TIME FOR NATURE

सुरक्षित जीवनका लागि जैविक विविधता

The Journal of
AGRICULTURE AND ENVIRONMENT

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EDITORIAL

The World Environment Day (June 5), UN Environment-led global event, which takes place on June 5 every year and is celebrated all over the world involving all categories of people. "Time for Nature" is the UNEP theme for World Environment Day 2020.

The day is being celebrated through several events and relevant environmental campaigns. Food Security and Food Technology Division in the Ministry of Agriculture and Livestock Development has been publishing **The Journal of Agriculture and Environment** on the auspicious occasion of the World Environment Day every year. The division now has brought the journal's new issue, Vol.21, in the hand of readers. The journal essentially includes technical research and review articles, and the volume has major coverage of plant breeding, agricultural biodiversity, agriculture product marketing, crops and livestock production technology, diseases and insect pests management, pravailing climate change issues and impact experienced in Nepal. The Editor-in-Chief acknowledges the valuable contributions from authors, reviewers, editors, and the editorial management team, and hopes that the readers find the issue informative and knowledgable. The Editorial Board will be pleased to receive valuable suggestions and feed backs to improve our forthcoming issues.

Editor-in-Chief

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GUIDELINES TO AUTHORS: MANUSCRIPT PREPARATION AND SUBMISSION

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

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5. Main text of the technical manuscripts should include introduction, objective, theoretical framework, methodology, results and discussions, conclusions and references.
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WEED DYNAMICS AND YIELD OF WHEAT IN LONG TERM SOIL FERTILITY EXPERIMENT UNDER RICE-RICE-WHEAT CROPPING SYSTEM

N. Khatri[1], B. P. Pandey[1], M. Yadav[2], B. P. Chaurasia[3], M. Bista[4] and B. Kunwar[5]

ABSTRACT

Weed dynamics and yield and yield parameters of wheat was studied in long-term soil fertility experiment underrice-rice-wheat system during winter season of 2018-19. The experiment was laid out in randomized complete block design with nine treatments replicated three times. Treatments were applied as: T1- no nutrients added, T2- N added; T3- N and P added; T4- N and K added; T5- N_2:P_2O_5:K_2O added at recommended rate for all crops. Similarly, T6- only N added in rice and N_2:P_2O_5:K_2O in wheat at recommended rate; T7- half N; T8- half NP of recommended rate for both crops; and T9- farmyard manure @10 t ha^{-1} for all crops in rotation. The results revealed that the use of Farm Yard Manure @ 10 t ha^{-1} gave significantly higher yield of 2393 kg ha^{-1} followed by recommended chemical fertilizer dose of 100:40:30 N:P_2O_5:K_20 kg ha^{-1} of 2383 kg ha^{-1}. Considerably, lower grain yield was obtained from treatments that did not receive phosphorus. Similarly, application of FYM @10 t ha^{-1} followed by recommended fertilizer dose recorded higher weed density and dry weed weight with compared to any of N,P_2O_5 and K_2O or all nutrient omitted treatments.

Keywords: FYM, inorganic fertilizer, weed, wheat, yield

INTRODUCTION

Rice and wheat are the major crops in Nepal. Suitable rice-wheat based cropping system has to be evaluated, to assess the stability in production (Kumpawat, 2001). Soil fertility and plant nutrient management are key issues to be addressed to understand the reasons for declining crop yields. Intensive agriculture, involving exhaustive high yielding varieties of rice and other crops, has led to heavy withdrawal of nutrients from the soil; imbalanced and discriminate use of chemical fertilizers has resulted in deterioration of soil health (John et al., 2001). The productivity of land under such a system is unlikely to be sustained unless nutrient deficiencies or

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imbalances are identified and corrected promptly. Example can be cited of zinc deficiency in rice and boron in wheat. Additionally, there is a risk of environmental hazards due to their imbalanced application resulting into declined soil fertility, crop productivity and environmental instability. On the other hand, inadequate plant nutrients supply has been considered as one of the factors of lower crop productivity. The long-term effects of using organic fertilizers are of great significance in relation to sustained crop yield, maintain soil fertility and protect the environment as well. Balanced nutrition of plant is a mean to improve crop yield. For a resource poor country like Nepal, the use of fertilizer alone may not be a viable solution to sustain the crop yield and maintain soil health under rice-wheat system, the predominant cropping system. Use of organic manures including farmyard manure, goat manure and poultry litter use for crop production might be a substitute of the chemical fertilizers (Sanchez-Monedero et al., 2004). Use of local agricultural bio resources as a substitute of fertilizers is now in great demand because they are more cost-effective and environment friendly (Bhattacharya et al., 2008). Crop production practices such as tillage, weed management and fertilizer application, influence weeds in agriculture (Barberi et al., 1997).

