents the results of the experiment conducted for the evaluation of production performance including phenotypic characteristics of Pakhribas pigs in two districts Dhankuta and Sunsari. The results of the study focused especially on their body weight, dam and litter traits, mortality of piglets and coat colour of parents and piglets. The findings are presented based on the experiences gained during the study period and are supported by the past research findings reviewed during this study.

Number of pigs studied in the study sites

The total number of pigs in the studied sites of two district of Eastern Nepal Dhankuta and Sunsari is presented in Figure 1. The data on 1226 pigs population out of which the boar, sow and piglets of Dhankuta and Sunsari district is 16,100, 395 and 31,121,563 respectively. This result indicates that in Eastern region population of Pakhribas pig is high.

A. Pre-weaning body weights of pakhribas pig

1. On the basis of ecological region

The birth weight ranged from 0.93 kg in Dhankuta to 0.89 kg in Sunsari. Similarly the weaning weight of both district were 9.6 and 9.1 kg respectively (Figure 2) .This showed that birth weight and weaning weight of pigs in Dhankuta is higher than that of pigs in Sunsari. The higher birth weight (1.05 kg) was reported by Shrestha (1998) and 1.25 kg by Neopane (2005). The lower birth weight in this study may be due to increased inbreeding rate and higher birth weight reported by authors taking On station data may be because of better management provide at the station.

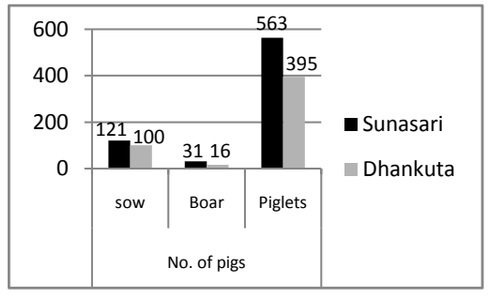

Figure 1 Total number of pigs in the study sites

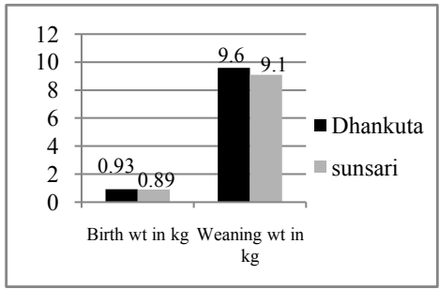

Figure 2 Growth pattern of pig

2. Birth and weaned weights based on sex

Body weight for Pakhribas Pig (kg) is presented in Figure 3. The findings revealed that the overall birth weight and weaning weight of male is 0.93 kg and 9.6 kg female is 0.89 kg and 9.1 kg respectively. The birth weight and weaning weight between male and female piglets was different. For all ages, the live body weights were significantly higher in males than females.

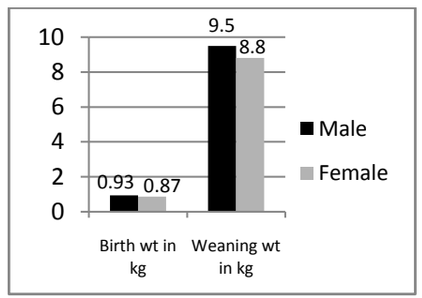

Figure 3 Growth pattern in male and female pig

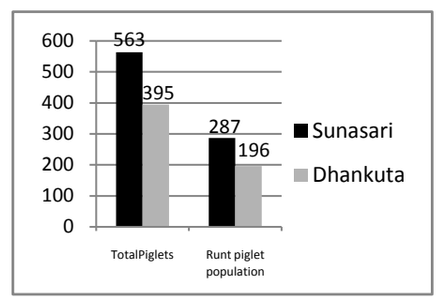

Figure 4 Total runt populations in the districts

The lower birth weight and pre weaning weight may be due to inbreeding.

B. Reproductive traits

1. Dam traits

The dam traits such as age of first service, gestation length, farrowing interval and age of first farrowing collected through recall basis of dam were 300 days, 113 days, 180 days and 365 days respectively. The age of first services is higher than the earlier findings reported by several authors (Shrestha, 1998; Rasali, 1995; Aryal, 1999). There is maximum chance of segregation of gene in the pig.

2. Litter traits

The most common measures of productivity for the sow herd is pigs weaned/sow/year (PSY). The number of litters farrowed/sow/year and number of pigs weaned/litter contribute equally to PSY (Frank *et al.,* 1998). The percentage of runt population found in Sunsari and Dhankuta was 50.9 % and 49.6 % respectively (Figure7). Jha *et al.* (1997) reported the weak population was 22% and still birth being 30%. The increasing in runt population may be attributed to increased inbreeding coefficient.

C. Health traits

Mortality percentage was found to be the highest in case of Sunsari district (47.1%) followed by Dhankuta (44.3%) (Ghimire and Aryal (1999) reported that the still birth and pre-weaning mortality were 4.86 % and 10.4 % respectively. Thakur (1997) reported higher still birth piglets (42%) followed by abortion (30%) and weak piglets (22%). Season of birth and managemental stress affected the health traits significantly. The inbreeding affects fitness traits (Falconer and Mackay, 1996).The increase in piglet's mortality may be due to inbreeding.

D. Phenotypic traits

A survey of colour preference among the farmers for pigs in Dhankuta and Sunsari districts using questionnaires result showed 76% black, 23% mixed and 1% white in parent pigs. But the piglets showed that 50% populations are mixed colour (black with white patches), 46%pure black and 4% pure white. Aryal (1998) reported that more than 90 % of the pigs were black and few were black with white patches.

CONCLUSIONS AND SUGGESTIONS

Conclusions

Based on the finding of the study, Pakhribas pig has lost its pure line traits day by day because of small stock population although pig needs special attention owing to its economic and public importance day by day in the country. This preliminary study showed that Pakhribas pigs have genetic potential in production performance than other breeds inside the country. Therefore, maintaining the breed with gene stabilized is an important issue. The Pakhribas pig is inbred within its population and its gene has become unstable because of lack of long term breeding strategy for pure line selection of breeding parent stock. It is recommended that while mating different breed to established new breed to fulfill the economic and public demand there should be short and long term breeding plan being recommended.

Suggestions

- The Pakhribas pig is highly inbred where most of the parent traits are lost so gene are unstable as it showed poorest performance its genetic improvement. Selection of pure line pigs with lower inbreeding rate should be initiated by breeders at the national level.
- Short term mating plan is suggested for production of F1 generation to fulfill the public demand of pig meat using only two breeds. The breed may be Hurrah, Hampshire/Saddle back, Nagpuri, Berkshire, Chwanche and wild pig (Bandel).
- Long term mating plan is suggested for second generation Pakhribas pig development. Long term mating plan emphasize on the use of rotational /triple crossing where three breeds are used for mating and the breeds are crossed in rotational manner. For this mating plan the breed may be Hurrah, Hampshire/Saddle back, Nagpuri, Berkshire, Large black, Tam Worth, Duroac, Chwanche and wild pig (Bandel).

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Phenotypic characterization of *Sakini* chicken of different agro-ecological zones of Nepal

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ABSTRACT

A total 162 birds were taken for the phenotypic and molecular characterization of Sakini chicken of different agro-ecological zones of Nepal. Rasuwa for high hills (61 birds), Kavre for mid hills (40 birds) and Rautahat for Terai (61 birds) districts were taken for the study. The birds were reared in intensive management system. The correlation with wattle length and comb length was found highest with value 0.950 followed by the correlation of body weight and breast girth with value 0.895. On principle component analysis of phenotypic traits first component contributes 68.67%, second component contributes 9.33% and third component contributes 5.01% respectively.

Key word: Genotypes, bird, intensive management system, correlation, body weight, breast girth

INTRODUCTION

Poultry alone contributes 4% of the agricultural GDP of the country with an output of 10 billion rupees from their sector (Dhakal, 2005). The contribution of poultry sector to the agriculture GDP is 38.15 % and contribution to livestock AGDP is 27.66% (MOAC, 2006). The total poultry population Nepal in fiscal year 2011/2012 is 45171185 and laying hen population is 7907468. The total chicken meat production in fiscal year 2011/2012 was 40346 metric ton. As well as total hen egg production is 7883180000 (MOAC, 2012). The production of poultry in focal year 2066/67 B.S in High hills, Mid hills and Terai is 7.19%, 54.66% and 38.15% respectively (MoAC, 2067). Commercial poultry farming particularly in urban areas has been particularly popular and is growing very fast in recent years. However, in rural areas, particularly where there is no electricity, road network and communication, the poultry raising in small scale under scavenging systems is only the option (Sharma, 2012).

Fifty percent of the total poultry population of the country comprises the indigenous stock (Neopane and Gorkhali, 2008). Indigenous poultry under scavenging systems plays a vital role in rural economy to poor people. The native chickens of Nepal are believed to have descended from *gallus gallus Murghi* which is found to be in the jungles of India and Nepal (Bhurtel, 2011). Nishida *et al.* (1988) reported that the Nepalese bird might belong to subspecies of *Gallus gallus mughi.* Chicken populations in the central part of Nepal were clustered into three groups by Maeda *et al.* (1988). It is considered as one of

the five subspecies of the Red Jungle fowl inhabiting wide areas of Nepal from Plain(terai), foot hills and up to 5000 feet above sea level at the Mahabharata range (Bhurtel, 2011). There are three indigenous breed of chicken in country that has been identified so far. They are Sakini, Ghanti Khuile and Puwankh Ulte (Neopane and Gorkhali, 2008) and out of these, Sakini is the most commonly found.

MATERIAL AND METHODS

The three ecological zones of central region was selected; i.e. Rasuwa for High hills, Kavre for Mid hills and Rauthat for Terai were selected for the sample collection. True to type Sakini breed and were unrelated up to two generations was considered while collecting egg. Maximum four eggs were randomly selected and collected from one household and transported to Animal Breeding Division, NARC, Khumaltar. Altogether 162 birds were used for the research; 61 for high hills, 40 for mid hills and 61 for plain Terai. The birds were reared and phenotypic measurements were taken.

RESULTS AND DISCUSSION

Phenotypic measurement of different lines of Sakini chicken

The overall body weight, breast girth keel length, shank length, thigh length, wing length, wing span length, body length, cob length, wattle length was found to be 1376.6±476.9 gm, 23.2±0.35,14.3±0.25, 8.7±0.11, 18.6±0.18, 19.7±0.23, 44.2±0.42, 52.9±0.55, 32.7±0.3, 5.2±0.24, 2.8±0.16 cm respectively (Table 1).

Table 1. Analysis of genetic parameters of three lines of Sakani chicken

Variable	Observations	Minimum	Maximum	Mean	Std. deviation
Body weight	52	592.000	2830.000	1338.115	476.065
Brest girth	52	17.000	33.000	22.856	3.625
Keel length	52	10.000	20.000	14.288	1.993
Shank length	52	7.000	11.000	8.625	1.128
Thigh length	52	15.000	23.000	18.471	1.761
Wing length	52	16.000	25.000	19.769	2.001
Wing span	52	36.000	53.000	42.240	3.666
Body length	52	51.000	68.000	58.990	5.344
Leg length	52	28.000	40.000	32.712	2.867
Comb length	52	0.500	11.000	5.031	2.906
Wattle length	52	0.500	7.000	2.671	1.848
Toes length	52	5.000	8.500	6.202	0.709

Correlation coefficient for phenotype traits

The correlation with wattle length and comb length was found highest with value 0.950 followed by the correlation of body weight and breast girth with value 0.895. The correlation of keel length, shank length, thigh length, wing length, body length, leg length, comb length wattle length and toes length with body weight was found; 0.77, 0.69, 0.74, 0.7, 0.785, 0.63, 0.82, 0.85 and 0.34 respectively. The correlation of all parts with all parts was found highly significant $p<0.0001$ except the correlation of toes with all parts (Table 2).

Table 2. Pearson's correlation coefficient for phenotype traits experimental birds of different AEZ

Variables	BW	BG	KL	S L	T L	W L	W S	B L	L L	C L	W L	TL
Body weight (BW)	**1**											
Brest girth (BG)	0.**895**	**1**										
Keel length(KL)	0.765	0.664	**1**									
Shank length (SK)	0.692	0.607	0.520	**1**								
Thigh length (TL)	0.737	0.663	0.642	0.739	**1**							
Wing length (WL)	0.703	0.562	0.628	0.712	0.628	**1**						
Wing span (WS)	**0.828**	0.735	0.613	0.739	0.634	0.685	**1**					
Body length (BL)	0.785	0.673	0.642	0.759	0.794	0.713	0.643	**1**				
Leg length (LL)	0.627	0.542	0.515	**0.839**	**0.813**	0.694	0.648	0.746	**1**			
Comb length (CL)	**0.816**	0.713	0.700	0.734	0.705	0.613	0.678	0.722	0.640	**1**		
Wattle length (WL)	**0.845**	0.774	0.687	0.719	0.713	0.606	0.750	0.712	0.606	**0.950**	**1**	
Toes length (TL)	0.343	0.347	**0.218**	0.513	0.382	0.479	0.415	0.455	0.509	**0.287**	**0.266**	**1**

Principle component analysis of phenotypic traits

All together three component contribute 83% divergence among the three lines of Sakini chicken in this study. First component contributes 68.67%, second component contributes 9.33% and third component contributes 5.01% respectively. Body weight, breast girth and keel length are major traits contributing variation (Table 3).

