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NUTRIENT MANAGEMENT PRACTICE FOR CONSERVATION AND CONVENTIONAL AGRICULTURE PRACTICES ON RICE BASED SYSTEM AT CENTRAL TERAI OF NEPAL

Santosh Marahatta[1]

ABSTRACT

A field experiment was conducted to evaluate the effect of inventive nutrient management practices on the system productivity and profitability of rice-wheat and maize in the rice-based cropping system under conservation agriculture and conventional tillage at Agriculture and Forestry University (AFU), Rampur, Chitwan, Nepal during 2018 - 2019.The experiment was executed in the field in split-split design (for rice), and split plot design (both for wheat and maize) with three replications which included two cropping system (rice-wheat and rice-maize) as main plot treatments, two establishment methods (conservation agriculture and conventional agriculture) as sub plots and four nutrient management practices (100% Recommended dose of fertilizer (RDF), Residue (5 t ha^{-1}) + 75% RDF, Nutrient Expert (NE) dose, brown/green manuring (BM/GM) + 75% RDF) as sub-sub plot treatments. The data on yield and economics were recorded and analyzed by R studio. The yield of wheat and maize were converted into rice equivalent yield (REY) from which system yield was calculated. The research revealed that the rice-maize system had significantly higher REY (12.21 t ha^{-1}), net returns (163.10 thousand NRs. ha^{-1}) over rice-wheat system (8.61 t ha^{-1} and 68.09 thousand NRs. ha^{-1}, respectively) whereas the crop establishment methods and nutrient management practices have no influence on the REY of the system. NE dose, Residue +75% RDF and 100% RDF produced similar REY. The rice grain yield was found higher (5.28 t ha^{-1}) for conventional tillage than under CA (4.52 t ha^{-1}) however the maize and wheat yield was not affected by the crop establishment methods. Under both establishment methods, NE dose performed better for all crops but NE dose and green manuring produced higher yields under conventional tillage for rice. The residue +75% RDF performed better than 100% RDF for maize and wheat. Rice-maize cropping system was more productive and eventually more profitable than rice-maize cropping system and the under both establishment methods, better yield can be obtained using NE dose, green manuring and residues in the fields with the saving of 25% RDF applied for each crops.

Keywords: Conservation agriculture, Green manuring, Nutrient expert, Residue management

INTRODUCTION

Rice-wheat cropping system is the world's largest cropping system occupying 85% of the Asia but its sustainability is being questioned due to stagnation in yield and reducing profitability, declining water availability and soil degradation (Ladha et al., 2003). Conventionally, rice in this region is established by transplanting rice seedlings on puddled field (Bhatt et al., 2016). But due to high labor and water demand in transplanted method, an alternative practice direct seeding is gaining popularity. Crop residues are the important plant nutrient sources and help to combat the nutrient mining through the

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intensive cropping. Green manures are the green plants or plant parts which are returned into the soil by incorporation in order to improve the growth of subsequent crops and soil organic carbon. The addition of green manure alone can help to make soil fertile, but the combined application of green manure and nitrogenous fertilizer increases the yield of rice by increasing the availability of NPK in the soil and hence the nutrient uptake (Islam et al., 2015). Brown manuring is an innovative cultural practice, especially for dry-DSR in which the *Sesbania* seeds are sown directly into field along with rice seeds and after allowing to grow for about 25-30 days after which the co-cultured *Sesbania* plants are killed by applying 2,4-D. Nutrient Expert (NE) is computer-based nutrient decision support software based on site-specific nutrient management (SSNM) principle and enables farm advisors to develop fertilizer recommendations tailored to a specific field or growing environment. NE does not require lot of data or very detailed information and is user friendly as NE combines all the steps and principles in SSNM into simple software tailored for farm directors and non-technicians (IPNI, 2017).

The current agricultural production practices in the rice-wheat systems are high resource demanding and also degrade the environment contributing to the climate change (Bhatt, 2016). The continuous practice of conventional system in most areas has led to degradation in soil health and consequently resulted in declined system productivity (Singh et al., 2011). In addition to this, the conventional wheat planting system involves repeated dry tillage to prepare the field which also leads to further delay in wheat seeding by almost a week compared to ZT planting (Kumar et al., 2014). Puddling in rice and also the intensive tillage for wheat delays wheat planting, and results in yield loss (Hobbs & Morris, 1996). Kumar & Ladha (2011) reported that the subsequent wheat increment was about 9% in the field followed after DSR than TPR. Rice-maize has now emerged as the best alternative to rice-wheat system where wheat planting is delayed after rice and faces terminal heat stress resulting in low productivity (Singh et al., 2016). The other drivers for replacing wheat are: better suitability of maize after harvest of long-duration rice cultivars, increasing demand of maize in poultry sector, higher productivity and profitability of maize compared to the other crops (Timsina et al., 2010). The edaphic needs of both subsequent crops i.e. maize and wheat are different from the rice crop. Aside the growing soil condition, the improper and imbalanced nutrition management and declining soil fertility are the major priorities of global research (Timsina et al., 2010). So, this research was done to examine the productivity and profitability of rice-based systems under different establishment methods and nutrient management practices. Along with this, the research aims at assessing the relevance and comparative advantage of the site-specific nutrient, management using Nutrient Expert (NE) software for all the major cereals.

MATERIALS AND METHODS

SITE DESCRIPTION

The experiment was conducted at the research block of Agronomy Farm of Agriculture and Forestry. University (AFU), Rampur, Chitwan district of Bagamati Province of Nepal (27°40' N and 84°23' E and256 masl) from June 2018 to May 2019. The soil in the experimental field was sandy loam with slightly acidic to neutral pH, medium to low OM and nitrogen content, high phosphorus and medium potassium content (Table 1) according to the standard rating of Government of Nepal, Kathmandu.

Table 1. Physico-chemical properties of the soil of agronomy farm at Agriculture and Forestry University (AFU), Rampur, Chitwan, 2018/19

S.N.	Properties	Average Content	Rating			Methods and References
1.	Physical properties					Hydrometer
	Sand (%)	63.10	Sandy loam			(Estefan, Sommer& Ryan,2014)
	Silt (%)	28.00				
	Clay (%)	8.90				
2.	Chemical properties					
		0-15cm	Rating	15-30cm	Rating	Methods and References
	Soil pH	6.40	Acidic	6.5	Neutral	Beckman Glass Electrode pH meter (Estefan et al., 2014)
	Soil organic matter (%)	3.20	Medium	1.79	Low	Walkey and Black (Estefan et al., 2014)
	Total nitrogen (%)	0.16	Medium	0.09	Low	Micro Kjeldhal Distillation (Estefan et al., 2014)
	Available phosphorus (kg ha^{-1})	85.03	High	130.97	High	Modified Olsen's method (Estefan et al., 2014)
	Available potassium (kg ha^{-1})	214.61	Medium	138.65	Medium	Ammonium Acetate method (Estefan et al., 2014)

The experimental site lies in the subtropical humid climate belt of Nepal. The area has sub-humid type of weather condition with cool winter, hot summer, and distinct rainy season with annual rainfall of about 2000 mm. The weather data during the cropping seasons was recorded from the metrological station of the National Maize Research Program (NMRP), Rampur, Chitwan (Figure 1).During the growth period of rice i.e. form third week of June to last week of October, the total rainfall during the experimental period 1430 mm and the average maximum temperature was 33.40˚C; average minimum temperature was 25.36˚C and average relative humidity was 89.46% (appendix 4). Likewise, during the wheat growth period (November first week to second week of March), the total rainfall, average maximum and minimum temperature, average RH was 59mm, 26.08 ˚C, 12.38 ˚C and 83.56% respectively and the same weather parameters during the growth period of maize (first week of November to second week of May) were 240.90mm, 31.05 ˚C, 18.92 ˚C and 91.22% respectively.

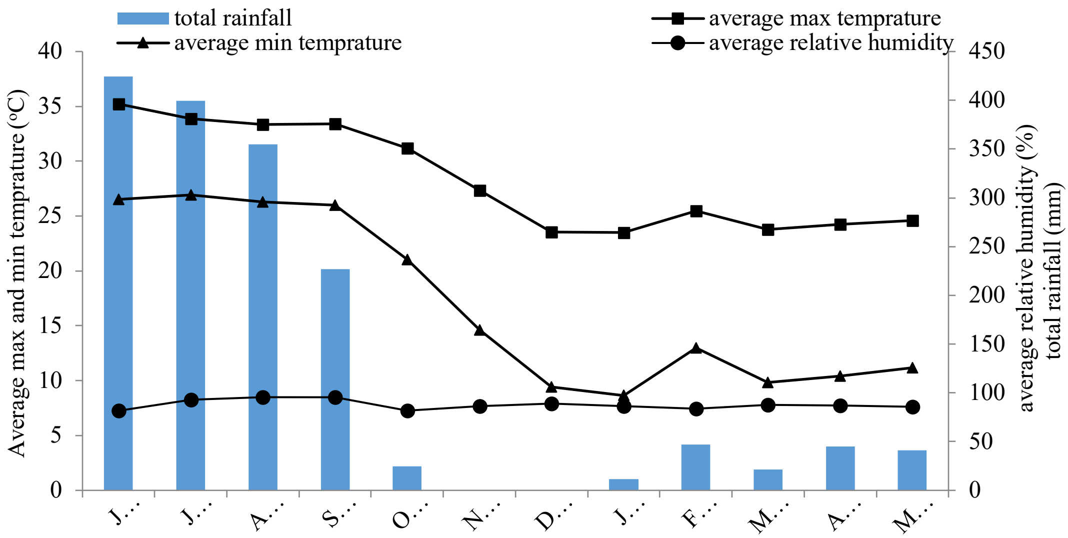


Figure 1: Minimum and maximum daily temperature (°C), daily rainfall (mm) and daily relative humidity during the experimental period at Rampur, Chitwan, Nepal, 2019 (Source: NMRP, 2019)

EXPERIMENTAL DESIGN AND TREATMENTS

In order identify the effect of various nutrient management practices for different establishment methods in R-W and R-M cropping system, an experiment consisting of 16 treatments combining two cropping system, two different establishment methods and four different nutrient management practice were laid out in split plot design with three replications. The variety of rice was US-312, a hybrid rice of maturity days of 120. The used variety of wheat was Bijay of maturity days 111-123 days and that of maize was Rampur hybrid 6, a winter maize with maturity days of 158-165 days.

The cropping system involved two rice based cropping systems viz. rice-wheat and rice-maize. In rice-wheat cropping system, wheat was sown after harvest of rice and for rice-maize system, maize was sown.

The establishment method for rice involved (i) dry-DSR at 20 cm row spacing after tillage (ii) transplanting 30 days old seedlings at 20 cm x 20 cm spacing on puddled field while for wheat (i) sowing the seeds in between the harvested rice rows without tillage making furrows with the help of hoes for the placement of the seeds (ii) sowing the seeds 20cm row spacing after tillage. Likewise, for maize establishment method included (i) sowing the seeds in between the rice rows at 60cm row spacing and 25 cm plant to plant spacing under no till making small furrows just to incorporate fertilizer and seeds (ii) sowing seeds at 60cm row spacing and 25 cm plant to plant spacing after tillage.

The nutrient management factor included (i) application of recommended dose of fertilizer ie. for rice 150: 45:45 kg N, P_2O_5 and K_2O ha^{-1}; for wheat 80:60:40 kg N, $P2O_5$ and K_2O ha-$^{1)}$ and for maize 180:90:60 kg N, $P2O_5$ and K_2O ha^{-1} (ii) mulching the straw of wheat and maize @5 t ha^{-1} at DSR plots under R-W and R-M systems respectively along with the 75% of the recommended fertilizer dose and incorporating the same amount of straw in which the rice seedlings are transplanted. Rice residues @5 t ha^{-1} was applied on the wheat and maize crops on which the same treatment is allocated. (iii) nutrient expert dose in which the fertilizer dose was determined using Nutrient Expert software prepared by IPNI i.e. for rice, Nutrient Expert for rice , Beta Version; for maize, Nutrient Expert for hybrid maize V 1.0; and for wheat, Nutrient Expert for wheat V 1.0., (iv) Green manuring (GM) along with the 75% of the recommended fertilizer dose for TPR plots where the *Sesbania* seeds (60kg ha^{-1}) were sown in the field 30 days before transplanting the rice seedlings and were cut and incorporated during the final land preparation. Likewise, the plots allocated with the brown manuring (BM) treatments, same rate of *Sesbania* seeds were broadcasted in the field along with the rice seeds and were killed by spraying 2, 4-D herbicide at the day when the GM crops were toppled down.

CROP MANAGEMENT

Conventional tillage dry direct seeded rice (CT-DDSR) and puddled transplanted (Pu-TPR) field were managed as the zero tillage (ZT) wheat/maize and convention tillage wheat and maize, respectively. The wheat and maize residues @ 5 t ha^{-1} were applied on rice crop as mulch in DDSR and incorporated in soil for Pu-TPR. ZT plots were prepared by spraying the glyphosate-47SL @ 5 ml L^{-1} a week prior to sowing and wheat and maize seeds were directly sown in lines. For CT, after Pu-TPR, the field was ploughed twice, pulverized and leveled and wheat and maize were sown. For both establishment methods, seed was sown on 5thNovember 2018. The RDF used for the crops was determined from the economic maximum dose obtained from various previous researches and the nutrient expert doses for all the crops were calculated using Nutrient Expert Model of each crop developed by International Plant Nutrient Institute(IPNI). The residue amount varied with treatments and was used as surface mulch for wheat and maize.

Full dose of K_2O and P_2O_5 was applied through muriate of potash (MOP) and di-ammonium phosphate(DAP) as basal dose whereas N in each treatment was divided three equal splits and each split was applied as basal dose, and at 30 days after sowing (DAS) for both crops whereas the third split was applied at 60 DAS for wheat and at 90 DAS for maize synchronizing the critical stages. For maize, tank mixture of Atrazine and Pendimethalin (each @ 0.75 a.i. kg ha^{-1}), was sprayed followed by one hand pulling of weeds at 50 DAS for both ZT and conventional tillage treatments. No weeding operation was conducted for wheat.

SAMPLING AND MEASUREMENTS

Biomass yield and grain yield of rice and wheat were taken at harvesting from net plot i.e. 12.60 m^2. The crop was sun dried in-situ for 3-4 days then threshed, sun dried, cleaned and final weight was taken along with grain moisture percent. The grain yield per hectare was computed for each treatment from the net plot yield. Finally grain yield was adjusted at 14% moisture using the formula as

Gain yield (t ha^{-1}) at 14% moisture = $\frac{(100-MC) \times \text{plot yield (kg)} \times 10000\ (m^2)}{(100-14) \times \text{net plot area } (12.60\ m^2)\ \times 1000}$

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

Biomass yield and grain yield of maize were taken at harvesting from net plot i.e. central 5 rows (9 m^2). Cobs were separated from the stover and both cobs and stover of each plot was sun dried, then shelling of grains and final weight of grain was taken along with exact grain moisture percent. The grain yield per hectare was computed for each treatment from the net plot yield. Finally grain yield was adjusted at 14% moisture using the formula above formula.

Cultivation cost of crops was calculated on the basis of local charges for different agro-inputs viz. labor, fertilizer, herbicides and other necessary materials and explained as total cost of NRs ha^{-1}.The price per unit kg of grain and straw on the basis of local market was multiplied with the grain yield and straw yield of each plot to determine gross return and expressed in NRs ha^{-1} for all treatments and replications. It was calculated by the use of following formula.

B: C ratio = $\frac{\text{Gross return}}{\text{Total cost of cultivation}}$

For system yield analysis, the wheat yield was multiplied by the price of wheat, and the product was divided by the price of rice, and maize yield was multiplied by the price of maize, and the product was again divided by the price of rice and then result was added to the rice yield.

Rice equivalent yield (REY) = Yield of rice +

$$\frac{\text{Yield of wheat (kg) x price of wheat (NRs per kg)}}{\text{Price of per kg rice}} + \frac{\text{Yield of maize (kg) x price of maize (NRs per kg)}}{\text{Price of per kg rice}}$$

STATISTICAL ANALYSIS

The data were subjected to analysis of variance, and Duncan's multiple range test at α level 0.05 (DMRT)for mean separations (Gomez & Gomez, 1984). Dependent variables were subjected to analysis of variance using the R Studio for split plot design. Sigma Plot v. 12 was used for the graphical representation. The rice equivalent yield of wheat and maize were compared using paired t-test.

RESULT AND DISCUSSION

PRODUCTIVITY AND PROFITABILITY OF RICE BASED CROPPING SYSTEMS UNDER DIFFERENT CROP ESTABLISHMENT METHODS AND NUTRIENT MANAGEMENT PRACTICES

The average rice equivalent yield (REY) was 10.41 t ha^{-1}(Table 2) and was significantly influenced by the cropping system where rice-maize cropping system had statistically high rice equivalent yield ie.12.21 t ha^{-1} than that of rice-wheat cropping system (8.61 t ha^{-1}). However, establishment methods and nutrient management practice did not have significant influence on the REY. However, REY under NE dose was 10.01% more compared to REY under100% RDF.

Table 2. Rice equivalent yield (t ha^{-1}), total cost of production (NRs. '000 ha^{-1}), gross and net returns (NRs. '000 ha^{-1}), and B:C ratio of rice-based systems as influenced by the establishment methods and nutrient management practices of rice, wheat and maize at Rampur, Chitwan, 2018-2019

Treatments	**System REY (t ha^{-1})**	**System economics**			
		Cost of cultivation (NRs. '000 ha^{-1})	**Gross return (NRs. '000 ha^{-1})**	**Net return (NRs. '000 ha^{-1})**	**B:C ratio**
Copping systems					
Rice-wheat	8.61^{b}	171.09	232.40^{b}	61.31	1.36
Rice-maize	12.21^{a}	183.71	329.77^{a}	146.07	1.81
SEm (±)	1.80		48.68	423.79	0.22
LSD (=0.05)	3.47		93.81	ns	ns
CV, %	26.90		26.90	72.90	26.30
Establishment methods					
CT Dry DSR fb ZT wheat/ZT maize	10.12	168.68	273.20	104.52	1.62
Pu-TPR fb CT wheat/ CT maize	10.70	186.12	288.97	102.85	1.55
SEm (±)	0.29		7.89	0.84	0.04
LSD (=0.05)	ns		ns	ns	ns
CV, %	8.00		8.00	21.70	8.10
Nutrient management practices					
100% RDF	9.99	169.39	269.63	100.24^{ab}	1.59^{b}
RR#+75% RDF	10.53	183.32	284.27	100.95^{ab}	1.55^{b}
NE dose	10.99	170.52	296.83	126.32^{a}	1.74^{a}
RR@+75% RDF	10.13	186.37	273.61	87.24^{b}	1.46^{b}
SEm (±)	0.23		6.09	8.17	0.06
LSD (=0.05)	ns		ns	26.36	0.14
CV, %	11.10		11.10	30.20	10.80
Grand mean	10.41	177.40	281.09	103.69	1.58

Note: RR#, residue retention (10t ha^{-1}); RR@, residue retention (green or brown manuring @ 60 kg Sesbania ha^{-1} followed by residue @ 3.5 t ha^{-1}); RDF, recommended dose of fertilizers (150:45:45 kg N, P_2O_5 and K_2O per ha^{-1}; 80:60:40 kg N, P_2O_5 and K_2O per ha^{-1}; 180:90:60 kg N, P_2O_5 and K_2O per ha^{-1} for rice, wheat and maize respectively); nutrient expert, (140:56:53 kg N, P_2O_5 and K_2O per ha^{-1}; 140:60:45 kg N, P_2O_5 and K_2O per ha^{-1}; 150:50:90 kg N, P_2O_5 and K_2O per ha^{-1} for rice, wheat and maize respectively); DAS, days after sowing. Same letter(s) within column represent non-significant difference at 0.05 level of significance based on Duncan multiple range test.

Rice-wheat cropping system is the most practiced system in the IGP (Kumar &Ladha, 2011) and rice-maize system has emerged as a pre-dominant option for diversification of existing rice-based cropping systems in Asia (Singh et al., 2016). Based on the various its evident that these cereals are cultivated under intensive tillage, receive most of the irrigation and consequent to the increased production cost, yield penalties due to late planting and deterioration of soil properties (Ladha et al., 2003).In the present experiment, the rice equivalent yield (REY) of rice-maize cropping system (12.21 t ha^{-1}) was 41.81% more than the yield rice-wheat cropping system (8.61t ha^{-1}) (table 33). The higher REY of rice-maize cropping system was due to the increased yield of maize than wheat under both establishment methods. The higher yield of maize was due to the suitable meteorological conditions compared to wheat. The average maximum temperature was 26.06˚C which was higher than optimum temperature (< 25˚C) and total rainfall during wheat period was 59 mm which was also less than the optimum (63-87mm) rainfall resulting in the forced maturity of crops ensuing lower yield. But the temperature (31.05 ˚C) and rainfall of 37.6mm during March and 125.3mm during April coincided with the tasseling, silking and grain filling stage of the maize crop which also resulted in the improved yield of maize over wheat. Along with the meteorological advantages, maize being C_4crop is more efficient in carbon assimilation even at higher temperature(Steven & Salvucci, 2002) and the heterogeneous genetic combination of maize attributed to higher yield of maize. Hence, the yield of rice-maize cropping system was more than rice-wheat system. The REY of the system under CA was less (10.12t ha^{-1}) compared to 10.70 t ha^{-1} yield under conventional system, however, the difference was not statistically significant. The higher yield of the system under conventional system is due to the higher yield of rice and wheat under conventional system. Rice and wheat yielded 14.28% and 8.90% less yield under CA than conventional agriculture and hence the system yield under conventional system was more. The reasons behind the lower yield of component crops of the system under CA and nutrient management practices are explained later with literature supports.

The average total system cost of production was NRs. 177399.70 ha^{-1}. The rice-maize system was found to be NRs.12610.86 more costly than rice-wheat system and the total system cost of production under Pu-TPR fb CT-wheat/maize was NRs.17447.30 ha^{-1} more than that under CT-dry DSR fb ZT-wheat/maize (Table 2). The highest system cost of production was under residue$^{@}$ + 75% RDF followed by residue$^{\#}$ + 75% RDF and minimum cost was incurred in 100% RDF. The highest cost under residue$^{@}$ + 75% RDF and residue$^{\#}$ + 75% RDF was due to higher cost of *Sesbania* and residues applied for the treatments. The system gross return was significantly influenced by the cropping system but not by the establishment methods and nutrient management practices (Table 2).The rice-maize system gave NRs. 97383.67 more revenue than rice-wheat system forms a hectare. The average B:C ratio of the cropping system was 1.58 with rice-maize cropping system and CT-dry DSR fb ZT-wheat/maize being more profitable in terms of B:C ratio compared to rice-wheat system and Pu-TPR fb CT-wheat/maize(Table 2). However, the difference among the B:C ratio is statistically significant for different nutrient management practices. Highest B:C ratio (1.74) was found under NE dose whereas the remaining nutrient management practices had lower B:C ratio but were statistically at par among themselves.

The higher cost of cultivation was incurred in all the crops viz. rice, wheat and maize under conventional agriculture compared to CA. Rice under conventional agriculture required more cost for nursery preparation, and 46.67% of the total cost of production was incurred for labor which was about 18% more than labor requirement under CA**.** Similar results were found by (Kumar & Batra, 2017)**.** Moreover, the cost of herbicide used in rice under CA was 193% more than conventional agriculture. Similarly, more cost for machinery and labor was required under conventional agriculture for the production of both wheat and maize whereas more cost for herbicides and labor for seed sowing under CA were required for wheat and maize and the cost for seed, fertilizers and intercultural operations remained similar which was also explained by (Leghari, Mirjat, Qadir Mughal, Rajpar & Magsi, 2015). The similar explanations of higher cost of tillage under conventional agriculture and cost reduction under CA were also given by Kumar et al. (2015),Tripathi (2010) and Lales et al. (2008) etc. Under nutrient management practices, the cost of rice production was more for GM/BM+75% RDF. Despite using 25% less fertilizers, the highest cost under this was due to the added cost of *Dhaincha*, its' sowing and knocking down / incorporating. Likewise, for wheat and maize, highest cost was incurred under $RR^{\#}$+75% RDF followed by $RR^{@}$+75% RDF which was due to the higher cost of rice residues (a valuable livestock feed) applied/left under the treatment which constitutes 26.73% and 18.71% of average cost of wheat production and 22.26% and 15.58% of average cost of maize production under the respective treatments.

Rice-maize cropping system was most profitable under both CA and conventional agriculture than rice- wheat system which was due to the fact of lower cost of production under CA and higher REY of maize compared to wheat and similar explanations were given by Kumar et al. (2018)**.** The rice-maize system net return was 138% more than that under rice-wheat cropping system. The cropping systems were profitable under CA due to the lower cost of production. The maximum net return of system and B:C ratio under NE dose was due to the superior performance of component crops under that nutrient management and hence was the best nutrient management practice. The better performance of NE dose assisted fertilizer management in major cereals were also agreed by Dahal et al. (2018) and Gupta.

EFFECT OF RICE ESTABLISHMENT METHODS ON YIELD OF RICE AND SUCCEEDING NON-RICE CROP

The grain yield of CT-DSR (5.28 t ha^{-1}) was significantly higher than puddled TPR (4.62 t ha^{-1}). (Figure 2a) While the effect of rice establishment methods on the yield of maize and wheat was not significantly influenced (Figure 2a). The yield under conventional tillage and zero tillage were also statistically similar for both wheat and maize (Figure 2b)

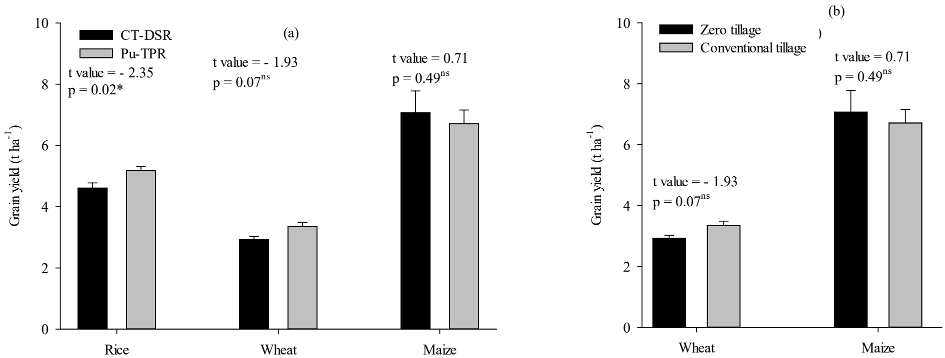
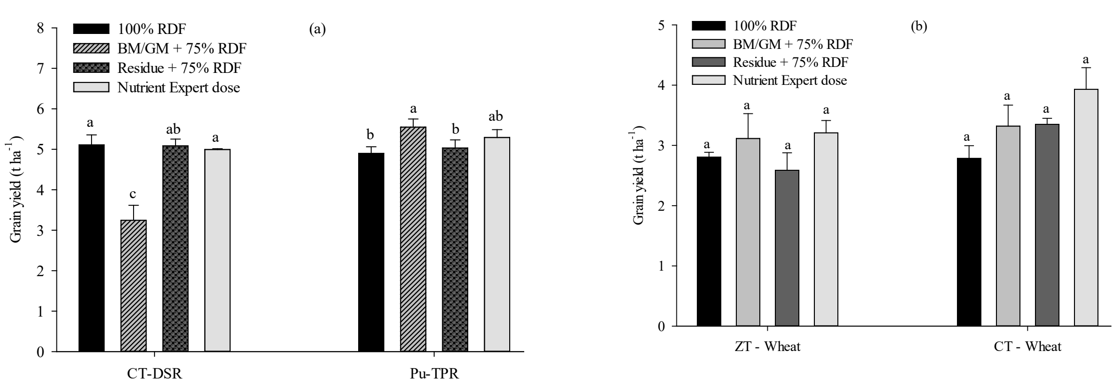


Figure 2. (a) Effect of rice establishment methods to the grain yield of rice, wheat and maize, (b) effect of tillage methods to the grain yield of wheat and maize at Rampur, Chitwan, 2018-19

NUTRIENT MANAGEMENT PRACTICES ACROSS THE DIFFERENT CROP ESTABLISHMENT METHODS

Overall, the maximum grain yield was found in GM + 75% RDF for conventional agriculture followed by NE dose and residue + 75% RDF treated plots under CA. Under CA, 100% RDF, NE dose and residue + 75% RDF had statistically similar grain yield and higher than the BM + 75% RDF and for conventional agriculture GM + 75% RDF had maximum grain yield which was statistically at par with that of NE dose treated plots. Among 100% RDF and residue + 75% RDF and NE dose were statistically at par for grain yield. The wheat grain yield under conventional tillage (3.31 kg ha^{-1}) was relatively higher than zero tillage (2.97 t ha^{-1}). The wheat grain yield for NE dose (3.43 t ha^{-1}) was the highest among the nutrient management practices followed by residue[@] + 75% RDF (3.28 t ha^{-1}), residue[#] + 75% RDF (3.02 t ha^{-1}) and 100% RDF (2.84 t ha^{-1}). In response to nutrient management practices, the maize grain yield for NE dose (6.44 t ha^{-1}) was the highest among the nutrient management practices followed by residue[@] + 75% RDF (6.25 t ha^{-1}) residue[#] + 75% RDF (6.24 t ha^{-1}) and 100% RDF (5.47 t ha^{-1}) where the differences were not significant.



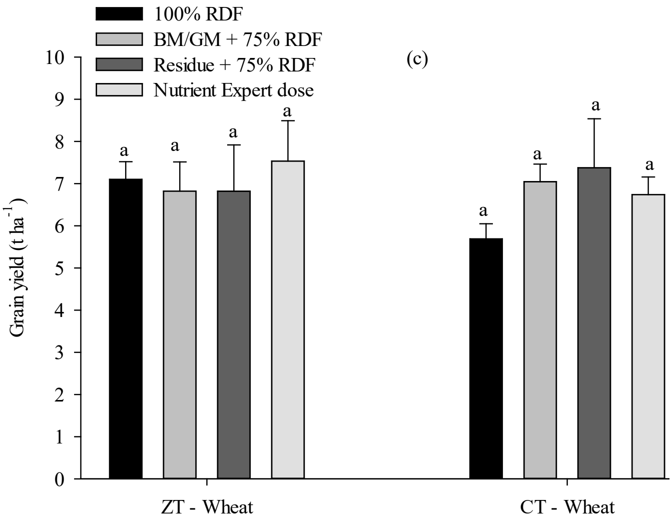


Figure 3. Interaction of establishment methods and nutrient management practice on (a) rice, (b) wheat, and (c) maize at Rampur, Chitwan, 2018-19

Note: Residue, residue retention (5 t ha^{-1}); RDF, recommended dose of fertilizer (150:45:45 kg N, P_2O_5, K_2O ha^{-1}); GM, green manuring (60 kg *Sesbania* ha^{-1}); BM, brown manuring (60 kg *Sesbania* ha^{-1}); DAS, days after sowing. Same letter(s) represent non-significant difference at 0.05 level of significance based on Duncan multiple range test. The nutrient expert dose used was 140:56:53 kg N, P_2O_5, K_2O ha^{-1}).

CONCLUSION

Rice-maize cropping system was more productive and profitable than rice-maize cropping system but the rice based cropping systems were similar in terms of productivity and profitability under both CA and conventional agriculture. Rice under CA was less productive but the profitability was similar under both establishment methods whereas wheat and maize were indifferent in terms of productivity and profitability under both CA and conventional agriculture. Nutrient expert model was found to be the best nutrient management practice for all crops for both CA and conventional agriculture whereas for TPR, green manuring was found equally efficient, nevertheless, for wheat and maize, residue retention in brown and green manure field was found better nutrient management practices under both establishment methods.