Weeds are omnipresent and compete with crops for nutrients, space, water and light. Weed density, type of the weeds, their persistence and crop management practices determine the magnitude of yield losses. Weed infestation is the major bottle neck to higher wheat productivity and accounts for more than 48% loss of potential wheat yield (Khan and Haq, 2002). Fertilizer use whether it is organic, or inorganic has definite influence on weed emergence, weed growth, weed dynamics, and weed dispersion attributes. Application of organic manure can increase weed population (Arif et al., 2013), as most of the time incorporation of organic manure such as FYM and poultry manure served as weeds seeds store bank (Baig et al.,2001). Unless controlled properly, weeds are major users of nutrients applied to crops. Crop management through residue retaining also had direct effect on the weed density in crop like wheat (Roder et al., 1998, Dastgheib, 2006). Therefore, the objective of this study was to determine the effects of organic manure and inorganic fertilizer levels on yield and weed diversity in wheat under rice-rice-wheat cropping system.The long-term experiment was initiated in 1978/79 at NWRP, Bhairahawa and it has been continued up to now. The major objective was to study the long-term application of mineral fertilizer or manure on crop yields and soil properties.

METHODOLOGY

The experiment was conducted in the experimental site of the Research Farm of at National Wheat Research Program (NWRP), Bhairahawa, Rupandehi, Nepal. The layout of the plots was kept undisturbed for growing all early rice, normal season rice and wheat. The treatments for wheat were applied as: T1-

no nutrients added, T2- N added; T3- N and P added; T4- N and K added; T5- N_2:P_2O_5:K_2O added at recommended rate for all crops. Similarly, T6- only N added in rice and N_2:P_2O_5:K_2O in wheat at recommended rate; T7- half N; T8- half NP of recommended rate for both crops; and T9- farmyard manure @10 t ha^{-1} for all crops in rotation (Table 1). The experiment was laid out in randomized complete block design as described by Gomez and Gomez (1984) with nine treatments, which were replicated three times. The plot size was 4 x 3 m^2. Wheat was sown in rows of 25 cm apart and continuous line sowing. Nitrogen, phosphorus and potash were supplied through Urea, Di-ammonium phosphate and muriate of potash, respectively. Full dose of phosphorus and potash and half dose of nitrogen were applied at the time of sowing. Farm-yard manure was applied at 10 days before seeding. Remaining 50% nitrogen was top dressed at 21-25 days after seeding in wheat. Yield and yield attributing parameters; tiller number m^{-2}, number of grains $panicle^{-1}$, panicle length, plant height, 1000-grain weight, grain yield and straw yield were recorded.

Data on only weeds flora and yield of wheat in 2018-19 wheat season is presented in this paper. Observations on weed density were recorded using quadrate method as described by Pound and Clements (1998). Data on different weed species and weed dry weight were recorded at 30, 60 and 90 days after sowing (DAS). These data were subjected to square root transformation before analysis. Weeds inside the quadrate measuring 0.5 m x 0.5 m were identified and counted. The weeds were then uprooted carefully. The uprooted weeds were washed thoroughly in clean water and dried first in the sun for two days and thereafter in a hot air oven for 72 hours at 72°C. The weight of the dried sample was taken, and the average data were expressed as weed dry weight (gm/0.25 m^2). The analysis of variance of all recorded parameters was analyzed by using GEN STAT Software.