Table 3. Principle component and proportion of variation generated by 12 Traits

	B W	BG	K L	S L	T L	WL	WS	BL	LL	CL	W L	T L
Eigen value	8.24	1.12	0.60	0.48	0.41	0.35	0.26	0.18	0.16	0.11	0.06	0.03
Variability %	68.67	9.33	5.01	4.01	3.39	2.96	2.18	1.48	1.31	0.93	0.49	0.25
Cumulative %	68.67	78.00	83.01	87.02	90.41	93.37	95.55	97.03	98.33	99.26	99.75	100.00

Sharma (2011) also reported the overall weight of Sakini was 1402 gm which is similar to over all weight of the present study but less than weight of Rasuwa line and higher than weight of Kavre and Rautahat line. Parajuli (2011) presented the body length, comb length, leg length, wattle length 18.7, 4.9, 8.8, 2.45 cm, respectively which is less than our present study.

Nishida (1988) used leg length of femur, tibiotarsus, tarsometatarsus, third digit, wing and maxilla, and the circumference of tarsometatarus. First three components are better to explain variability in selected lines of Sakani chicken as variance for three components are above more than 80%. Maeda (1988) presented the first three components were 46%, 34% and 18% in protein polymorphism of native chicken of Nepal and concluded five regional chicken population in central part of Nepal were clustered into three groups.

CONCLUSION

Correlation of body parts with weight was found to be higher ranging from 0.50 to 0.218 and was significantly different at p value 0.001 except the correlation of toes length and other body parts. The principle component analysis of morphmetric traits shows first three components are better to explain variability in selected lines of *Sakini* chicken as variance for three components more than 80% and separates all three lines of *Sakini* into three major groups.

ACKNOWLEDGEMENT

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Productive performance of Baruwal sheep under migratory system in Lamjung district, Nepal

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ABSTRACT

Productive performance of Baruwal sheep has not been studied well in Nepal. Hence, a field study was conducted to evaluate the effect of non-genetic factors on the productive performance of Baruwal sheep under migratory system, during August 2008 to May 2009 in Lamjung district, Nepal. A total of 156 adults and 186 lambs of both sex were used in this study. The different traits of productive performance were collected based on field study and measurements. Least square analysis was performed using Harvey (1990) software package, and means were compared using DMRT. The mean body weight of lambs at birth, three month, six month and twelve months was 3.06±0.05, 14.27±0.14, 18.83±0.11, and 26.53±0.36 kg, respectively. The weight gain from birth to 3 months age, 3 to 6 months, and 6 to 12 months age was 140.7 g, 55.65 g and 42.77 g per day, respectively. Similarly, the body weight of sexually mature and adult sheep was 33.80±0.47, and 43.88±0.27 kg, respectively. All the non-genetic factors such as parity, sex and season influenced significantly ($p<0.001$) to all the productive traits. The annual and per cm^2 wool production of mature sheep was 1.02 kg and 1.34±0.02 g with 70.39±3.96% of clean wool. Findings thus revealed potentiality of Baruwal sheep in promoting its productive attributes for wider benefits of herders.

Keywords: Non-genetic factors, growth performance, weight gain, wool production

INTRODUCTION

Major livestock species in Nepal are cattle, buffaloes, goat and sheep (APP, 1995). Especially, sheep is increasingly important species in developing countries, including Nepal as subsistence food producers. Sheep is one of the most important sources of income for resource poor farmers in Nepal which provides meat, wool and manure. Total sheep population in Nepal is 809,536 and there are 109,217 in mid-hill of western region. These total numbers of sheep produce 2,721 t meat and 587,834 kg wool annually (MoAC, 2013). The sheep population was decreased by 11% during 1981 to 1991; 21.8% during 1991 to 2001 and 5.3% during 2001 to 2011. Among four breeds of sheep, Baruwal comprise 63% (LMP, 1990). Wool is a main raw material for the production of warm garments such as sweaters, blankets *radi* and *pakhi*. The export of carpets and other woolen goods were contributed nearly 50% of the total national earning from the

export of agricultural and livestock commodities.15,600 people in carpet industry and 230,000 in washing, carding, spinning, dyeing and weaving of wool were engaged (LMP, 1990).

This study was undertaken to understand the effect of non-genetic factors such as parity of dams, season of lambing, and sex on weight as well as wool production traits of Baruwal sheep. This study could help to find out the key issues on productivity of Baruwal sheep under migratory system in Lamjung district of Nepal, so that the strength of the present practices of sheep keeping could be promoted while the weaknesses could be minimized.

MATERIALS AND METHODS

Site and animal selection

This study was carried out duringAug 2008 to May 2009 in Lamjung district, and two migratory routs were selected with the close coordination of DLSO, Lamjung. The first was *Ghermu* site (lower belt of Lamjung Himal to Bajhakhet), and the other was *Ghale gaun* site (lower belt of Manaslu Himal to Bhoje). Altogether, 186 lambs for growth performance from one to six month age; 40 sheep for yearling weight; 156 sheep for adult as well as sexually mature weight and 318 sheep for wool production were randomly selected and their productive performance assessed accordingly.

Productive traits of sheep

The birth weight, three month weight, six month weight, yearling weight, sexually mature weight, adult weight, weight gain, annual as well as per centimeter square wool production were measured.

Data Analysis

The collected data were analyzed by using descriptive data analysis technique and Harvey 1990 a statistical package after category of information on the basis of parity, sex and season (season was categorized on the basis of movement i.e. downward - 1 Sept-29 Feb and upward - 1 March-30 Aug) which was considered as growth performance where as spring and autumn for wool production.

Model for productive traits

The estimation of fixed effects (non-genetic factors) and variance components was done by using Henderson (1953) model. Productive traits of sheep were analyzed by using the following model.

$$Y_{ijkl} = \mu + a_i + b_j + c_k + e_{ijkl}$$

Where, μ is the overall mean

a_i is the effect of i^{th} number of parity of dam (i=1, 2, 3, 4 and 5)

b_j is the effect of j^{th} sex (j= 1 and 2)

c_k is the effect of k^{th} season of birth (k=1 and 2)

e_{ijkl} is the random element (error mean) assumed to be normally and independently distributed among the sampled population

RESULTS

Growth performance of lambs

The non-genetic factors such as dams' parity, sex of lambs, and season of lambing direct influence on growth performance of the lambs.

The study findings revealed that the body weight of lambs at birth, at 3 month of age, at six month age and one year sheep was 3.06±0.05 kg, 14.27±0.14 kg, 18.83±0.11 kg and 26.53±0.36 kg, respectively (Table1), which was significantly different ($p<0.001$) with respect to dams' parity, sex of lambs, and season of lambing.

Table 1. Body weight (kg) of lamb, LS means±SE

Factors	Birth weight	3 month weight	6 month weight	12 month weight
Overall	3.06±0.05 (186)	14.27±0.14(186)	18.83±0.11(186)	26.53±0.36(40)
Parity				
1	2.85^{b}±0.04(40)	12.97^{c}±0.20(40)	17.00^{c}±0.17(40)	
2	3.12^{a}±0.04(40)	14.49^{ab}±0.20(40)	19.13^{b}±0.18(40)	
3	3.17^{a}±0.04(40)	14.94^{a}±0.21(40)	20.59^{a}±0.18(40)	
4	3.10^{a}±0.04(36)	14.70^{a}±0.21(36)	18.76^{b}±0.19(36)	
5	3.05^{a}±0.04(30)	14.26^{b}±0.22(30)	18.69^{b}±0.20(30)	
	***	***	***	
Sex				
Male	3.14^{a}±0.05(98)	15.18^{a}±0.15(98)	19.70^{a}±0.13(98)	27.83^{a}±0.50(20)
Female	2.98^{b}±0.03(88)	13.37^{b}±0.16(88)	17.96^{b}±0.14(88)	25.23^{b}±0.50(20)
	***	***	***	**
Season				
Downward	3.26^{a}±0.02(166)	15.46^{a}±0.09(166)	20.29^{a}±0.07(166)	
Upward	2.85^{b}±0.05(20) ***	13.09^{b}±0.26(20) ***	17.38^{b}±0.22(20) ***	

Note: **: Significant at 1% level (P<0.01); ***: Significant at 0.1% level (P<0.001).

Weight Gain of Lamb

The finding of this study revealed that the weight gain of Baruwal sheep from birth to 3 months age, 3 to 6 months and 6 to 12 months age was 140.7 g, 55.65 g and 42.77 g per day, respectively (Figure1).

Figure 4. Weight gain of lamb from one to twelve months age

Growth performance of sexually mature and adult sheep

Sexually mature sheep are those that are capable to conceive and produce new one and the sheep above then 2 years old is called adult. Finding of this research revealed that the average age of sexual maturity of Baruwal sheep was 628.95±05.83 day's weight became 33.80±0.47 kg. Likewise, the average adult weight of Baruwal sheep was 43.88±0.27 kg and the sexually mature and adult sheep weight was significantly ($p<0.001$) difference with respect to fixed effect (Table 2).

Table 2. Weight of sexually mature and adult sheep, LS means±SE

Factors	Sexually Mature Weight (kg)	Adult Weight (kg)
Overall	33.80±0.47	43.88±0.27
Age		
3-4	-	43.67^{b}
5-6	-	46.20^{a}
≥7	-	41.77^{c}
	-	***
Sex		
Male	37.53^{a}	46.72^{a}
Female	30.07^{b}	41.04^{b}
	***	***

Note: ***: Significant at 0.1% level (P<0.001); **: Significant at 1% level (P<0.01)

Wool production of sheep

The overall wool production of Baruwal sheep was 1.02 kg, whereas single shearing value was 509.59±00.07g (Table 3) with 70.39±3.96% of clean wool and the wool production was significantly different ($p<0.001$) with respect to age, sex of sheep and season of shearing.

Table 3. Wool production (g) of sheep/shearing, LS means±SE

Factors	LS means ±S E	Significant level
Overall	509.59±00.07(318)	
Age (Year)		***
1-2	549.52^{b}±12.12(118)	
3-4	591.85^{a}±14.57(90)	
5-6	502.68^{c}±20.19(50)	
≥7	412.44^{d}±24.18(60)	
Sex		***
Male	554.21^{a}±13.35(90)	
Female	464.97^{b}±07.08(228)	
Season		***
Autumn	671.19^{a}±09.68(159)	
Spring	347.99^{b}±09.68(159)	
Note: ***: Significant at 0.1% level (P<0.001).		

Per cm^2 wool production

The overall per cm^2 wool production of Baruwal sheep was 1.34±0.02g during autumn season (Table 4), and highly significant ($p<0.001$) with respect to age and sex.

Table 4. Per cm^2 wool production (g) of sheep LS means±SE

Factors	LS means ±S E	Significant level
Overall	1.34±0.02(154)	
Age		***
1-2	1.41^{ab}±0.03(46)	
3-4	1.51^{a}±0.03(55)	
5-6	1.33^{b}±0.05(23)	
≥7	1.10^{c}±0.04(30)	
Sex		***
Male	1.46^{a}±0.04(54)	
Female	1.21^{b}±0.02(100)	
Note: ***: Significant at 0.1% level (P<0.001.)		

Discussion

The findings of this study revealed that on an average birth weight of lambs was 3.06±0.05 kg but Anon (2000) reported comparatively lower birth weight (2.51 kg) of Baruwal sheep in Guthichaur, Jumla. Mishra *et al.* (2008) reported that higher Lambs weight in third parity could be related to the better mothering capacity and higher birth weight. Dagma *et al*. (2003) reported that heavier dams reared heavier lamb and produced more milk during lactation. Abegaz and Duguma (2000) suggested that the maiden ewes produce lambs with lower body weight and their mothering ability is poor due to lack of experience and a poorly developed udder. Higher birth weight of male compared to females may be associated with male sex hormones which have anabolic effects and stimulate growth rate (Hafez, 1989). Mishra *et al*. (2008) reported that the significant effects of season of lambing in respect to body weight of lambs indicating differential availability of feed/fodder and climate condition.