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MAJOR CEREAL CROPS DAMAGE BY WILDLIFE: A CASE STUDY FROM CHITWAN NATIONAL PARK, NEPAL

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ABSTRACT

Human-wildlife conflict is a major issue for policymakers and conservationists due to economic damage by wild animals, resulting in increasing poverty. This study assesses the wildlife-induced damage to the major food crops viz. rice, wheat, and maize. A total of 434 households from the 10 forest user groups near the Chitwan national parks and buffer zone were randomly selected and interviewed by the use of questionnaires in 2021. A total of 87.86% of rice-growing households reported damage to rice, whereas 90.32% and 87.68% of households reported damage to wheat and maize, respectively. The annual loss of 78 kg of rice per household (NRs. 1776 at prevailing market rates) was reported in the study area. The loss of wheat and maize per household was 86 and 96 kg with the worth of NRs. 2523 and 2019, respectively. The severity of wildlife-induced damage to crops was more near the borders of national parks and buffer zone. Apart from the construction and maintaining permanent fences on the border of the national parks, there should be the provision of conservation education to communities residing along the buffer zone and near the protected areas to practice sustainable agriculture and income-generating programs that are conservation-friendly.

Keywords: Chitwan national park, Crop damage, Human-wildlife conflict,

INTRODUCTION

A protected area is defined as the geographical space that is recognized, dedicated, and managed through the legal and other effective means to achieve the long-term conservation of nature with associated ecosystem services and cultural values (IUCN, 2008). Protected areas include national parks, wilderness areas, community conserved areas, and nature reserves, and these are the mainstay of biodiversity conservation, while also contributing to people's livelihoods, particularly at the local level (https://www.iucn.org/). Besides conserving nature, protected areas provide food, clean water supply, and medicines, and mitigate natural disasters (Lopoukhine et al., 2012). Protected areas often occur in areas of high human population density (Kideghesho, Nyahongo, Hassan, Tarimo, & Mbije, 2006; Msoffe et al., 2007). Wildlife and people around have co-existed for many years, usually with a certain level of conflict (Woodrofee, Thirgood, & Rabinowitz, 2005; Dickman, Macdonald, & Macdonald, 2011). In recent years, the conflict has increased, particularly in developing countries, mainly due to increasing human and livestock populations and changing socio-economic and land use patterns (Gemeda & Meles, 2018). Human-wildlife conflict occurs when the wildlife's requirements

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overlap with those of human populations. Direct contact with wildlife occurs in both urban and rural areas, but it is generally more common inside and around protected areas, where wildlife population density is higher and animals often stray into adjacent cultivated fields or grazing areas. Communities bordering protected areas may suffer the loss of economic opportunities, including exclusion from potential resources as well as damage and depredation to crops and livestock by wild animals (Holmern, Nyahongo, & Roskaft, 2007).

The buffer zone concept was developed by United Nations Organization for Education, Science and Culture (UNESCO) to provide an additional layer of protection around protected areas as well as to balance the development needs of the local people and conservation objectives of protected areas (Bajracharya, 2009). The creation of buffer areas encourages both sustainable uses of forest resources from the protected areas and public participation in protected areas management through decentralization of natural resource use along with financial and technical support to the user groups (Wells & Brandon, 1993). This opportunity to meet the dual goals of conservation of protected areas and livelihood improvement (Parker & Thapa, 2012). In Nepal, the buffer zone concept has been adopted as a national strategy to address the issues between national parks and adjacent communities to ensure an optimal balance between the long-term conservation objectives and the immediate needs of residents (DNPWC, 1996). The major goal of the buffer zone program is to involve local communities in nature and wildlife conservation so as for improving the management of the natural resources, and ecological conditions in the buffer zones. The buffer zone areas serve to increase access to natural resources (e.g., non-timber forest products) to be sustainably harvested by the communities that reside within it, thereby reducing the pressure on the core protected areas. Legislation has provided for benefits sharing mechanisms for the implementation of conservation and community development programs related to institutional development, alternative natural resource development, capacity building, financial management, conservation education, and awareness, and gender and special target group mainstreaming (MoEF, 2018).

Chitwan National Park (CNP) is also home to many globally significant, rare, and endangered wild animals such as the Greater One-horned Rhinoceros, Asian elephants, Bengal Tiger (*Panthera tigris tigris*), and Gharial (*Gavialis gangeticus*). CNP is one of the most threatened national parks in Nepal (The Himalayan Times, 2021). The CNP buffer zone program started in 1996 with an area of 75,000 hectares (ha) spread out to three districts. It is essentially an impact zone intended to reduce the pressure of local people on the Park and vice versa (DNPWC, 2012b). The buffer zone area has increasing population density and similar projections in the future also; resulting in the human-wildlife conflict. Dense human populations in close vicinity to nature reserves seem to pose the greatest challenges in many countries (Western, 1989). The people-park conflict had also been an ongoing issue due to the wildlife impacts in adjacent communities. Also, local community members had continued to ignore regulations and were engaged in extractive behaviors as well as grazing their cattle inside the park (Nepal & Weber, 1995; Sharma, 1991). Competition between rural communities and wild animals over natural resources is more intense in developing countries, where local human populations tend to suffer higher costs. Considering the current human population growth rate, increasing demand for resources, and the growing demand for access to land, it is clear that human-wildlife conflicts will still be a challenge soon.

Human-wildlife conflict (WHC) has both direct and indirect costs for human beings. Destruction and loss of food crops, livestock depredation, and human harassment are direct costs of human-wildlife conflict. Wildlife is often seen by the local people as belonging to the government; as they alone seem to be responsible for its care (Mekonen, 2020). Wildlife agencies emphasize law enforcement, administrative procedure, and conservation education but cannot contain or fully control wildlife damage and destruction. Conflicts become more intense where livestock holdings and agriculture are an important part of rural livelihoods. Human activities such as expansions of settlements, cultivation, overgrazing, bushfire, and deforestation reduce wildlife habitats thus forcing wild animals such as elephants to enter the croplands causing trampling and destruction of crops in the farm (Galanti, Preatoni, Martinoti, Wauters, & Tosi, 2006; Roskaft, Larsen, Mojaphoko, Sarker, & Jackson, 2013). To control human-wildlife conflict the first approach should be to understand the negative impacts of wild animals on humans (Mekonen, 2020). This study aimed to document these negative impacts in terms of crop destructions in the periphery of Chitwan National Park. Understanding the negative impacts of wildlife on humans should assist the concerned wildlife departments and different stakeholders in proposing short-term and long-term management strategies for sustainable management of the ever prevailing wildlife-human population conflict.

METHODOLOGY

SITE SELECTION

The study was carried out in the buffer zones of Chitwan National Park in Southern-central Nepal (Figure 1). The buffer zone of the Chitwan National Park extends over Chitwan, Nawalparasi, Parsa, and Makawanpur districts and covers 750 km^2. A total of 223,260 people reside there in 36,193 households (DNPWC, 2012a). The human population in this buffer zone comprises 260,352 people, in 45,616 households (CNPO, 2012). The buffer zone is a legally delineated area surrounding national parks or reserves to provide forest resources to local people. It is essentially an impact zone intended to reduce the pressure of local people on the Park and vice versa (DNPWC, 2012b). The map of Nepal showing the study area is given in Figure 1.

Figure 1: Locations of the buffer zones (study area) of Chitwan National Park, Nepal.

SAMPLING TECHNIQUE AND SAMPLE SIZE

To achieve the objectives of the study, the target population comprised the households living adjacent to the national park. The study population covered a total of 45,616 households adjacent to the Park (buffer zone area). The sample size was determined by using the following formula given by Kothari (2004) at a 95% confidence level. Sample size (n):

$$\text{Sample size (n)} = \frac{N \ . \ Z^2 \ . \ p \ \cdot \ q}{e^2 \ . \ (N-1) \ + \ Z^2 \ . \ p \ \cdot \ q}$$

Where, N = population size (household number in buffer zone = 45,616)

z = standard variate at a 95% confidence level (1.96)

e = error limit of 5% (0.05)

p = sample proportion (value of 0.5 in which case 'n' was the maximum and the sample yield at least the desired precision)

q = 1 – p (0.5)

$$n = \frac{45{,}616 \ x \ (1.96)^2 \ x \ 0.5 \ x \ 0.5}{0.05^2 \ x \ (45{,}616-1) + (1.96)^2 \ x \ 0.5 \ x \ 0.5} = 381$$

The average response rate is 85% (Ary et al., 1996; Gall et al., 1996; Tuckman, 1999). Thus, an assumption was made that 15% of the respondent would not be able to complete the survey, so the addition of a 15% resulted in 434 sample size. From the secondary source, the total number of conflicts recorded in the different forest users' groups in the last four years, the top ten forest user groups were selected. Based on the total number of conflicts that occurred in the last four years the number of samples in each forest user group was estimated and shown in Table 1. In each forest user group, the communities near the national parks were purposively selected and simple random sampling was administered in that area.

Table 1: Top ten committees based on the number of human-wildlife conflicts (HWC) encounters in the last four years and the number of samples from respective forest user groups

S.N.	Forest user groups	No of conflict	Address	Number of samples	Sector
1	Ayodhyapuri	330	Ayodhyapuri-1*, 6, 7, 8, Madi 7, 8, 9, 10*, 11, 12	155	Madi
2	Rewa	101	Madi-6, 7*, 8, 9; Kalyanpur 3, 4, 5, 7, 8, 9*	50	Madi
3	Panchpandab	78	Gardi 1*, 2, 4, 7 Madi 1*	40	Madi
4	Mriga Kunja	70	Ratnanagar-5*, 6, 7*, 8, 9, 17, 18, Bachhyauli-2	34	Sauraha
5	Barandabhar	64	Gitanagar 4, 6, Bharatpur 6, 8*,13, 20, 21*	32	Kasara
6	Nirmal Thori	59	Nirmal Basti 1, 2*, 3, 7, Thori 8	30	Madi
7	Meghauli	46	Narayani 1, 2, 3, Bharatpur 27, 28	25	Kasara
8	Baghauda	34	Bagauda 2, 4 Madi 3, 5	18	Madi
9	Kerunga	32	Bharatpur 23, 24, Jagatpur 1, 9, Narayani 10, 11	15	Kasara
10	Lamichaur	27	Pithauli 4, Kawasoti 11, 13	35	Amaltari
	Total			434	

* Highly conflict-affected ward

METHOD OF DATA COLLECTION

Based on records from the Parks, and in consultation with the Park staff, first, identified the affected settlements (affected by the damage from wild animals within the previous 5 years), and face-to-face interviews were conducted with the head of the households (as possible) with the help of a semi-structured questionnaire. The questionnaires were first designed and pretested to 20 households of Bharatpur Metropolitan – 8, Gaurigunj Chitwan and necessary moderation was done. Data were collected regarding the nature and extent of the damage.

METHODS OF DATA ANALYSIS

To curb these illegal activities more effectively and efficiently, the CNP is divided into four sectors and the area of responsibility assigned, i.e., Sauraha, Kasara, Madi, and Amaltari. Based on this forest users' groups were grouped into four sectors (Table 1). After the collection of primary data, it was coded and entered in Microsoft Excel, and analysis was done by using the Statistical Packages for Social Sciences (SPSS). Mean, frequency and percentage were computed using descriptive statistics.

RESULTS AND DISCUSSION

The data on the loss due to wildlife on humans and properties being collected came from the victims through the CNP authorities and the buffer zone user committee (BZUC) covering the period from the year 1998 to 2018. The people started to report the loss of wildlife (primarily attacks on human and livestock depredation) to the BZUCs following the relief scheme for wildlife victims that started in 1999 along with the implementation of the Buffer Zone Program (GoN, 1996; CNP, 2015). The wildlife victims in the BZ self-reported the incidents through written applications to the local authorities (CNP or BZUC) primarily to claim compensation (only partial cost). The conflict incidents were verified by the BZUC and subsequently, relief was released as per the guidelines. These data on relief application and distribution were maintained in the registers by BZUCs between 1998 and 2009. The government endorsed the relief guideline for wildlife losses in 2009 and designated respective protected areas or district forest offices for relief distribution (Acharya, Poudel, Neupane, & Kohl, 2016). Thus, CNP started to process and verify the relief applications from 2009 onwards. We compiled all the relief applications of wildlife victims reported to both BZUCs and CNP during the last 20 years (1998 to 2018). The data were managed according to the Nepalese fiscal year which runs from mid-July to mid-July based on the Nepalese Calendar (Bikram Sambat). For the consistency of the data for time series analysis, we used these fiscal years. The trend of the total number of damage was found to be slightly increasing over time (Figure 2).

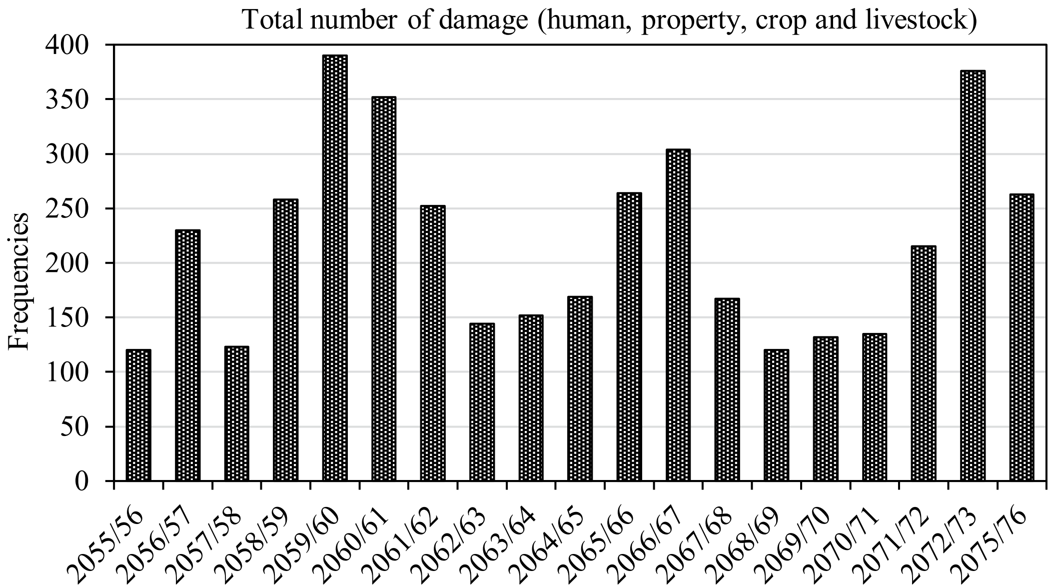

Figure 2: Frequency of total damage due to wild-life conflict around Chitwan National Park

The pattern of HWC in the BZUCs of the CNP revealed that livestock predation is the most common type of harm caused by wild animals in the study area followed by crop damage and human injured (Figure 3). Rhino, Wild boars and elephants were the most conflicting animal from the perspective of crop damage (Figure 4), which is similar to the finding of Sukumar (1994). The damage by wild boar is probably the most widespread because of its availability in almost all forested habitats including highly degraded and fragmented ones (Subedi, Joshi, Poudel, & Lamichhane, 2020). Dangol, Ghimire, & Bhattarai (2020) reported that elephants raid cropland because natural food in the forest is demanding as a result of increasing human encroachment and settlement near the forest. Most parts of the Terai of Nepal were uninhabited by humans until the 1950s due to malaria; but after the eradication of malaria and government resettlement programs in the 1950s, there was a rapid human footprint (Pradhan et al., 2011). Hence, encroachment of elephant habitat by humans resulting in increased croplands with palatable food near forest areas is one of the precursors of increased crop raiding. According to Shrestha (2007), Pradhan et al. (2011), and Neupane et al. (2013), the rate of human-wildlife conflict incidents in Nepal is increasing. Human-elephant conflict incidents in Asian countries such as Sri Lanka, Myanmar, and China is increasing both in extent and intensity (Perera, 2009; Fernando et al., 2011; Zhang, 2011; Das & Mrinmay, 2020; Prakash et al., 2020). Elephants are becoming more habituated to conflict as a result, they frequently raid crops and show more aggressive behavior (Fernando et al., 2011; Das & Mrinmay 2020). As identified by Nepal and Weber (1995) crop damage and threats to human and animal life by wildlife from the park are two of the five major causes of park-people conflict in Chitwan National Park. These animals are regarded as a destructive raiders and prefer crops such as maize, rice, wheat, mustard, and vegetables resulting in substantial losses to the local farmers. Rhino, wild boar, elephant, and deer are the main crop raiders in the study area. Crop damages by the rhinos are a major source of conflict between farmers and wildlife in communities that surround Chitwan National Park (Bailey, 2011).

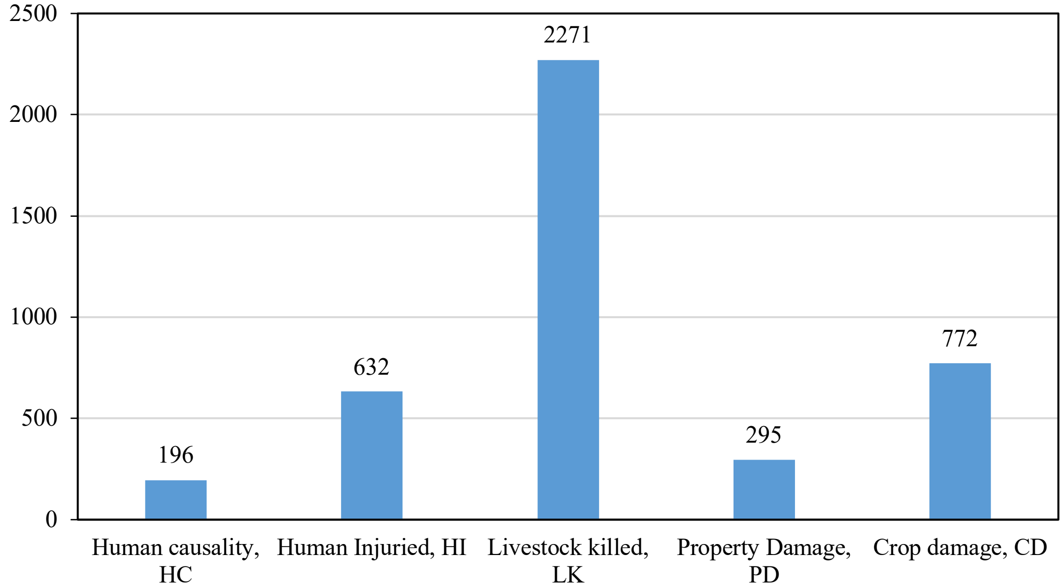

Figure 3: Total frequency of different types of wild-life conflict in the last 20 years around Chitwan National Park

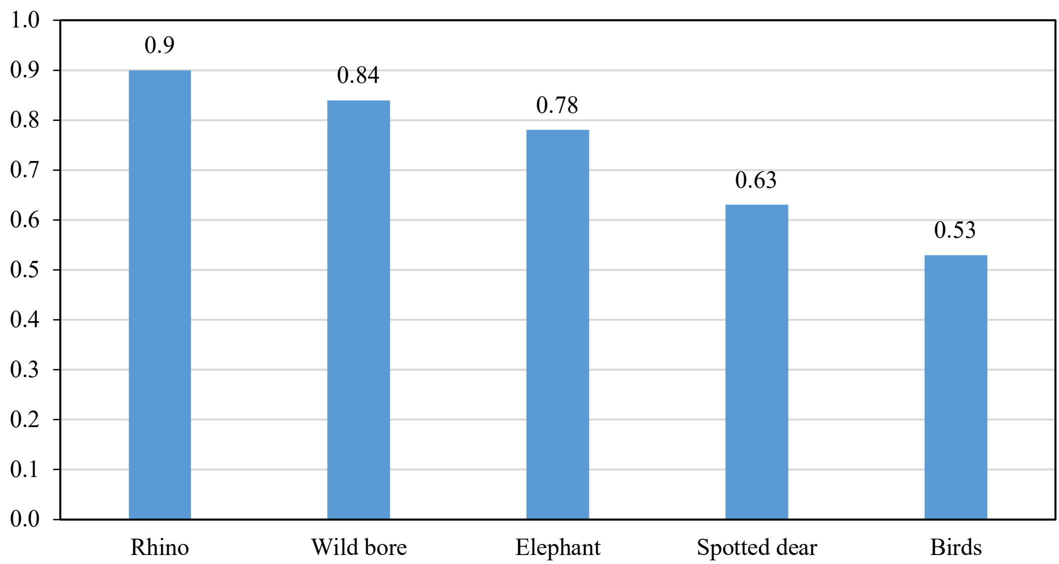

Figure 4: Ranking of wildlife for crop damage

CROP DAMAGE

A total of 369 households reported that the rice crop was damaged by the wildlife (excluding the birds) in a significant amount, whereas 90.32% of wheat growers and 87.68% of maize growers reported the damage during the household survey (Table 2, 3, and 4). All the respondents (100%) from Amaltari reported the rice crop damage by the wildlife, whereas 83.16% from the Madi sector reported the rice damage (Table 2). More than 95% of surveyed households reported their rice crop being damaged. Out of 13.12 kattha rice cultivation, 3.21 kattha was damaged by the wildlife with an average proportion of damage of 25.74%. The damage proportion of rice was the highest (38.72%) in the Sauraha sector and the least in the Madi sector (22.09%). The low proportion of damage from the Madi sector was due to the large area of field crops allocated for cultivation. The Rhino is often regarded as the most destructive raider (Uprety, 1995) and prefers crops such as maize, rice, vegetables, and mustard resulting in substantial losses to the local farmers (Studsrod & Wegge, 1995).

Table 2: Rice damage by wildlife among the sample households (n=434)

Sectors	HH report damage		Average area (kattha/HH)		Average production		Proportion of damage (%)	Damage amount	
	F	P	Overall	Damage	kg/kattha	kg/HH		Volume (kg/HH)	Value (NRs./HH)$
Amaltari (n=35)#	35	100	9.50	3.66	120	1142	33.99	172	3,958
Kasara (n=68)	65	95.59	10.43	2.66	124	1298	28.22	101	2,517
Madi (n=285)	237	83.16	14.65	3.17	77	1135	22.09	57	1,253
Sauraha (n=33)	32	96.97	9.24	4.16	113	1045	38.72	221	5,736
Total (421)	369	87.65	13.12	3.21	88	1155	25.74	78	1,776

Note: HH, household; F., frequency; P., percentage; # household report rice cultivation; 1 kattha = 0.033 hectares; $ Rice price depends on the area, on an average 1 kg rice priced NRs. 23 at Amaltari, 25 at Kasara, 22 at Madi and 26 at Sauraha

The data presented in Table 3 shows that all the respondents (100%) from the Sauraha area reported the wheat crop damage by the wildlife, whereas 80.00% from the Kasara sector reported the wheat damage. None of the respondents cultivated the wheat crop in the Amaltari sector. More than 90% of surveyed households reported their wheat crop damage. Out of 8.31 kattha rice cultivation, 3.14 kattha was damaged by the wildlife with an average proportion of damage of 41.27%. The highest area (3.25 kattha/HH) of the maize crop was from the Kasara sector. The damage proportion of wheat was the highest (50.00%) in the Sauraha sector and the least in the Kasara sector (32.28%). On average 86 kg wheat/HH in terms of grains was damaged by the wildlife with a worth of NRs. 2583 per household. At the prevailing market price, the highest damage (NRs. 2597/HH) of wheat was reported from the Madi and the least damage (NRs. 2030/HH) was from the Sauraha sector.

Table 3: Wheat crop damage by wildlife among the sample households (n=434)

Sectors	HH report damage		Average area (kattha/HH)		Average production		Proportion of damage (%)	Damage amount	
	F	P	Overall	Damage	kg/ kattha	kg/HH		Volume (kg/HH)	Value (NRs./HH)$
Amaltari (n=0)#	-	-	-	-	-	-	-	-	-
Kasara (n=5)	4	80.00	12.80	3.25	64	820	32.28	73	2,196
Madi (n=86)	78	90.70	8.17	3.17	55	451	41.50	87	2,597
Sauraha (n=2)	2	100.00	3.00	1.50	68	203	50.00	68	2,030
Total (93)	84	90.32	8.31	3.14	56	466	41.27	86	2,583

Note: HH, household; F., frequency; P., percentage; # household report wheat cultivation; $ On an average 1 kg rice priced NRs. 30

More than 90% of respondents from Sauraha, Kasara, and Amaltari reported the maize crop damage by the wildlife whereas comparatively lower (92.86%) from the Madi sector reported the maize damage (Table 4). Out of 8.94 kattha maize cultivation, 3.94 kattha was damaged by the wildlife with an average proportion of damage of 40.45%. The damage proportion of rice was the highest (52.72%) in the Kasara sector and the least in the Madi sector (38.12%). On average 96 kg maize/HH in terms of grains was damaged by the wildlife with a worth of NRs. 2019 per household. At the prevailing market price, the highest damage to maize was recorded from the Kasara (NRs. 4266/HH) and the least on the Sauraha (NRs. 1555/HH).

Table 4: Maize crop damage by wildlife among the sample households (n=434)

Sectors	HH report damage		Average area (kattha/HH)		Average production		Proportion of damage (%)	Damage amount	
	F	P	Overall	Damage	kg/ kattha	kg/HH		Volume (kg/HH)	Value (NRs./HH)$
Amaltari (n=28)#	26	92.86	7.64	3.33	81	616	29.60	91	2,004
Kasara (n=57)	53	92.98	8.51	4.73	53	448	52.72	185	4,266
Madi (n=169)	141	83.43	9.71	3.97	44	429	38.12	79	1,585
Sauraha (n=30)	29	96.67	6.62	2.87	50	332	39.05	68	1,555
Total (284)	249	87.68	8.94	3.94	49	441	40.45	96	2,019

Note: HH, household; F., frequency; P., percentage; # household report maize cultivation; $ Maize price depends on the area, on an average 1 kg rice priced NRs. 22 at Amaltari, 23 at Kasara, 20 at Madi and 23 at Sauraha.

CONCLUSION

There were negative interactions between the wildlife and local communities; there was increased crop damage and the wildlife induced-damage. The major problematic animals in the study area are rhinos, wild boars, elephants, spotted deer, and birds. Almost all (87.65-90.32%) people are suffering from crop and livestock as well as poultry loss damage. The average loss from crop damage was 78 kg rice/HH (worth of NRs. 1776), 86 kg wheat/HH (NRs. 2583/HH), and 96 kg maize/HH (NRs. 2019/HH). Thus, there should be the provision of conservation extension educational activities to communities adjoining protected areas to practice sustainable agriculture and income-generating programs that are conservation-friendly.

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PERFORMANCE EVALUATION OF CAULIFLOWER CULTIVARS IN MID-HILLS OF NEPAL FOR WINTER SEASON PRODUCTION

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ABSTRACT

Cauliflower (Brassica Oleracea botrytis) is one of the most popular and demanded vegetables in Nepal. Five cultivars: Barkha, Girija, Giewont, Whistler and Snow Mystique were transplanted in the first week of October 2016 and 2017 in the mid-hills (Kathmandu valley, 1300 masl) and grown during the winter season with 60X45 cm spacing. Source seed of Snow Mystique was Takii Seed Japan and the rest were Montsanto Seed, India. Crops were fertilized with 200:120:80N.P.K Kg/ha and 15-ton FYM/ha. Insecticide and fungicide were sprayed one time in the early period for crop establishment. The main objective of this experiment was to find out suitable high yielding and insect pest and disease tolerant hybrid cauliflower cultivars for commercial farming in the mid-hills of Nepal. Crops were evaluated with their vegetative, insect pest and disease, yield and farmers' and consumers' response in two consecutive years. Results showed that among the tested cultivars, Barkha was found to be highly uniform, vigorous, less attacked by insect pests and disease, early harvestable (62.7 days after transplanting), efficient per day yield (487.7 kg/ha), preferable average head weight (1039 g), freshness (4.3) and market preference (4.0) as compared to check variety Snow Mystique. On the other hand, Snow Mystique has only yield efficiency (436.2 kg/ha/day), greater insect damage and leaf spot disease, longer days to harvest (101 days), and freshness (3.8), respectively. Hence, Barkha has been selected and recommended for commercial cultivation in the mid-hills of Nepal.

Keywords: Cauliflower, Hybrid cultivars, Insect pest and disease, Mid-hills, Yield

INTRODUCTION

Cauliflower (*Brassica oleracea* Botrytis) is one of the popular vegetables of commercial crops globally because of its wider adaptability to climatic conditions and soil types, ease of production and storage, and its food value. Commercial cultivation of cauliflower is very common due to high market demand. Cauliflower can be cultivated throughout the year if appropriate varieties are selected and planted. It favors a cold climate and soil pH with 5.5 to 6.5. It is grown throughout the country from Terai (plain area) to high hills but planting time might be different. It is a cold season crop and generally cultivated during the winter season. Cauliflower belongs to Brassicaceae family and basically grown with seeds. The white part of the flower is used for culinary purpose. The stalk and surrounding thick, green leaves are used in vegetable broth or can be fed as fodder for livestock. Surrounding the curd are ribbed, coarse green leaves that protect it from sunlight, impeding the development of chlorophyll. The cauliflowers are attached to a central stalk.

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Cauliflower crop is very sensitive to soil and climatic requirement (Nath el al. 1987). Based on climatic requirements and maturity, cauliflower is divided into three types; early maturity, medium maturity and late maturity. Early maturing varieties need long days and warm temperatures, whereas late-maturing varieties can with stand late in the season. Cauliflower varieties are classified based on optimum temperature for curd initiation and availability period viz, early (20-27^0 C and September-October), mid-early (20-25^0 C and October-November), mid-late (16-18^0 C and November-December), and late (12-16^0 C and December-January) (Thamburaj and Sing, 1998). Seedlings are prepared in the nursery and transplanted for crop production. Cauliflower is cultivated in 34,967 ha with a production of 531,944 mt and 15.2 mt/ha productivity in Nepal and ranks first on the basis of area coverage (MOAD, 2016). In terms of sales, the most common commercial vegetables are cauliflower, cabbage and tomato, respectively (MOAD, 2016).

In recent years, hybrid cauliflower cultivation has been increasing. Due to the availability of heat-tolerant cultivars, cauliflower can be grown in summers as an off-season vegetable. Varieties also differ in temperature requirement for curd initiation (Saini 1990). In the high mountain area with a colder climate, it is grown during spring and summer. Cauliflower contributes positively in humal health. The plant was used for medicinal purposes to treat gout, stomach problems, deafness, headache and hangovers in the early days. Regular consumption of cauliflower reduces certain types of cancer risks. Cauliflower aids in weight loss management and promotes heart health, builds healthy immune system, lowers blood cholesterol levels, detoxifies the body system, and boosts vitamin K and calcium content. Cauliflower is a rich source of minerals and is also good for skin health. Curd is the edible part of the cauliflower, and the major nutrients available are vitamins, protein and minerals. Regular consumption of curds can save from cancers and heart diseases and helps maintain a healthy level of cholesterol and immune system in the human body (Keck, 2004).

The main objective of this experiment is to find out suitable high yielding and insect pest and disease field tolerant hybrid cauliflower cultivars for commercial winter season production in the mid-hills of Nepal.