Table 1: Treatments on wheat and rice crops

SN	Treatment (Wheat)	Treatment (Rice)	Symbol
1	0: 0:0 N:P_2O_5:K_2O kg ha^{-1}	0: 0:0 N:P_2O_5:K_2O kg ha^{-1}	T1
2	100:0:0 N:P_2O_5:K_2O kg ha^{-1}	100:0:0 N:P_2O_5:K_2O kg ha^{-1}	T2
3	100:40:0 N:P_2O_5:K_2O kg ha^{-1}	100:30:0 N:P_2O_5:K_2O kg ha^{-1}	T3
4	100:0:30 N:P_2O_5:K_2O kg ha^{-1}	100:0:30 N:P_2O_5:K_2O kg ha^{-1}	T4
5	100:40:30 N:P_2O_5:K_2O kg ha^{-1}	100:30:30 N:P_2O_5:K_2O kg ha^{-1}	T5
6	100:40:30 N:P_2O_5:K_2O kg ha^{-1}	100:0:0 N:P_2O_5:K_2O kg ha^{-1}	T6
7	50:0:0 N:P_2O_5:K_2O kg ha^{-1} + 30 cm rice stubble incorporation	50:0:0 N:P_2O_5:K_2O kg ha^{-1} + 30 cm rice stubble incorporation	T7
8	50:20:0 N:P_2O_5:K_2O kg ha^{-1} + 30 cm rice stubble incorporation	50:20:0 N:P_2O_5:K_2O kg ha^{-1} + 30 cm rice stubble incorporation	T8
9	F Y M 10 t ha^{-1}	F Y M 10 t ha^{-1}	T9

RESULTS AND DISCUSSION

WEED SPECIES

The recorded weed species during the experiment are presented below (Table 2). A total of 8 weed species from 6 different families were recorded during the field experiment. The observed weed species were *Chenopodium album, Cynodondaactylon, Anagalis arvensis, Solanum nigrum, Medicago denticulate, Vicia sativa, Lathyrus vestitus and Cyperusrotundus*. Among different weed floras, broad leaved weed species were found to be most dominant followed by sedge and grass.

Table 2: Observed weed species in experimental field

Weed Species	Family Name	Leaf Morphology
Chenopodium album	Amaranthaceae	Broad leaf
Cynodondactylon	Poaceae	Grass
Anagalis arvensis	Primulaceae	Broad leaf
Solanum nigrum	Solanaceae	Broad leaf
Medicago denticulate	Fabaceae	Broad leaf
Vicia sativa	Fabaceae	Broad leaf
Lathyrus vestitus	Fabaceae	Broad leaf
Cyperusrotandus	Cyperaceae	Sedge

WEED DENSITY

The result revealed that different treatments had significant effect on weed density (Table 3). Among different treatments, application of FYM 10 t ha^{-1} (T9) recorded significantly highest weed density in all date followed by application of recommended dose of fertilizer @100:40:30 kg ha^{-1} $N:P_2O_5:K_2O$ (T5), T6, T3, T4 and T2. Our results are in line with the findings of Ali et al. (2011) who also reported that weeds density m^{-2} in maize was higher in FYM incorporated plots as compared to control. Application of organic manure can increase weed population (Arif et al., 2013) as most of the time incorporation of organic manure such as FYM and poultry manure served as weeds seeds store bank (Baig et al., 2001). Similarly, Elmetwally et al. (2010) reported that application of higher level of nitrogen fertilizer markedly increased weed density at harvest in barley crop.

In treatment FYM @10 t ha^{-1}(T9), weed density of 9.64, 10.36, and 10.08 /0.25 m^{-2} recorded at 30, 60 and 90 DAS respectively. Lowest weed density was observed on those treatments where either in nitrogen, phosphorus and potash missing or in all nutrient missing treatments (T7, T8, T1, T2 and T3). Moreover, many weeds are high N or P consumers (Qasem, 1992; Blackshaw et al., 2003); thus, the growth of many weed species is enhanced by higher soil

N or P levels. Weed population were found highest at 60 DAS followed by 30 DAS and lowest was recorded at 90 DAS. This might be due to some weed species emerged earlier and some species emerged later, i.e. different weed species have different growth habit.