Sankhyan *et al*. (1999) reported that the digestible crude protein intake was significantly reduced in summer (15 gm/head/day) as compared to winter (31.7 gm/head/day) and monsoon (45.1 gm/head/day) which affect the milk yield and lamb weight. Karki (1985) reported that the average body weight of Baruwal sheep from migratory flocks of Gandaki zone was 50.8 kg for rams and 42 kg for ewes during the autumn and 45 kg for rams and 36 kg for ewes during winter. Likewise, Karki (1987) reported that the total annual wool production of a Baruwal sheep in Lumle's command area, Karnali sheep farm Jumla, and Pansayakhola sheep farm were 1.29 kg, 0.78 kg and 1.01 kg, respectively. The average annual wool yield of the Baruwal has been reported as 1.07kg (Karki, 1985), with a range of 0.78–1.29 kg. Similarly, Tiwari and Shrestha (2004) studied the wool production of Baruwal sheep in different location and reported that the average wool production/year/sheep was 750g and highest in Kalikot (1040g) followed by Mugu (830g) in migratory sheep. Karki (2004) also reported that the annual wool production of Baruwal sheep in migratory system was 1.3 kg/sheep/year, and the per cm^2 wool production in third and fourth year's sheep was higher because the wool production in these year was also high and animal at in fully developed stage.

CONCLUSION

The productive performance of Baruwal sheep was affected by both genetic as well as non genetic factors and was highly significant with respect to the parity of dam, sex, age and season. In migratory system, sheep are reared in natural pasture without providing additional diet thus the productive performance of Baruwal sheep could have been poor. Hence, productive efficiency of Baruwal sheep can be enhanced by providing additional diet, manipulating of lambing season and control of in breeding.

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Feeding practice and bodyweight estimation of goat in Chitwan district of Nepal

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ABSTRACT

The average annual increment of goat populations in Nepal was 3.17% during the last decade (1999-2009). As meat of goat is accepted by most ethnic groups, this species is remarkable for meat production in the country. Chitwan district is a low-altitude in southern plain region of Nepal. The livestock raising integrated with crop production is preferred by farmers in this region. However, feed management and body size variation of goats in small-scale farms in this region remain obscure. Therefore, thirty four small-scale farms in Chitwan district were selected for the survey in July 2009 in the pasture-sufficient-period (PSP) and January 2010 in the pasture-decreasing-period (PDP). Number, breed, age and sex of goats were recorded. Variety and quantity of feed supplied, bodyweight (BW) and body size of goats were examined in the both periods. Totally 62 and 117 head of bucks and does were studied in the survey, respectively. The breed of goats was Terai-crossbred. Natural grass and maize stover were fed as main roughage in PSP, and rice straw was mainly provided in PDP. The rate of roughage to supplements in PSP was higher than that in PDP. The rice straw had the lowest concentration of total digestible nutrient (TDN), crude protein (CP) and phosphorus (P) among the feed resources. The mean supply of dry matter (DM), TDN, CP, calcium (Ca) and P expressed as each nutrient per BW was higher in PSP than in PDP. Although the nutrient supply possibly met the requirement for the goats in PSP, the feeding of nutrients in PDP might be insufficient for the goats. The formulae to estimate BW with body length, heart girth and hip width in the goats were established by the multiple regression analyses.

Key words: *Body weight, feed, livestock, goat, meat, TDN,*

INTRODUCTION

Goats have been mainly raised for the production of meat, hide and manure in Nepal for a long time. In addition, the goats are also kept by pastoralists under transhumance migratory management system. The average annual increment of the goat populations in Nepal was 3.17% during the last decade (1999-2009) (FAO, 2011). As meat of goat is accepted by most ethnic groups, this species is remarkable for meat production in the country. The meat production of goats was 48,500 metric ton that occupied 18.2% of the national meat yield in 2009 (FAO, 2011). Therefore, the improvement of growth rate in this species is required for efficient meat production.

Chitwan district is a low-altitude in southern plain Terai region of Nepal and considered as the country's granary, even though it contributes only about 23.1% of the country's total area (CBS, 2006). The production of paddy and maize in Terai contributed 72.4% and 61.8% of the nationwide yield in 2005, respectively (AICC 2011). On the other hand, the population of goats in Terai was 2,600,000 that accounted for 36.4% of the total livestock number in the country in 2005 (AICC 2011). Thus, the livestock raising integrated with crop production is preferred by farmers in this region. The average annual growth rate of meat productions in Terai from 1997 to 2003 was 4.85% (IDGL 2006). These rates are higher than the nationwide averages (2.87%) (IDGL, 2006). However, feed management and body size variation of goats in small-scale farms in this region remain obscure.

The government of Nepal has been giving high priorities for goat raising through women farmers for income generation (DLS, 2005). Therefore, women's participation in goat farming is increasing (Poudel et al., 2009). Understanding the bodyweight (BW) of a goat has important reasons, related to breeding, feeding, health care and trading. However this basal knowledge is sometimes unavailable to women and men working with goats in the small-scale farming area due to unavailability of weighing scales. The method of weighing goats without scales is to predict BW using values of body characteristics which can be measured easily even by women. Body size values have been utilized to predict BW by several authors in many breeds of neighboring Indian goats (Tandon 1965; Das et al., 1990; Ulaganathan et al., 1992; Singh and Mishra, 2004). However, such information for estimation in the goats raised in Chitwan district is almost non-existent. Enevoldsen and Kristensen (1997) reported that different models might be needed to estimate BW in different environmental conditions and breeds. Thus, the formulae for predicting BW of goats in Chitwan district are required.

Hence, the present study is conducted to identify the feeding trait and body dimension of goats raised by small-scale farmers in Chitwan district of Nepal.

MATERIALS AND METHODS

Survey Site

Thirty four small-scale farms with an adequate number of goats in Chitwan district of Nepal were selected for the survey in July 2009 and January 2010. This area was in a sub-tropical climate with annual 2740 mm precipitation, maximum 40.0^{o}C and minimum 4.2^{o}C temperature in 2007. There are three periods based on environments of pasture and fodder: the pasture-sufficient-period (PSP), characterized by increased pasture from June to October; the pasture-decreasing-period (PDP), characterized by decline of pasture due to rainless and cool climate from November to February; and the fodder-shortage-period, characterized by scarcity of fodder with dry climate from March to May (Hayashi et al., 2006).

Data and Sample Analysis

Fifty eight bucks and 51 does were collected as goats of 12 months old or below. As goats above 12 months old, four bucks and 66 does were utilized for the survey. Breed and age of the goats were recorded. Variety and quantity of feed supplied, bodyweight (BW) and body size were examined in both the periods. The nutrient concentration of the feed resources was calculated using the composite representative samples in the survey area. Body dimensions of body length (BL), withers height (WH), criss-cross height (CH) which was the height of crossed point between the spine and a connected line of both sides of hip born tip, heart girth (HG) and hip width (HW) were measured. The effect of data collection time on nutrient supply was analyzed using Student's t-test. The multiple regression equations to estimate BW from body dimensions of bucks and does of 12 months old or below and does of above 12 months old were developed with stepwise method.

RESULTS AND DISCUSSION

Feeding Traits of Goats

(a) Flock size per house hold

The average number of goats per farm was 2.8. The breed of the goats was Terai crossbred. Terai breed was developed from Jamunapari and native breed in the Nepal southern plains (Joshi and Shrestha, 2003). The number of the females was higher than that of the males (64.2% in PSP and 67.1% in PDP).

(b) Feeding practices and regimes

Natural grass and maize stover were fed as main roughage in PSP, and rice straw was mainly provided in PDP (Table 1). Natural grass and maize were much present in PSP due to high temperature and rainfall in this period. On the other hand, a plentiful amount of rice straw was present in almost all the year because rice was harvested twice a year in this area. Thus, the feeding amount of rice straw was possibly controlled by the availability of the other roughage resources. Although wheat bran as a supplemental resource was higher supplied in PDP than in PSP, the supply of rice bran was lower in PDP than in PSP ($P<0.01$). As wheat was usually harvested in PDP, the higher amount of the wheat by-product was probably utilized for the goats in this period. The rate of roughage to supplements in PSP was higher than that in PDP ($P<0.01$). This could be caused by the much supply of natural grass and maize stover in PSP. Hayashi et al (2006) reported that the feed supply of natural grass for cattle and buffalo was higher in PSP than in PDP in a village of the survey site. On the other hand, the rice straw supply for large ruminants was lower in PSP than in PDP in the same village. The similar feeding traits for large and small ruminants in this region were identified.

The rice straw had the lowest concentration of total digestible nutrient (TDN), crude protein (CP) and phosphorus (P) among the feed resources (Table 1). The wheat bran showed the highest CP content among the resources. The lowest concentration of calcium (Ca) and the highest content of TDN and P among the feed stuff were in maize flour. The mean supply of dry matter (DM), TDN, CP, Ca and P expressed as each nutrient per BW

was higher in PSP than in PDP (Table 2, $P<0.01$). This could be attributed to the higher availability of natural grass and maize stover in PSP. Following to the report of Ranjhan (1993) for the daily nutrient requirements of goats with BW between 25 kg and 50 kg, the requirement of DM, TDN, CP, Ca and P expressed as each nutrient per BW (g/kg) for maintenance and production can be calculated as 30.0 to 40.0, 15.2 to 24.0, 2.5 to 3.6, 0.10 to 0.11 and 0.07 to 0.08, respectively. Although the mean of nutrient supply in PSP met the requirement for the goats, the feeding of nutrients in PDP was insufficient for the goats on an average. The feeding regime in PDP on the survey site should be improved.

Table 1. Daily dry matter supply per bodyweight of goat (g/kg BW), rate of roughage to supplements supplied (R/S) and nutrient content of feed (g/kg on a DM basis)

	DM supply per BW		P value	Nutrient concentrate				
	PSP	PDP		DM	TDN	CP	Ca	P
Natural grass	26.1 (0-170.5)	0.2 (0-4.7)	<0.01	354	550	134	9	4
Rice straw	0	25.5 (0-132.7)	<0.01	810	385	44	4	1
Maize stover	23.3 (0-300.8)	0	<0.01	862	492	91	7	3
Wheat bran	5.8 (0-46.1)	10.5 (0-50.6)	<0.01	846	618	170	1	11
Rice barn	3.5 (0-48.5)	1.5 (0-49.0)	0.03	850	719	146	1	20
Maize flour	2.9 (0-28.3)	2.5 (0-32.8)	0.56	864	752	95	0.1	37
CF	0.2 (0-7.9)	0.5 (0-24.7)	0.40	806	662	159	10	16
R/S	6.6 (0.7-33.6)	2.6 (0.8-8.0)	<0.01	-	-	-	-	-

Table 2. Daily nutrient supply per bodyweight of goats (g/kg BW)

	PSP	PDP	P value
Dry matter	69.6±63.1	27.6±31.3	<0.01
Total digestible nutrient	36.9±24.9	5.0±13.3	<0.01
Crude protein	8.0±5.1	1.0±2.8	<0.01
Calcium	0.44±0.34	0.05±0.20	<0.01
Phosphorus	0.45±0.26	0.05±0.10	<0.01
Mean±SD. PSP: pasture-sufficient-period, PDP: pasture-decreasing-period.			

Bodyweight estimation using body size

The maximum values of BW, BL, WH, CH, HG and HW of the male and female goats were shown in Table 3. The BW of adult Terai breed was reported to be 35.0 kg in male and 32.0 kg in female (Shrestha, 1994). The maximum BW of the goats in this survey area was heavier than the matured BW of Terai breed. In addition, the BL, WH and HG of matured Terai breed raised in central area of Nepal were reported as 60.6 cm, 60.3 cm and 68.3 cm, respectively (NARC, 1999). The body size of the goats in this survey site was also higher than the morphological characteristics of adult Terai breed. Thus, the goats in this area might have been improved to be larger body size due to crossbreeding.

Table 3. Bodyweight and body size of goats

	Male	Female
Body weight (kg)	8.7-37.8	6.6-48.7
Body length (cm)	38.0-66.4	33.4-72.8
Withers height (cm)	38.4-70.0	35.4-70.6
Criss-cross height (cm)	41.6-72.1	38.9-72.2
Heart girth (cm)	43.0-75.0	37.0-83.5
Hip width (cm)	6.5-12.0	6.5-15.5
Male: 1-18 months old, Female: 1-84 months old.		

The following formulae to estimate BW (kg) with BL (cm), HG (cm) and HW (cm) in bucks and does of 12 months old or below and does of above 12 months old were established by the multiple regression analyses.

Goats of 12 months old or below
Bucks BW = 0.41 × BL + 0.42 × HG + 0.87 × HW – 34.4 (R^2=0.94, P<0.01).
Does BW = 0.24 × BL + 0.42 × HG + 1.51 × HW – 32.5 (R^2=0.90, P<0.01).

Does of above 12 months old
BW = 0.59 × BL + 0.58 × HG + 1.29 × HW – 60.2 (R^2=0.88, P<0.01).