MATERIALS AND METHODS

Five hybrid cultivars of cauliflower were evaluated at NHRC farm Khumaltar where four hybrid cultivars for testing were collected from Monsanto Holding Pvt. Ltd. India through Nepal Agrocenter Janakpur, and one widely grown cultivar in Nepal (Snow Mystique) collected from the market, as a check variety. Three-week-old seedlings were transplanted in the first week of October in 2016 and 2017 consequent years in mid-hills (Kathmandu valley, 1300 masl) and grown during the winter season with 60X45 cm spacing. One dose of insecticide and fungicide was sprayed during the crop establishment stage. The standard recommended dose of fertilizers (200:120:80 NPK kg/ha + 15 ton FYM/ha) was applied, and pesticide and fungicide were minimized. Plants were top-dressed with urea after 25 days of transplanting. Irrigation was done as needed with pipe irrigation. Vegetative, insect pest and disease, and yield parameter data were recorded during the crop growing season. Insect damages on leaves was scored on 1 to 9 score where 1 is no any damage and 9 is highly damaged. Likewise, leaf spot disease was also recorded on 1 to 9 score where 1 is no any symptom and 9 is dead due to heavily infested. Per day yield efficacy is one of the parameter for the varietal selection that tends to become higher as the earlier and higher yielding varieties. It was calculated by using following formula:

$$\text{Per day yield efficacy} = \frac{\text{Yield kg/ha}}{\text{Days to harvest}}$$

RESULTS AND DISCUSSION

VEGETATIVE PARAMETER

No significant difference was observed in plant uniformity and plant vigor in both the years among the tested varieties. However, cv. Barkha showed more plant uniformity in both the years followed by Snow Mystique. Cumulative plant uniformity mean of the two years was 4.6 score in Barkha and 4.4in Snow Mystique out of 5 score. Giewont had the least plant uniformity (4.1) in both years (4.1) (Table 1). Cumulative mean of plant vigor was highest in Snow Mystique (4.7 score) followed by Barkha (4.5 score out of 5) but not significantly different. In 2017, all the varieties showed vigorous growth in early-stage compared to 2016, but it did not correlate with curd formation (Table 1).

The effect of varieties on plant size was not significant in both the years on its area coverage length. Cv. Girija and Barkha had the longest plant spreading length in 2016 (42 cm) and 2017 (50.6 cm) with a mean 50.6 cm followed by Girija, which had plant length in 2016 (42 cm) and 2017 (50.8 cm) with a mean 46.4 cm. Whistler had the least plant length (41.7 cm) (Table 1). Likewise, the combined mean plant width was widest in Barkha (38 cm), which was 22 cm in 2016 and 54.1 cm in 2017.All the cultivars were more vigorous in 2017 due to timely rainfall. It also reflected in its yield performance; all the cultivars had a better curd yield in 2017 (Table 2).

Plant spreading size was highest with Barkha (50.6x38 cm), followed by Girija (46.4x36.8 cm) and Snow Mystique (46.3x36.7 cm) and least spreading size was with Giewont (40x22 cm) in 2016. It showed that early maturing varieties generally have fast vegetative growth and loose type of curd compared to late maturing varieties.

Table1: Combine mean of plant uniformity and plant vigor of Cauliflower for the 2 year test on Khumaltar (2016 & 2017)

Cultivars	Plant uniformity[x] (1-5)			Plant vigor [x] (1-5)		
Year	2016	2017	C Mean	2016	2017	C Mean
Girija	4.5	4.0	4.3	4.5	4.0	4.3
Barkha	4.5	4.7	4.6	4.5	4.8	4.5
Giewont	4.2	4.0	4.1	4.2	4.3	4.3
Whistler	4.2	4.4	4.3	4.2	4.6	4.4
Snow Mystique	4.5	4.4	4.4	4.7	4.7	4.7
CV%	11.92	11.2	4.81	13.7	9.33	5.57
F-test	ns	ns	ns	ns	ns	ns

[x] 1: unacceptable, 5: excellent

Table 2: Combined mean of plant length and width of hybrid varieties of Cauliflower at Khumaltar (2016 & 2017)

Cultivars		Plant length (cm)			Plant width (cm)	
Year	2016	2017	C Mean	2016	2017	C Mean
Girija	42	50.8	46.4	26	47.6	36.8
Barkha	42	59.2	50.6	22	54.1	38.0
Giewont	40	49.4	44.7	22	48.3	35.1
Whistler	41	42.5	41.7	23	49.9	36.4
Snow Mystique	40	52.7	46.3	23	50.4	36.7
CV%	8.15	10.48	8.88	5.64	13.98	7.21
F-test	ns	ns	ns	*	ns	ns

The longest leaf length (41 cm) was found in Barkha, which was significantly longer than the rest of the cultivars, followed by Girija and Snow Mystique (36.9 cm), but the widest leaf was measured in Girija (23.1 cm) followed by Snow Mystique (22.5 cm) (Table 3).

Table 3: Combined means of leaf length and width of hybrid varieties of Cauliflower at Khumaltar (2017)

Cultivars	Leaf length (cm)	Leaf width (cm)
Year	2017	2017
Girija	36.9	23.1
Barkha	41.0	22.3
Giewont	34.1	21.6
Whistler	37.2	22.4
Snow Mystique	36.9	22.5
CV%	5.52	6.79
F-test	*	ns
LSD (0.05)	3.87	

Plant height up to leaf tip was highest in Whistler and Snow Mystique (48 cm) followed by Barkha (47 cm) whereas plant height up to curd tip was highest in Whistler (23.1 cm) followed by Snow Mystique and Girija (22.3 cm) even though significantly not different. Plant height up to curd top was higher in the year 2017 than in 2016 because of timely rain fall in the second year (Table 4).

Table 4: Plant height (cm) up to leaf tip and up to curd top of hybrid varieties of Cauliflower at Khumaltar

Cultivars	Height upto leaf tip (cm)	Height upto curd top (cm)		
Year	2016	2016	2017	Mean
Girija	46	18	26.6	22.3
Barkha	47	19	24.8	21.9
Giewont	46	16	27.6	21.8
Whistler	48	19	27.2	23.1
Snow Mystique	48	17	27.7	22.3
CV%	6.95	9.3	5.47	7.21
F-test	ns	ns	ns	ns

INSECT AND DISEASE PARAMETER

Insect damage was not significantly different among the cultivars; however, all the tested cultivars were less damaged by an insect (< 2.5 scores) than check Snow Mystique. Leaf spot (*Alternaria cruciferae*) disease was noticed in both years, where Girija and Barkha had significantly lower leaf spots (0.5 and 1.7 score) in 2017 and also had a low cumulative mean (<2.5), whereas Snow Mystique had a 3.0 score. Insect damage was due to the occurrence of an aphid, cabbage butterfly and diamondback moth. (Table 5).

Table 5: Insect and disease parameters of hybrid varieties of Cauliflower at Khumaltar (2016 & 2017)

Cultivars	Insect damage (1-9)			Leaf spot (1-9)		
Year	2016	2017	C Mean	2016	2017	C Mean
Girija	3.7	1.7	2.7	3.2	1.7	2.5
Barkha	3.7	2.3	3.0	3.5	0.5	2.0
Giewont	3.5	1.7	2.6	2.7	2.1	2.4
Whistler	3.5	2.3	2.9	3.2	2.5	2.9
Snow Mystique	3.7	3.0	3.4	3.5	2.5	3.0
CV%	12.51	38.92	12.44	20.45	31.42	27.32
F-test	ns	ns	ns	ns	*	ns
LSD (0.05)					1.104	

YIELD ATTRIBUTING PARAMETER

The day to curd initiation was significantly earlier in Barkha (33 DAT) and Girija (53 DAT), whereas Snow Mystique had 62 DAT. Whistler had late curd initiation (61 DAT) (Table 5). Different varieties have unique genetic characteristics that may cause different duration for curd initiation to the different variety despite the same planting date. These findings were also in line with earlier finding of Pandey *et al.* (1981). Beside this, Barkha had significantly earlier days to harvest (62.7) compared to the rest of all the tested cultivars (Table 6). So, Barkha could fulfill the early market demand of cauliflower with better price opportunity. According to Booij (1990) about 55 % of the variance in the duration of the harvest period of a crop could be explained by the combined effect of variation in the duration of the curd initiation period and temperature during curd growth. Siddikul (2011) reported that days taken for curd maturity of cauliflower were significantly affected by different planting dates and varieties from his experiment. Days taken for marketable curd maturity (days) was 80.50 days in Girija. In this experiment, Girija also had days to marketable curd maturity of 88.7 days, which is quite near.

Likewise, the varietal effect on average curd weight was significant in year 2017,where the cumulative mean was not significantly different. Average curd weight ranged from 1039 g (Barkha) to 1286 g (Giewont) (Table 7). Curd weight for all cultivars was higher in 2017. This might have been due to timely rainfall in the year 2017. However, Barkha had the least average curd weight, 943 g in 2016 and 1135 g in 2017, consumers' preferred size during the early season with high market price. This is because Barkha has high demand and fetches a good market price in the early season. This finding also supports the Sharma *et al.* (2006), who found that different varieties produced different size curd, which may be due to their genetic characteristics. Kundo and Singh, 2018 found a significant head weight and head diameter difference among the varieties tested.

Table 6: Days to curd initiation and average head weight of Hybrid Cauliflower Varieties at Khumaltar

Cultivars	Days to curd initiation	Days to harvest	Average head wt. (gm)		
Year			2016	2017	C Mean
Girija	53	88.7	1038	1481	1259
Barkha	33	62.7	943	1135	1039
Giewont	60	113.3	923	1649	1286
Whistler	66	94.7	1021	1467	1244
Snow Mystique	62	101.0	975	1503	1239
CV%	15.2	4.86	9.30	9.85	11.19
F-test	**	**	ns	*	ns
LSD (0.05)	-	18.1	-	268	

The yield difference among the tested cultivars in 2016 was not significant where it ranged from 33.66 t/ha (Giewont) to 37.07 t/ha (Girija). But in 2017, Giewont gave the highest curd yield (55.85 t/ha) followed by Snow Mystique (54.52 t/ha) (Table 7). Even though Giewont have a higher yield, it is not preferred because of very late marketable maturity and very tight curd, which is not easily cookable. Cumulative mean yield ranged from 36.85 t/ha (Barkha) to 44.75 t/ha (Giewont). Yield difference between Girija and Snow Mystique is not significant, where Girija had a higher yield than Snow Mystique in 2016 and at par with Snow Mystique in the second year but the days to marketable harvest is twelve days earlier than Snow Mystique. Besides this Girija had a higher per day yield efficiency (499.7 kg/ha) than Snow Mystique (436.2 kg/ha). Likewise, Barkha had a lower yield in both years but gave per day yield efficiency (587.7 kg/ha) (Table 7). Similarly, in farmers' field conditions, Bhattarai et al. (2014) has also obtained the highest fresh curd yield in Kathmandu Local (41.9 t/ha) followed by HRDCAU005 (29.72 t/ha) and White Flash (28.41 t/ha), where yield range is not much different with this result. In this experiment, the hybrid cultivar's yield is higher than the obtained; it may be due to favorable weather in 2017, better management practices and may be due to potential modern high yielding varieties. However, yield variation was also mentioned by Giri et al. (2018),who recorded the maximum curd yield (55.7 t/ha.) in Bishop at Rampur, but the lowest curd yield (19t/ha) in Snowball16 in varietal evaluation trial. Even in India, different genotypes of cauliflower grown in plains and higher altitude of Kerala in 2018 showed significant differences in cauliflower yield, ranging from 21 – 26.4 kg /1.6 m^2 in hills and 7.8 – 14.3 kg /1.6 m^2 in plains (Elavarasan & Narayanankutty 2014).

Table 7: Yield Parameter of hybrid Cauliflower varieties at Khumaltar.

Cultivars	Total yield (t/ha)			Per day yield efficiency (kg/ha)
Year	2016	2017	C Mean	
Girija	37.07	51.58	44.32	499.7
Barkha	34.04	39.66	36.85	587.7
Giewont	33.66	55.85	44.75	395.0
Whistler	35.50	51.96	43.73	461.8
Snow Mystique	35.60	54.52	44.06	436.2
CV%	10.65	11.31	10.28	
F-test	ns	*	ns	
LSD (0.05)		10.80		

FARMERS PREFERENCES

Response from the invited farmers showed that Barkha and Girija were highly preferred due to their size, color, freshness, plant appearance, market value and yield. Based on size, shape, freshness, market value, yield, insect damage and disease infection, the early maturing varieties; Barkha and Girija were more preferred than late-maturing varieties; Giewont and Mystique (Table 8).

Table 8: Farmers and consumers responses to hybrid Cauliflower varieties at Khumaltar in 2017

Cultivars	Farmers response^y (1-5)								
	Size	Shape	Color	Freshness	Plant appearance	Market value	Yield	Insect	Disease
Girija	4.0	3.7	4.0	4.0	4.7	4.0	3.7	3.6	3.5
Barkha	4.3	3.7	4.2	4.3	4.3	3.3	4.0	3.6	3.6
Giewont	4.0	4.0	4.0	4.2	4.0	3.3	4.0	3.4	4.0
Whistler	4.0	4.0	4.0	4.0	4.3	4.0	4.5	4.0	4.1
Snow Mystique	3.3	3.0	3.8	3.8	3.5	3.8	3.7	3.3	4.2
CV%	11.37	14.94	8.54	7.61	13.33	14.8	12.92	10.89	10.95
F-test	ns	ns	ns	ns	ns	ns	ns	ns	ns

^{y} 1: unacceptable, 5:excellent

Barkha *Girija* *Snow Mystique*

Figure 1.Curd structure of Barkha, Girija and Snow Mystic varieties of cauliflower

Barkha *Girija* *Snow Mystique*

Figure 2. Internal structure of Barkha, Girija and Snow Mystique

CONCLUSION

Based on overall characters, cv. Barkha was found to be highly uniform, vigorous, less attacked by insect pests and disease, significantly early harvestable (62.7 days after transplanting), per day yield efficiency (487.7 kg/ha), preferable average head weight (1039 g), freshness (4.3) and market preference (4.0) as compared to check Snow Mystique, the most widely grown cultivar. Barkha has high demand and fetches a good market price in the early season. On the other hand, Cultivar Snow Mystique has only yield efficiency (436.2 kg/ha/day), higher insect damage and leaf spot disease, longer days to harvest (101 days), and freshness (3.8), respectively. It is followed by Girija as a medium marketable maturity cultivar. Yield difference between Girija and Snow Mystique is not significant, where Girija had a higher yield than Snow Mystique in 2016 and at par with Snow Mystique in the second year but the days to marketable harvest is twelve days earlier than Snow Mystique. Besides this Girija had a higher per day yield efficiency (499.7 kg/ha) than Snow Mystique (436.2 kg/ha). Hence, Barkha is selected and recommended for winter season commercial farming in the mid-hills of Nepal.

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RELATIVE COST, PROFITABILITY AND EFFICIENCY AMONG DIFFERENT TYPES OF DAIRY FARMS AT BHARATPUR, CHITWAN, NEPAL

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ABSTRACT

Dairy sector is gradually commercializing and modernizing with the use of improved breeds, processed feeds, cultivated grass, fodders, medicines and additives in Nepal. In this context, this study was designed to evaluate the relative cost, return, resource use efficiency, return to scale and profitability of milk production in different type of dairy farms. Primary data were collected through face-to-face interview using semi-structured interview schedule from a sample of 240 dairy farms selected from simple random sampling technique in 8 wards of Bharatpur Metropolitan City, Chitwan. Data were analyzed using descriptive statistics, cost and profit analysis, linear production function and Cobb-Douglas function. It was found that pure buffalo farms were facing negative profit margin against the profit of Rs. 32565 and Rs. 106627 at cow and mix system of dairy farming, respectively. Average variable cost of per liter milk production was Rs. 93.70, Rs. 54.80 and Rs. 44.73 for buffalo, cow and mix farms, respectively with benefit-cost ratio of 0.99, 1.44 and 1.62 for respective categories of the farms. Green grass, dry fodder, labour, feed, medicines and additives were significantly contributing to milk production in buffalo and cow farms. But, only grass, fodder and labour were contributing to milk production in mix dairy farms. All categories of farms were suffering from decreasing return to scale but they were still profitable over variable cost. Labour was the most contributing factor in all three categories of farms and thus dairy farming seems potential to create productive employment. This is concluded that dairy farming system can be promoted profitably by enhancing the level of use of labour, grass, fodder, medicines and additives.

Key words: Benefit-cost ratio, Cobb-Douglas function, Dairy farms, Profit margin

INTRODUCTION

Production of crops, livestock, forestry and fisheries are the key sources for natural resource-based income in Nepalese economy. Agriculture alone contributes about 26.2% to the National Gross Domestic Product (NGDP) of which 11.5% of the contribution comes from livestock and poultry sector in Nepal (MoF, 2020). Milk forms a bulk share in livestock products (MOAC, 2017). The total population of cattle and buffalo in Nepal accounts about 7.6 million and 5.3 million, respectively (MOALD, 2020). In spite of this large population, the contribution of livestock sector has not been fully utilized for increasing food and nutritional security, poverty reduction and raising the livelihood of dairy farming communities. Low productivity of Nepalese dairy farming systems has been placed as a primary problem limiting dairy development in the country. The ultimate approach for increase the productivity and profitability of dairy farming system is to enhance the productivity and efficiency of resources using in the production. Nepal is short of about half million liters of milk daily and spends billions of Rupees importing milk or other dairy products annually (FNCCI, 2017). The Nepalese dairy sector faces higher cost of production (10-20%) than several other Asian countries

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including India (NDDB, 2014). The productivity and profitability study of the dairy sub-sector is a subject that has not been fully investigated at farm level with location specific characteristic. Several studies showed high cost of production attributed to low productivity and high input cost (NDDB, 2014). Agriculture Development Strategy (ADS) of Nepal has also prioritized dairy as the second most important commodity after maize for trade and value chain promotion (MOAD, 2015). As envisioned in the ADS, this study was targeted for increasing self-reliance on milk production, sustainability, competitiveness, productivity, as well as reducing cost of production through identification of cost structure, profit conditions, resource productivity, resource use efficiency and return to scale.

Chitwan district lies in inner terai region which is very favorable for livestock promotion. From the record of District Livestock Development Office of Chitwan, milk is the lead production of the district. From the business point of view, Chitwan is the urbanizing district with growing local demand of dairy products. However, dairy sector of the district is in slow motion due to growing remittance economy, fragmentation of land, poor motivation towards dairy business, low yielding dairy animals and poor technological advancement (DLSO, 2016). In the light of these problems and context, commercialization of dairy farming with involvement of youth generation may be possible only after operating the dairy business in viable unit backed by minimized cost of production, maximized productivity and efficiency and, from policy intervention on key economic factors affecting profitability of diary production system. In these contexts, this study was conducted to estimate the cost and profit level, productivity and resource use efficiency of different type of dairy farms in Chitwan district of Nepal. Studying productivity and profitability, and the responsible determining factors are important for farmers, planners, researchers and policy makers. Farmers could use the findings of this type of study for increasing their performance in dairy farms through optimum allocation of resources and policy makers could identify and prioritized the intervention required to increase the productivity and efficiency of dairy farms in the country (Solís et al., 2009).

METHODOLOGY

STUDY AREA AND SAMPLING DESIGN

The study was conducted in Bharatpur Metropolitan City of Chitwan district, Nepal. It is one of the potential districts for the promotion of dairy farming characterized by gradual commercialization of different agriculture and livestock-based firms. A total of 8 most commercial wards from the metropolitan city and one Dairy cooperative from each eight wards were selected to frame the sample required for the study. A total of 10 dairy farms from each cow, buffalo and mix farms were selected randomly from each cooperative using simple random sampling technique to make a sample of 240 dairy farming households. Thus, the dairy farms selected for the study are semi-commercial to commercial who sold their milk at the nearby cooperatives.

DATA COLLECTION

Literature review and preliminary field visit were done to develop coordination schema before design of interview schedule. This coordination schema was used to develop interview schedule required for collecting primary data. Thus, primary data were collected from face-to-face interview of selected respondent households using semi-structured interview schedule. Interview schedule prepared in this manner was pretested in 10 dairy farming households at ward number 7 of the Metropolitan city. Collected data were entered in Microsoft excel sheet and analyzed using STATA and SPSS software wherever applicable.

ANALYTICAL TOOLS

Socioeconomic and demographic variables were analyzed using the tools of descriptive statistics like mean, frequency and percentage. All variable inputs like human labor, feed, fodder, medicines, additives, breeding cost and others for different dairy production practices were considered and valuated at current market prices to calculate variable cost of production. Similarly, fixed cost incurred in different assets, their depreciation and interest were summed up to estimate total fixed cost.

Total annual variable cost = $C_{labor} + C_{feed} + C_{dry\ fodder} + C_{green\ grasses} + C_{medicines} + C_{additives} + C_{breeding\ cost}$

Total fixed cost= Depreciation + Interest

Where,

C_{labor} = Cost on human labor used (NRs./farm),

C_{feed}= Cost on concentrate feed used (NRs./farm),

$C_{dry\ fodder}$ = Cost on dry fodder (NRs./farm),

$C_{green\ grasses}$ = Cost of green grasses (NRs./farm),

$C_{medicines}$ = Cost on veterinary medicines (NRs./farm),

$C_{additives}$ =Cost on additives (NRs./farm),

$C_{breeding\ cost}$ = breeding cost (NRs./farm)

These individual cost items, fixed cost and total cost were compared among buffalo farms, cow farms and mix of cow and buffalo farms. Similarly, variable cost, fixed cost and total costs were also calculated on per liter of milk production basis to derive average cost of milk production.

Gross return was calculated by multiplying the total volume of product from dairy enterprise by the average price of the product (Dillon & Hardaker, 1993). Thus, gross return was calculated by using following formula:

Gross return (NRs.) = Total quantity produced (litre) × Price (NRs./litre)

In addition to main product, the return from by product like manure and sale of calf were also estimated to derive total income of dairy farms. Gross margin calculation was done to have an estimate of the difference between the gross return and variable costs. Net margin on the other side was estimated by deducting total cost from total return.

Gross Margin (NRs./lit) = Gross return (NRs./lit) - Average variable cost (NRs./lit)

Net Margin (NRs./lit) = Gross return (NRs./lit) – Average total cost (NRs./lit)

Furthermore, average cost per litre of production was compared with average revenue received from milk on per litre basis for deriving meaningful comparison of profitability.

Resource productivity of different type of dairy farms were estimated using linear production function of the following form (Shrestha, 2016).

$Y = a+b_1$ grass and fodder+ b_2 labour+ b_3 feed, medicines and additives+ b_4 breeding cost

Similarly, Cobb-Douglas production function of the following form was employed to estimate the resource use efficiency and return to scale from dairy farming systems as adopted from Battese and Coelli (1988).

$LNY=LNa+ b_1LN$ grass and fodder+ b_2LN labour+ b_3 LN feed, medicines and additives

All these dependent and independent variables used in the linear and Cobb-Douglas production functions were estimated at current market price and considered in monetary terms on per farm per year basis.

RESULTS AND DISCUSSION

SOCIO-ECONOMIC AND DEMOGRAPHIC CHARACTERISTICS

The average age of the household head among dairy farming households was 53.25 years in study area. The study showed all household heads in the study area were economically active population which is higher than national distribution of economically active population in agriculture (64%) (CBS, 2011). As far as educational background of respondents is concerned, it was found average of 8.05 formal years of education. Family size of respondents' household was 5.68 out of which 2.81 were female and 2.87 were male. Majority of the respondents (69.17%) were male respondents whereas percentage of female respondents were 30.83% only. The proportion of female respondents varied by type of farms and was 20.0%, 31.25% and 41.25% in mix, buffalo and cow farms, respectively. The average own land was 17.87 kattha[1] with 12.54 kattha as irrigated land. Out of which, 2.22 kattha was allocated for grass and fodder cultivation, and 2.15 kattha was allocated for pasture. The average number of adult milching cows and buffalos in study area were 3.04 and 2.11, respectively.

COST, RETURN AND PROFITABILITY

Investment can be considered as one of the important propulsive forces in determining the capital formation, which in turn leads to generate future dividends to the investor. Level of investment reflects the extent of business activity and its income generating capacity in long term. The total capital investment on various purposes by type of study farms is presented in Table 1. As far as investment distribution is concerned, it is seen that in terms of overall distribution, the average capital investment was worked out to be over NRs. 435387 out of which, the buildings/shed alone

[1] 1 kattha=0.033 ha

constituted nearly 33.91 per cent followed by cows (33.16%), buffalos (30.23%) and other items (2.69%). In the cow farm, the average capital investment was worked out to be NRs. 478838, out of which, the buildings/shed alone constituted nearly 38.45%. Whereas the average capital investment in the buffalo farm was NRs. 262655, out of which, the buildings/shed alone constituted nearly 38.56 per cent followed by buffalos 57.15 per cent and other items 4.27 per cent. In mix farm, the average capital investment was worked out to be over NRs. 388782, out of which, the buildings/shed alone constituted nearly 40.25%.

Table 1: Average level of investment for different purposes by type of study farms

Investment items	Buffalo farm		Cow farm		Mix farm		Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Buildings/shed	101299	108336	184091	563432	156520	228688	147628	360768
Cows	-	-	183427	371398	105817	168973	144372	292304
Buffalos	150127	209573	-	-	114007	145913	131641	180687
Other items	11229	21440	11570	26674	12439	33295	11747	27464
Total	262655	115506	478838	18641	388782	89604	435387	104075

The average level of different components of variable cost and total variable cost of dairy farming in study area is presented in Table 2. The total variable cost per year was NRs. 165773 in cow farm, NRs. 187559 in buffalo farm and NRs. 222737 in mix farm. The total variable cost in dairy farming comprised cost for concentrate, green grass, dry fodder, water, labour use, medicine and veterinary charge, breeding and additive cost. Cost for concentrate comprised 26.58 per cent, 21.21 per cent and 22.96 per cent of the total variable cost in cow farm, buffalo farm and mix farm, respectively. Sharma (2007) also reported that animal feed is one of the major inputs of production as it shares around 50-60 percent of cost of production of milk. The percentage bearing of feed cost on total cost was lower in this study as the farm family labour cost was imputed while deriving the total cost of production. Cost of green grass comprised 25.64 per cent, 20.43 per cent and 19.21 per cent of the total variable cost in cow farm, buffalo farm and mix farm, respectively. Cost of dry fodder comprised 4.73 per cent, 3.79 per cent and 3.73 per cent of the total variable cost in cow farm, buffalo farm and mix farm, respectively. Cost of labour, taking into account of family labour, comprised 60.57 per cent, 50.14 per cent and 49.13 per cent of the total variable cost in cow farm, buffalo farm and mix farm, respectively. Deshetti, Teggi and Hosamani (2017) also found the paid labour costs accounted to be 28.01 percent and 30 percent in Vijayapura and Bagalakote district of Karnataka, India. Medicine and Veterinary charge comprised 5.44 per cent, 2.48 per cent and 4.22 per cent of the total variable cost in cow farm, buffalo farm and mix farm, respectively. Breeding cost comprised 1.02 per cent, 0.66 per cent and 0.86 per cent of the total variable cost in cow farm, buffalo farm and mix farm. The study revealed that nearly half of the total variable cost is comprised of labour cost only.

Table 2: Average level of different components of variable cost and total variable cost of dairy farming

Particulars	Type of farms			
	Buffalo farms	Cow farms	Mix farms	Total
Concentrates (kg/day)	3.40	4.09	3.86	3.78
Concentrate cost (Rs./year)	39786	44065	51141	44998
Green grass (kg/day)	27.41	29.34	29.15	28.63
Green grass cost (Rs./yr)	38330	42510	42806	41215
Dry fodder and straw (kg/day)	12.93	13.65	14.09	13.55
Dry fodder cost (Rs./year)	7126	7848	8328	7767
Water (lit/day/animal)	55.75	55.38	54.50	55.21
Labour use (hrs./day)	5.59	5.79	6.86	6.08
Labour cost (Rs./year)	94058	100419	109444	101307
Medicine cost (Rs./year)	4648	9031	9400	7693
Additive cost (Rs./yr)	2388	4293	6755	4479
Breeding cost (Rs./yr)	1253	1691	1937	1630
Total variable cost (Rs./yr)	187559	165773	222737	192023

Different type of cost by categories of farms is presented in Table 3. The total cost was about NRs. 205609 in cow farm, NRs. 209881 in buffalo and NRs. 255032.66 in mix farms. The total variable cost shares 80.62%, 89.36%, and 87.34% of the total cost in cow, buffalo and mix farm, respectively. Gavali (2001) also found that the total cost of milk production composed of working cost (82%) and fixed cost (18%) of the total cost. As far as profitability by type of farms is concerned, it is seen that in terms of overall distribution, the gross margin and net margin were found to be NRs. 69605.18 and NRs. 32273.19, respectively. Similarly, gross margin and net margin was found to be positive for cow as well as mix farms and these were negative for buffalo farms. Thus, the result portrays that both cow and mix farms in the study area are profitable. This study has included the imputed value of all farm produced inputs including labour as cost components in dairy production.

Table 3: Average variable, fix cost, and profitability by type of farms

Costs	Buffalo farms	Cow farms	Mix farms	Total
Fixed cost	22323.41	39836.19	32296.13	37331.99
Variable cost	187558.58	165773.13	222736.53	192022.74
Total cost	209881.98	205609.31	255032.66	229354.74
Gross margin	-2509.08	72401.63	138922.99	69605.18
Net margin	-24832.48	32565.44	106626.86	32273.19

In terms of average lactation period (days) of dairy animals by type of farms under study, it is seen that the average lactation period of cow was 291.43 days and that of buffalo was 268.84 days. In the cow farm, the average lactation period of cow was 290.19 days, whereas the average lactation period of buffalo in the buffalo farm was 272.11 days. In mix farm, the average lactation period of cow was 292.66 days and that of buffalo was 265.56 days. The study revealed that cows have consistent longer lactation period as compared to buffalo in all type of farms (Table 4).

Table 4: Average lactation period (days) of dairy animals by type of farms under study

Type of dairy animal	Buffalo farm		Cow farm		Mix farm		Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Cow	-	-	290.19	34.77	292.66	32.90	291.43	33.77
Buffalo	272.11	61.26	-	-	265.56	54.84	268.84	58.05

An Attempt was made to understand the average income in dairy farm enterprise in study areas (Table 5). The study revealed that in terms of overall distribution, the total income was NRs. 261628 with 81.01 per cent as milk income. In the cow farm, the total income was NRs. 238175 with 82.55 per cent as milk income, whereas the total income was NRs. 185050 with 75.71 per cent as milk income in Buffalo farm. In mix farm, the total income was NRs. 361660 with 82.61 per cent as milk income. The milk income includes the cow milk and buffalo milk and the non- milk income includes income from manure and sale of calf.

Table 5: Average income in dairy farm enterprise from milk and non-milk sources

Particulars	Buffalo farm		Cow farm		Mix farm		Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Cow milk	-	-	196619	84614	173651	57558	185062	72959
Buffalo milk	140112	62539	-	-	132264	54434	136263	58649
Milk total	140112	62539	196619	84614	298785	98156	211966	105858
Manure	27775	38027	41775	57542	45500	45249	38350	48038
Sale of calf	17163	23225	4696	13405	17375	28239	13078	23164
Total non-milk	44938	30626	46471	35473	62875	36744	51428	35601
Total income	185050	98258	238175	112525	361660	127637	261628	135122

The cost of milk by type of farms was presented in Table 6. As far as average cost (Rs./litre) by type of farms is concerned, it can be seen that in terms of overall distribution, the average cost of milk/litre was NRs. 70.33. The total cost of per litre milk production was NRs. 67.97 in cow farm, NRs. 104.86 in buffalo farm and NRs. 51.21 in mix farm. The total variable cost shares 80.62%, 89.35%, and 87.35% of the total cost in cow, buffalo and mix farms, respectively.