The BW of goats raised in this region can be estimated using BL, HG and HW accurately.
As the BL, HG and HW can be easily measured in the raising field even by women, these formulae would be applicable to implement BW estimation. In addition, these formulae should be useful for goat farmers, most of whom lack reliable weighing devices.

CONCLUSION

The periods divided by the pasture environments induced a different supply of nutrients to the goats. The goats were assumed to have insufficient DM, TDN, CP, Ca and P supplies for their production in PDP. The nutrient supply in PDP should be kept attention. The BW estimation with BL, HG and HW measurements may easily indicate the accurate goat size in the field. Goat trades with understanding approximate BW are promised in Chitwan district.

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REVIEW ARTICLES

Comparison of dairy cattle production systems in Austria and Nepal

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ABSTRACT

Livestock farming in Nepal, especially, dairy farming alone contributes a major share in total Agricultural Gross Domestic Product. We generally try to focus our livestock farming and its policies comparing it to other SAARC nations. Comparing our production system with other developed countries is lacking or beyond comparison. So we tried to compare our dairy production system based on five parameters: housing, feeding, breeding, dairy market structure and production outputs with one of the EU members, Austria. Austria has similar geographical situation with Nepal and dairy farming in Austria is small scale compared to other EU members. Next to the quality of the barn, the main difference in housing between Austria and Nepal is the herd size. Even though still small in comparison to other developed countries, Austrian farms on average hold 18-20 cows, whereas Nepali farms usually do not keep more than one or two cows. The tremendous gap in milk yield in Austria and Nepal reflects the two very different feeding systems. In Nepal, the basis of the dairy cow rations is made up by fibre-rich and low-energy forages like rice straw. Concentrates are scarce and are usually crop residues or industrial by-products. Even if fodder is available, dairy cows are less likely to receive high-quality fodder than dairy buffaloes. This fodder scarcity stands in great contrast to the permanent availability of forage and concentrates in relatively high quality in Austria. This allows Austrian farmers to achieve many times higher milk yields, often encountering feeding-related health problems on the other end of the spectrum, e.g. acidosis from too high a concentrate portion. In terms of breeding it seems that the Nepali breeding program is in a similar position like the Austrian breeding program was in the 1980's. Nepal is focussing on crossing in exotic/industrial breeds, while in Austria this has already happened to the point where there are justified worries about preserving indigenous breeds. The difference in religious and cultural values greatly affects the utilization of production outputs. Meat production from cattle is not allowed in Nepal, since it is illegal to slaughter a cow, making cattle production quite inefficient, especially in comparison to keeping buffaloes, which can be slaughtered. On the other hand, production outputs like draught power for working the fields, faeces for cleaning or urine for purification are common in Nepal, whilst unknown in Austria. These factors contribute to the fact that milk production in Nepal is low despite the high cattle population.

INTRODUCTION

Nepal, one of the least developed countries, lies in Southern Asia between India and China, with a total area of 147.181 km^2. 2.6% of the total area is covered by water. The climatic condition varies from cool summers and severe winters in the north to subtropical summers and mild winters in the south. The terrain is divided into three different types: the rugged Himalayas in thenorth, a hilly region in the centre and theTerai plain in the south. The altitude varies from 70 m (Kanchan Kalan) to 8850 m (Mount Everest). 16% of the total land is arable(CIA, 2014a). The population was estimated to be 27.8 million in 2013 with the GDP of 19.29 billion US dollars.

Austria, a prosperous and developed country, lies in Central Europe, north of Slovenia and Italy, with a total area of 83,871 km^2 (half of the area of Nepal). Only 1.64% of the total area is covered by water. The climate is temperate with moderate summers with occasional rains and cold winters with frequent rain and snow in the mountains. The terrain is mostly flat or gentle sloping along the eastern and northern margins and Alps (mountains) in the west and south. The altitude varies from 115 m (Neusiedler Lake) to 3798 m (Grossglockner). 16.25 % of the land is arable(CIA, 2014b). Though the geographical area of Austria is nearly half that of Nepal, population is only one third (8.5 million) of Nepal and the GDP (415.7 billion US dollars) is more than 20 times higher than in Nepal. The dairy production system is unique in different countries. Socio-economic status, religion, culture and topographical factors may be responsible for these differences. Although both Austria and Nepal are landlocked (CIA, 2014a) and have similar geographical conditions, the vast difference in the economic situation and religious belief has made the dairy production system differ among them. So, we tried to compare the dairy production system in both countries with focus on the following five parameters: housing, feeding, breeding, dairy market structure and production outputs, as shown in figure 1.

METHODOLOGY

Literature review was the method used to compare the production systems. Publications on peer reviewed journals, national journals, information on government websites, publications of national research centers and other government organisations were used as the source of information and data. While it was not possible to properly exclude farms

on extreme production sites like high mountainous areas, those farms are not represented strongly in the studies cited in this paper due to their small numbers and little representation in scientific literature. These would be for example the Nepali farms in the Himalaya region and Austrian alpine pastures, which cannot support a farm's livestock around the whole year.

Some literature on Austrian dairy farming in this paper does not represent the average Austrian farm, but only the so called Arbeitskreis farms. These farms receive a higher level of education and consultation. The average Arbeitskreis farm is a bit bigger and production levels are a bit higher due to more professional management. Considering the vast differences between the Austrian and Nepali dairy production systems, we think that even if they are above average in certain parameters, they still represent the Austrian dairy production system very well in its main aspects.

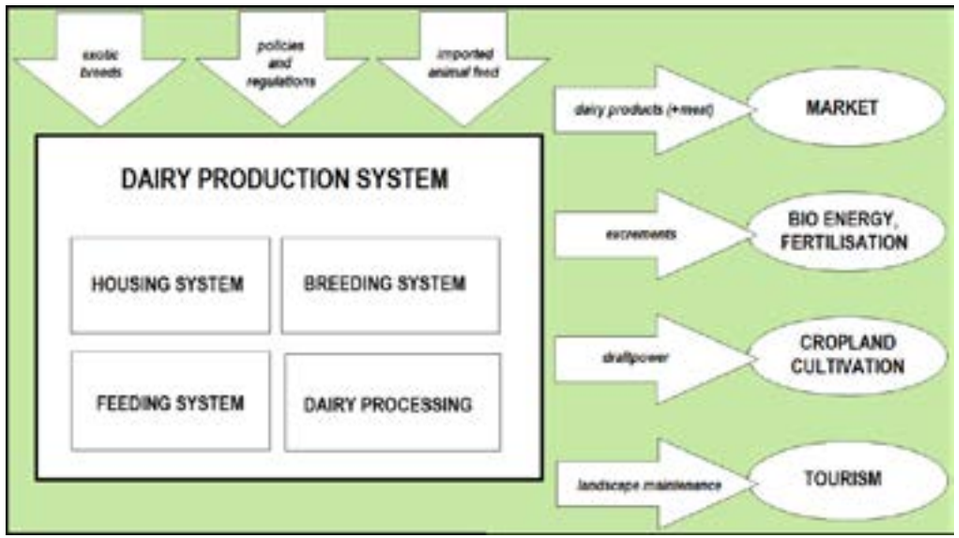

Figure 1. *Parameters of production system used to compare between Austria and Nepal (own graphic).*

RESULTS AND DISCUSSIONS

Nepal has 3.36% of exotic (i.e. high yielding) cattle with the total cattle population of 6.43 million. Around 2.3 million households keep cattle with the average holding of 2.72 cattle per household. 59.6% of the cattle population are male and only 15% of the total cattle population are milking animals (Statistics, 2013). The most common breeds of exotic cattle are Jersey, Holstein and their crosses (DLS, 2010).

Austria has 2.01 million cattle, among which 26.1% are dairy. Fleckvieh, Braunvieh and Holstein are the major breeds (Kalcher, 2014). The dairy cattle population is relatively small compared to other EU countries (Arendonk,2003). There are 21,905 dairy cattle farms holding 405,077 dairy cows. 39.658 of these farms have dairy cattle. The average

number of dairy cows per farm is about 20, which is quite high compared to Nepal (BMLUFW, 2014).

Dairy farming in Austria has experienced considerable structural change over many decades , for example, the number of dairy farms declined by 33% from 1995 to 2003 (Kirner 2007). In Nepal on the other hand, the livestock sub-sector has grownbetween 1.6% and 3.6 %in the 1990s (Goletti, 2001).

The total cattle population in Austria is decreasing since 2005/06 at an average annual rate of around 2% as seen in table 1, whereas the number of dairy cows increased. In Nepal on the other hand, the total cattle population increased at an average annual rate of around 0.5%until 2010and then decreased by 10.7% until 2013. The dairy cow population, however, grew continuously.

The milk price in Nepal ranges from 0.18 to 0.24€, which varies in flush and lean seasons (FAO, 2010). In 2013 the milk price for producers in Austria reached an all-time high of 0.42€ per kg milk, which is slightly above EU average (BMLUFW, 2013). Producers in Austria receive nearly twice the money for their product compared to Nepal. Also in Nepal, the milk prices differ in different seasons (higher in lean seasons and lower in flush seasons), while in Austria the fluctuations of the milk price are multifactorial.

Table 1. Annual statistics of cattle population in Austria and Nepal

YEAR	*2004/05*	*2005/06*	*2006/07*	*2007/08*	*2008/09*	*2009/10*	*2013*
TOTAL CATTLE							
Austria	2.010.680	2.002.919	2.000.196	1.997.209	2.026.260	2.013.281	1.958.282
Nepal	6.994.463	7.002.916	7.044.279	7.090.714	7.151.198	7.199.260	6.430.397
DAIRY COWS							
Austria	534.417	527.421	524.500	530.230	532.976	532.735	529.560
(% of total cattle)	26.58	26.33	26.22	26.55	26.3	26.46	27.04
Nepal	902.286	903.376	908.712	915.411	932.876	954.680	-
(% of total cattle)	12.9	12.899	12.9	12.91	13.045	13.26	-

Statistic Austria. STATcube-Statisitcal Database of Statistic Austria web:http://www.statistik.at/

The statistics for dairy cattle population in Nepal has been taken from paper:(Bhandari,2011)

Comparison of housing systems

The dairy farms in Austria are still very small in size compared to farms in many other countries. Furthermore, the predominant part of distribution in the Austrian dairy sector is characterized by a high share of mountain farms (70%)(Ortner,2007).Housing conditions are mostly characterized by two types of housing: a loose housed system and tie stall system, with equal proportion of percentage or slightly dominant on tie stall. Based on survey from Arbeitskreis farms in 2013 from 1000 estimated farms shown that tied stall occupy 16% while loose house occupy 68% (BMLUFW, 2014), but this survey cannot be comprehensive of overall percentage of housing type in all regions in Austria.

In Nepal cattle is most frequently found on small farms in the hill regions. The indigenous cattle are well adapted to the type of extensive production seen on small rural farms. Housing generally consisted of open stalls only (9%), closed stalls only (44%), or a combination of pasture and open stalls (46%). Relatively high in number, cattle in Nepal are not considered very efficient animals to keep: their milk production is very low and since cattle are considered sacred, they cannot be killed or culled, which means that sick or unproductive cattle become a burden on a family. However, steers and bulls provide labour for crop production and therefore indirectly provide income (Redding,2012).

Table 2. Comparison between dairy cattle population in Austria (dairy cattle 2 years old and more) concentrated on the size range from 1 cow up to 51 > cows, with dairy cattle population in Nepal concentrated per hectare area of holding from0.1/ha up to 10/ha and more

Austria / size range cow cow > 2 years	no.cow	Nepal/ by total area of holding cow >2 years	no.cow
1 cow	774	under 0.1 ha	45,627
2 cow	1.587	0.1 ha and under 0.2 ha	88,986
3 cow	3.686	0.2 ha and under 0.5 ha	288,866
4 cow	5.300	0.5 ha and under 1 ha	287,151
5 cow	7.367	1 ha and under 2 ha	163,371
6 cow	10.300	2 ha and under 3 ha	36,823
7 -10 cow	47.214	3 ha and under 4 ha	13,188
11-20 cow	184.058	4 ha and under 5 ha	5,916
21-30 cow	116.58	5 ha and under 10 ha	3,786
31-50 cow	106.633	10 ha and over	368
51 and more cow	53.503	/	/

Statistic Austria. *STATcube-Statisitcal Database of Statistic Austria web:http://www.statistik.at/*
National report: *National Sample Census of Agriculture (National Report, 2011/12)*

On the comparison of the farm scale (Table 2) between the two countries we assume that the lowest number of dairy cows in Austria occupying house hold with 1 cow or extensive rearing only 774 cows, while in the Nepal the lowest number of dairy cow, occupying bigger farms with area holdings from 10 and more /ha with only 368 cows.

In Austria the highest number of dairy cows occupying the farms with range cow from 11-20 cows with total 184.058 cows, whereas in Nepal the highest number of dairy cows is estimated on the significantly small farms with capacity of area holdings from 0.2/ha and under 0.5/ha with total 288.866 cows.

Based on the statistics above the Austrian dairy farms are relatively in intensive systems, with majority of cattle population on small scale farms up to 20 cows, while in Nepal the dairy production is predominantly in extensive or family economy with 1-2 cows.

The average farm size in Austria is about 18.4 ha, the average number of dairy cows per farm amounts to 9 heads which is less than in most European countries (BMLFUW, 2006). In the mountainous area 52% of all Austrian farms and 70% of all dairy farms can be found, mainly based on traditionally used permanent grassland (Poetsch,2006). Housing condition in Austria is characterized with medium size farm sheds and wind protector and the bedding system varies from fully concrete floor ,with rubber mats, straw bedded and a system combining straw bedded area (Muelleder,2012).

In Nepal traditional practices of livestock farming are quite common in rural areas. Such practices are based upon the indigenous knowledge of farming. Due to poor knowledge about livestock farming system the health status and hygienic condition of animals are degrading day by day (Bhandari,2011). Housing condition in Nepal is quite different from the standards in Austria, and it is still far away from a satisfying level on a variety of reasons such as extensive rearing, obstacles in the distribution of milk to the market and the absence of an appropriate developed strategy. Due to subsistence nature of farming animal sheds are built near the home. The Nepal housing system is quite poor, rural farmers built animal sheds with the help of straw, while use of concrete materials is only seen in commercialized farming in urban areas. In rural areas, there is no separation of diseased and healthy animals. This situation helps in rapid spread of diseases which suppress the current condition and increase troubles for the farmers (Bhandari,2011).

Housing conditions varied among farms. 44% of water buffalos, 92% of cattle, and 50% of goats have access to pastures, usually for a minimum of 8 h a day. Over 60% of farms produce straw for their animals from threshed rice plants by drying them in the sun for five to seven days. Water was either provided to the animals from wells or home-based water sources (Redding, 2012). The legislation regarding keeping and protections of animals define clearly the mandatory conditions for specific species. In Austria, based on paragraph 16 (freedom from movement) from legislation for animal protection, keeping animals permanently tied is forbidden. Cattle have to have access to an adequate run or pasture on at least 90 days a year.(The Legal Information System of the Republic of Austria „RIS“) Exceptions are possible for both rules, if there are farm-specific technological or legal reasons for making them. As opposed from Austria, Nepal is still facing with the absence of appropriate legislation for specific species related to freedom from movement and other issues.

Comparison of feeding systems

Differences in ration composition

The relatively high production level of Austrian dairy cows of about 7600kg milk per year is realized by feeding a combination of roughage and concentrates. On the average farm about 2600kg milk from the total milk yield come from feeding concentrates and 5000kg from roughage (BMLFUW, 2014). Dairy cows consume roughage directly on pastures or in the stall as fresh-cut grass, hay or grass/corn silage. Roughage is mostly produced on farm and very rarely bought commercially (Buchgraber & Gindl, 1994).

The average amount of concentrate in Austrian dairy cows' diets is about 1700kg per year, making up between 20% and 25% of the total feed intake (BMLFUW, 2014). There are some farms that use very little to no concentrate feeding in addition to the roughage. However, considering the high price of commercial organic concentrate feed, many organic farms in Austria strive to use ever less concentrate and increase their milk yield from high quality roughage only (Ertl, 2014). To meet high production levels of over 30kg milk per day, the amount of concentrate per day may exceed 5kg of grains (barley, wheat, corn) or industrial residues like oil seed cakes or residues from brewing beer. These production levels also require a daily feed intake of about 20kg of dry matter (Kirchgessner, 2011). A survey in the Terai district of Nepal showed the daily feed intake of dairy cows to usually be within the range of 10 to 20kg DM per day, depending on the season. A large proportion of this is rice straw, about 10kg of which is fed all year round. Additional forages are native grasses, bamboo leaves, corn stover and mustard straw. Concentrates are usually home-made and make up between 15 and 30% of the ration, also depending on season. Typical non-commercial concentrates are wheat bran, brewery waste, corn flour or rice polish (Hayashi et al., 2005).

A survey in the Kaski district showed that 67% of cattle received concentrate feeding, and almost all the farms used self-made concentrate. Only dairy cows and working cattle received concentrate. Lactating dairy cows would be fed around 1kg of concentrate per day. The survey also revealed that 92% of dairy cows had access to pasture. Fodder was also often gathered manually from nearby pastures and fed ad libitum. If no pasture was available, straw was often fed ad libitum instead. Nepali veterinarians often recommend feeding around 10% of the animal's body weight in forage, but the survey showed that most farms fed forage ad libitum anyway (Redding, 2012).

Differences in feed availability

One of the most striking differences in the dairy cow feeding systems of Nepal and Austria is the difference in feed availability. Along with other industrial countries, animal feed is not a limited good in Austrian agriculture, meaning that it is usually available commercially in abundance. Hence most Austrian farmers do not need to struggle to produce the necessary amount of feeding, but aim to optimise their animals' diet.

In Nepal on the other hand, animal fodder is scarce and the resources are ever depleting due to land loss to settlement and cultivation. This feed scarcity causes malnutrition, low production levels and a generally bad health status of dairy cows. Feed scarcity is severest in the hilly region of Nepal, which has the highest livestock density. Also, poorer farms are hit more strongly by the closing of community forests, which provide a large cut of their animals' feed (UNO, 2010). Livestock feeding in the poorer regions of Nepal depends largely on crop residues and kitchen wastes. This results in bad animal health due to malnourishment and even occasional poisoning. In the hilly region a feed deficit of 56% has been estimated (Bhandari, 2005).

Differences in feed quality

Forage sampling in the Kaski district of Nepal showed that most forage were very low in energy and protein and very high in fibre. So even though most farms feed forages ad libitum, animals are probably ingesting insufficient amounts of protein and energy to sustain a higher level of production. The samples of grass pasture that were analysed contained 7.8% crude protein, 76.3% non-detergent fibre and 3.3% sugars (Redding, 2012). The comparison to the nutritional content of forages fed on Austrian dairy farms show vast differences. The average well-prepared grass silage in Austria contains about 10-15% crude protein, which is twice as much as the aforementioned sample from Nepal. With 25-30% the crude fibre content is significantly lower and the high fraction of 45% nitrogen free extracts suggests a much higher content of available carbohydrates (Buchgraber&Gindl, 1994).
This vast difference in forage composition shows, that the adaptation of the Austrian and the Nepali feeding system to respective intensity of their dairy production systems. If an increase or decrease of production intensity in either of these systems were to be achieved, adjusting the forage quality as the very base for milk production could be considered crucial.

Comparison of breeding systems

Nepal: Breeding policy and strategies

The government policy has been to upgrade and replace local cattle breeds with improved stocks (Wilson, 1997). The official strategy is to increase the production and productivity of the non-descript animals by cross breeding through artificial and natural breeding with focus on artificial insemination (AI) in the road approachable areas. In 1998 the national breeding policy has focused on the following breeding strategies (NLBC, 2011a):

1. Jersey bulls/semen should be used to upgrade nondescript and crossbred cows in mid-hills and Terai, with blood level not exceeding 62.5%.
2. Haryana bulls/semen should be used in Terai, to upgrade the native cows for milk and draft purpose.
3. Existing Holstein and Brown Swiss crossbred animals will be maintained at 62.5% of respective blood level in dairy pocket areas and bulls/semen of these breeds will be used to upgrade nondescript cows up to 62.5% of respective blood level. Exotic blood level above 62.5% will be lowered through back-crossing.

4. The productivity of Yak, Lulu and Achhamee cattle will be improved through group breeding scheme to conserve and maintain their population up to 50,000 heads.
5. Bull exchange programs between farmer groups will be followed to check inbreeding.
6. Nondescript bull elimination programs, for controlling indiscriminate breeding, will be started in districts with intensive AI.

The National Livestock Breeding Centre said that this policy has nearly failed (except AI)(NLBC, 2011b). So, a new policy was needed. Recently in 2011 a new breeding policy has been formulated with the aim to increase the productivity of livestock through increase of genetic capabilities and biodiversity.

Nepal: breeding programme

In 2012, the progeny testing and pedigree and performance recording system has been started, but its sustainability due to fund constraint is also a challenge. The Dairy Cattle Improvement Program has been started in 28 clusters of 14 districts in the farms with more than 20 cows by monthly milk recording and milk analysis to estimate the breeding values of the animals. AI coverage in milking cows is at a level of 20.86% with the conception rate of 56.05% (NLBC, 2011a).

Austria: breeding programme

The breeding program in Austria is much more advanced than in Nepal. 21,905 dairy breeding farms in Austria work towards the systematic improvement of the breeding population of the individual races with 405,077 registered cows and milk performance recordings (BMLUFW, 2014). The average artificial insemination density in Austria was 95.2% in 2013(ZAR, 2013). Breeding value estimation for cattle started in 1985 with the introduction of BLUP father model for milk. In 1998, breeding values based on economic overall value was started. In 2000, joint breeding value estimation with Germany for Simmental was started which was expanded to all breeds and traits in 2002. In 2008, genomic selection has started in Fleckvieh breed with the development of a genomic merit index. With regard to the status as of May 2014, there are about 36,000 genotyped Simmental in the genomic merit index estimation. Genomic selection is practiced in Braunvieh and Holstein breeds also (ZAR, 2014).

Compared to the breeding program practiced in Austria, Nepal is in a very initial stage, a stage where Austria was during the 1980s. While Austria is trying to preserve its indigenous Simmental breed, Nepal has been focusing on cross breeding with exotic breeds. Very low coverage of artificial insemination in Nepal can be another disadvantage.

Comparison of dairy market structure
Nepal

In Nepal earlier days when there were no organized dairies, demand for milk was fulfilled by raising cows/buffaloes by the people themselves or through the direct supply from the professional milk producers. These producers used to go house by house and deliver the required quantity of milk to the households. Today, there are many private dairies (including cooperatives) of various sizes both within and outside the Kathmandu valley. Prominent among the private dairies with modern milk processing facilities are Nepal Dairy, Himalaya Dairy, etc(FAO, 2010).

Nearly 66% of urban households purchased milk compared to about 23% of rural households, reflecting that many rural households have dairy animals. In the whole country, only 26% of households purchased milkfrom the market. The number of milk buyers decreased from south to north. The current per capita consumption of milk in urban areas (38 l) is 1.46 times higher than in rural areas (26 l). The average income and population growth in urban areas is much higher than in rural areas(Banskota, 2005). The market structure for dairy products in Nepal is spread into several segments: the rural or informal component and the urban or formal component. The rural component of dairy marketing comprises the over 90% of farm households with dairy animals where most of the milk produced is consumed within the households either in the form of fresh milk (usually boiled).Some products are traded directly with consumers (raw milk) or through traditional collecting agents for consumption in urban areas or export to India.

In the urban component of dairy marketing, most of the dairy products consumed in households and in restaurants and hotels are purchased from rural producers through several market networks. Milk-marketing agents include both private dairies and Dairy Development Cooperation (DDC) supported outlets. In some smaller cities, some households may also produce, consume, and sell dairy products. Fresh and pasteurised milk, yoghurt, cream, butter, ghee, cheese, and ice-cream are the main products of both - the private and the public dairy industries.

Austria

86% of the produced milk goes to processing plants, which process it to market-ready dairy products. The rest is either sold on-farm, consumed on-farm, or fed to animals (BMLFUW, 2014). So, very negligible quantity of milk goes to the informal sector.

Comparison of production outputs
Nepal

Livestock farming, especially, dairy farming alone contributes 78% in total Agricultural Gross Domestic Product (AGDP) (CBS, 2002). Characteristics of Dairy production system of Nepal are small holder dairy production systems in which the animals are either tethered or stall fed. Some of the produced milk is used for human consumption, but most of it is sold (Devendra, 2000).Dairy farming is presently in the transition phase from subsistence based to commercial type in the lowlands. Dairy farming is an

important means for cash income from the sale of milk, manure and draft power(Bhandari, Köfer, &Schobesberger, 2011).