Table 6: Average cost of milk production (Rs./litre) by type of farms

Particulars	Buffalo farm	Cow farm	Mix farm	Total
Variable cost (NRs./Lit)	93.70	54.80	44.73	58.88
Fix cost (NRs./Lit)	11.15	13.17	6.49	11.45
Total cost (NRs./Lit)	104.86	67.97	51.21	70.33

The average percentage composition of milk and non-milk income is presented in Table 7. It can be seen that in terms of overall distribution, the average composition of milk income was 80.29 per cent and that of non-milk income was 19.71%. The total milk income shares 82.55%, 75.72%, and 82.61% of the total income in cow, buffalo and mix farms, respectively.

Table 7: Average percentage composition of milk and non-milk income

Particulars	Buffalo farm	Cow farm	Mix farm	Total
Milk	75.72	82.55	82.61	80.29
Non-milk	24.28	17.45	17.38	19.71
Total	100.00	100.00	100.00	100.00

As far as average price of cow and buffalo milk in study area is concerned, it is seen that in all type of farms in study area, the average price of cow milk was NRs. 60 that of buffalo was NRs. 70 as shown in Table 8. The study revealed that there was no any price variation with type of farms in study area. These price levels are the price received by dairy farmers from the dairy cooperatives.

Table 8: Average price of cow and buffalo milk in study area

Particulars	Buffalo farm	Cow farm	Mix farm	Total
Cow milk	-	60.00	60.00	60.00
Buffalo milk	70.00	-	70.00	70.00

In terms of average milk yield (litres/day) by type of farms in study area, it is seen that the average milk yield of cow was 10.49 litres/day and that of buffalo was 7.14 litres/day. In the cow farm, the average milk yield of cow was 11.06 litres/day, whereas the average milk yield of buffalo in the buffalo farm was 7.21 litres/day. In mix farm, the average milk yield of cow was 9.91 litres/day and that of buffalo was 7.07 litres/day. The study found that average milk yield of cow was greater than that of buffalo in all type of farms in study area (Table 9).

Table 9: Average milk yield (litres/day) by type of farms in study area

Farms	Buffalo farm		Cow farm		Mix farm		Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Cow	-	-	11.06	4.38	9.91	3.10	10.49	3.83
Buffalo	7.21	2.26	-	-	7.07	2.59	7.14	2.42

An attempt was made to understand the BC ratio of dairy farm business in different categories of farms, it was seen that in terms of overall distribution, the average BC ratio was 1.36 which suggest that dairy business in study area was feasible. The average BC ratio was 1.44 and 1.62, respectively in cow and mix farm which suggest that these farms in the study area are profitable. However, commercialization and adoption of technologies can provide a high return in these farms whereas, the BC ratio of buffalo farm was 0.9 which suggest that buffalo farm in existing situation was nearly at breakeven condition.

Table 10: Average BC ratio of dairy farm business in different categories of farms

Particulars	Buffalo farm	Cow farm	Mix farm	Total
Mean	0.99	1.44	1.62	1.36
SD	0.40	0.75	0.75	0.73

RESOURCE PRODUCTIVITY OF DAIRY FARMING

Productivity of dairy farms in study area was affected by various factors like cost on grass and fodder, labour cost, cost on medicines and additives and breeding cost. Resource productivity of buffalo farms in study area is presented in Table 11. In buffalo farm, cost on grass and fodder, labour cost and cost of feed, medicines and additives significantly affect the productivity of buffalo at 5% level of probability. Osti et. al, (2013) also found that milk production was less (8 kg/day/head) prior to protein based feeding, while higher during protein based feeding (10.0 kg/animal/day) was provided. The feed supply of Nepal is not sufficient to meet the demand of dairy animals. There is shortfall of 38% in crude protein, 42% in metabolizable energy and 33% in dry matter (Osti, 2020). Cost on grass and fodder increases the productivity of buffalo more than other factors of production. The cost on grass and fodder coefficient 0.998 depicts that with Re. 1 increase in the cost of grass and fodder, the income of buffalo farms will be increased by about 99 Paisa.

Table 11: Resource productivity of buffalo farms in study area

Factors of production	Coefficient	Std. error	t	P-value
Cost on grass and fodder (Rs.)	0.998	0.124	8.04	0.000
Labour cost (Rs.)	0.339	0.082	4.09	0.000
Cost on feed, medicines and additives (Rs.)	0.897	0.300	2.99	0.004
Breeding cost (Rs.)	1.077	5.65	0.19	0.849
Constant	29854.64	11799.24	2.53	0.013

R-squared: 0.6458 Adjusted R-squared: 0.626

Resource productivity of cow farms in study area is presented in Table 12. In cow farms, cost on grass and fodder, labour cost and cost of medicines and additives significantly affect the productivity of buffalo at 5 % level of probability. Cost on grass and fodder, and labour cost had positive relation with output. Vishnoi, Gupta and Pooniya (2015) also found that the expenditure on concentrate and labour were found positive and significant contribution on milk yield. On other hand, productivity of cow was negatively affected by cost on medicines and additives. Cost on grass and fodder increases the productivity of cow more than other factors of production.

Table 12: Resource productivity of cow farms in study area

Factors of production	Coefficient	Std. error	t	P-value
Cost on grass and fodder (Rs.)	1.301	0.187	6.93	0.000
Labour cost (Rs.)	0.872	0.113	7.67	0.000
Cost on feed, medicines and additives (Rs.)	-1.265	0.420	-3.01	0.004
Breeding cost (Rs.)	2.846	3.675	0.77	0.441
Constant	58081.07	16299.33	3.56	0.001

R-squared: 0.598 Adjusted R-squared: 0.577

Resource productivity of buffalo and cow mix farms in study area is presented in Table 13. In mix farms, cost on grass and fodder, and labour cost significantly affect the productivity of cows and buffalos at 5% level of probability. Both the afore-mentioned factors affect the productivity of buffalo and cow positively. Cost on grass and fodder increases the productivity of cattle more than other factors of production. The cost on grass and fodder had coefficient 1.780 depicting that with Re. 1 increase in cost of grass and fodder, the income of cow farms will be increased by NRs. 1.78. Meena et al. (2012) also found that concentrates and roughages influenced the returns of milk from dairy enterprises significantly.

Table 13: Resource productivity of buffalo and cow mix farms in study area

Factors of production	Coefficient	Std. error	t	P-value
Cost on grass and fodder (Rs.)	1.780	.357	4.98	0.000
Labour cost (Rs.)	1.714	.276	6.21	0.000
Cost on medicines and additives (Rs.)	0.026	1.234	0.02	0.983
Breeding cost (Rs.)	-6.364	5.889	-1.08	0.283
Constant	89527.24	28275.29	3.17	0.002

R-squared: 0.468 Adjusted R-squared: 0.440

EFFICIENCY AND RETURN TO SCALE

Income of dairy farms in study area was affected by various factors like cost on grass and fodder, labour cost and cost on medicines and additives. Estimate of efficiency and return to scale from Cobb-Douglas production function for buffalo farms is presented in Table 14. In buffalo farm, all factors of production significantly affect the income at 5% level of significance. Cost on grass and fodder, labour cost, and cost on medicines and additives had positive relation with income and were underutilized. Deshetti and Teggi (2016) also found underutilization of labour and veterinary costs in cattle farming. The sum of coefficients was 0.910 which is less than 1 implied decreasing return to scale; 100% increase in all the factor of production included in this model would result in 91.0% increase in farm income.

Table 14: Estimates of efficiency and return to scale from Cobb-Douglas production function on buffalo farms

Factors of production	Coefficient	Std. error	t	P-value
Cost on grass and fodder (Rs.)	0.331	0.052	6.31	0.000
Labour cost (Rs.)	0.534	0.078	6.78	0.000
Cost on feed, medicines and additives (Rs.)	0.045	0.020	2.25	0.027
Constant	1.848	1.018	1.81	0.074
Return to scale	0.910			

R-squared: 0.606 Adjusted R-squared: 0.590

Estimate of efficiency and return to scale from Cobb-Douglas production function for cow farms is presented in Table 15. In cow farm, all factors of production significantly affect the income at 5% level of significance. Cost on grass and fodder, labour cost, and cost on medicines and additives had positive relation with income. Timsina (2010) also found similar findings that with increase in labour by 100 percent on an average the output goes up by 67 percent. The sum of coefficients was 0.757 which is less than 1 implied decreasing return to scale; 100% increase in all the factor of production included in this model would result in 75.7 % increase in farm income.

Table 15: Estimates of efficiency and return to scale from Cobb-Douglas production function for cow farms

Factors of production	Coefficient	Std. error	t	P-value
Cost on grass and fodder (Rs.)	0.164	0.031	5.17	0.000
Labour cost (Rs.)	0.575	0.039	14.41	0.000
Cost on feed, medicines and additives (Rs.)	0.018	0.009	2.09	0.040
Constant	3.927	0.556	7.05	0.001
Return to scale	0.757			

R-squared: 0.785 Adjusted R-squared: 0.777

Estimates of efficiency and return to scale from Cobb-Douglas production function for buffalo and cow mix farms is presented in Table 16. In mix farms, all factors of production significantly affect the income at 5 % level of significance. Cost on grass and fodder, labour cost and cost on medicines and additives had positive relation with income. The sum of coefficients was 0.716 which is less than 1 implied decreasing return to scale; 100% increase in all the factor of production included in this model would result in 71.6% increase in farm income. Deshetti, Teggi and Hosamani (2017) also found the decreasing return to scale on dairy farming with value 0.85 in Vijayapura district of Karnataka which is similar to the findings of this study. The direction of coefficients for both labour and other capitals items are compatible with the findings of Shrestha (2016) showing the need to expand their level of uses.

Table 16: Estimates of efficiency and return to scale from Cobb-Douglas production function for buffalo and cow mix farms

Factors of production	Coefficient	Std. error	t	P-value
Cost on grass and fodder	0.078	0.040	1.95	0.054
Labour cost (Rs.)	0.554	0.074	7.44	0.000
Cost on feed, medicines and additives (Rs.)	0.084	0.039	2.15	0.034
Constant	4.901	o.873	5.61	0.000
Return to scale	0.716			

R-squared: 0.545 Adjusted R-squared: 0.527

CONCLUSION

This study examined the relative performance of different type of dairy farms in terms of cost, return, profitability, return to scale and resource use efficiency using different concepts of cost and profit; and production function approaches. It was found that overall dairy farming was profitable business in spite of no-profit-no-loss condition in pure buffalo farming. Buffalo milk production was costly as compared to cow milk because of low productivity, shorter lactation period and smaller size of operation. Farmers are still rearing buffalo in the study area because of lower risk in production, easiness in selling the sterile she buffalo and male calf, preferred taste of buffalo milk for home consumption. Similarly, green grass, dry fodder, labour, medicines and additives were significantly contributing to milk production in buffalo and cow farms. All categories of farms were suffering from decreasing return to scale but cow farms and mix farms are still profitable in milk production. It was also found that labour was the most contributing factor in all the three categories of farms based on the estimation of Cobb-Douglas Production Function and thus they seem to create productive employment to unemployed youth. Promotional activities to increase the level of use of modern inputs like cultivated green grass and fodder, use of trained labour, and medicines and additives could increase the profitability and sustainability of dairy farming in study area irrespective of type of farms.

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PROFITABILITY AND PERCEPTION OF NEPALESE FARMERS IN PROTECTED VEGETABLE FARMING IN NEPAL

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ABSTRACT

The study was conducted 7 districts of Nepal by selecting 90 respondents to understand profitability of vegetable farming under different type of protected structures namely temporary, semi-permanent and permanent. Descriptive statistics and scaling techniques were used to analyze data. The financial analysis showed significantly higher benefit cost ratio and payback period in temporary structures than that of semi-permanent and permanent structures. The net present value was found statistically similar in all types of protected structures. The age of household head and area under protected farming were found statistically higher among the adopters of temporary structure while the years of farm registration and experience in protected vegetable farming were found statistically higher among the adopters of semi-permanent structures. This shows graduation process of growers from temporary to semi-permanent structure. The productivity of vegetables under protected structure in the study area was found 191.55 mt./ha/year. The yield was found most satisfying factor, whereas the availability of technician was found to be the factor with highest index of difficulty. The findings of the study will have implication for the policy makers, suppliers and farmers regarding the promotion and adoption of different types of protected structures.

Keywords: Financial analysis, Protected structure, Semi-permanent, Temporary

INTRODUCTION

The worldwide production of vegetables has tremendously gone up during the last two decades and the value of global trade in vegetables now exceeds that of cereals. The harvested global amounts of vegetables were about 1.13 billion metric tons in the year 2019 out of which around 879.3 million metric tons (78 percent) were produced in Asia. Vegetables crops, which are the integral part of Nepalese farming system and are considered very important for food security and income source for smallholder farmers. Contributing around 11.92 percent (MoALD, 2021) on National AGDP, fresh vegetable is one of the important sector of agriculture in the country. Over the 20 years' period, vegetable area and yield grew at an annual rate of 3.6% and 5.42 % respectively. Although the area and yield under vegetable has increased, the import of vegetable have also increased over the last decade with decreased exports. The demand for vegetables is increasing due to population growth, economic progress, and increased spending power from income growth and migrant remittances (Vegetable Sector Strategy-Nepal, 2020). The increasing demand of vegetables and its fulfilment from import points the oppourtunity for furthur commercialization of vegetable sector.

The estimated global protected agriculture area is 5,630,000 hectares, whereas the protected area under vegetables is 496,800 hectares (cuestaroble, 2019), which is around 0.83 percent of the total

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area under vegetable cultivation (FAO, 2019). Among more than 115 countries cultivating under protected structure, China is leading country with around 2.5 million hectares of land under protected cultivation (Jiang & Yu, 2008) while India has around 0.04 million hectares (Singh, 2014). Nepal has a young history in protected farming which started with the development of rain shelter type bamboo plastic houses by Agriculture Research Center, Lumle in 1996, for off season production of vegetables especially tomato. The further advancement of protected structures remained stagnant until the projects like Project for Agriculture Commercialization and Trade (PACT), High Value Agriculture Project (HVAP), High Mountain Agribusiness and Livelihood Improvement Project (HIMALI), Raising Income of Small and Medium Farmers (RISMFP), Integrated Water Resource Management Project (IWRMP), Agriculture and Food Security Project (AFSP), and Prime Minister Agriculture Modernization Project (PMAMP) intervened some permanent protected structures. Since last 4-5 years investment in protected structures has been gaining momentum with an area of around 700 hectares till 2018 (Subedi, 2020).

High installation cost, difficulty in availability of installation materials, and poor technical knowhow are major limiting factors for benefiting from this technology. Quality and timely availability of inputs such as seeds and water soluble fertilizers is also one of the important factor hindering the development of protected vegetable farming (Atreya et.al., 2019). Although some basic techniques of protected farming are in use, they are not organized and little study have been done on their efficacy. This study aims to determine the profitability of vegetable farming in different types of protected structures, and determine the perception of farmers regarding protected vegetable farming.

METHODOLOGY

STUDY SITE AND SAMPLING DESIGN

The study was conducted in seven districts of Nepal namely Kathmandu, Makawanpur, Dhading, Sindhupalchok, Kaski, Lalitpur and Nuwakot. The districts were selected purposefully to include the districts with highest area under protected cultivation. The roster of the farmers registered as adopter of the protected farming was prepared with the help of Agriculture Knowledge Center (AKC) and Agriculture Section of the local levels of the respective districts. The farmers adopting protected farming were categorized into clusters according to local level in the respective districts and the local levels were purposefully selected. Thus stratified simple random sampling technique was adopted. Primary data was collected through household survey with the help of structured and semi-structured interview schedule, focal group discussion and key informant interview. To supplement the data from the primary sources various published and unpublished secondary sources of data, proceedings of NCPVSCD[1], AKC[2], related reports, journals and books were consulted. A total of 90 households were surveyed and to make a comparative study 50 households adopting temporary protected, 20 households adopting semi-permanent and 20 households adopting permanent structures were decided to include in the sample.

[1] National Center for Potato, Vegetable and Spice Crop Development
[2] Agriculture Knowledge Center

METHODS AND TECHNIQES OF DATA ANALYSIS

Data collected were entered in SPSS and analysis was done using SPSS, STATA and Microsoft excel. Mean, standard deviations, ordinary least square (OLS) technique of multiple regression and likert scale technique was done to derive inference needed.

To determine level of difficulty of availability and satisfaction towards various factors of protected vegetable farming five point Likert scaling technique used. It compares most important, somewhat important, important, less important and least important using the scores of 1.00, 0.80, 0.60, 0.40 and 0.20 respectively (Joshi, Kale, Chandel, & Pal, 2015). The formula is:

$$\mathrm{I} = \Sigma\,\mathrm{I} = \frac{S_i\,F_i}{N}$$

Where,

- I = Index value for Satisfaction/difficulty
- S_i= Scale value of i^{th} intensity
- F_i = Frequency of i^{th} response
- N = Total number of respond

COMPONENTS OF ANALYSIS

Net Present Worth (NPW)

The NPW is defined as the difference between present worth of savings and cost of investment. The formula used to calculate the NPW is

$$NPW = \sum_{t=1}^{t=n} \frac{(B_t - C_t)}{(1+i)^t}$$

Where,

B_t= Benefit in the year t

C_t= Cost in the year t

i = discount rate

t = number of years

Benefit cost ratio

This ratio was obtained when the present worth of the benefit stream was divided by the present worth of the cost stream. The mathematical benefit-cost ratio (Sengar & Kothari, 2008) can be expressed as:

$$Benefit\ Cost\ Ratio = \frac{\sum_{t=1}^{t=n} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{t=n} \frac{C_t}{(1+i)^t}}$$

Payback Period

The payback period is the length of time from the beginning of the project until the net value of the incremental production stream reaches the total amount of the capital investment. It shows the length of time between cumulative net cash outflow recovered in the form of yearly net cash inflows.

$$Payback\ Period\ (PP) = \frac{Investment\ cost\ (IC)}{Annual\ Net\ Income\ (ANI)}$$

RESULT AND DISCUSSION

SOCIO-DEMOGRAPHIC CHARACTERISTICS (CONTINUOUS)

Table 1 presents the socio demographic (continuous) characteristics of the respondents by structure type. The result of ANOVA showed that among various socio-demographic characteristics, age, years of farm registration, experience in protected farming and area under protected farming were found statistically different between the farmers adopting different types of protected structures.

The average age of the respondent was found statistically higher among farmers adopting temporary structure (40 years) than that of farmers adopting semi-permanent structure (34.30 years) which was significant at 10 % level of probability this could be explained that younger farmers are more associated with extension services and access to extension service directly influence the adoption of modern technologies. (Ahmad, 2012), in similar study regarding adoption of protected tomato farming found that majority of respondents adopting protected tomato farming were young aged. The years of farm registration was statistically higher among farmers adopting semi-permanent structure (5.40) than that of farmers adopting permanent structure (34.30 years) and temporary structure (2.44), which was significant at 1% level of probability. The experience in protected farming was statistically higher among adopters of semi-permanent structure (4.00 years) than that of adopters of temporary structure (2.64 years) at 5% probability level and then that of permanent structure (3 years) at 10% probability level. The higher experience in semi-permanent structures than that of temporary could be explained that majority of the temporary structure holders in the study area were on rented land which had uncertain future, thus their profession would be of short period. The lower experience of farmers on permanent structures could be explained it being recently adopted technology. The area under protected farming was statistically higher among adopters of temporary structure (4120.24 square meters) than that of adopters of semi-permanent structure (1568 square meter) at 5% level of probability and then that of permanent structure (1427.20 square meter) at 1 % probability level. The higher area under temporary protected area could be justified by the lower cost of installation and lower life of the project as compared to that of semi-permanent and permanent structures.

Table 1. Socio-demographic characteristics of respondents by type of protected structure

Variable	Type of Structure	N	Mean	Standard Deviation	ANNOVA Comparison	Tukey HSD 1	Tukey HSD 2
Age (Years)	0	50	40.00	10.62	*p=0.055*	*p=0.062**	*p=0.986*
	1	20	34.30	7.62			*p=0.106*
	2	20	40.40	7.40			
	Overall	90	38.82	9.60			
Members in Agriculture (Number)	0	50	2.44	1.21	*p=0.867*		
	1	20	2.30	1.30			
	2	20	2.30	1.21			
	Overall	90	2.38	1.223			
Years of Farm Registration	0	50	2.44	1.74	*p=0.000*	*p=0.000****	*p=0.000****
	1	20	5.40	1.53			*p=0.363*
	2	20	4.60	2.34			
	Overall	90	3.58	2.24			

Experience in Protected Farming (Years)	0	50	2.64	2.09	p=0.021	*p=0.017***	*p=0.710*
	1	20	4.00	1.62			*p=0.076**
	2	20	3.00	1.02			
	Overall	90	3.02	1.87			
Area under protected farming (Square Meter)	0	50	4120.24	3623.21	p=0.000	*p=0.030***	*p=0.002****
	1	20	1568.00	1171.37			*p=0.986*
	2	20	1427.20	1241.61			
	Overall	90	2954.62	3093.42			

*Note: 0= temporary structure, 1= semi-permanent structure, 2= permanent structure *, ** and *** denotes significance at 10%, 5% and 1% levels respectively*

SOCIO-DEMOGRAPHIC CHARACTERISTICS (CATEGORICAL)

The result of chi-square test showed that there was a statistical difference in the major source of income in various categories of adopters of protected structure, which was significant at 5% level of probability. Majority of respondents having agriculture as a major source of income had adopted temporary and semi-permanent structures. This can be justified with the cost of installation of structures as the cost of installation of permanent structures was found high and the respondents whose major source of income was agriculture would be reluctant invest higher cost for the installation of permanent structures. Other variables namely, gender, education of household head, ethnicity, religion and family type were statistically similar among the adopters of different types of protected structures.

Table 2. Socio-demographic characteristics of respondents by type of protected structure

Variable	Overall (N=91)	Temporary Structure (N=50)	Semi-Permanent Structure (N=20)	Permanent Structure (N=20)	Chi-square value	p-value
Gender						
Male	82.22	76	90	90	2.980	0.225
Education of HH Head						
Higher Secondary	55.56	48	70	60	3.006	0.222
Ethnicity						
Brahmin/Chhetri	51.11	44	60	60	1.853	0.396
Religion						
Hindu	62.22	56	70	70	2.276	0.32
Family Type						
Nuclear	46.67	48	30	60	3.696	0.158
Source of Income						
Agriculture	97.78	100	100	90	7.159**	0.028

*Note: ** denotes significant at 5% probability level.*

CROPPING PATTERN IN PROTECTED STRUCTURE

Majority of farmers (20%) followed Tomato-Cole cropping pattern followed by tomato only (17.5%). The least practiced cropping pattern was found to be Tomato-Capsicum followed by 2.5% of sampled households.

Table 3. Cropping pattern in protected structure

S.N.	Cropping Pattern	Percentage (N=90)
1	Tomato-Cole	20
2	Tomato-Fallow	17.5
3	Tomato+ Cole-Cole	12.5
4	Tomato-Leafy green-Bean	7.5
5	Tomato-Leafy green	7.5
6	Tomato+ Cole-Leafy green	7.5
7	Cucurbit-Leafy green	7.5
8	Tomato-Leafy green-Cole	5
9	Cucurbit-Cole	5
10	Tomato-Beans	5
11	Beans/Tomato/Leafy green	2.5
12	Tomato-Capsicum	2.5

PRODUCTIVITY OF VEGETABLES UNDER PROTECTED STRUCTURES

The average productivity of vegetables under protected structure in the study area was found to be 191.55 mt./ha/year. The productivity of vegetables was found higher in semi-permanent structures (218.87) followed by permanent structure (197.24) and temporary structure (178.35). However, the productivity of vegetables under different structures were found to be statistically similar. (Duhan, 2016), (Engindeniz & Tuzel, 2002), and (Diab, Magdi, & Hassan, 2016) in their studies comparing the productivity of different vegetables in open field and protected structure found three to five times higher productivity of vegetables in protected structures.

Table 4. Productivity of the protected vegetable farming based on structure type

Type of Structure	Productivity (mt./ha/year)					ANNOVA Comparison
	N	Mean	Standard Deviation	Minimum	Maximum	
0	50	178.35	89.363	46.250	437.500	p=0.208
1	20	218.87	90.019	120.000	350.000	
2	20	197.24	77.715	133.333	395.585	
Overall	90	191.55	87.686	46.250	437.500	

Table 5 shows the productivity of vegetables under protected structure in the study area based on cropping pattern. The average productivity of vegetables under protected structure in the study area was found to be 191.55 mt./ha/year. Farmers producing more than two crops in a year had experienced more productivity (250.86) than that of farmers producing two crops (175.78) and single crop (164.16) which were found to be statistically different at 1 percent level. Please discuss your results with relevant literatures.

Table 5. Productivity of the protected vegetable farming based on cropping pattern

Cropping Pattern	Productivity (mt./ha/year)					ANNOVA Comparison
	N	Mean	Standard Deviation	Minimum	Maximum	
Single crop	20	164.16	42.134	120.000	250.000	p=0.01
Two crops	48	175.78	87.056	46.250	395.580	
More than two crops	22	250.86	95.138	77..333	437.500	
Overall	90	191.55	87.686	46.250	437.500	

FARMERS PERCEPTION ON AVAILABILITY OF INPUTS FOR PROTECTED VEGETABLES FARMING

Table 6 presents the difficulty of farmers regarding the availability of various inputs required for protected vegetable farming. It was calculated using five point likert scale. The difficulty index showed that availability of technician for installation of the structure was the most difficult task while constructing protected structure with the difficulty index of 600.

Table 6. Farmers Perception regarding difficulty in availability of inputs

Materials	Very Difficult	Neutral	Easy	Very Easy	Index of Difficulty	Rank
Cladding Material	0%	40%	49%	9%	0.339	IV
Bamboo	0%	16%	76%	0%	0.330	V
MS Pipe	0%	40%	60%	0%	0.350	III
GI Pipe	0%	75%	15%	0%	0.488	II
Technician for Installment	2%	13%	24%	0%	0.600	I
Inputs for Crop Production	0%	12%	82%	0%	0.308	VI

FARMERS PERCEPTION REGARDING VARIOUS FACTORS THAT AFFECTS PROTECTED VEGETABLE FARMING

Table 7 presents the satisfaction of respondents in the study area with respect to various factors that affect the protected vegetable cultivation. The index of satisfaction of respondents was calculated using five point likert scale. The satisfaction index showed that performance of the crops under the protected structure was the most satisfying factor with the index of satisfaction of 0.511. The least satisfying factor regarding the vegetable production under protected structure was found to be the cost of materials for the construction of protected structure with the index of satisfaction of 0.172.

Table 7. Farmers Perception regarding various factors that affects protected vegetable farming

Factors affecting protected farming	Extremely Satisfied	Very Satisfied	Moderately Satisfied	Slightly Satisfied	Not at all Satisfied	Index of Satisfaction	Rank
Availability of Materials	0%	29%	24%	42%	4%	0.444	III
Cost of Materials	0%	0%	2%	64%	33%	0.172	IX
Availability of Technicians	0%	2%	40%	33%	24%	0.300	VII
Cost of Technicians	0%	11%	29%	20%	40%	0.278	VIII
Quality of work performed by Technicians	0%	13%	49%	27%	11%	0.411	IV
Quality of Inputs	0%	11%	33%	33%	22%	0.333	VI
Performance of Crops	0%	29%	53%	11%	7%	0.511	I
Price of the produce	2%	22%	56%	16%	4%	0.506	II
Guidance of Extension staff	0%	16%	24%	51%	9%	0.367	V

PROFITABILITY OF VEGETABLE PRODUCTION IN TEMPORARY STRUCTURE FOR 10 YEARS

Table 8 presents the cost and benefit components of vegetable cultivation based on the average yield according to the cropping pattern presented in Table 3 in temporary structure along with the indicators of financial analysis. The calculations were done for 1 Ropani (500 square meter) of protected structure. For the ease of comparison, the 3 years' project life was converted to 10 years' project. Highest cost was incurred for structure installment (NRs. 109000). The financial analysis of vegetable production under temporary structure for 10 years found net present value (NPV) of NRs. 1753000. The benefit cost ratio (BCR) was found to be 2.89. Since the cash inflows in the first year were sufficient to cover the cash outflow internal rate of return was not applicable. The payback period was found to be 0.78 years (around 9 months).

Table 8. Profitability of vegetable production in temporary structure Per 500 square (Cost and Benefits in thousand NRs.)

Particulars	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
Structure Installment Cost	109	0	0	109	0	0	0	109	0	0	327
Fixed Asset Cost	58	0	0	0	0	0	0	0	0	0	58
Variable Cost	92	92	92	92	92	92	92	92	92	92	923
Total Cost	260	92	92	201	92	92	92	201	92	92	1309
Income from Production	397	397	397	397	397	397	397	397	397	397	3971

Book Value of Fixed Asset	0	0	0	0	0	0	0	0	0	6	6
Total Income	397	397	397	397	397	397	397	397	397	403	3977
Discount Factor	0.93	0.86	0.79	0.74	0.68	0.63	0.58	0.54	0.50	0.46	-
Discounted Cost	241	79	73	148	63	58	54	109	46	43	914
Discounted Benefit	368	340	315	292	270	250	232	215	199	187	2667
Net Present Value (NPV)											1753
Benefit Cost Ratio (BCR)											2.89
Internal Rate of Return (IRR)											NA
Payback Period											0.78

PROFITABILITY OF VEGETABLE PRODUCTION IN SEMI-PERMANENT STRUCTURE

Table 9 presents the cost and benefit components of vegetable cultivation based on the average yield according to the cropping pattern presented in Table 3 in semi-permanent structure along with the indicators of financial analysis. The calculations were done for 1 Ropani (500 square meter) of protected structure. The life of the project was assumed to be of 10 years. Highest cost was incurred for structure installment (NRs. 544000). The financial analysis of vegetable production under semi-permanent structure for 10 years found net present value (NPV) of NRs. 2272000. The benefit cost ratio (BCR) was found to be 2.47. The internal rate of return (IRR) was found to be 264%. The payback period was found to be 1.91 years (around 23 months).

Table 9. Profitability of vegetable production in semi-permanent structure Per 500 square meter (Cost and Benefits in thousand NRs.)

Particulars	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
Structure Installment Cost	544	0	0	0	0	0	0	0	0	0	544
Maintenance Cost	0	0	0	0	300	0	0	0	0	0	300
Fixed Asset Cost	56	0	0	0	0	0	0	0	0	0	58
Variable Cost	112	112	112	112	112	112	112	112	112	112	1120
Total Cost	712	112	112	112	412	112	112	112	112	112	2020
Income from Production	560	560	560	560	560	560	560	560	560	560	3496
Book Value of Fixed Asset	0	0	0	0	0	0	0	0	0	49	6691
Total Income	560	560	560	560	560	560	560	560	560	609	10187
Discount Factor	0.93	0.86	0.79	0.74	0.68	0.63	0.58	0.54	0.50	0.46	-
Discounted Cost	659	96	89	82	280	71	65	60	56	52	1511
Discounted Benefit	519	481	445	412	381	353	327	303	280	282	3784
Net Present Value (NPV)											2272
Benefit Cost Ratio (BCR)											2.47
Internal Rate of Return (IRR)											264%
Payback Period											1.91

PROFITABILITY OF VEGETABLE PRODUCTION IN PERMANENT STRUCTURE

Table 10 presents the cost and benefit components of vegetable cultivation based on the average yield according to the cropping pattern presented in Table 3 in permanent structure along with the indicators of financial analysis. The calculations were done for 1 Ropani (500 square meter) of protected structure. The life of the project was assumed to be of 10 years. Highest cost was incurred for structure installment (NRs. 1293000). The financial analysis of vegetable production under permanent structure for 10 years found net present value (NPV) of NRs. 1342000. The benefit cost ratio (BCR) was found to be 1.60. The internal rate of return was found to be 30%. The payback period was found to be 3.16 years (around 38 months).

Table 10. Profitability of vegetable production in permanent structure Per 500 square meter (Cost and Benefits in thousand NRs.)

Particulars	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Yea r 7	Yea r 8	Yea r 9	Year 10	Total
Structure Installment Cost	1293	0	0	0	0	0	0	0	0	0	1293
Maintenance Cost	0	0	0	0	300	0	0	0	0	0	300
Fixed Asset Cost	52	0	0	0	0	0	0	0	0	0	52
Variable Cost	107	107	107	107	107	107	107	107	107	107	1070
Total Cost	1452	107	107	107	407	107	107	107	107	107	2715
Income from Production	501	501	501	501	501	501	501	501	501	501	5010
Book Value of Fixed Asset	0	0	0	0	0	0	0	0	0	319	319
Total Income	501	501	501	501	501	501	501	501	501	820	5329
Discount Factor	0.93	0.86	0.79	0.74	0.68	0.63	0.58	0.54	0.50	0.46	-
Discounted Cost	1344	92	85	79	277	67	62	58	54	50	2167
Discounted Benefit	464	430	398	368	341	316	292	271	251	380	3510
Net Present Value (NPV)											1342
Benefit Cost Ratio (BCR)											1.6
Internal Rate of Return (IRR)											30%
Payback Period											3.16

COMPARISON OF NET PRESENT VALUE OF DIFFERENT TYPES OF STRUCTURES

Table 11 presents the result of analysis of variance (ANOVA) for discounted net present value of different types of protected structures. The discounted net present value for 10 years of agricultural project for vegetable production under temporary, semi-permanent and permanent structure were found to be NRs. 1753368.226, NRs. 2272357.420, and NRs. 1342210.064 respectively. The result of ANOVA showed no significant difference among the net present value in different types of structure

Table 11. Comparison of net present value of different types of protected structures

Type of Structure	Net Present Value					ANNOVA Comparison
	N	Mean	Standard Deviation	Minimum	Maximum	
0	50	1753368.226	1305765.908	159274.096	5244997.892	p=0.178
1	20	2272357.420	2479170.355	-188785.096	6847396.091	
2	20	1342210.064	881413.035	375219.973	3421842.925	

Note: 0= temporary structure, 1= semi-permanent structure, 2= permanent structure.

COMPARISON OF BENEFIT COST RATIO OF DIFFERENT TYPES OF STRUCTURES

Table 12 presents the result of analysis of variance (ANOVA) for discounted benefit cost ratio of different types of protected structures. The mean discounted benefit cost ratio for 10 years of agricultural project for vegetable production under temporary, semi-permanent and permanent structure were found to be 2.89, 2.47, and 1.60 respectively.

Table 12. Comparison of benefit cost ratio of different types of protected structures

Type of Structure	Benefit Cost Ratio					ANOVA Comparison	Dunnett's test	
	N	Mean	Standard Deviation	Minimum	Maximum		1	2
0	50	2.89	1.1556	1.146	6.457	p=0.000	p=0.636	p=0.000***
1	20	2.47	1.5713	0.883	5.162			p=0.070*
2	20	1.60	0.2770	1.138	1.979			

Note: 0= temporary structure, 1= semi-permanent structure, 2= permanent structure
* and *** = significant at 10% and 1% probability level

Since there was significant difference among the benefit cost ratio of different protected structures, Dunnett's test (assuming non equal variance) was applied. The result of the Dunnett's test showed that benefit cost ratio of temporary structure was statistically different from that of permanent structure at 1% probability level and the benefit cost ratio of semi-permanent structure was significantly different from that of permanent structure at 10% probability level. However, there was not statistical difference in benefit cost ratio between temporary structure and semi-permanent structures. (Murthy, Prabhakar, Hebbar, Srinivas, & Prabhakar, 2009) in their study of economic feasibility tomato and capsicum production under poly house found benefit cost ratio of 1.80 which was slightly lower than the findings of this study. Similarly, (Kumar, Singh, & Chaudhari, 2018) found the 1.18 benefit cost ratio of capsicum production in naturally ventilated greenhouse.

(Engindeniz & Tuzel, 2002) found benefit cost ratio of 2.66 for netted cabbage and benefit cost ratio of 1.58 for rain shelter type of protected structure.

COMPARISON OF PAYBACK PERIOD OF DIFFERENT TYPES OF STRUCTURES

Table 13 presents the result of analysis of variance (ANOVA) for payback period of different types of protected structures. The payback period for vegetable production under temporary, semi-permanent and permanent structure were found to be 0.78, 1.91, and 3.16 years respectively.
Since there was significant difference among the payback period of different protected structures, Dunnett's test (assuming non equal variance) was applied. The result of the Dunnett's test showed that payback of each type of protected structure were statistically different at 1% probability level.

Table 13. Comparison of payback period of different structures

Structure Type	Pay Back Period					ANNOVA Comparison	Dunnett's test	
	N	Mean	Standard Deviation	Minimum	Maximum		1	2
0	50	0.78	0.302	0.288	1.557	p=0.000	p=0.004***	p=0.000***
1	20	1.91	1.350	0.546	5.013			p=0.006***
2	20	3.16	1.011	1.750	4.475			

Note: 0= temporary structure, 1= semi-permanent structure, 2= permanent structure
*** = significant at 1% probability level

CONCLUSION

This study indicates that socio-demographic characters like age, years of farm registration, experience in protected farming, area of household under protected farming, and major source of income affects the adoption of different types of protected structures. The lower productivity in high tech (permanent) structures than that of semi-permanent and temporary structures clearly pictures the weak technical knowhow of operating permanent structures to exploit their production potential. Looking at the profitability ratios, mainly benefit cost ratio and payback period temporary structures were found more profitable than that of semi-permanent and permanent structures. In conclusion, given the existing condition of technical knowhow about the operation of permanent structures, investment in such structure was not found to be economically conducive.

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STUDY ON LIMNOLOGY OF THOSNE RIVER LOCATED IN LALITPUR DISTRICT, NEPAL

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ABSTRACT

Study on limnology of Thosne River was done to identify the diversity of aquatic insect and fish, and also to determine the water quality parameters for assessing suitability for fish farming. Some water quality parameters were recorded on the spot and others were analyzed in the laboratory. Altogether 14 different limnological parameters (3 physical, 8 chemical, 2 biological and 1 geographical) of Thosne river were studied in winter and spring seasons. During study period, the water temperature at the 1st (downstream) and the 5th (upstream) sampling stations ranged from: 15.75±2.81°C and 12.29±2.61°C: the pH 7.59±0.22 and 6.37±0.23; conductivity 194±10.7 µS/cm and 130±12 µS/cm; turbidity 5.91±2.74 NTU and 2.75±1.89 NTU, dissolved oxygen 9.62±0.87 mg/L and 10.58±0.7 mg/L; hardness 86.70±10.86 mg/L and 60.54±8.9 mg/L; chloride 14.25±25 mg/L and 7.79±1.44 mg/L; and flow rate 22.47±3.5 L/Sec and 13.5±2.4 L/Sec respectively. The ammonia nitrogen at the 1st (downstream), 3rd (midstream) and 5th (upstream) sampling stations ranged from 0.19±0.07; mg/L, 0.031±0.0056 mg/L and 0.013±0.003 mg/L whereas nitrate nitrogen ranged from 2.20±0.84 mg/L, 0.50±0.10 mg/L and 0.17±0.060 mg/L respectively. All the parameters were positively correlated with each other except dissolved oxygen and altitude. Three native fish species and aquatic insects from eight different families were identified. All the water quality parameters were within the recommended limit for rainbow trout fish farming up to midstream.

Key words: Biodiversity, Fisheries, Ichthyologist, , Limnology, Nepal,

INTRODUCTION

Nepal has tremendous geographic diversity. It rises from as low as 59 meters elevation in the tropical plains to the earth's highest peak 8,848 meters Mount Everest. Nepal lies between India and China, with the latitude of 20°21' to 30°27' north and longitude of 80°4' to 88°12' east. Nepal is rich in water resources. Nepal has 6,000 rivers. Total inland water resource of Nepal is 818,500 ha (3% of Nepal's total land area) of which irrigated paddy field covers the greatest area 398,000 ha (49%), marginal swamp cover 12,500 ha (1.4%), rivers cover 395,000 ha (48%), lakes 5,000 ha (0.60%), reservoirs 1,500 ha (0.20%), village ponds 6,500 ha (0.80%) and marginal/swamps …. ha (1.4%) (CFPCC, 2017). There are 240 species of fin fish including 217 indigenous fish species, 9 species of crabs, 3 species of prawn, 50 species of mollusks, 53 species of frogs, 193 species of water birds and 84 species of aquatic plants found in Nepal (CFPCC, 2017). Fisheries and aquaculture production of Nepal is 91,832 metric ton (mt)/year in which 21,500 mt comes from the captured fisheries from major rivers and lakes (CFPCC, 2017). There are about 462,070 people engaged in capture fisheries among them 60 percent are female (Mishra, 2015). According

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to the UUCN report 2004, 10 ethnic groups are partially engaged in capture fisheries which is about 10 percent of total population of the country.

The aquatic insect diversity in Nepal had been poorly studied relative to other fauna. Fish especially trout farming along the river side is only possible with the continuous monitoring of water quality parameters protecting aquatic ecosystem. Mishra (1975) reported a short list of aquatic insects of Nepal. Malla et al. (1978) carried out the studies on the aquatic insects of Kathmandu valley. He had collected altogether 61 species of insects from various water bodies in Kathmandu valley, of these 37 were new generic and specific records from Nepal. Yadav et al. (1980, 1981, 1982 and 1983) studied macro-invertebrates of Rajdal Pond, Godawari Khola and Godawari fish pond. Yadav and Rajbhandari (1982) studied the benthic fauna of Bansbari Khola and Dhobi Khola. Ojha (2016) reported insects belonging to 5 genera, 5 families and 3 orders from the NA PUKHU pond of Bhaktapur district.

Thosne river is located at the southern part of Lalitpur district which is made up of many small perennial spring-fed torrential streams flowing from east to west.

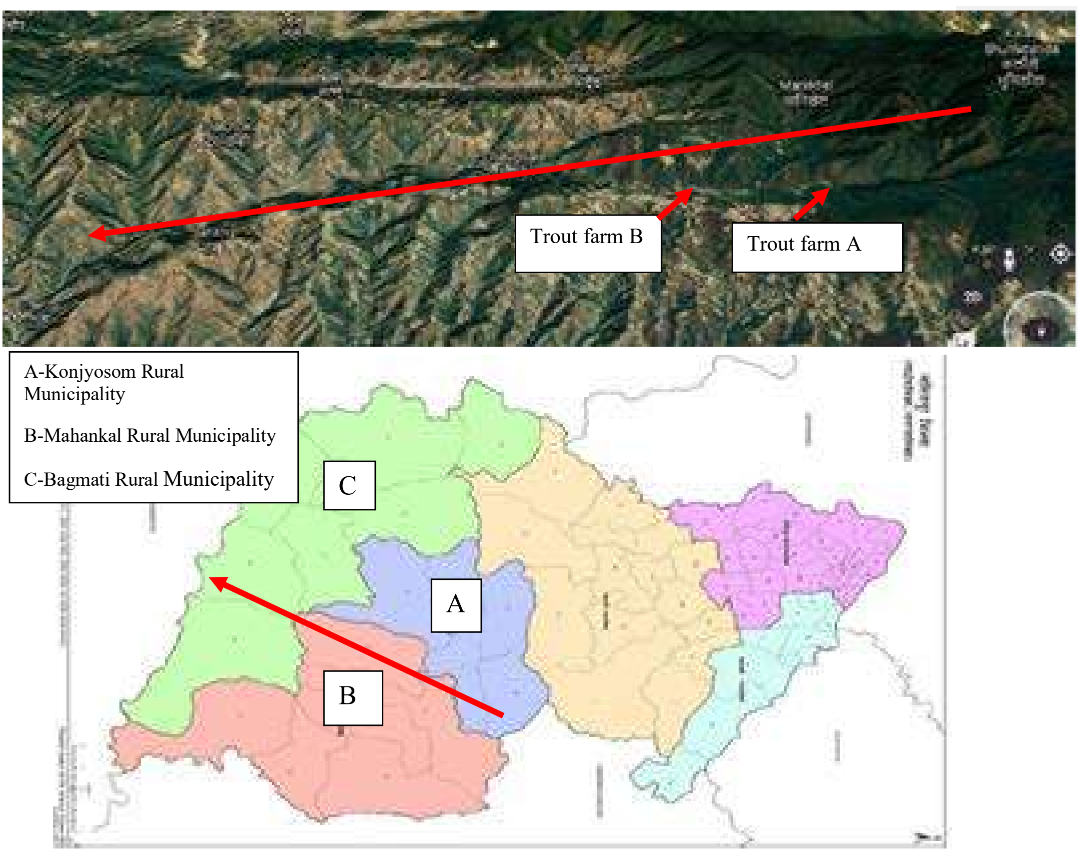
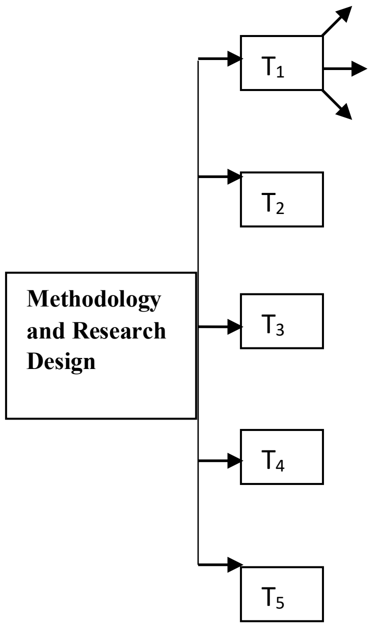


Figure 1: Satellite view of the Thosne river and political map of Lalitpur district

Study on limnology (chemical, physical, biological and geographical characteristics) of Thosne river was done to understand baseline diversity of fish and aquatic insect along with their proper identification. In Nepal, rainbow trout is popular aquaculture fish in the temperate hilly region. Its annual production was 420 mt /year (CFPCC, 2017). This study aims to determine the water quality parameters for assessing suitability and feasibility for fish farming.

MATERIALS AND METHODS

The study was carried out from 15th December 2017 to 8th June 2018 representing two seasons: winter (December to February) and spring (March to May). Samples were collected in the interval of 20 days for water quality parameters and 45 days for insect and fish. Five different sampling stations were selected for the study which was about 10 km apart from each other. Fifth sampling station was located at the mouth of the river where no villages and trout farms were located. Fourth and third sampling stations were located just behind the trout farm A and trout farm B and second and first sampling stations were located behind the villages viz. Chaughare and Sankhu. Water quality parameters were measured in both field/on the spot and laboratory. Water temperature, pH, conductivity, altitude and flow rate were measured in the field. Determination of dissolved oxygen, hardness, turbidity, chloride, ammonia and nitrate were done in laboratory of Nepal Academy of Science and Technology (NAST), Lalitpur, Nepal. Identification of aquatic insect and fish were done in laboratory of Fisheries Research Division (FRD) under Nepal Agriculture Research Council (NARC).



Chemical parameters

Water sampling was done in plastic bottles (500ml) and BOD bottles (300ml). Collection of insects and fish were done in plastic bottles (500ml) with 10 percent formalin solution. Samples were transported in insulated ice box for 4 hours to laboratory.

arameters	Method of determination
Dissolved oxygen	Determinatiopn of dissloved oxyegen was done by **Winkler titration method** (titration with sodium thio-sulphate solution to a color end point).MnSO4 soln and KI + NaOH soln was added in a BOD oxygen bottle using a pipette. The bottle was closed and thoroughly shaken to ensure proper mixing. A brown precipitate was formed at the bottom of the bottle after the process. The bottle was then, transported to the laboratory for further analysis.
Ammonia (NH_3)	Ammonia was determined by Nessler's method using spectrophotometer.This method depends on the yellow to brown colour production when reacted with Nessler' reagent which is strougly absorbed over a wide range spectrum (λ=400-500nm). With the help of standard cuve preparation, concentration of ammonia nitrogen of unknown sample can be determined.
PH and Conductivi ty	DTSI water proof meters having 99% accuracy
Nitrate	Nitrate was determined by Brucine method using spectrophotometer.This method gives results range from 0.02-0.8 mg/L Nitrate nitrogen. The colour produced from adding reagents in samples bears linear relationshipe with the nitrate concentration. With the help of standard cuve preparation, concentration of nitrate nitrogen of unknown sample has been determined.
Chloride, arsenic and hardness	Water quality kid product of Machery-Nagel having 99% acuracy.

Biological parameters: Fish and insects collection was done from each 40 m^2 area and 4 m^2 area of river respectively in 45 days interval. Sample collected were preserved in 10% formalin solution then identification was done in fisheries research division, NARC.

Physical parameters

-Turbidity was measured by Nephalometer in lab.
-Temperature was measured by digital thermometer in the field.
-Flow rate was measured by making temporary spill way by using plastic sheath and locally available materials.

Geographical parameters; Altitude and latitude was measured by using application called Altimeters operated in android phone.

Figure 2: Schematic presentation of measurement of chemical, physical and geographical parameters

STATISTICAL ANALYSES

Physico-chemical parameters recorded were first tabulated and then analyzed. Data synthesized were average of sampling stations in upstream, midstream and downstream. Following Karl Pearson's method, correlations between different water quality parameters were calculated and the corresponding significance tests were done using SPSS statistical software.

RESULT AND DISCUSSION

Acherjee and Barat (2014) reported 0.6°C decrease in water temperature per 100 m increase in altitude and they also reported water velocity 0.61-1.5 m/sec with its lowest value in November and highest in July. During the study period flow rate (mean±SD) of Thosne river was 13.53±2.3 L/Sec at upstream in winter and 22.5±4.33L/Sec at downstream in spring. The flow rate of Thosne river was found suitable for 4 to 5 rainbow trout farms operation with the production capacity of 1-2 mt/year from each farm.

Table 1: Season-wise water quality parameters of the Thosne river with mean±SD at upstream, midstream and downstream from 15th December 2017 to 8th June 2018

Particular	Unit	Winter			Spring		
		Upstream	Midstream	Downstream	Upstream	Midstream	Downstream
1. Water temperature	°c	10.05±0.8	11.9±0.7	13.9±1.8	14.35±0.89	16.13±0.68	17.14±1.80
2. pH		6.38±0.25	6.55±0.21	7.42±0.15	6.32±0.25	6.87±0.28	7.45±0.14
3. Conductivity	µS/cm	105.3±6.12	143.43±11.1	185.83±2.36	117.5±6.48	148.9±12.15	200.7±3.86
4. Dissolved oxygen	mg/L	11.04±0.18	10.53±0.31	10.81±1.1	10.04±0.18	9.57±0.20	9.19±0.73
5. Hardness	mg/L	66.47±8.9	78.66±11.01	93.91±13.22	54.66±8.73	67.77±11.33	82.16±12.78
6. Turbidity	NTU	1.72±0.54	2.42±1.2	3.82±0.92	4.1±1.79	5.82±1.85	7.91±1.73
7. Chloride	mg/L	5.01±0.86	7.90±1.01	10.61±1.2	7.05±0.68	11.60±1.38	16.44±2.99
8. Ammonia	mg/L	0.013±0.002	0.014±0.006	0.12±0.03	0.015±0.01	0.015±0.03	0.19±0.07
9. Nitrate	mg/L	0.01±0.06	0.03±0.18	0.073±0.42	0.02±0.003	0.046±0.01	0.09±0.02
10. Altitude	M	1932	1741	1509	1932	1741	1509
11. Flow rate	L/sec	13.53±2.3	19.62±5.1	21.91±3.2	15±2.9	20.69±5.3	22.5±4.33

Bhagat and Barat (2015) reported 8.63±1.21 mg/L dissolved oxygen, electrical conductivity 107.83±55.61 µS/cm and hardness 47.08±24.08 mg/L in the raceway of Kathmandu in the year 2010/11. In Thosne river dissolved oxygen recorded was 10.58±0.7 mg/L at upstream in winter and 9.62±0.87mg/L at downstream in spring. The conductivity was 105.30±6.12 and 200.70±3.89

at the upstream and downstream in the months of winter and spring respectively. The hardness recorded were 82.708±10.86 mg/L and 66.47±8.9 mg/L at the upstream and downstream sampling in winter and spring seasons respectively. All three chemical parameters viz. dissolved oxygen, hardness and electrical conductivity were recorded slightly more in Thosne river than in the raceway of Kathmandu.

The acceptable ammonia (NH_3) concentration is less than 0.05 mg/L for cyprinids and 0.0125 mg/L for salmonids (Svobodova *et al.*, 1993) farm fishes. There are two forms of ammonia present in water as ammonium ion (NH_4^+) and ammonia (NH_3). Ammonia is highly toxic to fish and ammonium ion is nontoxic, because ammonia (NH_3) is permeable through the gills to the blood. The concentration of ammonia increases with increase in the alkalinity and temperature while the concentration of ammonium ions increases with the decrease in temperature and pH. In Thosne river, concentration of ammonia nitrogen recorded were 0.013±0.002 mg/L at upstream in winter and0.015±0.006 at midstream and 0.19±0.07 at downstream in spring. So Thosne river is suitable for trout farming up to mid-stream. The appropriate nitrate concentration is <0.5mg/L for trout farming (CFPCC, 2017). The concentration nitrate nitrogen recorded was found suitable for trout farming up to mid-stream of the river.

WHO guideline for chloride concentration in drinking water is 250mg/L. In most of the rivers and lakes chloride content was found to be less than 150 mg/L. The chloride concentrations (mean±SD) recorded were 16.45±2.93 mg/L and 5.01±0.86 mg/L at downstream in spring and at upstream in winter respectively. Chloride recorded at all the sampling stations found within the WHO standard for drinking water. Chloride concentrations were found to be higher in spring months than in winter months. Water temperature, pH and turbidity were higher in midstream and downstream than in upstream.

Table 2: Pearson correlation coefficient along with significance (two-tailed) of physico-chemical parameters of the Thosne river from 15th December 2017 to 8th June 2018

Parameters	WT	PH	EC	DO	TH	TBD	CL	NH_4^+	NO_3^-	ALTD	FR
Water temperature	1										
pH	0.450 *	1									
Electrical conductivity	0.450 *	0.641 **	1								
Dissolved oxygen	-0.901 **	-0.35	-0.46 *	1							
Total hardness	0.063	0.337	0.65 **	- 0.13	1						
Turbidity	0.771 **	0.476 *	0.49 *	-0.7 **	0.182	1					
Chloride	0.736 **	0.667 **	0.76 **	-0.7 **	0.244	0.735 **	1				

Ammonia	0.487*	0.651**	0.77**	-0.5**	0.384	0.564**	0.787**	1			
Nitrate	0.526**	o.693**	0.83**	-0.5**	0.438*	0.594**	0.827**	0.912**	1		
Altitude	-0.42*	-0.67**	-0.90**	0.44*	-0.67**	-0.44*	-0.74**	-0.80**	-0.82**	1	
Flow rate	0.471*	0.428*	0.412*	-0.5**	-0.01	0.540**	0.534**	0.551**	0.488*	-0.572**	1

All the water quality parameters were positively correlated with each other except dissolved oxygen and altitude which were negatively correlated with rest of the other parameters.

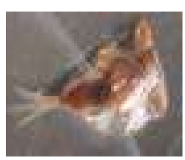
During the study period, three species of fish under three orders, three families and three genera were recorded. The most common species distributed in the Roshi khola was *Schizothorax richardsonii* second common species was *Schistura rupecula.*

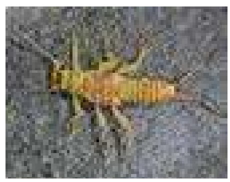
Order/family/genus	Description
A. Order: Cypriniformis family: Cyprinid  Fig:*Schizothorax richardsonii(Gray,1832)*	According to wagle et al 2015, this is cold water valuable game fish commonly known as Asala in Nepal. It prefers to live under the rocks and is primarily a phytophagous bottom feeder having special mouth to scrape the algal slime attached on the stone surface. It used to be one of the widely distributed and abundantly available species in the Himalayan foothills of Nepal, India, Bhutan Pakistan, and Afghanistan (Talwar and Jhingran, 1991). Electro fishing, use of acid for harvesting fish and water quality degradation are the main causes of present reduction in abundance in this river than in the past. It feeds on algal slime, detritus, and insects encrusted on the stones. It breeds during April-May before monsoon flood the river. No technology has been developed yet for commercial culture particularly due to not being able to develop appropriate feed for Asala in Nepal. Introduction of exotic fishes like rainbow trout in hill streams of the Himalayan foothills may be threat for this fish.
B. Order: Cypriniformes Family: Cobitidae  Fig *Schistura rupecula* (Mc Clelland, 1839)	It is also called stone loach in Nepal which is very popular for its delicious white flesh. It has been used as ornamental fish because of its beautiful appearance with the 14-16 light and dark bands on body. It feeds on small larvae found at the bottom. According to the Gupta and Gupta (2006) stone loach accepts most of the formulated feed. It favors a sandy bottom where there is a possibility of hiding under various stones. The breeding season starts from spring (February) until May and June. It sheds ripe eggs at periodic intervals. It is found at the altitudinal ranges from 1,000 to 1,800 m. This fish is also found in Koshi, Narayani, Gandaki, Trishuli, Bheri and Karnali rivers. Soft water having pH 6-7.5 and temperature (16-25) were recorded at their natural habitat.

C. Order: Siluriformes Family: Sisoridae  Fig: *Glyptosternum maculatum* (Regan)	It is inhabited in shallow, rocky rivers with moderate water current where it feeds on invertebrates. *Glyptosternum maculatum* is important hillstram fish commonly known as torrent catfish in Nepal belonging to family Siluriformes. It is locally known as Til Kabre in Nepal (Bhusal and Chitrakar, 2017). It is found in cold water of foothill of Nepal, India, Tibet and Bhutan. Its body is flattened ventrally, having inferior mouth, four pairs of thick barbells and pointed teeth. It has distinct dark brown body color with depressed head. Mouth has villiform teeth in bands on jaws. Its dorsal fin is longer while the adipose fin is very small. The caudal fin is not forked consisting of black lines.

Sharma (1996) reported 2 species of Odonata, 3 species of Ephimeptera, 3 species of Diptera, 5 species of Hemiptera, 7 species of Coleopteran, 10 species of Orthoptera and 2 species of Crustacea orders from Koshi river basin belt of Nepal-India (North-Bihar). List of aquatic insects collected in Thosne river were as follows.

Table 4: Insects from different orders and families collected in Thosne river

Order/family/genus	**Description**
1. Order: Ephemeroptera family:Ephemerillidae Fig:*Ephemerella spp.*  2. Order: Ephemeroptera Family: Heptagenidae *Fig: Stenonema spp.* 	Insects belongs to the order Ephemeroptera have elongated, cylindrical or somewhat flattened body that passes through a number of instars molting and increasing in size. Three pairs of legs, operculate gills, thoracic developing wing pads were seen in these insects. Nymphs were found under stones and decaying vegetation. For the hatching of eggs and the larval development they need cold flowing water. They feed on the aquatic micro vegetation including algae.
3. Order: Lepidoptera Family: pyrilidae Fig: Aquatic moth 	The adults were found near the water feeding on nectar which means they also play role in pollinator of semi aquatic plants. Larvae were found at the bottom of the water column. Their portable shelter made by using their silk produced from their special gland and small pieces of leaves were found at clayey bottom of river.

4. Order: Trichoptera Family : Phryganidae  5. Order:Trichoptera family: Glossosomatidae Fig: Caddisflies 	Adults of most of the Phryganidae are said to be nocturnal and attracted by light. Larvae were found in water. They can build cages of silk produced by them. Pupation takes place in a silicon cocoon inside the cage. Three pairs of legs and two pairs of wings were found in larvae. Insects from Glossomatidae make hard cases of sand particles. Small Sand particles were bonded well by their silk thread produced by special glands to make strong cases.
6. Order: Plecoptera Family: Perlidae Fig: Stone fly 	Most of the adults were grey in color with transparent wings. They dip abdomen on fresh water below the surface of water and laid eggs. Nymphs were seen in water eating aquatic vegetation. When they became ready to be adult they come on the surface of water and break their final nymph skin. Since they produce single generation in a year, they are They are said to be univoltine.
7. Order: Coleptera Family: Gyrinidae Fig: Water beetle 	whirligig beetle are highly carnivorous eating aquatic insects trapped on the water surface and swimming with the help of two pairs of legs as oars. They can swim exceptionally fast in circle. They go complete metamorphosis.
8. Order: Odonata Family: Aeshnidae Fig: Dragonfly nymph 	Dragon flies are the predatory semi-aquatic predatory insects which consume small flying insects like mosquitoes. They have two pairs of long membranous transparent wings. Head possess large compound eyes and three ocelli; and pair of short antennae. They have chewing type mouth part with teeth and strong legs to catch the prey. Their nymph remains in the water feeding aquatic insects.
9. Order: Hemiptera Family: Gerridae Fig: Water striders 	Water skeeters are true bug having piercing and sucking type mouth parts and distinguishing themselves by having the unusual ability to walk and jump on water surface, making them surface living animal. These carnivorous insects' nymphs were similar to adults. They eat aquatic insects and small fish hatchlings. Adults lay eggs under the submerged stone with gelatinous substances.

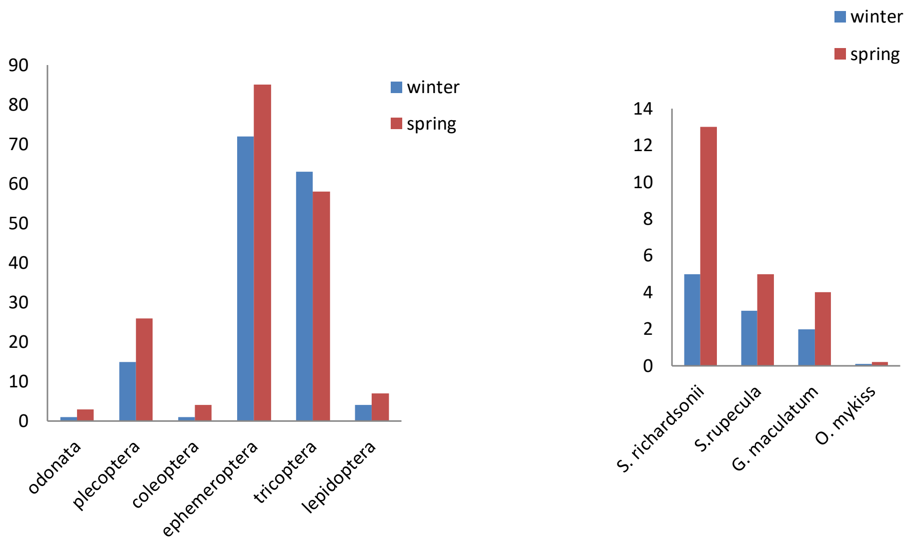


Figure 3: Seasonal abundances of insects and fishes in Thosne river

Insect collection was done in 4 square meters area and fish collection was done in 40 square meters of the river. Similar kind of trend of insect population was reported in Tamakoshi river by Directorate of Fisheries Development, Balaju, Nepal (DoFD, 2014). Snow trout (*Schizothorax richardsonii)* and insects from Family Ephemeridae were most abundant in Thosne river.