None traded goods

Cattle is important, not only for the goods that can be sold in the market (like milk); but also for the products that are part of the general household economy, e.g. manure and draught power for cropping. 59.6% of the cattle population are cattle bullocks (Statistics, 2013) and most of them are used as draught animals. So, majorly there is the trend of rearing cattle for draught purpose rather than the milk. In 2002 the draught animals generated 1.37 million kilowatts of energy and it was worth an equivalent of Nrs. 1300 million (10.49 million euros) (Rushton, 2009).
One of the other important aspects of dairy farming is to generate energy in household level for cooking and heating in terms of biogas, which is produced by decomposition of animal dung in an airtight digester. Biogas technology is one of the technologies that is renewable and is regarded as directly contributing in minimizing the over use of traditional energy sources. 7% of the total energy consumed in the country is generated from cow dung (MOF, 2008). Farmers in rural areas use an average of 76.13 kg dung cake per month for cooking (Katuwal&Bohara, 2009). Dairy farming for large farmers may be mainly for self-consumption and for the farmyard manure to maintain the soil productivity (Singh &Maharjan, 2005)**.**

Joshi (2002) estimated that 33 Mt of manure are generated annually equivalent to US$58.75 million. Only half of the total manure produced is collected. Manure is used as such raw in the fields or as bio-slurry. The digested bio-slurry, a by-product of the biogas has been proved to be the best fertilizer for farms in the rural households and almost all households with biogas apply bio-slurry on their land (Katuwal&Bohara, 2009). Another important by-product is cattle urine. People consider it has medicinal value and use it as a component of some ethno-medicine to treat gastritis, diarrhoea, dysentery, etc. (Bhattarai, Chaudhary, & Taylor, 2009). Cattle urine also holds religious value. It is used to purify a place or a person (Sapkota, 2008).

Dairy and dairy products
Nepal

The milk pricing system in Nepal is based on content of fat, solids-not-fat (SNF) and total solids (TS) in the milk (Joshi & KC, 2001). The annual production of milk is increasing at 3.44% and was about 1.4 million metric ton in 2010. There is the shortage of milk at the rate of 500,000 litres/day in lean season and 250,000 litres/day in flush season. Nepal imported dairy products worth Nrs. 861 million (6.9 million euros) (1 euro=124.31 Nrs) (DLS, 2010). Cattle milk contributes nearly 28% of total milk production of the country. Being Hindu, consuming milk and dairy products are considered as a part of culture (Pradhan, n.d.). Processed liquid milk is the prominent product of the dairy industry as almost 80 per cent of milk collection in the formal sector is used to produce processed milk (FAO, 2010). Dahi (curd), ghee (clarified butter), chhurpi, khoa and khoa-based sweets are the main traditional commercial dairy products (Banskota 2005). Besides these

the non-traditional commercial dairy products are mohi, khir, cheese, butter and ice cream (Pradhan, n.d.).

Austria

Dairy farming in Austria is small scale compared to other EU members. The production conditions are tough compared to other EU-15 countries and alternative production possibilities are rather limited (Fernandez-Amador, Baumgartner, & Crespo-Cuaresma, 2010).

Non-traded goods

Austrian farmers use the slurry from dairy production as a fertiliser in their grassland and cropland. Furthermore, since dairy production in Austria is mainly grassland-based, dairy farming provides a valuable service in maintaining the landscapes of Austria (Buchgraber and Gindl, 1994). This is an absolutely essential service for the Austrian tourism industry.

Dairy and dairy products

The milk production system in Austria (in terms of quantity and prices) is highly regulated under the milk quota system until April 2015(Fernandez-Amador, Baumgartner, & Crespo-Cuaresma, 2010). The milk pricing system is based on a standardised milk composition of 4.2% milk fat and 3.5% milk protein (AMA, 2015). In 2012, the gross domestic production of milk was 1,071,000 tonnes, but the domestic consumption was only 659,000 tonnes. Similarly the domestic consumption of cheese and butter were 180,000 and 47,000 tonnes with the gross domestic production of 170,000 and 36,000 tonnes respectively (BMLUFW, 2014). So, there was an overproduction of milk and an underproduction of cheese and butter. Cattle milk contributes nearly 99 % of total milk production (BMLUFW, 2013). In 2013, Austria exported dairy products worth 1.1 billion Euros. The prominent milk products which are produced and consumed are matured cheese, fresh cheese, butter and yoghurt (BMLUFW, 2013).

The information from above shows us that the religious and cultural values greatly affect the utilization of production outputs. In Nepal, it is against the law to slaughter cattle (DurgaDatt Joshi, Maharjan, Johansen, Willingham, & Sharma, 2003) and they consider the cow as their mother(Margul, 1968). So, people rear unproductive cattle for the non-traded goods like draft power, faeces and urine. This can be one of the reasons for milk shortage despite having large cattle population. People use cow dung and urine in daily household activities. The average milk production per cow also highly differs in both countries.In Nepal it is around 1.9 kg/day (Redding et al., 2012), whereas in Austria a dairy cow produces about 12.58 litres/day (Krausmann et al., 2003). The vast difference in the production may be due to the different breeding criteria, rearing of unproductive cattle or the different reasons for rearing the cattle. Male cattle are used to plough the land in Nepal, which is also one of the chief reasons for the difference in the cattle sex

ratio between the two countries. It is also clear that Nepal is more dependent on buffalo for local milk production.

CONCLUSION

The comparison of the dairy production systems of two countries as different as Austria and Nepal proved to be quite challenging due to the differences in certain aspects of these two systems which are are vast almost beyond any comparability. Next to the quality of the barn, the main difference in housing between Austria and Nepal is the herd size. Even though still small in comparison to other developed countries, Austrian farms on average hold 18-20 cows, whereas Nepali farms usually do not keep more than one or two cows. The tremendous gap in milk yield in Austria and Nepal reflects the two very different feeding systems. In Nepal, the basis of the dairy cow rations is made up by fibre-rich and low-energy forages like rice straw. Concentrates are scarce and are usually crop residues or industrial by-products. Even if fodder is available, dairy cows are less likely to receive high-quality fodder than dairy buffaloes. This fodder scarcity stands in great contrast to the permanent availability of forage and concentrates in relatively high quality in Austria. This allows Austrian farmers to achieve many times higher milk yields, often encountering feeding-related health problems on the other end of the spectrum, e.g. acidosis from too high a concentrate portion. In terms of breeding it seems that the Nepali breeding program is in a similar position like the Austrian breeding program was in the 1980's. Nepal is focussing on crossing in exotic/industrial breeds, while in Austria this has already happened to the point where there are justified worries about preserving indigenous breeds.

The difference in religious and cultural values greatly affects the utilization of production outputs. Meat production from cattle is not allowed in Nepal, since it is illegal to slaughter a cow, making cattle production quite inefficient, especially in comparison to keeping buffaloes, which can be slaughtered. On the other hand, production outputs like draught power for working the fields, faeces for cleaning or urine for purification are common in Nepal, whilst unknown in Austria. These factors contribute to the fact that milk production in Nepal is low despite the high cattle population.

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Conservation of the indigenous buffalo genetic resources in Nepal: a review

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ABSTRACT

Indigenous buffaloes of Nepal consist of three indigenous breeds namely Lime, Parkote and Gaddi. These breeds play an important role in supporting the livelihood and income generation of traditional rural farmer. They are valuable animal genetic resources (AnGR), but their population is declining. Indiscriminate cross breeding and farmers attraction to exotic breeds is a major threat and reason for a declining population trend of these indigenous buffaloes. Nepal government has several policies in-line with the conservation of indigenous genetic resources. Nepal agriculture policy 2061, Agriculture biodiversity policy 2063, National biodiversity strategy 2002, Animal slaughterhouse and meat inspection act 2055 and its regulation 2056 are some of the initial government efforts. After implementation of breeding policy 2068, Nepal has been doing the in-situ conservation of indigenous breeds, and special pocket area for conservation of Lime and Parkote is an example. Nepal government recent effort is the Long term action plan on animal genetic resource in Nepal (2011-2021). This plan is implemented with a vision to promote the sustainable use, conservation and development of animal genetic resource. The action plan has four major strategic priority areas and 19 specific strategic priorities. This action plan focuses on the identification of the indigenous animal genetic resources, recognition and sustainable conservation and conservation of our indigenous buffalo breeds are also listed as a priority. This document provides a long roadmap for the sustainable conservation and utilization of our indigenous buffaloes. Scientific studies are important for identifying our indigenous breeds and effective conservation activities with identification and participation of all national and international stakeholders.

Keywords: *Conservation, AnGR, Indigenous, Buffaloes, Nepal,*

INTRODUCTION

Buffaloes are an important livestock commodity for Asian agrarian economy. The domesticated buffaloes in Asia, representing 98 percent of the world buffalo population, are broadly grouped as the river and swamp types. The former which constitute approximately 69 percent are found predominantly in the Indian subcontinent. There are 5.1 million buffaloes in Nepal (Statistical information, 2005). Thirty five of this are exotic (either pure or crossbred) and rest are indigenous (Neopane, 2006). The contribution of buffalo is considerable by way of milk, meat and draught power production and as a source of security that requires minimum inputs. Apart from those there are many other uses such as hides, bones and hairs. More than 45% of household community in the country keeps buffaloes for their regular farm activities. Buffalo rank the first for contributing to the total livestock GDP (52.9%). They contribute about 70% milk to national pool. Regarding the meat production, the largest meat to the national pool also comes from the buffaloes (64% of total meat) (MOAD, 2012/2013). Buffaloes have evolved within their ecosystem over several centuries and have thus acquired adaptive characteristics and still remain useful in food production (Sivarajasingam, 1987).

Indigenous buffaloes play a crucial role in the livelihood system and well-being of the traditional rural farmers. Buffaloes are integral contributor of food, agricultural power, agrarian culture and biodiversity (Arora et al., 2004). Small holder farming system, as a predominantly prevailing system in Nepal, supports mostly subsistence agricultural system. Buffalo indigenous breeds, despite having valuable adaptive traits, low productivity diminishes their survival value necessitating conservation. Therefore, development of strategies for conservation of animals like local cattle needs consideration of multiple factors involved in biology of animals, agro-ecology of the environment, husbandry system of the animals, purpose of rearing and affordability of the owners duly to be addressed (Hammond, 1994; FAO, 1999). Farm level situations of breeding status, preference of native cattle by the small holder cattle farmers, causes of reduction of native cattle and profitability differences between native and crossbred cattle should be taken into account while developing sustainable conservation strategy.

Conservation is the act or process of protection, preservation, management or restoration of wildlife, livestock and natural and cultural resources and management of human use of bio-sphere so that it may yield the greatest sustainable benefit to present generation. The Convention on Biological Diversity (CBD) adopted at the United Nations Conference on Environment and Development held in Rio in 1992 states that “the conservation of biological diversity is a common concern of humankind” and “conservation and sustainable use of biological diversity is of critical importance for meeting the food, health and other needs of the growing world population”. The Interlaken Conference held in Switzerland in 2007 (FAO, 2007) noted that livestock diversity is decreasing at an accelerated pace, with many breeds being lost throughout the world. It concluded that local livestock diversity in developing countries represents a unique resource for productivity and provides a major pathway out of poverty, and adopted the Interlaken Declaration and a Global Plan of Action for animal genetic resources (AnGR).

INDIGENOUS BUFFALOES OF NEPAL

Lime, Parkote, and Gaddi buffaloes are considered the important economical animals for milk and meat production. They are good converter of roughages. They are raised even above 3000 meter sea level. The indigenous buffaloes can produce milk with high percentage of fat and thrive well in low resource situation with better disease resistance compared with exotics. Wide variations have been found on economic traits (milk, draught and pack) of these buffaloes. Several researches have shown the genetic potential of indigenous breed for higher milk production. These Nepalese breeds have been characterized on phenotypic and chromosomal level. DNA level characterization is still ongoing. The three indigenous breeds of Nepal with their breed characteristics are described below.

1. Parkote (*Bubalus bubalis*): Parkote is a high altitude water buffalo. They are scattered from low to high hills of the country and found predominantly in the mid hills. These lime and Parkote buffaloes make up about 58 percent of total buffalo population in the countryIts population is also declining and require concerted efforts for conservation.

2. Lime (*Bubalus bubalis*): Lime is a water buffalo generally found in mid hills of Nepal. Lime buffaloes are located in low to mid hills of the country. They are primarily used for meat, organic manure and small proportion of milk. Milk production for this breed is comparatively lower than other buffalo breeds in the country. Their population is declining at the faster rate as indiscriminate cross breeding with Indian buffaloes is heavily progressing-on for uplifting the milk productivity. Moreover, there is great problem in getting pure male buffaloes of this breed since superior male calves are either used for meat purpose after emasculation or for draught purpose so this breed requires attention from conservation point of view.

3. Gaddi (*Bubalus bubalis*): Gaddi buffaloes are located in far western hilly region of the country and are good milk yielder. They are also used for meat and manure. They are riverine type. The population is declining at a faster rate; pure breed males are rarely found and needs attention from the conservation point of view.

Nepal also houses the population of wild buffalo (*Bubalus arnee*)- *Arna* in the eastern part of Nepal. The indigenous buffaloes are speculated to be originated from *Arna*. They are localized in the Koshi Tappu Wildlife Conservation Area in Sunsari district. There could be good potentiality for meat production from this breed. Apart from these identified breeds, there are native terai and hill buffaloes found in terai and hills but both are nondescript type. According to Neopane *et al.,* (2007), phenotypic characterization of these buffaloes has been completed.