CONCLUSION

Thosne river is one of the most important rivers of the district because it avails its resources to many nearby villages. Biodiversity of this river is in risk due to continuous degradation of aquatic environment. Illegal fishing and bad aquaculture practices, deforestation, construction of roads along the side of the river, soil erosion and growing demand of water for irrigation and other purposes were found the main causes of biodiversity degradation in this river.

All the water quality parameters were found suitable for rainbow trout fish farming up to mid-stream (Thing Tol). Local people were found helpful and supportive in water sampling and fish and insect collection. Collection of water samples and their analysis was done using standard methods in the laboratory of NAST, Lalitpur, Nepal. Identification of fish and insects were done in laboratory of FRD, Godawary, Lalitpur, Nepal. Still there was no considerable effluence pollution seen due to the rainbow trout farming in this river. Continuous monitoring of water quality and aquatic biodiversity along with the effective conservation management practices were highly recommended.

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AGRO-MORPHOLOGICAL CHARACTERIZATION AND DIVERSITY ASSESSMENT OF RICE LANDRACES IN NEPAL

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ABSTRACT

Plant genetic resources are raw materials and their use in breeding is one of the most sustainable ways to conserve agro-biodiversity. Field research was conducted at National Agriculture Genetic Resources Centre (NAGRC) during 2018 & 2019 with the objective of agro-morphological characterization and diversity assessment of rice landraces. Forty-two landraces collected from 21 districts of Nepal were characterized and evaluated by using non replicated row design. The phenotypic diversity was assessed based on fourteen qualitative and thirteen quantitative characters following the descriptors developed by Bioversity International, IRRI and WARDA. Basic statistics were calculated by using Excel 2016 and UPGMA clustering and PCA was done with MINITAB-17. The diversity index (H') and coefficient of variation for different traits ranged from 0.16-0.96 and 8.00-47.77 respectively. Clustering grouped the landraces into four clusters with minimum similarity level of 46.33%. Landraces of cluster three i.e. NGRC01917, NGRC03034, NGRC03395, NGRC03057, NGRC03163 are found to be superior in terms of maturity days and yield. PCA partitioned the total variation into three principal components contributing 75.5% of the cumulative variance. Thus, the present study is the preliminary picture for characterization and diversity analysis in Nepalese rice landraces that can be used by the breeder in rice improvement program.

Keywords: Agro-biodiversity, Characterization, PCA, Phenotypic, Trait

INTRODUCTION

Rice (*Oryza sativa* L.) belonging to the family Poaceae is one of the most important food crops grown worldwide. The Sativa rice species found in Asia, America, and Europe are commonly grouped into three sub-species named Indica, Japonica, and Javanica. Rice is believed to originated and been cultivated in tropical Asia, the oldest record dating 5000 years BC (Kandel & Shrestha, 2018). Nepal is also considered as one of the centers of rice genetic resources which include several wild species, their relatives, and thousands of landraces (Joshi et al., 2016). National Agriculture Genetic Resources Centre (NAGRC) has a collection and conservation of 2237 rice germplasms from different parts of the country (Genebank, 2021). Despite this large collection and conservation of rice germplasms, there has been very limited use of these in breeding by rice breeding program in Nepal. They are more dependent on foreign germplasm for varietal development. There are more than 1000 genotypes of rice introduced from IRRI for evaluation (Joshi, 2017). Until now, only 10 rice landraces have been used in the rice breeding program (Paudel et al., 2017). Among the rice landraces, only three (Chhomrong, Pokhreli

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Jethobudho, and Lalka Basmati) out of 76 released rice varieties are the landraces improved and released (Ghimire et al., 2014; Ghimire et al., 2020).

Landraces have been nurtured and cultivated by the farmers through the traditional method of selection over the years. With the increase in population and increase in the food demand, breeding activities these days are being directed towards high yielding varieties development (Dhakal et al., 2020). Though a wide range of genetic resources is available nationally and internationally, the breeders tend to concentrate only on adapted and improved materials avoiding wild and weedy relatives, and landraces in their crossing program (Upadhyaya et al., 2014). The use of landrace diversity in breeding programs is low either because of a lack of knowledge about the genetic worth or the linkage drag associated with the transfer of beneficial traits from such germplasm (Upadhyaya et al., 2014). Non-availability of quality seeds of the local varieties and the introduction of high yielding varieties are also contributing to their deliberate replacement. Although the traditional varieties or landraces have a low yield as compared to improved and hybrid varieties, they have a high capacity to tolerate biotic and abiotic stresses, with high yield stability and an intermediate yield level under a low input agricultural system (Manohara et al., 2018). Landraces are the reservoir of genetic potential and several resistant genes for biotic and abiotic stress, whereas modern varieties are devoid of such quality. They are more adapted to local conditions, have a higher chance of survival and reproduction, and pass on their characteristics to the next generation (Dhakal et al., 2020). Direct use of genebank materials re-introducing with preliminary characterization and evaluation benefits the farming community because, despite lower yield in comparison to improved and hybrid varieties, these landraces acquire several comparative advantages such as premium quality and taste, longer straw suitable for livestock feed, and traditional mat (Gundri) making and resilience to various biotic and abiotic stresses (Ghimire et al., 2020).

Landraces are raw materials and their use in breeding is one of the most sustainable ways to conserve biodiversity. Agro-morphological characterization of germplasm is fundamental in order to provide information for plant breeding programs (Lin, 1991). Characterization and landrace enhancement are required to increase the utilization of landraces (Thapa et al., 2021). Systematic study and characterization of germplasm are not only important for utilizing the appropriate attribute but also essential in the present era for protecting the unique germplasm. Well-characterized and evaluated germplasm collections would have greater chances of contributing to the development of new varieties and consequently greater realization of benefits for the resource-poor farmer (Manohara et al., 2018). Nepalese rice landraces have a high level of genetic diversity that will be a very important input for future improvement and sustainability of the rice-based production system (Gauchan, 1999). Rice diversity and diversity traits found in Nepalese rice can be commercially utilized in rice breeding program to increase yields and develop biotic and abiotic stress tolerant rice varieties. There is, therefore, a need to discover new sources of variation and assess the pattern of diversity to identify genetically diverse germplasm with beneficial traits to promote utilization of such germplasm in the rice improvement program.

METHODOLOGY

EXPERIMENTAL MATERIALS AND DESIGN

The experiment was carried out at NAGRC Khumaltar, Lalitpur in 2018 and 2019. Geographically it is located at an altitude of 1368 m, latitude of 27°40'N, and longitude of 85°20'E. The characterization blocks have black loamy soil. Forty-two rice landraces collected from twenty-one districts of the country as depicted in Table 1 are grown in the field of NAGRC. The experiment was conducted in a non-replicated row design with a direct seeding method for agro-morphological characterization and diversity assessment. The seeding dates were 31st May and 7th June in 2018 and 2019 respectively. Each accession was seeded in four rows of 3-meter length with 20 cm × 20 cm spacing with 2 to 3 seeds per hill. The chemical fertilizer was applied at the rate of 80, 60, 40 kg ha-1 N, P2O5, K2O. The entire dose of phosphorus and potassium and half dose of nitrogen was applied as a basal dose. The remaining dose of nitrogen was applied in two equal splits, one at the time of tillering and the remaining another at the panicle initiation stage. Weeding and pulverizing of soil were done regularly whenever necessary to keep the plots free from weeds and to ensure good aeration in the soil.

Table 1. Rice landraces with their local name and collection sites

S.N.	Landraces	Local Name	Collected site	Altitude (m)	Latitude	Longitude
1	NGRC01676	Masino dhan	Dudhpokhari, Lamjung	1920	28.28	84.40
2	NGRC01685	Seto dhan	Gaunsahar, Lamjung	1981	28.28	84.40
3	NGRC01780	Kalo marse dhan	Dharabari, Humla	2350	30.00	81.90
4	NGRC01837	Rambilash Dhan	Kuntadevi, Okhaldhunga	1384	27.91	85.25
5	NGRC01917	Ghaiya dhan	Orang, Dolakha	2251	27.80	86.24
6	NGRC02819	Ekle dhan	Nauthar, Lamjung	1402	28.28	84.40
7	NGRC02829	Lahare dhan	Bichaur, Lamjung	1996	28.28	84.40
8	NGRC02833	Anadi dhan	Nauthar, Lamjung	1402	28.28	84.40
9	NGRC02851	Madhise dhan	Dhorphirdi, Tanahun	1311	27.95	84.21
10	NGRC03034	Rate ghaiya	Latamandau, Doti	605	29.16	80.88
11	NGRC03057	Churi dhan	Patan, Baitadi	1266	29.49	80.60
12	NGRC03089	Dudhraj dhan	Dahathum, Syangja	1304	28.07	83.76
13	NGRC03093	Kalo dhan	Deurali, Doti	508	28.30	84.77
14	NGRC03097	Mansara Dhan	Hespur, Gorkha	3296	28.30	84.77
15	NGRC03141	Jado Dhan	Bagaicha, Myagdi	1124	28.57	83.50
16	NGRC03158	Jumli Dhan	Chandannath, Jumla	2290	29.22	82.25
17	NGRC03161	Kalo marsi	Depal, Jumla	2340	29.22	82.25
18	NGRC03163	Jumli Dhan	Mahat, Jumla	2815	29.22	82.25
19	NGRC03195	Darmali Dhan	Yarsha, Dolakha	1855	27.80	86.24
20	NGRC03322	Aaun dhan	Bhojpur bazar,	1528	27.17	87.05

			Bhojpur			
21	NGRC03332	Sokan Dhan	Nijgadh, Bara	193	27.20	85.23
22	NGRC03341	Kataura dhan	Nijgadh, Bara	192	27.20	85.23
23	NGRC03352	Jumli Dhan	Depal, Jumla	2290	29.22	82.25
24	NGRC03371	Ruwani dhan	Bansagadhi, Banke	150	27.05	81.80
25	NGRC03291	Rato basmati Dhan	Bharatganj, Bara	194	27.20	85.23
26	NGRC03314	Naiharwa Dhan	Bharatganj, Bara	195	27.20	85.23
27	NGRC03333	Langhi Dhan	Nijgadh, Bara	192	27.20	85.23
28	NGRC03342	Sankharika dhan	Nijgadh, Bara	193	27.20	85.23
29	NGRC03348	Palsa moto dhan	Kadmaha, Morang	73	26.45	87.37
30	NGRC03349	Bhatte dhan	Laxmipur, Dang	606	28.00	82.49
31	NGRC03361	Kariya kamod dhan	Chuhadwa, Siraha	81	26.29	86.10
32	NGRC03362	Panchali Dhan	Rayapur, Saptari	116	26.36	86.45
33	NGRC03363	Makhul sayar dhan	Deliya, Saptari	120	26.60	86.72
34	NGRC03364	Basmati Dhan	Chinnamasta, Saptari	90	26.60	86.72
35	NGRC03366	Nanhiya Dhan	Chinnamasta, Saptari	90	26.60	86.72
36	NGRC03367	Matiya dhan	Haripur, Sunsari	85	26.31	87.01
37	NGRC03384	Baruwa Dhan	Bankatwa, Banke	106	27.05	81.80
38	NGRC03393	Jiri Dhan	Murarwa, Rautahat	250	26.48	85.40
39	NGRC03395	Jiri Dhan	Murarwa, Rautahat	250	26.48	85.40
40	NGRC03272	Local Dhan	Lakhanpur, Parsa	90	27.10	84.79
41	NGRC03403	Local Dhan	Madar, Siraha	80	26.63	86.18
42	NGRC03418	Local Dhan	Madar, Siraha	85	26.63	86.18

DATA RECORDING AND ANALYSIS

Agro-morphological traits were measured at various growth stages according to descriptors for rice (IPGRI, 2007). Five random plants from each landrace were selected for agro-morphological traits evaluation. Fourteen qualitative traits like leaf blade pubescence, leaf blade color, basal leaf sheath color, flag leaf attitude, ligule color, collar color, etc. were observed at different growth stages. Likewise, thirteen quantitative traits like days to emergence, days to maturity, plant height, leaf length and width, seed length and width, test wt. and yield etc. were recorded as mentioned in descriptors.

Shannon–Weaver diversity indices (Shannon & Weaver,1949) were calculated in order to estimate the phenotypic diversity for each qualitative and quantitative trait with Microsoft Excel using the formula:

$$H' = \left[\Sigma\left(\frac{n}{N}\right) \times \left\{Log2\left(\frac{n}{N}\right) \times (-1)\right\}\right] / Log2\kappa$$

Where, H′ is the standardized Shannon–Weaver diversity index, *k* is the number of phenotypic classes for a character, n is the frequency of a phenotypic class of that character and N is the total number of observations for that character. For the H′ of quantitative traits, accessions were divided into 10 phenotypic classes as <x-2sd, x-2sd, x-1.5sd, x-sd, x-0.5sd, x, x+0.5sd, x+sd, x+1.5sd,

x+2sd, and >x+2sd are as the margins of the classes, where x is average and sd is the standard deviation. The diversity index was considered as low (0.10≤H′≤0.40), intermediate (0.40≤H′≤0.60), high (0.60≤H′≤0.80), and very high (H′≥0.80) (Eticha et al., 2005).

DATA ANALYSIS

Basic statistics including mean, maximum, minimum, coefficient of variation (CV), and diversity index (H') were calculated by using Excel 2016 and UPGMA clustering, and Principal Component Analysis was done with MINITAB 17 for quantitative characters. Estimates of similarities among the landraces were calculated using Euclidean distance and average linkage and PCA was conducted to know the contribution of traits in total variation among the landraces.

RESULT AND DISCUSSION

DIVERSITY IN QUALITATIVE TRAITS

The morphological character-based diversity index of rice landraces is presented in Table 2. Among qualitative variables, all characters are found to be polymorphic. The diversity index *(*H'*)* ranged from 0.16 to 0.96, which indicates low to very high diversity present in the rice landraces for qualitative traits. A very high diversity index (H') was inferred for the panicle exertion trait (0.96). However, this value of diversity index (H') was found high for secondary branching of panicle (0.70) and coloration of apiculus (0.66). Qualitative characters are considered as marker characters in the identification of landraces of rice, which are less independent of the environmental responses (Singh et al., 2014). Flag leaf angle is an important growth character in which maximum photosynthesis occurred. It might be due to the higher light penetration in the crop canopy due to erect leaves (Zafar et al., 2004). In our study, 83% of the landraces had erect, 15% semi erect, and 2% horizontal flag leaf attitudes. Farmers prefer awnless grain because awns are objectionable in threshing and milling (Singh et al., 2014). Among the landraces, 96% were awnless and the remaining 4% were having awn.

Table 2. Morphological character-based diversity index of rice landraces

S.N.	Qualitative characters	Shannon-weaver index	Descriptor's states	Frequency	Percentage
1.	Leaf blade pubescence	0.37	1-Glabrous	39	93
			2-Intermediate	3	7
2.	Leaf blade color	0.34	2-Green	37	88
			3-Dark green	3	8
			5-Purple margin	1	2
			7-Purple	1	2
3.	Basal leaf sheath color	0.20	1- Green	40	96
			2-Green with purple line	1	2
			4-Purple	1	2

4.	Flag leaf: Attitude	0.47	1-Erect 3- Semi-erect 5-Horizontal	35 6 1	83 15 2
5.	Ligule color	0.20	1-White 2-Purple lines 3-Purple	40 1 1	96 2 2
6.	Collar color	0.27	1-Pale green 3- Purple	40 2	96 4
7.	Auricle color	0.27	1-Pale green 2-Purple	40 2	96 4
8.	Panicle exsertion	0.96	3-Moderately well exserted 5-Just exserted 7-Partly exserted 9-Enclosed	12 8 7 15	29 19 17 35
9.	Culm habit	0.16	3-Semi-erect 5-Open	41 1	98 2
10.	Panicle type	0.27	5- Intermediate 9-Open	40 2	96 4
11.	Panicle: Secondary branching	0.70	0-Absent 1-Light 2-Heavy	17 24 1	40 58 2
12.	Shattering	0.71	5-Moderate 7-Moderately high 9-High	1 21 20	2 50 48
13.	Awn distribution	0.27	0-Absent 7-Long and partly awned	40 2	96 4
14.	Lemma: Coloration of Apiculus	0.66	1-White 2-Straw 3-Brown 6-Purple	2 27 11 2	5 64 26 5

DIVERSITY IN QUANTITATIVE TRAITS

Thirteen quantitative traits were measured for evaluating variation among rice landraces (Table 3). The result showed the existence of high variation with quantitative traits among the landraces. The coefficient of variation ranges from 8.00 (days to emergence) to 47.77 (yield). Out of thirteen quantitative characters, five have a CV value of more than 20% indicating greater variability among the landraces. The result indicated that there is a high level of variation in characters of interest i.e., Plant height, test wt. and yield in rice landraces. This signifies that selection for these traits could be effective. Shannon Weaver index ranges from 0.48-0.89 which showed intermediate to a very high level of diversity among the landraces for quantitative traits. Very high diversity was found in test wt. (0.89), Leaf length (0.84), seed length (0.82), ligule length (0.82), plant height (0.81), and no of grains/panicle (0.80), and remaining characters showed intermediate to a high level of diversity. Knowledge of existing diversity and its distribution in crop species is useful for landrace conservation and selection of parents with the diverse genetic background to make improvement more efficient (Teklu et al., 2006). The existence of high genetic diversity in the Nepalese rice landraces increases the space for selection for breeders as well as for farmers. This diversity can be utilized in crop improvement and enhancement of the genetic potential of rice landraces. Agro-morphological traits can be considered by farmers to discriminate varieties regarding the selection and adoption of a variety.

Table 3: Diversity based on quantitative traits

S.N.	Characters	Mean±SE	Std.	CV(%)	Max.	Min.	SWD(H')
1	Days to emergence	11±0.14	0.88	8.00	13	9	0.48
2	Days to 50% heading	107±2.34	15.19	14.10	125	79	0.75
3	Days to maturity	157±2.67	17.28	10.95	174	123	0.59
4	Leaf length (cm)	34±1.12	7.27	20.96	48	16.2	0.84
5	Leaf width (cm)	0.98±0.03	0.19	19.5	1.4	0.7	0.79
6	Ligule length (cm)	1.66±0.06	0.38	22.8	2.7	1.0	0.82
7	Plant height (cm)	101±4.19	26.14	25.75	157	63	0.81
8	Panicle length (cm)	59±1.16	7.16	12.1	72	42	0.79
9	No of grains panicle^{-1}	54±1.74	10.80	19.9	77	35	0.80
10	Seed length (mm)	35.1±0.70	4.37	12.45	43.7	28.0	0.82
11	Seed width (mm)	29.1±0.66	4.12	14.17	37.9	21.9	0.78
12	Thousand grain weight (g)	23.9±0.76	5.26	22.06	36.1	14.5	0.89
13	Yield (t ha^{-1})	2.08±0.14	0.99	47.77	4.69	1.01	0.51

SE = Standard Error, Std. = Standard Deviation, CV = Coefficient of Variation, Min. = Minimum, Max. = Maximum, SWD = Shannon–Weaver diversity, H' = Notation for Shannon–Weaver diversity index

CLUSTER ANALYSIS

A dendrogram was constructed by using UPGMA clustering method based on average linkage and Euclidean distance across the 42 landraces. The cluster analysis grouped the landraces into four clusters for 13 quantitative traits (Table 4). The accessions were clustered using days to emergence, days to heading, days to maturity, plant height, Ligule length, leaf length, leaf width, panicle length, grains per panicles, seed length, seed width, test wt. and yield as variables. The critical examination of the dendrogram revealed four clusters with a minimum of 46.33% similarity level in UPGMA clustering. Clusters were obtained based on similarity percentage and related characters.

Cluster 1, 2, 3 and 4 consist of 13, 10, 5 and 14 rice accessions respectively. Cluster-1 has accessions having a higher value for plant height, panicle length, no of grains/panicle, seed length and seed width, and intermediate value for yield and days to maturity. Accessions in cluster-2 were early mature and high yielder than that of cluster-1 and 4 and had higher test weight. Accessions in cluster-3 were early mature and high yielder and had intermediate values for plant height, panicle length, and no of grains/panicle than the remaining clusters. Similarly, cluster-4 consists of late mature and low yielder accessions with lower plant height.

Characterization of accessions and clustering of them based on their morphological and genetic similarity helps to identify and select the best parents for hybridization. Hence, a grouping of landraces using multivariate analysis such as UPGMA clustering would be valuable for the breeders in such a way that the most promising landraces in the population may be selected from different clusters for pre-breeding and further evaluation. Accessions of the cluster- 3 i.e. NGRC01917, NGRC03034, NGRC03395, NGRC03057, NGRC03163 are superior in terms of yield and days to maturity. After further selection, these accessions can be included in the rice improvement program to develop early and high yielding varieties of rice. Accessions having higher plant height may be useful as a potential donor for increasing total plant biomass. The accessions with early maturity, higher test wt., higher panicle length, and higher yield might serve as potential donors for increasing grain yield of predominant rice varieties.

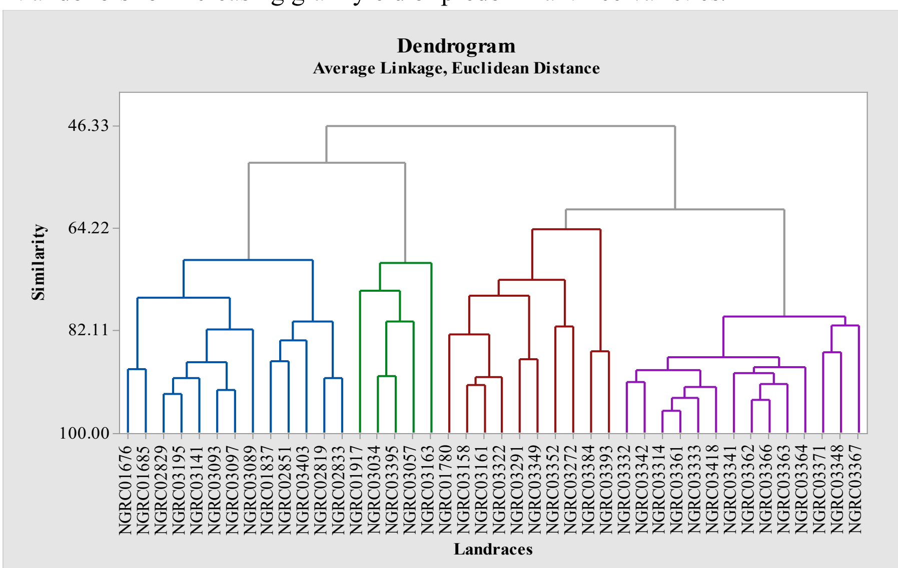

Figure 2: Dendrogram of 42 rice landraces derived by UPGMA from thirteen quantitative traits

Table 4: Number of accessions with an average of major quantitative traits in each cluster

Variables	Cluster-1	Cluster-2	Cluster-3	Cluster-4
No of accessions	13	10	5	14
Days to emergence	11	11	11	12
Days to 50% heading	114	93	83	120
Days to maturity	167	141	132	170
Ligule length (cm)	1.8	1.4	1.8	1.6
Leaf length (cm)	40.8	27.7	36.5	33.3
Leaf width(cm)	1.05	0.90	1.11	0.98
Plant height (cm)	130	84	118	77
Panicle length (cm)	68.3	51.1	57.9	56.6

No of grains panicle^{-1}	67	46	59	45
Seed length (mm)	40.3	32.5	36.4	31.7
Seed width (mm)	33.3	27.8	31.1	25.4
Thousand grain weight (g)	23.8	26.6	25.8	22.8
Yield (t ha^{-1})	1.89	2.32	2.83	1.64

PRINCIPAL COMPONENT ANALYSIS

In this study, the first three principal components are most important in reflecting the variation pattern among accessions, and traits associated with these are more useful in differentiating accessions. The first three components with eigen value greater than 1 accounted for 75.5 % of total variation (Table 5). The first component accounted for 42.7% of the total variance indicating that no of grains/panicle, panicle length, plant height, seed length, and width were the variables that contributed most positively. The second PC accounted for 21% of the total variance which was mainly influenced positively by days to maturity, days to heading, days to emergence, and negatively by yield. The third component accounted for 11 % of the total variance which was positively associated with leaf length, leaf width, and yield and negatively with test wt. trait. The proper value measures the importance and contribution of each component to total variance, whereas each coefficient of the proper vectors indicates the degree of contribution of every original variable with the principal component it is associated with (Dhakal et al., 2020). Higher the coefficient (regardless of the sign), more will be the effectiveness of those corresponding parameters in discriminating the landraces. The results of PCA suggested that traits, viz. Days to maturity, no of grains/panicle, grain yield, plant height,

and panicle length were the principal discriminatory characteristics of the Nepalese rice landraces.

Table 5: Principal Component Analysis based on thirteen quantitative characters

Variables	PC-1	PC-2	PC-3
Eigen value	5.54	2.83	2.43
Proportion	0.42	0.21	0.11
Cumulative Variance (%)	42.7	64.5	75.5
	Coefficient vector		
Days to emergence	-0.135	0.350	-0.082
Days to 50% heading	0.061	0.484	-0.064
Days to maturity	0.090	0.525	-0.124
Leaf length (cm)	0.351	0.185	0.146
Leaf width (cm)	0.184	-0.073	0.538
Ligule Length (cm)	0.233	0.090	0.477
Plant height (cm)	0.393	-0.137	-0.054
Panicle length (cm)	0.396	0.179	-0.060
No of grains panicle^{-1}	0.407	-0.069	-0.051
Thousand grain weight (g)	-0.033	-0.287	-0.432
Seed length (mm)	0.395	-0.089	-0.245
Seed width (mm)	0.352	-0.196	-0.299
Yield (t ha^{-1})	-0.011	-0.368	0.302

CONCLUSION

The rice landraces exhibited sufficient genetic variation for most of the qualitative and quantitative traits. Agro-morphological traits, namely days to maturity, no of grain panicle^{-1}, grain yield, plant height, and panicle length were the principal discriminatory characteristics of the Nepalese rice landraces. Rice landraces, Ghaiya dhan from Dolakha, Rate Ghaiya from Doti, Jiri dhan from Rautahat, Churi dhan from Baitadi, and Jumli dhan from Jumla were found superior based on preliminary evaluation of important traits such as days to maturity and yield. These landraces could be evaluated further in multiple environments and used to develop new rice varieties.

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FACTORS AFFECTING ADOPTION OF HOME GARDEN FARMING AMONG DISADVANTAGED GROUP (DAG) OF JHAPA DISTRICT

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ABSTRACT

Home garden provides fruits and vegetables to the household with direct access to important nutrients that may not be readily available or within their economic reach. Therefore, home gardening would be a good means to improve household food security. The study was conducted in the Dharampur, Dangibari and Dhaijan area of Jhapa to assess the factors affecting adoption of home garden farming among disadvantaged group of people. Altogether 120 respondents (40 respondents from each places mentioned above) were randomly chosen for study. The study showed that the home garden contribution on annual household income was 19.23% and livestock component was identified as most profitable component as it contributes 50.92% of home garden incomes followed by vegetable component (25.02%). It was found that the mean annual income from home garden was NRs 37697.24 in practitioner household and was significant (P=0.05). The study revealed that age of household head, years of schooling were negatively related to home garden adoption, whereas trainings, exposure, number of species were positively related to home gardens adoption. In regard to the problems related with production, respondents ranked unavailability of quality seedling or sapling (64.2%) as major problem followed by limited cultivable land (57.5%). Home garden was sustainable approach as it relies on low external input use system and better institutional linkage, socio economic empowerment of women and disadvantaged groups made it further sustainable. This necessitates diversifying home garden approach so as to cover social and economic dimension of household resources for sustainable development and to support in livelihood system.

Keywords: Factors, Income, Home garden, Problems, Sustainable

INTRODUCTION

Nepalese agriculture is subsistence based and furthermore, farms are getting smaller and subsistence farm families are on the rise. Nationally, 47 percent of the land owning households owned only 15 percent of the land with an average size of less than 0.5 ha, whereas the top 5 percent owned nearly 37 percent of land. Most of the disadvantaged families are landless in Nepal. A recent rough estimate by WFP stated that the minimum amount of land required for households self-sufficiency is approximately 0.54 ha (OCHA, 2008). Despite decades of planned efforts for development of agriculture, food insecurity and malnutrition has emerged as national concern. The World Food Summit in 1996 has defined food security as the situation when all people at all times have access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. One of the major reasons underlying food insecurity is low agricultural productivity and lack of purchasing power of people to buy required amount of food.

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Malnutrition is a serious public health problem. It retards child growth, increases the risk and duration of illness, reduces work output, and slows social and mental development. Malnutrition among women of reproductive age increases the risk of mortality during pregnancy and delivery and puts their newborn children at risk of long-term deficiencies. Improving nutritional status, including micronutrient status, can lead to increased productivity, increased child survival and growth, and reduced maternal morbidity and mortality.

Three types of interventions are commonly employed to improve micronutrient status, namely: capsule and tablet supplementation, fortification of commonly consumed foods, and diet diversification. Diet diversification is arguably the most sustainable and affordable strategy to improve nutrition for the majority of the population particularly the poor. For poor households, vegetables and fruits are often the only source of micronutrients in the family diet. Home garden, traditional land use system around a homestead, where several species of plants are grown along with livestock and maintained by household members and their products are primarily intended for the family consumption (HKI, 2001; Mictchell and Hanstad, 2004). Home garden provides fruits and vegetables to the household with direct access to important nutrients that may not be readily available or within their economic reach. Therefore, home gardening would be a good means to improve household food security. Equally important, home gardening has been shown to be a source of additional income, because the household can sell a portion of the garden's produce. Studies suggest that this additional income is generally utilized to purchase supplementary food items, further increasing the diversification of the family's diet. Home gardening is especially important in overcoming seasonal availability of foods and promoting household self-sufficiency (Shrestha *et al.*, 2004).

Home gardening activities are centered on women and it can also increase the income of women, which may result in the better use of household resources and improved caring practices and empowerment. This empowerment of women also addresses a priority area of poverty alleviation and provides important socio-economic returns through lower health and welfare costs, lower fertility, and lower maternal and infant mortality rates. Thus, the simultaneous impact of home gardening programs in terms of giving women a voice and promoting their full participation in domestic life can make an important contribution to the overall development of communities.

The home garden, literally known in Nepali as *Ghar Bagaincha*, refers to the traditional land use system around a homestead, where several species of plants are grown along with livestock and maintained by household members and their products are primarily intended for the family consumption (Shrestha *et al.,* 2002). In Nepal, 72% of households have home gardens of an area 2-11% of the total land holdings (Gautam *et al.*, 2004). Because of their small size, the government as well as development programs never identified home gardens as an important unit of food production and it thereby remains neglected from research and development although it is important contributors to the food security and livelihoods of farming communities particularly women and disadvantage groups in Nepal.