CAUSES OF THREAT TO THE INDIGENOUS BUFFALO BREEDS IN NEPAL

Most of the domestic livestock of developing countries are endangered; and one-fifth of

the world's total breeds are at risk (Sere, 2010). In global context, the economic and technological factors like intensification and commercialization of agriculture plays major role on the existence of indigenous breeds. The consumer demand for certain types of products and market preferences is the major factor. The relatively low economic competitiveness of indigenous genetic resources as compared to exotic ones, in terms of production, may be the cause of their decreasing number. The inadequate human capacity in terms of labour, lack of non-labor intensive and automated farming systems have compelled local people to keep less number of animals but with higher production thereby replacing indigenous with exotic ones. The lack of animal breeding and conservation policy in most of the countries including Nepal has led to the indiscriminate crossbreeding through artificial insemination programme and gradual giving up of buffalo husbandry by the rural poor farmers. Although crossbreds are high producing but they demand heavy initial investment as well as high maintenance cost which is unaffordable to majority farmers. Also, there is lack of coordinated involvement of the concerned government departments, institutions and private sectors. The awareness concerning the conservation issues and needs may also be an important factor for increasing threat. Insufficiency of technical know-how of the resource poor farmers for rearing crossbred apart from biological adaptability issue of exotic inheritance is another issue. Situation described above dictates the indiscriminate breed substitution in indigenous population leading to an incredible loss to traditional agriculture if immediate and appropriate measures are not taken to conserve indigenous bovine genetic resources (Quddus and Amin, 2010).

In Nepalese context, government's breeding policy is not regulated with the scientific study of the genetic potential of the indigenous genotypes. The importance of indigenous animals in contributing to the animal genetic resources has not been still taken seriously while the FAO has already established the guidelines through Global Plan of Action for Animal Genetic Resources through the Interlaken Declaration on Animal Genetic Resource (FAO, 2007). Before that several government projects and plan were undertaken, but rarely any of them focused on this aspect, and less emphasis hase been given to indigenous buffaloes. Conservation measures and use of *Yak, Lulu* and *Achhame* cattle was proposed in the Ninth Five-year Plan of the then His Majesty's Government of Nepal. But no plan and attention in policy level has been given on the indigenous buffaloes. Nepal government's breeding policy, 2055 (NLBC, 2013/014) promotes using Murrah buffalo bull/semen to upgrade low producing buffalo cows with no restriction in Murrah blood level in the Terai belt but a 62.5 percent ceiling Murrah blood level for mid-hills. Both the National Conservation Strategy and NEPAP I recommend the implementation of a strategy that stresses multiple use of livestock and optimisation of productivity while minimising over-grazing and loss of soil fertility as central tenets of the nation's livestock development strategy. Such policies favour the local farmers who have been rearing the indigenous buffaloes for optimising the productivity of their indigenous cattle and the haphazard mating to the other bulls or artificial insemination to improve the productivity of their animals, which have ultimately led to the loss of indigenous genetic merit and typical breed characters of these indigenous buffaloes and a decline in the population.

Crossbreeding has been widely conducted in Nepal since 1960 to upgrade poorly producing cows and buffaloes without the studies on the genetic potential of indigenous genotypes. The consequence of this ineffective policy and indiscriminate breeding and artificial insemination program for grading up is upon the native genetic characters in the indigenous buffaloes. An example can be taken for consequence of this ineffective policy, Siri cattle is almost extinct and many other indigenous breeds have decline in the number and the typical breed characteristics have been lost. This had circumscribed the population of indigenous population of gaddi, lime and parkote to a narrow geographical area and a declining population additionally affected with an increase in non-descriptive characteristics from an unplanned mating, i.e. identified breeds are being bred with other breeds which may cause the loss of breed characters. Thus from a conservation point of view, Nepal government has been facing a huge loss of these indigenous domestic animal genetic resources. Yet this is getting far less attention than what wild animals in Nepal have been receiving all these years.

Nepal government introduced the new breeding policy 2068 with little improvement over their existing policy favouring in-situ conservation of indigenous breeds. Yet, proper implementation of these policy and realization of the importance of conservation of these native breeds at farmers' level is still a challenge that could direct that actual success of the conservation strategies of the government. The in-situ conservation might alone not be sufficient as farmer's level herd often suffers from the use of non-superior breeding stocks and mixing with other indigenous breeds thus leading the loss of the typical breed characteristics. An example could be the offspring of Lime X Parkote in the Lime-Parkote conservation area in Gandaki region.

Additional threats that have been observed in the indigenous livestock breeds including indigenous buffalo breeds can be summed up as follows: breed survey has not been done to estimate the population of different breeds of livestock, and the genetic differences of the breeds have not been clearly marked. Many people of Nepal do not know about the "Convention on Biological Diversity" 1993 which specifically includes domestic animal genetic diversity. Many Nepalese people who are below poverty line cannot think of biodiversity. The concerned organizations to conserve the domesticated Animal Genetic Resources in Nepal do not have enough knowledge and capacity to undertake the conservation program. The blood polymorphism or DNA techniques can be used to estimate the genetic distances of the breeds. There is no initiation of formation of breeding societies which can take the leading role to conserve and to improve the indigenous breeds genetically in future. Nepal has not yet developed a plan for germplasm conservation of domesticated animal. There should be concrete plan for conservation of domesticated animal diversity. Wide variation and complex farming system are making difficult to launch genetic improvement program. Lack of selection mechanism for superior breeding animals for true to breed type of different indigenous breeds of livestock and birds. Low production and productivity of indigenous breeds have tendency to go for cross breeding or substitution by other breeds. Indigenous systems have been followed for draft power, disease resistance and other such traits which are important in the Nepalese farming system of diverse environment. Lack of national or regional herd performance recording system for different indigenous breeds of livestock.

NEPAL GOVERNMENTS' EFFORTS FOR THE CONSERVATION OF INDIGENOUS BUFFALOES

Conservation need of the indigenous livestock breeds have been realized much later at which time some serious impact had already been done in the reduction of the population of the indigenous domestic animals including indigenous buffaloes in Nepal. Some steps have been initiated earlier as enlisted in the Nepal biodiversity strategy 2002 from the government for in-situ conservation of the indigenous livestock breeds. Conservation of the indigenous animal genetic resources is a fairly new concept that took its pace after the fao published the guidelines on the global plan of action for animal genetic resources through Interlaken Declaration (2002) enlighten the inadequacy of the government level plans in conservation of the indigenous buffaloes in Nepal. The agriculture perspective plan does not mention the conservation of livestock genetic resources, and neither of the department of livestock services the then ongoing projects addresses conservation issues regarding indigenous animal genetic resources. Small conservation efforts were carried out in yak, lulu and achhame cattle of the government's ninth five-year plan. But no plan and attention in policy level has been given on the indigenous buffaloes. Despite such inadequacies, existing breeding guidelines adopted by the department of livestock services that deal with artificial insemination and crossbreeding with exotic breeds address the concern of indigenous breeds. the guidelines for indigenous buffalo were (i) parkote and lime buffalo will be conserved and maintained in some pocket areas; (ii) promoting bull exchange programmes between user groups to check inbreeding.

Some of national soft and hard binding laws like Nepal Agriculture Policy (2061), agriculture biodiversity policy (2063), national biodiversity strategy (2002) and national biodiversity strategy and action plan (2014-2020) have emphasized on conservation of biodiversity and animal genetic resources for future. Also, the animal health and livestock services act (2055) and its regulation (2056) and animal slaughterhouse and meat inspection act (2055) and its regulation (2056) has incorporated the animal genetic resources conservation issues. Animal breeding policy developed in line with national agriculture policy (2061), which is in drafting phase, has also emphasized on conservation, improvement and utilization of angr for domain/ecological wise. Poultry policy (2068), also developed in line with national agriculture policy (2061), has emphasized the same. Nepal has submitted '*country report'* on angr, regional thematic areas are identified and Nepal Global Plan of Action (NGPA) has been developed based on the FAO guidelines.

Nepal government has initiated the **long term action plan of animal genetic resources in Nepal (2011-2021)** to conserve the angr with one vision to promote the sustainable use, conservation and development of animal genetic resources to ensure long term maintenance of domestic animal diversity. The overall purpose of the plan is the conservation and sustainable use of animal genetic resources. The action plan has recommended **four major strategic priority areas** and within this there are **19 specific strategic priorities**. The plan includes both commercial breeds and native breeds of cattle, sheep, goats, swine and poultry, as well as indigenous horse. the path suitable for

achieving long term conservation can therefore be very different for different groups and breeds.

RECOMMENDATION AND CONCLUSION

For the conservation of our three indigenous buffaloes namely Lime, Parkote and Gaddi, this plan provides a long roadmap with different priorities areas and activities to meet these priorities. This includes the DNA level characterization of these indigenous breeds, inventory and evaluation of current situation, identifying breed specific traits, sustainable use and development of the breed development policies and strategies for in-situ as well as ex-situ conservation and breeding plans and strategies and contingency plans to prevent extinction of the breeds, breed promotion and breed research and development, formation and sharing of breed database etc. The responsibility for achieving this rests on many actors' shoulder, such as farmers and livestock owners, non-governmental non-profit making organization, breeding associations/groups/committee, researchers and other stakeholders. Achieving collaboration between these actors and coordinating the different actors and their responsibilities is crucial to achieving the goal of protecting the Animal Genetic Resources for the future.

The effective management of these valuable resources, at all levels, depends on the inclusion and willing participation of all relevant stakeholders. Pastoralists, farmers and breeders, individually and collectively, and indigenous and local communities, play a crucial role in the in-situ conservation and development of Animal Genetic Resources. It is important to understand the role of each stakeholder who should contribute in a context of rapid economic and social change, to play an effective function in situ management, and share fairly and equitably in the benefits arising from the utilization of these resources.

The breed registration/improvement system to register animals of specific breeds should be developed, maintain the herd book and purity of breed should be ensured first. Arna, donkey and duck should be enlisted under indigenous group and breed specific conservation plan should be made. The national livestock information system should be developed for reliable data flow. The true productive potential of individual breeds in their breeding tract needs to be documented to describe the true genetic potential. The baseline database of native environment, management practices, qualitative and quantitative aspects of morphological, physiological and functional traits, blood groups, blood polymorphisms, DNA analysis, their utility, demographical and geographical distribution need to be documented. This will lead to the identification of the types of genes and gene combinations available in different breeds and will also assist in formulating breeding policies and selection of animals for conservation, propagation and improvement programmes for our indigenous valuable animal genetic resources.

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Proteoglycan and its possible role in "Wooden Breast" condition in Broilers

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ABSTRACT

"Wooden Breast", a quality defect in M. pectoralis major in broilers has been recently observed in many European countries. This condition do not seem to cause any health problems, however, the meat is rejected from human consumption causing greater economic loss to the producers. The histological examination of defective muscle have shown a thick layer of poorly organized connective tissue but, did not indicate the significant accumulation of collagen. The large proteoglycans interact with hyaluronic acids forming larger aggregates providing swelling pressure as well as matrix resilience and finally stiffness to the tissue. The pathophysiology of this condition is not well understood but, it does seem like increased proteoglycans could be the cause of stiffness in Wooden Breast muscles. Study about the various types of proteoglycans along with glycosaminoglycan hyaluronic acid could be done to look into the mechanisms of the development of this defect. Also, identifying and defining the contributions of different cell types that may have been altered and have been responsible for the macromolecular changes will contribute in understanding the pathophysiology of this condition.

Keywords: Connective tissues, Glycosaminoglycans, Hyaluronic acids, Macromolecules, Proteoglycans

INTRODUCTION

The global poultry industry has been continuingly expanding with a greater increase in demand of poultry meat. As a consequence, efforts have been made to increase the meat yield in carcasses (Berri et al., 2007) through intensive selection for rapid growth rate, increased feed efficiency and meat production (An et al., 2010; Petracci and Cavani, 2012). The improvement in growth rate and carcass yield has been obtained by significantly increasing proportion of breast muscle (Nicholson, 1998; Le Bihan-Duval et al., 2003) which not only increased the yield but also caused many other changes in broiler meat quality (Dransfield and Sosnicki, 1999; Barbut et al., 2008; An et al., 2010; Petracci and Cavani, 2012). White striping (Kuttappan et al., 2012a; Kuttappan et al., 2013a; Kuttappan et al., 2013b), Deep Pectoral Myopathy also known as Oregon disease, PSE like breast meat and poor cohesiveness of meat are some of the examples of various observed defects (Petracci and Cavani, 2012). Changes in appearance of meat and meat products have a greater effect in its acceptance (Kuttappan et al., 2012b).