MATERIALS AND METHODS

The study was conducted in the Dharampur, Dangibari and Dhaijan area (the then three VDCs) of Jhapa, which currently lie in Shivasatashi municipality, Barhadashi rural municipality and Mechinagar municipality, respectively. Study was done to assess the factors affecting adoption of home garden farming among disadvantaged group of people of Jhapa district of Nepal. Both descriptive and analytical survey design was used for this study. Altogether 120 respondents (40 respondents from each places mentioned above) were randomly chosen. Descriptive statistics and also the regression model was adopted to assess the factors affecting adoption of home garden in study district.

ECONOMETRIC MODEL

Following econometric model i.e., Logit Regression Model was adopted to assess the factors affecting adoption of home garden.

LOGIT REGRESSION MODEL

In the logit model, suppose Yi be the binary response of the farmers and take only two possible values; Y = 1, if farmer practiced different stronger adaptation strategies and Y = 0, if practicing few (poor) adaptation strategies. Suppose x was the vector of several explanatory variables affecting to practice different adaptation strategies and β, a vector of slope parameters, which measures the changes in x on the probability of the farmers to practice stronger adaptation strategies. The probability of binary response was defined as follows:

If Yi = 1; P (Yi = 1) = Pi

Yi = 0; P (Yi = 0) = 1-Pi

Where, Pi = E(Y = 1/x) represents the conditional mean of Y given certain values of X.

The logit transformation of the probability of the practicing stronger adaptation strategies by farmers were represented as follows (Gujrati, 2003).

$$L_i = \ln \left[\frac{P_i}{1-P_i} \right] = z_i = \alpha + \sum_{i=1}^{n} \beta_i x_i + \epsilon_i$$

Where Yi = a binary dependent variable (1, if farmers practicing stronger adaptation practices, 0 otherwise), xi includes the vector of explanatory variables used in the model, βi = parameters to be estimated, €I = error term of the model, exp (e) = base of the natural logarithms, Li = Logit and $\left[\frac{P_i}{1-P_i} \right]$ = odd ratios.

Thus, the binary logit regression model may be expressed as;

Yi = f (βi xi) = f (Age of household head, caste of the ethnicity, marital status, years of schooling, total owned land, home garden income, total plant species under home garden, registration in DADO, frequency of training received)

$$Z = \alpha + \sum \beta_i x_i + \epsilon_i$$

MODEL SPECIFICATION

The logit model specified in this study to analyze factors affecting the adoption of home garden approach was expressed as follows.

$Pr(1=intervention)=(b_0+b_1X_1+b_2X_2+b_3X_3+b_4X_4+b_5X_5+b_6X_6+b_7X_7+b_8X_8+b_9X_9+b_{10}X_{10})$

Where,

P(1=Intervention)= Probability of adopting home garden approach
X_1= Age of household head (Years)
X_2=Caste of the respondents (Dummy)
X_3=Marital status of the respondent (Dummy)
X_4= Years of schooling (years)
X_5= Total owned land (kattha)
X_6= Log home garden income
X_7= Total plant species (number)
X_8= Registration in DADO (Dummy)
X_9= Frequency of training received (Number)
X_{10}= Exposure visit (Dummy)
$b_1, b_2, b_3 \ldots\ldots\ldots b_{10}$ = Logit coefficient
b_0 = Regression coefficient

Table 1. Description of the variables used in the logit model

Variables	Type	Description	Value	Expected sign
Dependent variable Yi	Dummy	Farmers adopting home garden approach	1 if farmer is adopting home garden approach, 0 otherwise	
Independent variables				
X_1	Continuous	Age of household head	Year	+/-
X_2	Dummy	Caste of the respondent	1 if respondent is Brahmin/Chettri otherwise 0	+
X_3	Dummy	Marital status of the respondent	1 if respondent is married otherwise 0	+
X_4	Continuous	Years of schooling	Years	+/-
X_5	Continuous	Total owned land	Kattha	+
X_6	Log	Home garden income		+
X_7	Continuous	Total plant species	Number	+
X_8	Dummy	Registration in DADO	1 if registered in DADO, 0 otherwise	+
X_9	Continuous	Frequency of training received	Number	+
X_{10}	Dummy	Exposure visit	1 if exposure visit 0 otherwise	+

RESULTS AND DISCUSSION

LAND HOLDING CHARACTERISTICS

The mean size of land holdings of the home garden practitioners was higher in Dangibari (23.61 kattha) followed by Dharampur (10.13 kattha), whereas the mean land holding under home garden was also higher in Dangibari (2.25 kattha) followed by Dhaijan (2.12 kattha). The maximum land holding was 60 kattha whereas the minimum was found 0.5 kattha: moreover, the maximum land holdings under home garden were 8 kattha and minimum 0.2 kattha in the study area (Table 2).

Table 2. Distribution of home garden practitioner based on land holdings in the study district

Name of VDCs	Mean	St. Deviation	Maximum	Minimum
Dharampur				
Total own land (Kattha)	10.13	9.81	40	1
Home garden size (Kattha)	1.64	1.12	6.0	0.2
Dangibari				
Total own land (Kattha)	23.61	15.35	60	0.5
Home garden size (Kattha)	2.25	1.67	8.0	0.5
Dhaijan				
Total own land (Kattha)	7.15	5.54	20.0	1.0
Home garden size (Kattha)	2.06	1.08	6.0	1.0
Total				
Total own land (Kattha)	13.63	13.04	60.0	0.5
Home garden size (Kattha)	1.98	1.32	8.0	0.2

Source: Field survey, 2013. Note: 1 hectare = 30 Kattha

From this study it was evident that average home garden size was 14.52 % of average total land holdings which is slightly higher than the findings of Gautam *et al.*, 2004 i.e. 72% of households have home gardens of an area 2-11% of the total land holdings and smaller than the findings, it occupies 20% of the total arable land (Jensen, 1993). The variation in such result may due to differential socioeconomic character.

CONTRIBUTION OF HOME GARDEN AND ITS COMPONENTS ON ANNUAL HOUSEHOLD INCOME

As different components are integrated on home garden, its profitability in terms of income generation is worthwhile to be noted. In this perspectives attempt was made to identify the most profitable component. From the study it was evident that the home garden contribution on annual household income was 19.23% and livestock component was identified as most profitable component as it contributes 50.92% of home garden incomes followed by vegetable component (25.02%) (Table 3).

Table 3. Contribution of home garden and its component on household income and home garden income

Particulars	Annual income (NRs)						
	Household	Home garden	Vegetable	Fruit	Livestock	Poultry	Other
Mean	196025.56	37697.20	9434.44	2846.60	19197.70	2672.22	3546.10
St. Dev.	141182.24	35082.10	10737.80	5553.40	24927.40	5257.50	13682.10
Percentage contribution		19.23#	25.02##	7.55##	50.92##	7.08##	9.40##

Source: Field survey, 2013

Home garden contribution on annual household income

Component contribution on home garden annual income

HOME GARDEN AND ITS PRODUCTION

Home garden had its positive impact on food security by making direct access to the diverse diets. In this perspective, attempt was made to analyze the production of different components under home garden. For this production of vegetables, fruit, livestock, poultry and total number of edible plant species were compared between home garden practitioner and non-practitioner. Study revealed that all the components average productions were higher in project intervention household. Among the components, vegetable production 9.98 kg/week, fruit production 3.11 kg/week and total number of edible plant species (25.5) was found higher and statistically significant at 5% level of significance and 1% level of significance respectively as compared to that of non-practitioner households. Whereas, per week production of livestock, poultry and other were found higher as compared to non-practitioner households but were not found statistically significant (Table 4).

Table 4. Production of different components (kg/week) in home garden

Particulars	HGP (n=90)	Non practitioner (n=30)	t-value	Mean Difference
Vegetable production (kg/week)	9.98	5.01	0.04	4.97**
Fruit production (kg/week)	3.11	1.90	0.05	1.27**
Livestock production (kg/week)	3.28	1.55	0.16	1.73
Poultry production(kg/week)	1.07	0.31	0.12	0.75
Other production (kg/week)	0.83	0.0	0.80	0.83
Edible plant species	25.5	13.0	5.09	12.5***

Source: Field survey, 2013

*** Significant at 1% level, ** significant at 5 % level

The study findings reveled that home garden was effective for availing the diverse diets which was in line with the findings that home gardening has contributed to food security by making direct access to a diversity of nutritionally rich foods (Akosa, 2011).

HOME GARDEN AND ITS CONTRIBUTION ON HOUSEHOLD INCOME

The total annual household income; income from home garden and income from home garden components were analyzed in home garden practitioner and non-practitioner household and mean was compared.

The total household income was found higher in home garden practitioner compared to the non-practitioner household but it was not statistically significant. It was found that the mean annual income from home garden was NRs 37697.24 in practitioner household and significant (P=0.05). Among the home garden components, the annual income was found highest in livestock component (NRs. 19197.77) followed by vegetable component (NRs. 9434.44). The annual income from home garden components such as vegetables, fruits and livestock components were found significant and higher in practitioner household whereas annual income from poultry and other component was not significant and higher in non-practitioner household (Table 5).

Table 5. Annual household incomes from different sources

Annual HH income	Home garden practitioner (n=90)	Non practitioner (n=30)	Mean Difference	t-value
Total HH income (NRs.)	196025.56	168873.33	27152.22	0.987
Home garden annual income (NRs)	37697.24	19463.34	18233.91**	2.593
Annual home garden income from vegetable (NRs)	9434.44	2723.33	6711.11***	3.375
Annual home garden income from fruit (NRs)	2846.66	1166.66	12297.77*	1.631
Annual home garden income from livestock (NRs)	19197.77	6900.0	12297.77***	2.660
Annual home garden income from poultry component (NRs)	2672.22	3033.33	-361.11	-0.289
Income from other component (NRs)	3546.13	5640.0	-2093.86	-0.550

Source: Field survey, 2013

*** Significant at 1% level, ** significant at 5 % level, * significant at 10%

Study revealed that home gardens adoption had positively contributed to income generation which is similar to the findings of Calvet *et al.* 2012 and Vassey, 1985 that is home garden contribute to income generation, improved livelihoods, and household economic welfare as well as promoting entrepreneurship and rural development.

EXPENDITURE OF HOUSEHOLD ON DIFFERENT COMPONENTS

Economic capability i.e. purchasing power of farmers is another aspect which has direct impact on household food security. So, in this perspective attempt had been made to assess whether home garden approach helps to improve purchasing power by saving of expenditure on food items in the study area. Study revealed that among home garden practitioner and non-practitioner households, home garden helps in reducing expense on vegetable, fruits and animal protein. Further, it was found that the expense on animal protein was found highest in both home garden practitioner and non-practitioner. The expense on vegetables components, fruit components and animal protein among the household was found significant at 10 %, 5% and 10% level of significance, respectively (Table 6). It may be due to the fact that the home garden practitioner grows more seasonal vegetable, fruits in scientific way that helps to meet the family requirement.

Table 6. Expenditure pattern of household on different components

Particulars	Home garden practitioner (n=90)	Non practitioner (n=30)	Mean difference	t-value
Expenditure on vegetable (NRs/week)	208.22	380.0	-171.78*	-5.49
Expenditure on fruits (NRs/week)	182.33	248.33	-66.0**	-2.21
Expenditure on animal protein (NRs/week)	407.39	498.67	-91.27*	-1.75

Source: Field survey, 2013

** Significant at 5 % level, * significant at 10%

Study revealed that home garden intervention helps on saving expenditure on food bill thereby contributed to household food security which is similar to the findings of Akosa, 2011 i.e., home garden helps to attain food security by increased purchasing power from savings on food bills.

SUFFICIENCY OF HOME GARDEN PRODUCTS ON HOUSEHOLD REQUIREMENT

Home gardens, with their intensive and multiple uses, provide a safety net for households when food is scarce. To analyze duration of food supply by home garden, duration of time was categorized as year-round, 9-12 months, 6-9 months, 3-6 months and 0-3 months. On study, 85.6% home garden practitioner responded that a vegetable produced under home garden was sufficient for more than 6 months. Furthermore, 71.1% and 48.9 % respondent agreed that fruit produced under home garden and animal protein derived from home garden is sufficient for only 0-3 months.

Table 7. Sufficiency of home garden components on household requirement

Components	Sufficiency				
	Year round	9-12 months	6-9 months	3-6 months	0-3 months
Vegetable	23(25.6)	27(30.0)	27(30.0)	11(12.2)	2(2.2)
Fruit	2(2.2)	6(6.7)	9(10.0)	9(10.0)	60(71.1)
Animal protein requirement	6(6.7)	7(7.8)	19(21.1)	14(15.6)	44(48.9)

Source Field survey, 2013, Figures in the parenthesis indicate percentage

From the study it was found that home garden plays important role on year round supply of food particularly vegetables which is consistent with the finding of (Budowski, 1990; Eibl *et al.*, 2000). According to Budowski, 1990 and Eibl *et al*. 2000 home gardens are very important for supplying the household with food products year-round.

FACTORS AFFECTING THE LEVEL OF HOME GARDEN APPROACH ADOPTION

To identify the factor that influence the level of home garden approach adoption, logit regression model was used. Farmers in the study area were likely to adopt the practice at different level. The adoption level was studied as the home garden practitioner and non-practitioner.

The Wald test (LR chi 2) for the model indicated that the model have the good explanatory power at the 1% level. The pseudo-R ^{2} was 0.8699. For the interpretation of the model, the marginal effects were driven from the regression coefficients, calculated from partial derivates as marginal probability. The interpretation is shown in the table 8 (Details of analysis in Appendix 1).

Table 8. Logit regression model of adoption of home garden approach

Variable	Coefficients	P>|z|	Standard error	dy/dx[b]	S.E[b]
Age of household head (years)	-0.209	0.135	0.139	-0.00004	0.00014
Caste of the respondent (Dummy)	4.311*	0.088	2.52	0.00135	0.00447
Marital status of the respondent (Dummy)	1.135	-0.11	11.648	-0.00015	0.00086
Years of schooling (years)	-0.967**	0.052	0.499	-0.00018	0.00062
Total owned land (97atha)	-0.0152	0.817	-0.065	-0.000003	0.00002
Home garden income (ln)	1.348*	0.066	0.733	0.00257	0.00089
Total plant species (number)	0.417**	0.041	0.205	0.000079	0.00026
Registration in DADO (Dummy)	4.726*	0.076	2.66	0.007325	0.01999
Frequency of training received (number)	0.965**	0.065	0.523	0.00018	0.00066
Exposure visit (Dummy)	4.654*	0.075	2.610	0.00088	0.00292
Constant	-16.63	0.296	15.92		
Summary statistics					
Number of observation (N)	120				
LR $chi^2(10)$	117.41***				
Prob > chi2	0.0000				
Log likelihood	-8.7768692				
Pseudo R^2	0.8699				

*** significant at P= 0.01; ** Significant at P= 0.05; * significant at P>0.1

[b] Marginal change in probability (marginal effects after Logit) evaluated at the sample means

Logit regression showed that among the variables seven variables were found statistically significant for the level of adoption of the home garden. Those variables were caste of the respondent (dummy), years of schooling, home garden income, total plant species, registration in DADO, frequency of training received, and exposure visit (Table 8). Others variables like age of household head, marital status of the respondent, total owned land were found statistically non-significant.

The study revealed that age of household head is negatively related and not significant to home garden adoption. But the caste or ethnicity (dummy) is positively significant. Keeping all the other things constant, probability of adopting the home garden by Brahmin and Chettri is increased by 0.14% and significant at 10% level.

The year of schooling is significant but negative. The coefficient values indicated that the one year increase in the years of schooling will decrease the probability of adopting the home garden approach by 0.018% and is significant at the level of 5%. A higher educated person tends to the better farming practice such as commercial farming.

Annual home garden income which is log transferred has the positive impact on the probability of adopting home garden approach. The value entered as the positive signed and significant (P>0.1). Per unit increase in the annual home garden income increases the probability of adopting home garden by 0.26%. Income will attract the farmer to adopt new technology.

The number of species in the home garden increases the probability of adopting the home garden approach. The value signifies that the one number of species increase in the home garden increased the home garden approach intervention by 0.008% and is significant in (P=0.05)

DADO helps in the intervention and adoption of the practices. The value indicated that the group registered in the DADO (dummy) have positive role in adopting the home garden approach. Study indicated that the probability of adopting home garden will increase by 0.73% if the group is registered in DADO, which is significant at 10% level.

The study revealed that the frequency of training received on home garden increase by number 1, probability of adoption of home garden approach would increase by 0.018% which was positively significant (P=0.10) and exposure and visit has the positive relationship on the adoption of home garden approach. Exposure (dummy) helps in adopting the home garden approach by 0.8% which was positively significant (P>0.10).

PERCEPTION AND PROBLEMS OF HOME GARDEN

PERCEPTION OF HOME GARDEN PRACTITIONER TOWARDS HOME GARDEN

In the study area, home garden approach had been adopting for more than 3 years and respondents have their own perception regarding home garden. In this study attempt was made to analyze perception of respondents towards home garden. Thus, various statements were identified through focus group discussion and administered to home garden practitioner. Study revealed that in all statements regarding different perspective of home garden positive responses had been reported but their degree of agreement was varied differently (Table 9).

Table 9. Perception of home garden practitioner toward home garden

Statements	Frequency		
	Strongly agree	Agree	Neutral
Home garden have significant contribution to HH economy	38(42.2)	51(56.7)	1(1.1)
Product grown on own garden is more environmentally safe, healthier and tastier than that brought from store	53(58.9)	37(41.1)	0(0.0)
Diverse HG can contribute to healthy environment and human being can benefit from it	23(25.6)	66(73.3)	1(1.1)
HG can improve family member physical and mental health	33(36.7)	56(62.2)	1(1.1)
HG is possible at low investment	31(34.4)	57(63.3)	2(2.2)
HG not only effective on biodiversity conservation but also on family nutrition and Socio-economic empowerment	18(20.0)	68(75.6)	4(4.4)
Home garden is more important to become self-sufficiency rather than increase in income	15(16.7)	69(76.7)	6(6.7)
Integration of income generating activity in HG is profitable	34(37.8)	53(58.9)	3(3.3)

Source: Field survey, 2013

Figures in parenthesis indicate percentage

PROBLEMS FACED BY HOME GARDEN PRACTITIONER

Although home garden is effective for ensuring family nutrition, socio economic empowerment, respondents had perceived and ranked many problems which had been identified during focus group discussions. Problems identified were categorized under three sub-sections namely problems related with production, marketing and others. Under problems related with production, respondents ranked unavailability of quality seedling or sapling (64.2%) as major problem followed by limited cultivable land (57.5%) and so on.

Table 10. Problems faced by home garden practitioner in study area

Problems	Frequency	Rank
Problems related to production		
Unavailability of quality seed and seedlings	76(64.2)	I
Labor intensive	31(25.8)	IV
Limited cultivable land	69(57.5)	II
High incidence of insect pest	58(48.3)	III
Problems related to marketing		
Lack of collective market	73(60.8)	III
Lack of proper linkage	80(66.7)	I
Low volume of production	71(59.2)	IV
Lack of awareness	78(65.0)	II
Other problems		
Low income	66(55.0)	I
Less sustainable	19(15.8)	IV
Unequal access	37(30.8)	II
Tedious management	20(16.7)	III

Source: Field survey, 2013

Figures in parenthesis indicate percentage

It was learnt that respondents ranked first for unavailability of quality seedlings followed by limited cultivable land, high incidence of insect pest and labor-intensive production problem related to production. Accordingly, lack of proper linkage, awareness followed by lack of collective marketing was ranked as marketing related problems. Not only these problems low income, unequal access and tedious management along with sustainability issues were identified as other problem.

CONCLUSION

Home gardening activities are centered on women and it can also increase the income of women, which may result in the better use of household resources and improved caring practices and empowerment. This empowerment of women also addresses a priority area of poverty alleviation and provides important socio-economic returns through lower health and welfare costs, lower fertility, and lower maternal and infant mortality rates. The study showed the evident that the home garden contribution on annual household income was 19.23% and livestock component was identified as most profitable component as it contributes 50.92% of home garden incomes followed by vegetable component (25.02%). Home garden had its positive impact on food security by making direct access to the diverse diets. Home garden has been effective for availing the diverse diets. Home gardens adoption positively contributes to income generation. Home garden helps in reducing expense on vegetable, fruits and animal protein. Home gardens, with their intensive and multiple uses, provide a safety net for households when food is scarce. Vegetable produced under home garden plays important role in ensuring food security as it ensures protein to be sufficient for more than 6 months. Age of household age, years of schooling were negatively affecting the adoption of home gardens whereas number of species in home garden, frequency of training, exposure visits have positive role in increasing the adoption of home gardens. Under problems related with production, unavailability of quality seedling or sapling (64.2%) as major problem followed by limited cultivable land (57.5%) were the major problems faced.

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ECONOMICS OF LENTIL PRODUCTION UNDER RELAY AND CONVENTIONAL TILLAGE PRACTICE

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ABSTRACT

The study was intended to find out the most profitable method between the relay and tillage growing method of lentil production. For primary data collection, a simple random sampling method was followed. Household survey was conducted in two districts Bardiya and Kailali in 2021 AD. A total of 107 lentil farmers (43 farmers following relay and 64 farmers following tillage practices) were randomly selected from two pockets area (relay and tillage method adopters) of each district. Benefit-Cost (BC) ratio analysis was done to find out the most profitable method of lentil cultivation. Multiple regression model was applied to estimate the factors determining the lentil production. The average BC ratio is 2.18 which indicates that lentil cultivation is profitable with average productivity of 0.64 mt/ha. The total cost incurred per ha in relay and tillage method was NRs. 24345 and NRs. 33549 respectively. Similarly, gross income from relay and tillage method was found NRs. 56160 and NRs 69870, per ha respectively. In between the two popular methods (relay and tillage) of lentil cultivation, the BC ratio was found 2.31 in the relay method compared to 2.08 in the tillage method. Among the several socio-economic independent variables used in the model, the age of the household head and fertilizer application significantly influenced the lentil production. However, lentil production is negatively affected by the practice of intermixed cropping. Hence the result indicates that relay cropping with mono-cropping and appropriate management of fertilizer could play a crucial role to boost the profitability of lentil farming

Keywords: Benefit-cost ratio, Lentil, Relay, Multiple regression model, Tillage.

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INTRODUCTION

Lentil is the leading pulse crop in terms of area (63 %) and production (64 %), (Upadhyay et al., 2019) which is widely cultivated in Nepal as a winter pulse crop under rice-based cropping system. It is primarily grown from October to April just after the harvest of monsoon-based rice crop. Lentil is almost produced in all districts however commercial production is concentrated in the Terai regions of Nepal. The total amount of lentils produced in 2019 AD was 262835 mt in 212878 ha area with the productivity of 1.23mt/ha (MoALD, 2020). High protein content in lentils ensures the nutritional security of subsistence and marginal farmers along with soil fertility maintenance (Matny, 2015). It has the potential of fixing free nitrogen up to 107 kg per ha soil. Besides having nutritional and conservative values, lentil is also known as a commodity having high export potential and socio-economics impact in Nepal (Darai et al., 2020).

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Lentil is generally cultivated before/after rice harvesting by relay method or from tillage practices. Relay cropping is perceived as a conservation technology that ensures timely sowing, best use of soil residue moisture, and cost reduction by 45% (Oli and Sarker, 2017). Similarly, relay cropping is taken as one of the productive ways to increase profitability, as relay cropping has the capacity of optimum utilization of residue moisture and fertilizer residual (Kundu, 2017). Whereas tillage practice reduces weed infestation by 71% compare to the no-till system (Jonas et al., 2017). However, excessive tillage leads to the adverse effect on soil distribution and aggregates and reduce soil carbon stocks in the long term (Shrinivasarao, 2012). The conventional tillage method requires more resources and inputs which are increasingly becoming scarce and expensive too. Conservational agriculture could be an appropriate way for sustainable cost reduction.

Approximately 84% of the farmers reside in the rural areas (SINA, 2020). More than half population (60.4%) is dependent on agriculture for their basic requirements and subsistence form of agriculture is common for the farmers in Nepal (MoALD, 2020). Yield from farming is the major source of their income. Small parcels of land, higher competition, agri-business challenges reduce the return to farmers (Dhital, 2017). Proper cost estimation analysis helps farmers and development stakeholders to make the proper decisions required for further improvement. In this light, BC ratio analysis will help to recognize the strength of revenue from each method.

Lentil is generally grown by almost farmers either from tillage or relay method based on the availability of irrigation facility, soil moisture, labour, time, intention of intermixed cropping etc, basically to meet their consumption demand. However, the profitability of the sowing method of lentil cultivation has not been widely evaluated. Most lentil-related studies were based on the adoption, production aspect of lentils and less attention was paid towards the profitable methods of cultivation. So the objective of this study is to find out the most beneficial method in between relay and tillage of lentil cultivation. This study will help farmers and development stakeholders to imply the effective method and policies respectively, to increase the farmer's income from lentil production in Nepal.

METHODOLOGY

STUDY SITE AND SAMPLING

Primary data was collected in 2021 AD (FY: 2077/78) from Kailai and Bardiya districts. Two districts (Kailali and Bardiya) were selected based on the highest area of lentil cultivation in Far West Province and Lumbini Province respectively. Based on consultation with Agriculture Knowledge Center (AKC), Nepal Agricultural Research Council (NARC), Integrated Agricultural and Livestock Development Office (IALDO)'s officers, and local leader farmers, pocket area of relay and conventional tillage practice of lentil cultivation were selected in each district. In Bardiya district, Madhuban municipality was selected as a pocket area where relay cropping is a widely adopted method of lentil cultivation while Thakurbaba municipality was selected as the other pocket area where the tillage method is mostly adopted for lentil cultivation. Similarly in the

Kailali district, two pocket areas viz. Godavari municipality and Bhajani municipality were selected as a pocket areas of relay and tillage practices respectively. A random sampling method was applied for the survey. Farmers were selected randomly from the pocket area. In total 107 farmers were surveyed, among which farmers following relay practices were 43 and that of tillage practices were 64. Direct interview was approached with key informants and lentil growers for data collection. The data was collected with the help of a pre-tested open as well as close-ended set of questionnaires. The cost was calculated as a function of inputs such as seed, fertilizer, irrigation, labour cost whereas income is calculated as the market value of economic yield. Further, the collected information were validated with secondary data gathering through the literature review of articles and books.

DATA ANALYSIS

Data entry, cleaning, transformation were primarily carried out in excel sheets. Descriptive analysis was done in excel, and for the inferential analysis, STATA 12 was used.

MULTIPLE REGRESSION MODEL

To estimate the socioeconomic factors influencing the lentil production, multiple regression model was used. Adhikari et al. (2018) have used the multiple regression model to estimate the factors determining hybrid maize production. Multiple linear regression analysis is an extension of simple linear regression analysis, used to assess the association between two or more independent variables and a single continuous dependent variable. The multiple linear regression equation is as follows:

$$Y=c+b0\ X0+ b1\ X1+ b2\ X2+ b3\ X3+b4\ X4\ +\ldots\ldots..+ bi\ Xi\ +ei$$

Where

c =Constant
b= Coefficient
X=Explanatory variables (input cost)
ei = Error term

BENEFIT COST RATIO ANALYSIS

BC ratio was calculated after calculating the total cost and total revenue from the lentil production. It was calculated by dividing the total revenue by total cost.

$$\text{Benefit Cost Ratio} = \frac{\text{Total revenue}}{\text{Total cost}}$$

Lamichhane et al. (2017) and Adhikari et al. (2018) also used a similar formula to assess the profitability of tomato cultivation under plastic house and maize farming respectively.

RESULTS AND DISCUSSION

SOCIOECONOMIC AND DEMOGRAPHIC CHARACTERISTICS OF RESPONDENT IN STUDY AREA

Average age of the household head was found 46.42 years in the study area. The age of farmers practicing the relay method (47) was found higher than the age of the farmers following the tillage method (46). On an average, years of schooling of household head was 7 years in the study site. The average household size was found six with an average of four members involved in agricultural activities. Average cultivated land was found 15 kattha among the respondents. Land allocated for relay and tillage method is statistically significant at a 5% level of significance. Farmers practicing the relay method have average cultivated land of 12.41 kattha which was lower than the farmers practicing the tillage method (16.74 kattha). Similarly, an average of 7 kattha land was found allocated for lentil cultivation, farmers practicing the tillage method are found to allocate higher land area (nearly 8 kattha) for lentil cultivation than the farmers practicing the relay method (6 kattha) which is statistically significant at a 5% level of significance. Lentil farmers were found to have an average of 32 years of farming experience. The farming experience was found significantly higher (significant at 1% level of significance) in the case of farmers who adopted the relay method (36.67years) than the farmers following the tillage method for lentil cultivation (29.45years).

Table 1. Socio demographic characteristics of lentil growers by land preparation method

Variables name	Total (N=107)	Relay practice(N=43)	Tillage practice(N=67)	t-value
Age of HH (years)	46.42	47.18	45.90	0.62
Education of HH (years)	6.41	6.97	6.03	1.55
Total household size (No.)	5.70	5.25	6	-1.51
Members involved in agriculture (No.)	3.61	3.51	3.70	-0.55
Total cultivated land (kattha)	15.00	12.41	16.74	-2.02**
Lentil cultivated land (kattha)	6.87	5.51	7.79	-2.19**
Farming experience (years)	32.35	36.67	29.45	3.63***

****,** and * indicate significance at 1% 5% and 10% levels, respectively. 30 kattha = 1 hectare. Source: Field survey,2021*

In total, about 54 % of households had received training on lentil cultivation. Numbers of farmers acquired the training related to lentil cultivation was significantly higher at a 5% level of significance for the tillage method adopters than the farmers follow relay method. Similarly, total cultivated land (5% level), and farming experience (1% level) had significantly higher value for the farmers following tillage methods. Likewise, training received on lentil cultivation, subsidy, and involvement in agricultural organizations were found higher for the farmers following tillage practice than the farmers following relay practice.

Table 2. Categorical socio-demographic characteristics of lentil farmers in study area

Variables name	Total	Relay practice	Tillage practice	chi^2 value
Training on lentil cultivation (1=yes, 0=otherwise)	54.2	16.82	37.38	3.49**
Gender of HH Head(male=1, female=0)	83	32.71	50.46	0.16
Ethnicity(Brahmin/chettri=1,0= otherwise)	28.03	20.56	0.07	20.74***
Membership in an agricultural cooperatives (1=yes, 0=otherwise)	16.82	37.38	54.20	3.4*
Migration (1=Yes, 0= otherwise)	25.23	0.07	17.75	1.35
Subsidy received (1=yes, 0=otherwise)	30.84	0.05	25.22	9.61***

****, ** and * indicate significance at 1% 5% and 10% levels, respectively. Source: Field survey,2021*

AREA AND PRODUCTIVITY OF LENTIL FARMERS

The average area under the lentil cultivation was found about 7 kattha with an average productivity of 21.46 kg per kattha. Productivity was found higher in case of the tillage method (23.29kg/kattha) of lentil cultivation compared to the relay method (17.68kg/kattha). The average productivity of lentil was found 0.64mt/ha which is lower than the national average yield of lentil (1.2mt/ha) which might be due to no use of micronutrients and insufficient use of fertilizer. Darai et al. (2020) also observed lower productivity of lentil because of poor access to quality seeds, inputs and technology delivery services. Byproduct yield (straw, husk) was not taken into account as farmers do not keep any record and buying and selling of lentil byproduct is not in practice in the study area.