Recently, an emerging quality defect known as Wooden Breast in *M.* p*ectoralis major* in broilers has been observed in many European countries. The live birds do not show any symptoms of the condition but the defective area in carcass is pale, hard, often with white

striations. The pathophysiology of this condition is still not known in detail (Sihvo et al., 2014). According to Sihvo et al. (2014), although there are no other health problems, the meat is rejected from human consumption causing greater economic loss to the producers and as a whole, the poultry industry.

Normal ***Wooden Breast***

Sihvo et al.. 2014

REVIEW OF LITERATURE

Ground substance

The extracellular components of connective tissue are reinforced by fibrous proteins in an amorphous matrix with high water content known as ground substance present in varying quantities with different chemical composition (Bailey and Light, 1989). The composition and amount varies with the function and location of the tissue (Bailey and Light, 1989) but in general, it includes proteoglycan (Kuettner and Kimura 1985), hyaluronan and non-fibrous proteins (Bartold, 1995).

Proteoglycans (PG)

PG are soluble polymers present in the matrix of all connective tissues (Suzuki et al. , 1991) that links together the fibrous elements of the extracellular matrix ((Purslow 2002) and maintains space between collagen fibrils providing channels for movement of water soluble materials and also maintaining tissue hydration. It consists of at least one sulphated glycosaminoglycans (GAG) side chain attached covalently to a core protein (Ruoslahti, 1988; Suzuki et al., 1991; Hardingham and Fosang, 1992; Carrino et al., 1999) and the size can be small, large or very large (Scott, 1992) depending on the repeating units of small numbers or up to 100 chains of disaccharides in the GAG chain (Carrino et al., 1999). The central core protein can be from 40,000 to greater than 350,000 daltons to which several PG can be attached with one common region, the hyaluronic acid binding site (Iozzo and Murdoch, 1996; Iozzo, 1998). The diverse nature of GAG chains i.e. size, type, composition etc. (Vynios et al., 2002) in PG result in their involvement in different tissue functions like tissue hydration, cell proliferation, adhesion and migration, regulation of gene expression (Velleman, 2012), regulation of growth

factors and other various essential functions (Scott, 1992). Thus PG are prerequisite for the optimal mechanical function of a tissue (Eggen et al., 1994).

Almost all PG contain small glycoprotein type oligosaccharides that can be N-linked or O-linked or both. However, it is the GAGs that distinguish different PG and carries important functions. GAG chains are polymers of repeating disaccharide each consisting of uronic acid and one amino sugar as other member (Carrino et al., 1999) having high negative charges and are highly sulphated, except hyaluronic acid, resulting in ion interactions with molecules like water or growth factors (Fernandez et al., 1991; Velleman et al., 1999). There are four major classes of GAGs; hyaluronic acid, chondroitin/dermatan sulphate, keratan sulphate and heparan sulphate existing as PG with an exception of hyaluronic acid that exists as a free glycosaminoglycan not as PG (Carrino et al., 1999; Rozario and DeSimone, 2010). All the major GAGs have repeating chains of uronic acid, except keratan sulphate (Carrino et al., 1999) and are synthesized as PG in Golgi apparatus, except HA (Vynios et al., 2002). The amount and composition of PG varies between and within tissues due to difference in mechanical stress (Vogel et al., 1984), age, hormonal status, differentiation and age. The distribution of PG in leg and breast muscle of broilers differs due to difference in fibre types: fast and slow fibres (Carrino and Caplan, 1984). They are essential in maintaining normal tissue structure and function but limited information on composition of skeletal muscle PG is available (Velleman et al., 1997) though there are some studies about the role of PG during developmental processes and differentiation (Eggen et al., 1998). Although not in detail, some information about skeletal muscle PG in different species including chicken and turkey is available (Velleman et al., 1997). Dermatan sulphate, chondroitin sulphate, decorin (dermatan or chondroitin sulphate) and heparan sulphate have been identified in skeletal muscle of beef, rabbit, including chicken and turkey (Young et al., 1989; Fernandez et al., 1991; Velleman et al., 1997).

Skeletal muscle PG in chicken undergo various changes during the development process (Young et al., 1989; Fernandez et al., 1991) where large molecular weight myoblastic chondroitin sulphate with sulphation at C-6 position decreases and increase in fibroblastic small PG like dermatan sulphate, heparan sulphate occur with the maturity (Carrino and Caplan, 1982; Velleman et al., 1999; Velleman, 2012). Progressive decrease in amount of chondroitin sulphate occurs with increase in small PG. Large PG function in early myogenesis and the small PG play a role during the maturation and maintenance (Velleman et al., 1999).

a. Large PG

- Chondroitin sulphate (CS)

CS is composed of repeating units of glucuronic acid and N-acetylglucosamine with sulphation at C4 or C6 position in the amino sugar (Fernandez et al., 1991; Velleman et al., 1999), and sometimes at 2-position of the uronic acid (Carrino et al., 1999). There is presence of large amount of sulphated groups in glycosaminoglycan chains of CS which draws water into the muscle tissue and maintains spacing in the muscle fibres (Fernandez et al., 1991). CS can be aggrecan found in cartilages and versican found in skeletal

muscle. Versican is also present in many other tissues like skin, loose connective tissue of many organs, nervous tissue, smooth muscle, lungs and aorta (Carrino et al., 1999).

The skeletal muscle chondroitin sulphate PG (versican) is a large aggregating PG (Velleman et al., 1997) with a high negative charge causing ionic hydration of the extracellular matrix (Farnandez et al., 1991; Velleman et al., 1997) capable of forming link protein stabilized aggregates at hyaluronic acid binding site (Velleman et al., 1996). During early embryonic life of chicken, relatively high synthesis of large CS PG occur followed by synthesis of small DS and HS in later stages (Carrino and Caplan, 1984). Moreover, the distribution of HA is similar to that of CS, thus providing hyaluronic rich matrix for proliferation during early stages (Young et al., 1989). As development of chicken skeletal muscle proceeds, there is a decrease in CS synthesis (Carrino and Caplan, 1984; Fernandez et al., 1991). As a result, CS rich matrix turns into adult ECM where mixture of fibroblast specific chondroitin-4 sulphate, DS and HS are present (Young et al., 1989). The synthesis of large CS PG is reinitiated in the regenerating muscles after injury with a significant decrease in later stages; unlike that of uninjured muscle where synthesis of only dermatan and heparan sulphate occur (Carrino et al., 1999).

- Dermatan sulphate (DS)

It is similar in structure to CS but the C-5 GlcA is epimerized to IdoA and O-sulphation is present at C-2 of IdoA. This IdoA provides flexibility to the dermatan sulphate chain and makes it more negatively charged than GlcA of chondroitin sulphate. The IdoA are sulphated at carbon position 4 of GalN whereas sulphation at 6 is more commonly associated with GlcA (Vynios et al., 2002).

- Heparan sulphate (HS)

HS PG is present on the cell surface and basement membrane and increases with the maturity of embryo due to increase in basement (Velleman et al., 1999). It consists of repeating units of glucuronic acid and N-acetylglucosamine (Fernandez et al., 1991; Velleman et al., 1999) and can be matrix or membrane associated. Perlecan and agrin are two matrix HS PG present in excess in basement membrane (Bosman and Stamenkovic, 2003). Perlecan plays an important role at neuromuscular junction directly interacting with a wide variety of ECM molecules including type IV collagen, laminin and fibronectin (Voermans et al., 2008).

Among the membrane associated HS PG syndecans and glypicans are major in skeletal muscle. All four members of syndecans have been identified in skeletal muscle. Their structure has a core protein, extracellular domain with GAG and N-glycosylated chain with a cytoplasmic domain (Larrain et al., 1997; Fuentealba et al., 1999).

HS chain in PG is necessary for the regulation and functioning of fibroblast growth factor that maintains cell proliferation (Rapraeger et al., 1991), development and growth of muscle structure, which finally influences meat quality (Velleman, 2012). Along with that, HS also plays a role in cell attachment and maintaining cell-cell and cell- matrix interaction (Kuettner and Kimura, 1985) which indicates their role in many pathological processes (Bosman and Stamenkovic, 2003).

- Keratan sulphate (KS)

KS is a small molecular mass PG (Vynios et al., 2002) consisting of repeating units of galactose instead of uronic acid and N-acetylglucosamine with sulphation at 6th position of amino sugar (Fernandez et al., 1991; Velleman et al., 1999). There is absence of keratan sulphate in non-cartilaginous tissues like skeletal muscle (Carrino and Caplan, 1984; Pechak et al., 1985; Carrino et al., 1999) and adipose tissue (Nakano et al., 2012) and is mainly present in cartilages (Vynios et al., 2002).

b. Small leucine rich PG

Decorin and biglycan are the homologous small leucine rich PG distinguished from each other by the presence of one (decorin) or two (biglycan) chondroitin or dermatan sulphate side chains. Both of these PG have the ability to interact with the collagen where biglyan is also able to bind to α- and γ- sarcoglycans (Voermans et al., 2008). According to Voermans et al. (2008), decorin is mainly found in ECM whereas biglycan is mostly associated with sarcoglycans near sarcolemma. The ECM in adult skeletal muscle shows high level of decorin whereas amount of biglycan is low (Brandan and Guiterrez, 2013).

Decorin is a chondroitin or dermatan sulphate PG (Velleman et al., 1997) produced by fibroblastic cells (Carrino and Caplan, 1982) detected in skeletal muscles from other species like rabbits, rat, bovine (Eggen et al., 1994; Velleman et al., 1999) and also in chicken (Lennon et al., 1991). Decorin is one of the small PG having 45 kDa/46 kDa core protein (Velleman et al., 1999), present in higher amount in fibrous connective tissue areas (Fernandez et al., 1991) in later stages of chicken muscle development (Lennon et al. 1991; Carrino et al., 1999). It is found in epimysium at first, and in later stages it can be observed in epimysium, perimysium and also in endomysium (Fernandez et al., 1991). It also has an ability to bind to both collagen type I and II and FACITS collagens (Velleman et al., 1996; Weber et al., 1996). Hence, it modulates collagen fibrillogenesis (Vogel et al., 1984; Iozzo and Murdoch, 1996; Weber et al., 1996) and influence the tensile strength and tenderness of muscle (McCormick, 1994). It also binds to fibronectin (Eggen et al., 1998) and growth factors (Eggen et al., 1998) and thus, plays a role in cell proliferation (Santra et al., 1995; Moscatello et al., 1998) and affects transforming growth factor activity by influencing protease activity and tissue metabolism (Yamaguchi et al., 1990). Alteration in GAG occurs in variety of diseases, and defects may occur in biosynthesis or catabolism of the glycosaminoglycans (Vynios et al., 2002). The CS/DS are the most abundant proteolgycans found during several kinds of muscular dystrophies along with increase in HS PG (Brandan and Guiterrez, 2013). During hypoxia, ischemia, infections or any kind of muscle injury, increase in PG occur to aid in the repair process (Wynn, 2008). According to Sihvo et al. (2014), in microscopic observation, myodegeneration with regeneration along with accumulation of loose connective tissue was present in all cases of Wooden Breast condition.

CONCLUSION

The microscopic examination of Wooden Breast muscle have shown a thick layer of poorly organized connective tissue with compact and collagen-rich deep layer but, did

not indicate the significant accumulation of collagen rather, revealed thick layer of unknown substances within the connective tissue area (Sihvo et al., 2014). Changes in the nature and pattern of the macromolecules in tissue alter its character and properties (Hardingham et al., 1972). Elucidation of the changes and the mechanisms involved help in understanding the etiology and factors involved in development of different muscle defects and may finally aid in preventing the further occurrence of such conditions. Collagen, constituting the major component of connective tissue in muscles, its effect and relation to the meat quality and its quality defects has been studied a lot. There have been lesser studies regarding other macromolecules in the extracellular matrix of muscles.

The large PG does not interact with the collagen fibrils but rather with the hyaluronic acids forming large aggregates that provide the swelling pressure within the tissue. Thus, the space filling large PG contributes to the matrix resilience against the compressive forces resisting it (Eggen et al., 1994) and finally, provides stiffness to the tissue (Kuettner and Kimura, 1985). This functional property of PG contributes for the compressive stiffness and resilience to the cartilage. Moreover, loss of PG from cartilage matrix results in reduced ability of cartilage to maintain its water content and finally result in loss of resistance to compression (Greenwald et al., 1978). In fact, Jackson et al. (2002) described the deposition of hyaluronic acid bound to chondroitin sulphate and heparin as wood like non-pitting hardened condition in sclererderma, a cutaneous mucinosis of skin. The increased PGs could be the cause of stiffness in Wooden Breast muscles.

Based on the reviews on this issue, no studies have been done describing the biochemical changes that occur in pectoralis muscle and changes in constitution or composition of macromolecules in connective tissue and hardening in the Wooden Breast muscle.

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