Table 3. Area and productivity of lentil in study area by land preparation method

Variables name	Total (N)	Relay practice	Tillage practice	t-value
Area (kattha)	6.87(0.22)	5.51 (0.18)	7.79(0.26)	-2.19**
Productivity (kg/kattha)	21.46	18.72	23.29	-1.35
Productivity (mt/ha)	0.64	0.56	0.69	-1.35

*Note: Figure in parenthesis represents the land unit in ha. ** indicates significance at 5% level, respectively. Source: Field survey,2021*

COST AND RETURN ANALYSIS

The average total cost of lentil production per ha for one year considering farmer's practices was estimated as NRs.29603. Average total cost for lentil cultivation by the tillage method was NRs 33549 which is higher than the cost of lentil cultivation by relay method NRs 24345. In case of revenue, average revenue from lentil cultivation was calculated as NRs 64386 per ha. Revenue was higher for the farmers who cultivated lentil by the tillage method (NRs 69870) than the farmers who adopted the relay method (NRs 56160) for lentil cultivation. Average benefit-cost ratio calculated for lentil cultivation was 2.18, BC ratio is found higher for the relay method (2.31) than the tillage method (2.08). Benefit cost ratio higher than 1.5 (in agricultural crop and cropping system) is regarded as economically viable for farmers (Dhital, 2017). Lentil cultivation is considered a profitable crop for marginal and smallholder farmers.

Table 4. Benefit cost ratio (per ha) of lentil cultivation by land preparation in study site

Variables name	Total	Relay practice	Tillage practice
Total cost (NRs)	29602.5	24345.47	33549.07
Revenue (NRs)	64386	56160	69870
BC ratio	2.18	2.31	2.08

Source: Field survey,2021

Seed rate was found higher in case of the relay method. Farmer's practice relay method applied higher seed (1.43 kg per kattha) in comparison of seed rate of farmers practice tillage method (1.29kg per kattha). Parveen and Bhuiya (2010) have proven from a field experiment that higher seed rate is better than lower seed rate as it gave the higher yield. A study conducted by using the Iowa max program participant's survey data set, have found that in case of soybean, conventional tillage resulted in lower profit than the conservational tillage like no-till, relay method.

The present result is similar to a research done in Bangladesh by Islam et al. (2017). Study has presented that seed yield is higher in furrow method of sowing (tillage method) but benefit-cost ratio is high in the relay method. Muhammad et al. (2017) also stated that conventional tillage lowers wheat productivity and profitability as it increases the cost production, soil compaction, and weed infestation. Similarly, another study done by Magar et al. (2014) in Nepal has also observed the similar kind of result in which the BC ratio of lentil cultivation was found higher in the relay method (1.26) than the tillage method (1.15). Likewise, a study conducted by CRS-Nepal (2020) has discussed that BC ratio can go up to 9 for lentil cultivation where farmers invest less and use family members as labour with the general BC ratio of 1.7 for lentil cultivation.

Table 5. Cost estimation of lentil production by land preparation in study site

Variable cost (NRS per ha)	Tillage practice	Relay practice
Seed rate (kg)	38.7	42.9
Seed cost	3990 (11.89)	4456.5 (18.31)
Land preparation cost	8187.6 (24.40)	0
Seed sowing cost	184.8 (0.55)	270.9 (1.11)
Urea cost	214.2 (0.64)	20.4 (0.08)
DAP Cost	991.872 (2.96)	41.328 (0.17)
Potash Cost	51 (0.15)	17.34 (0.07)
Irrigation cost	510 (1.52)	0
Weeding cost	5203.5 (15.51)	6624 (27.21)
Harvesting cost	8792.1 (26.21)	8863.2 (36.41)
Threshing cost	5424 (16.17)	4051.8 (16.64)
Total cost	33549.07	24345.47
Production	698.7	561.6
Lentil price (Rs/kg)	100	100
Total revenue	69870	56160
BC ratio	2.08	2.31

Figures in parenthesis are in percentage; Source: Field survey,2021

FACTORS AFFECTING LENTIL PRODUCTION

To determine the socioeconomic factors influencing the lentil production, multiple regression model was used, statistical description of the variables used in the multiple regression model are presented in Table no 6 and the estimated results are shown in Table 7. The dependent variable used in the regression model is lentil production in kg per kattha.
The value of the coefficient of determination (R2), 0.47 shows that 47% of the variation in lentil production kg per kattha is explained by the selected independent variables. Table 7 shows that the F- statistic (7.69) confirms the stability of the overall regression equation and joint significant at 1 percent level (P=0.000) in explaining lentil production and confirms the coefficients to changes in specifications. Variance Inflation Factors (VIF) is 1.49 means there was no multicollinearity between the independent variables used in the model.

Independent variable like the practice of mixed cropping has the significantly negative effect on the lentil production. Commercialization aspect was found lacking in the farmers. They produce for home consumption, only surplus production is sold. Lentil is generally grown as an intermixed crop with rapeseed, chickpea to minimize the risk of complete crop failure of lentil as it is perceived to be sensitive to high rainfall. However, the result depicts that lentil production is decreased by 8 kg per kattha if lentil is cultivated as intermixed crop. Discussion with the farmers revealed that even though the relay practice is found beneficial, farmers are reluctant to continue relay farming as they perceive mono-cropping is risky. One light rain is required to enhance the lentil production, however; heavy rainfall during the bloom season can destroy the whole production. In reverse, if the farmers follow the tillage and intermixed practice, production from alternate crops can ensure their production and saves them from severe loss. Past experience of complete crop failure caused by heavy rainfall, leads a significant number of commercial farmers being unwilling to continue the commercial lentil production. Lentil farmers switched to wheat to minimize the loss. Crop insurance can be the solution to demoralize the decreasing pattern of lentil areas.

Independent variables *viz.* age of the household head and application of fertilizer have a positive and significant effect on the lentil production. Regression coefficient of age (0.25) is statistically significant at a 10% level. This implies that the age of the household head is significantly related to the lentil production, i.e. yield will be increased by 0.25 kg with one year increment in farmer's age, holding other variables constant. It might be because older farmers have more experience of farming, knowledge of minimize the weather shocks.

Similar result was found in a research conducted by Tiwari et al. (2021) at Sindhupalchowk where the maize production has positively correlated with the age of the farmers. Positive coefficient of fertilizer application (22.85) suggests that households used fertilizer have 22 kg more production than the households where fertilizer was not applied, ceteris paribus, and the finding is statistically significant at a 1 percent significance level. Result is in corresponds with the Poudel et al. (2020). Study has discussed that purchased fertilizer is positively correlated with yield of lentil. The recommended fertilizer dose for lentil is 20:40:20 NPK per hectare (Krishi diary, 2020). However, the fertilizer application was found very low i.e. 12.6 kg of urea, 21.6 kg of DAP, and 0.15 kg of MoP per ha in the study site. Though not significant, lentil production is found to increase by 2 kg per kattha if single hand weeding is done in comparison to the production of field with no weeding.

Table 6. Statistical description of the variables used in the multiple regression model

Variables	Description	Value	Expected sign
Tillage	Land preparation practice for lentil cultivation	If followed tillage =1 relay=0	+/-
Mixed cropping	Practice of lentil cultivation with mixed crop	If intermixed=1 sole cropping=0	+/-
Seed Rate	Applied seed rate	in kilogram/kattha	+/-
Seed source	Seed used from formal or informal source	If formal=1 informal=0	+
Age of household head	Age of the household head	Years (in number)	+/-
Gender of household head	Gender of the household head	Male=1, otherwise = 0	+/-
Economic active members in family	Total number of economic active members in HH	in number	+
Training related to lentil cultivation	If family member/HHH has received lentil farming related training	If received=1 otherwise=0	+
Total cultivable land	Total land cultivated by the HH	In kattha	+
Fertilizer application	Application of inorganic fertilizer	If applied =1 otherwise=0	+
Weed management	Practice of weed management	If weeding/herbicide applied =1 otherwise=0	+

Table 7. Parameter estimates of regression model for lentil production with different explanatory variables in study area

Variables	Coefficients	Standard error	T value	p value
Tillage	-0.59	3.83	-0.15	0.877
Mixed cropping	-8.40	3.46	-2.44	0.017
Age of household head	0.24	0.14	1.77	0.080
Gender of household head	0.81	3.55	0.23	0.820
Economic active members in family	0.02	0.70	0.03	0.972
Seed rate	-0.15	2.50	0.06	0.950
Seed source	-1.81	3.22	-0.56	0.575
Training	2.25	4.50	0.50	0.618
Total cultivable land	0.08	0.14	0.59	0.552
Fertilizer application	22.80	3.80	5.99	0.000
Weed management	1.65	3.45	0.48	0.633
Constant	4.51	8.61	0.52	0.601

Variables	Coefficients	Standard error	T value	p value
Summary Statistics				
Number of observation (N)	107			
LR chi^2 (11)	7.69*** (Prob> chi^2 =0.0000)			
Pseudo R^2	0.47			
VIF	1.49			

CONCLUSION

Since the lentil is one of the important exportable agricultural commodities, research and development efforts should be primarily focused on the promotion of commercial and profitable lentil production. BC ratio of 2.30 indicates that relay cropping is highly profitable for lentil production. All categories of farmers can be benefitted from the relay cropping. Less use of input, resources and reduction in operational cost ensures the higher benefit from lentil in a relay than the tillage practice. To minimize the risk of crop failure during mono-cropping, development stakeholders must prioritize the insurance of lentil crops. Therefore, mono and relay cropping with the use of inorganic/organic fertilizer and an efficient weed management strategy would be a sustainable way to increase lentil profitability.

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EVALUATION OF POTATO GENOTYPES FOR PLANT AND YIELD TRAITS AT DAILEKH DISTRICT, NEPAL

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ABSTRACT

Field experiments were conducted at on-farm condition of Dailekh during the spring season for two years (2019 and 2020) to study the plant and yield traits of potato genotypes, and to select high yielding and farmers' preferred genotype. Five promising potato genotypes (PRP226567.2, CIP395017.242, PRP136769.1, PRP276264.1 and CIP393617.1) were studied for their plant and yield traits and compared them with 'Kufri Jyoti', a popular check variety. Experiments were laid-out in randomized complete block design (RCBD) with four replications. Results showed that genotypes exhibited significant differences in all the plant and yield characters. CIP395017.242 gave the highest marketable (23.5 t/ha) and total tuber yield (25.9 t/ha). As compared to Kufri Jyoti, CIP395017.242 gave 12.4% higher marketable tuber yield. Farmer's preferences on plant and tuber of CIP395017.242 were also similar to Kufri Jyoti. Therefore, genotype CIP395017.242 can be recommended to grow at on-farm condition of Dailekh.

Keywords: Genotypes, Marketable, On-farm, Tuber, Yield traits

INTRODUCTION

Potato (*Solanum tuberosum* L.) is a tuberous crop of the Solanaceae family and it is the world's fourth-largest food crop after rice, wheat and maize. In Nepal, it ranks the first crop in total productivity (NPRP, 2019). It is a staple food crop in high hills but this is used as a major vegetable crop in mid hills and terai. Potato is considered as important crop for food and nutritional security at high hills and mountains. Potato is also rich in micronutrients and vitamins and one medium size potato boiled provides half adult daily requirements of vitamin C, iron and potassium (cipotato.org). Potato produces more energy and protein per unit area and unit of time than other food crops (Lutaladio and Castaldi, 2009).

Potato is cultivated in all agro-ecological regions of Nepal ranging from 100 to 4,400 m asl (Dhital and Khatri, 2004). It is cultivated 1, 93, 997 ha of arable land with total production 3,112, 947 tons and the productivity of 16.05 t/ha (MoALD, 2019). Mid hills of Nepal is a dominant region for potato production which occupies 44% of total area (NPRP, 2019). Despite Nepal has favorable agro-ecology for potato production, the national productivity is still low (MoALD, 2019). Lack of improved varieties, high seed demand during planting seasons, use of recycled seed tubers in high

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hill, and continuous growing of old and degenerated varieties are principal factors for limiting production at hills (Luitel et al., 2016).

National Potato Research Program (NPRP) has been developed and released eleven potato varieties so far since its establishment in 1991 (NPRP, 2019) but all the varieties cannot cope the growers' demand for their desired traits. With changing the needs of growers' and industry, there is a need to develop new variety. Cultivar development is a continuous process (Struik and Wiersema, 1999). Potato tuber yield is a complex polygenic trait (Killick, 1977) which is the product of interactions between various factors. Potato genotypes bred in the tropics and temperate regions may perform differently. The performance of potato varieties varies from place to place and none of the released varieties equally potential to perform throughout the country (Bradshaw, 2007). Cultivars of same species grown even in same environment have differences in the yield (Bairwa et al., 2018). On-farm trials are vital to speed up the variety development and enhancing the adoption of new varieties in farm communities (Assefa et al., 2005). The phenotypic characterization and evaluation of different crops in on-farm condition had been studied by several researchers (Bucheyeki and Mmbaga, 2013; Luitel et al., 2016 and Luitel et al., 2017). Dailekh, the second largest district of Karnali Province, represents the mid-western of Nepal and is also a potential area for potato production where many farmers use ‘Cardinal’ as improved variety for fresh production. Farmers are still used Lal Gulab, an Indian variety, and some other local varieties due to lack of access of well-adapted high yielding varieties. The varietal diversity is very low in this region (personal communication). Therefore, this study was carried out to evaluate different potato genotypes for their plant and yield characters, and to identify superior genotypes particularly at on-farm condition of Dailekh.

MATERIALS AND METHODS

The study was conducted at on-farm, Kalbhairab, Dullu Municipality-11 for two years (2019 and 2020). The mean annual rainfall ranged from 153 to 265 mm with rainy season extending from June to August (HRS, 2019). In the cropping season from Feb. to May, the average maximum temperature varied from 18.9 to 30.9˚C in 2019 whereas it varied from 20.1 to 27.9˚C in 2020. Average maximum and minimum temperature increased consistently from Feb. to May but rainfall was inconsistent in both years (Figure 1.)

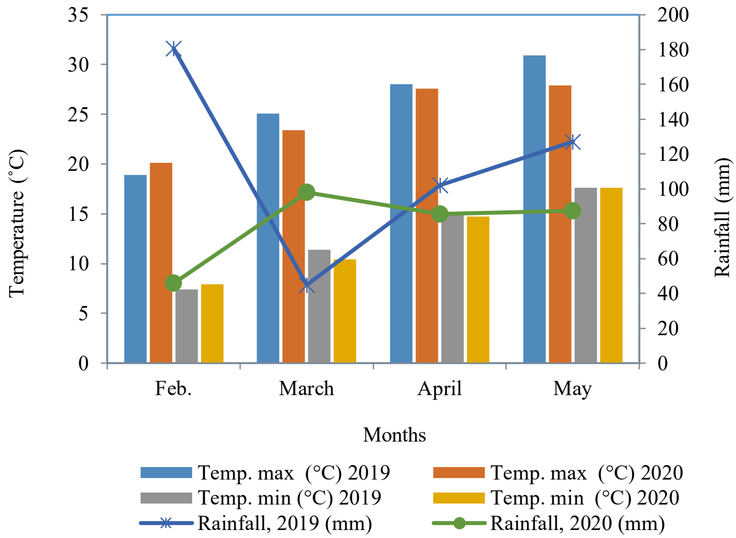

Figure 1. Temperature and rainfall in the cropping season of potato during 2019 and 2020 at Kalbhairab, Dailekh

Seed tubers of six potato genotypes (PRP226567.2, CIP395017.242, PRP136769.1, PRP276264.1, CIP393617.1 and Kufri Jyoti) were received from NPRP, Khumaltar. Out of six genotypes, CIP395017.242 and CIP393617.1 were bio-fortified and enriched with Zn and iron (Luitel et al., 2016). Experiments were arranged in a RCBD with four replications. 'Kufri Jyoti' is a popular variety in mid hills and it was used as check variety. The soil was tilled three times and compost (14.4 kg/plot) was applied a month before planting with a rate of 20 t/ha. Well-sprouted medium sized (30-50 g) tubers were planted on Feb. 14, 2019 and 2020 by hand in rows 60 cm apart and 25 cm between plants within rows. Four farmers were chosen at similar agro-climatic region where six genotypes were planted at each farmer's field and each farmer was considered as one replication. Four rows for each genotype were maintained with plot size 7.2 m^2. Each plot was fertilized with the rate of 100:100:60 kg/ha $NP_2O_5K_2O$ as recommended by NPRP (2019). Urea and DAP fertilizer were used as source of nitrogen and phosphorus, respectively. The entire rate of phosphorus, potash and half the rate of nitrogen was applied at the time of planting and the remaining half of nitrogen was applied 45 days after planting. Cultural practices such as earthening-up and weeding were carried out two times by hand during the growing period.

Observation on plant uniformity was recorded at 45 days after tuber emergence using 1 to 5 scale (1 = least uniform, 5 = most uniform and 2-4 in between). Ground cover was taken at about 60 days after emergence. Each plot was assessed for the percentage of ground cover by foliage converted to a 1-9 scale using following key; 1 = No emergence; 2 = Less than 20% ground cover, 3 = 29-35 % ground cover, 4 = 36-50 % ground cover, 5 = 51-65 % ground cover; 6 = 66-75 % ground cover; 7 = 76-90 % ground cover; 8 = 91-99 % ground cover and 9 = 100 % ground cover (Khatri and Luitel, 2014). Plant height (cm) was measured from the soil surface to the top most growth point of the main shoot apex when 50% of the plants produce flowers. The number of stem per plant was recorded the stems that emerged independently above the soil as single stems at 50% flowering. Tubers were graded after harvesting; and tubers less than 25.0 g and diseased and insect infected was categorized as non-marketable whereas tubers size with greater than 25.0 g, and more than 50.0 g were categorized into marketable tuber. The marketable tuber yield was calculated using marketable tuber weight/plant (g) multiplied by planting density divided by area in hectare basis (De Haan et al., 2014.). Total tuber yield (t/ha) was calculated by adding the weight of all tubers (marketable and non-marketable tuber yields). In addition, plant and tuber characters such as maturity, shape, color, skin type and eye depth was recorded by visual observation of plant foliage and tubers as mentioned in Potato Field Book (Khatri and Luitel, 2014). ANOVA was performed using GenStat Release 10.3 DE Software (VSN International Ltd., UK) and phenotypic correlation of quantitative characters was analyzed by IBM SPSS Statistics (Version 20.0).

RESULTS AND DISCUSSION

PLANT TRAITS

The combined analysis showed that genotypes showed significant differences in plant uniformity, ground cover, plant height and stem number/plant (Table 1). The highest (5.0) plant uniformity was observed in PRP226567.2 and CIP395017.242. Year showed non-significant difference in plant uniformity but genotype and year interaction effect were significant. The variation in plant uniformity of the potato genotypes was reported by previous researchers (Luitel et al., 2016). CIP395017.242 produced the highest (80.0%) ground cover but it was statistical similar to CIP393617.1 (79.0%) and PRP226567.2 (77.0%) but the lowest (64.0%) ground cover was observed in PRP276264.1. Year and, genotype and year interaction showed highly significant differences in ground cover. Ground cover is also determined by the growing condition, planting time and tuber bulking behavior of genotypes. The tallest plant was measured in PRP276264.1 (67.0 cm) followed by CIP393617.1 (65.0 cm) but the shortest (51.0 cm) was measured in PRP136769. Differences in plant height among the genotypes may be caused by genetics of the plant as well as the quality of planting materials used (Eaton et al., 2017). CIP393617.1 produced more (6.0) number of stem/plant but it was statistically similar to PRP226567.2 (5.0) and CIP395017.242 (5.0) but the least (4.0) number of stem/plant was counted in PRP136769.1 and Kufri Jyoti. The variation in stem number/plant among the genotypes might be due to genetic traits (Nielson et al., 1989).

Table 1. Plant traits of potato genotypes evaluated at on-farm, Dailekh during 2019-2020.

Genotypes (G)	Uniformity (1-5 score)		Mean	Ground cover (%)		Mean	Plant height (cm)		Mean	Stem/plant (no.)		Mean
	2019	2020		2019	2020		2019	2020		2019	2020	
PRP226567.2	4.0	5.0	5.0	64.0	90.0	77.0	41.0	76.0	59.0	5.0	4.0	5.0
CIP395017.242	4.0	5.0	5.0	70.0	90.0	80.0	47.0	66.0	56.0	5.0	5.0	5.0
PRP1367	4.0	5.0	4.0	61.0	88.0	75.0	47.0	56.0	51.0	4.0	5.0	4.0

Genotypes (G)	Uniformity (1-5 score)		Mean	Ground cover (%)		Mean	Plant height (cm)		Mean	Stem/plant (no.)		Mean
	2019	2020		2019	2020		2019	2020		2019	2020	
69.1												
PRP276264.1	3.0	5.0	4.0	35.0	92.0	64.0	60.0	74.0	67.0	6.0	4.0	5.0
CIP393617.1	4.0	4.0	4.0	71.0	87.0	79.0	45.0	85.0	65.0	6.0	5.0	6.0
K. Jyoti (Ch)	4.0	5.0	4.0	55.0	92.0	74.0	49.0	61.3	55.0	3.0	5.0	4.0
Mean	3.83	4.75	4.39	59.4	90.1	74.7	48.1	69.6	58.13	4.84	4.91	4.88
Genotypes (G)			*			**			*			*
LSD (0.05)			0.541			8.98			14.50			1.12
Year (Y)			NS			**			**			NS
LSD (0.05)			0.33			5.19			8.40			0.64
G x Y			*			**			*			NS
LSD (0.05)			0.80			12.7			20.58			1.58
CV (%)			13.1			11.8			23.7			22.5

ns, *, ** non-significant or significant at 5% and 1%, respectively.

YIELD TRAITS

Genotypes revealed highly significant differences in non-marketable, marketable tuber number and total tuber number/plant (Table 2a). The highest (108.0) non-marketable tuber number/plot was produced in PRP136769.1 followed by CIP395017.242 (102.0) but the lowest (76.0) was in CIP393617.1. Year showed highly significant effect on non-marketable tuber/plot and, genotype and year interaction was also significant. Similarly, CIP395017.242 produced the maximum (214.0) marketable tuber number/plot followed by PRP136769.1 (211.0) but it was the lowest (148.0) in PRP276264.1. Year had non-significant effect on marketable tuber number/plot but interaction of genotype and year was highly significant. Total tuber number/plant was produced the highest (11.0) in CIP395017.242 and PRP136769.1 but the lowest (8.0) tuber number was produced in PRP276264.1, CIP393617.1 and Kufri Jyoti. Year showed significant effect on total tuber number/plant but genotype and year interaction showed highly significant. The significant variation in tuber number/plant might be due to genotypic factors. Lahlou et al. (2003) reported that tuber number was more affected by the bulking nature of genotypes. Seifu and Betewulign (2017) also reported a significant difference in total tubers number/plant among potato varieties.

Table 2a. Yield traits of potato genotypes evaluated at on-farm, Dailekh during 2019-2020.

Genotypes (G)	Non-marketable tuber/plot (no.)		Mean	Marketable tuber/plot (no.)		Mean	Total tuber/plant (no.)		Mean
	2019	2020		2019	2020		2019	2020	
PRP226567.2	136.0	58.0	97.0	237.0	171.0	204.0	9.0	9.0	9.0
CIP395017.242	116.0	88.5	102.0	183.0	245.0	214.0	8.0	15.0	11.0
PRP136769.1	146.0	71.0	108.0	223.0	198.0	211.0	10.0	13.0	11.0
PRP276264.1	81.0	76.0	79.0	107.0	190.0	148.0	5.0	11.0	8.0
CIP393617.1	108.0	75.0	76.0	198.0	121.0	159.0	8.0	7.0	8.0
K. Jyoti (Ch)	83.0	33.0	58.0	148.0	205.0	177.0	7.0	10.0	8.0
Mean	111.5	61.8	86.7	182.6	188.1	185.4	7.88	10.73	9.33
Genotypes (G)			**			**			**
LSD (0.05)			25.46			36.13			2.580
Year (Y)			**			NS			**
LSD (0.05)			14.7			20.86			1.49
G x Y			*			**			*
LSD (0.05)			36.01			51.09			3.65
CV (%)			28.9			19.2			23.7

ns, *, ** non-significant or significant at 5% and 1%, respectively.

Results of marketable tuber weight, marketable tuber yield and total tuber yields of potato genotypes are presented in Table 2b. Significant effect was found in marketable tuber weight among the genotypes. CIP395017.242 produced the highest (12.4 kg) marketable tuber weight followed by PRP136769.1 (11.8 kg) and PRP226567.2 (11.7 kg) and the lowest (8.9 kg) was observed in PRP276264.1. Marketable tuber yield produced the highest (23.5 t/ha) in CIP395017.242 and the lowest (17.0 t/ha) was in PRP276264.1.Variation in marketable tuber weight among the genotypes may be due to genetic make-up of the plants. Besides genotypes, management practices, seed quality and agro-ecological condition of the experimental site also affect the weight of tubers (Eaton et al., 2017). With respect to tuber yield, CIP395017.242 gave the highest (25.9 t/ha) but the lowest (19.1 t/ha) yield was recorded in PRP276264.1.Year showed highly significant on total tuber yield but interaction between genotype and year was significant. Genotypes showed significantly different in marketable tuber weight and yield at on-farm condition and this variation might be due to genotypic and similar results were reported by previous researchers (Hassanpanah et al., 2011; Luitel et al., 2017). High tuber yield might be due to better plant uniformity, ground cover and high number of tuber/plant (Patel et al., 2008; Luitel et al., 2017). Tuber yield variation in potato genotypes were reported by different researchers in Nepal (Luitel et al., 2017; Gainju et al., 2019).

Table 2b. Yield traits of potato genotypes evaluated at on-farm, Dailekh during 2019-2020.

Genotypes (G)	Marketable wt./plot (kg)		Mean	Marketable tuber yield (t/ha)		Mean	Total tuber yield (t/ha)		Mean
	2019	2020		2019	2020		2019	2020	
PRP226567.2	12.6	17.3	14.9	17.6	23.9	20.8	20.3	26.2	23.2
CIP395017.242	10.8	22.2	16.5	16.2	30.8	23.5	18.2	33.5	25.9
PRP136769.1	12.3	18.2	15.2	17.0	25.3	21.1	20.1	27.5	23.8

PRP276264.1	6.8	17.7	12.3	9.4	24.6	17.0	11.6	26.6	19.1
CIP393617.1	13.9	11.4	12.7	19.4	15.7	17.6	22.0	16.8	19.4
K. Jyoti (Ch)	8.1	21.9	15.1	11.3	30.5	20.9	13.3	31.4	22.3
Mean	10.79	18.11	14.4	14.9	25.2	20.07	17.6	27.0	22.3
Genotypes (G)			*			*			*
LSD (0.05)			1.1			5.13			2.16
Year (Y)			NS			**			**
LSD (0.05)			2.27			3.87			4.11
G xY			NS			*			*
LSD (0.05)			5.56			9.49			10.07
CV (%)			18.9			19.2			23.1

ns, *, ** non-significant or significant at 5% and 1%, respectively.

PHENOTYPIC CORRELATION

Plant uniformity showed strong positive association with ground cover, marketable tuber number, total tuber number/plant, marketable tuber weight, marketable tuber yield and total tuber yield (Table 3). Ground cover showed moderate correlation with plant height, marketable tuber number, total tuber number/plant, marketable tuber weight, marketable tuber yield and total tuber yield. Similarly, marketable tuber number exhibited positive correlation with total tuber number/plant, marketable tuber weight, marketable tuber yield and total tuber yield. Total tuber number/plant had positively correlated with marketable tuber weight, marketable tuber yield and total tuber yield. This result indicates that as the total number of tuber increases, tuber yield per plot also increases. So, selection of this trait is useful for potato variety improvement. Marketable tuber weight showed strong positive association with marketable yield and total tuber yield. The strong positive correlation between tuber weight and yield was also reported by Khayatnezhad et al. (2011). The positive correlation between tuber size and tuber yield was also reported by Yuan et al. (2016).

Table 3. Correlation coefficient of plant and yield traits of potato genotypes evaluated at on-farm, Dailekh during 2019-2020.

Variables	UNIF	GC	PHT	STPP	NMNO	MTN	TTPP	MTWT	MYLD	TYLD
UNIF	1.0	.87**	.15	.18	-.17	.50**	.50**	.68**	.64**	.63**
GC		1.0	.40**	.09	-.34*	.41**	.57**	.42**	.71**	.68**
PHT			1.0	.18	-.44**	-.30*	.07	-.13	.14	.10
STPP				1.0	0.02	.18	.03	.51**	.63**	.54*
NMNO					1.0	.26	.12	.16	-.19	-.09
MTN						1.0	.67**	.82**	.66**	.68**
TTPP							1.0	.82**	.84**	.87**
MTWT								1.0	.83**	.85**
MYLD									1.0	0.99**
TYLD										1.0

* and ** indicate significance at 5 and 1%, respectively. UNIF = Uniformity (1 to 5 scale), GC = Ground cover (%), PHT = Plant height (cm), STPP = Stem number/plant, NMNO = Non-marketable tuber/plot (no.), MTN = Marketable tuber/plot (no.) TTPP = Total tuber/plant (no.) MTWT = Marketable tuber weight/plot (kg), MYLD = Marketable tuber yield (t /ha), and TYLD = Total tuber yield (t/ ha)

MATURITY AND TUBER TRAITS

PRP226567.2, CIP395017.242, PRP136769.1 and Kufri Jyoti were medium (90-120 days) maturing types but PRP276264.1 and CIP393617.1 were late maturing (>120 days) genotypes (Table 4). Tuber shape varied from oblong, round, round flat to oval type. Out of six genotypes, PRP226567.2 and PRP276264.1 observed as light red and red tuber, respectively and remaining genotypes produced white tuber. Likewise, eye depth in tuber varied from shallow, medium to deep. Farmers' preferences in plants and tuber were not different considerably in the tested genotypes. Qualitative traits such as skin and flesh color, and eye depth are stable over the environments and therefore, tuber characters over the years did not change. In contrast, maturity class, tuber number and yield are influenced by environment (Struik and Wiersema, 1999). On the other hand, tuber shape, skin and flesh color, eye depth and general appearance are the distinctive quality parameters that influence consumer's choice (Pandey et al., 2000).

Table 4. Maturity and tuber traits of potato genotypes evaluated at on-farm, Dailekh during 2019-2020.

Genotypes	Maturity	Tuber shape	Tuber color	Eye depth	Farmers' preferences (1-5 score)	
					Plants	Tubers
PRP226567.2	Medium	Oblong	Light Red	Shallow	5	4
CIP395017.242	Medium	Round	White	Medium	5	4
PRP136769.1	Medium	Round flat	White	Shallow	4	4
PRP276264.1	Late	Round	Red	Deep	5	4
CIP393617.1	Late	Round flat	White	Shallow	3	4
K. Jyoti (Ch)	Medium	Oval	White	Shallow	4	4

Maturity; Early = < 90 days, Medium = 90-120 days, and Late = >120 days (Khatri and Luitel, 2014).
Farmers preference, 1-5; 1 = Very poor, 5 = Very good (Luitel et al., 2016).

CONCLUSION

Genotypes revealed the significant variation in all the plant and yield traits. CIP395017.242 produced the highest (23.5 t/ha) marketable tuber yield and it imparted 12.4% yield advantage over check variety Kufri Jyoti. Plant uniformity, ground cover, marketable tuber number/plot, total tuber number/plant and marketable tuber weight/plot recorded high positive and significant correlation with tuber yield suggesting their potential use in potato improvement. Since CIP395017.242 is a medium maturing type, white skin with medium eye depth in tuber, farmers preferred similar to Kufri Jyoti. CIP395017.242 is also zinc and iron enriched genotype and therefore, cultivation of this clone would help to contribute food nutrition of the people of Karnali Province.

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