Table 3: Effect of different combination of inorganic fertilizers and farm-yard manure on weed density during 2018-19

Treatment	Weed density/0.25 m^2		
	30 DAS	60 DAS	90 DAS
T1	5.48 (33.3)	6.48 (44.7)	5.31 (29)
T2	7.45 (65.3)	7.72 (62.7)	5.44 (31)
T3	8.68 (75.7)	7.96 (66.7)	5.47 (32)
T4	7.94 (66)	7.25 (54.3)	6.51 (43.3)
T5	9.55 (91.7)	10.14 (103)	9.89 (98)
T6	9.49 (90)	10.07 (101.3)	9.76 (95.3)
T7	5.18 (31.7)	6.25 (39.3)	5.48 (31.3)
T8	5.23 (28.3)	7.2 (54.7)	5.86 (36.3)
T9	9.64 (93)	10.36 (107.3)	10.08 (102.7)
F-test	*	*	**
LSD (0.05 %)	3.11	2.51	2.14
CV %	23.5	17.8	17.4

** and ** denotes significant at 1 % and 5 % level of significance respectively*
Data in parentheses indicates original value.

WEED DRY WEIGHT

There was significant difference in weed dry weight during 30 DAS and 90 DAS however not during 60 DAS (Table 4). Weed dry weight was found highest in treatment T9 (FYM @ 10 t ha^{-1}) followed by T5 (100:40:30 kg ha $^{-1}N:P_2O_5:K_2O$). Similar results were reported by Jama et al. (1997) who reported that application of organic manures resulted in higher weeds biomass and weeds density. Balanced fertilization also recorded higher weed dry weight in all date. In 30 DAS, higher weed dry weight of 2.45 gm was obtained in T9 followed by 2.17 gm in T5 and the trend was found similar in 60 and 90 DAS. Lowest weed dry weight was recorded in any of N, P_2O_5 and K_2O nutrient omission or whole nutrient omission treatments.

Table 4: Effect of different combination of inorganic fertilizers and farm-yard manure on weed dry weight during 2018-19

Treatment	Weed dry weight (gm/0.25 m^2)		
	30 DAS	60 DAS	90 DAS
T1	1.37 (1.93)	2.10 (4.63)	1.22 (1.6)
T2	2.04 (4.5)	2.22 (6.4)	1.91 (3.67)
T3	2.15 (4.6)	2.31 (7.2)	1.83 (3.83)
T4	2.05 (4.5)	2.08 (4.33)	1.89 (4.33)
T5	2.17 (4.8)	2.53 (6.97)	2.88 (8.33)
T6	2.12 (4.5)	2.51(6.3)	2.83 (8.00)
T7	0.55 (0.35)	1.27 (1.7)	1.54 (3.3)
T8	0.91 (0.9)	1.66 (3.4)	1.79 (3.87)
T9	2.45 (6.27)	2.61 (7.1)	2.91(8.5)
F-test	**	ns	*
LSD (0.05 %)	0.77	-	0.93
CV %	25.2	34.2	25.6

***, * and ns denote significant at 1 % and 5% level of significance and non-significant respectively, Data in parentheses indicates original value.*

EFFECT ON YIELD PARAMETERS

There was a significant difference in plant height, thousand grain weight and grain yield of wheat in various treatments during the experiment (Table 5). The average plant height ranged from 74 to 96 cm depending upon the treatment. Tallest plant height of 96 cm recorded from treatment T9 (FYM 10 ton ha^{-1}) followed by T6 (100:40:30 $N:P_2O_5:K_2O$ kg ha^{-1}) where as shortest plant height was found in T2, T7 and T4 respectively. The effect of different treatments on number of tillers m^{-2} and number of grains per spike was found non-significant. However, highest number of tillers m-2 and number of grains per spike was found highest of 248 and 43 in application of FYM @ 10 t ha^{-1} respectively. Similarly, 1000 grain weight was also found significantly higher (43.7 gram) in application of FYM @ 10 t ha^{-1} (T9) followed by application of $N:P_2O_5:K_2O$ @100:40:30 kg ha^{-1} (T6). The observed lower thousand grain weight was recorded in potassium omission treatment (100:40:0 $N:P_2O_5:K_2O$ (kg ha^{-1}) (T3). The grain yield was found significantly higher (2393 kg ha^{-1}) with the use of FYM @10 tha^{-1} (T9) followed by recommended fertilizer dose (T5) of 2383 kg ha^{-1}. Significantly lowest grain yield of wheat was observed in phosphorus omitted plots (T2, T4 and T7). These results indicated that severe deficiency of potassium and phosphorus was observed in wheat and plays a major role in increasing the wheat yield. The highest grain yield on T9 treatment may be mainly attributed to an increased thousand grain weight, number of grains per spike and number of tiller m^{-2}.

Table 5: Yield and yield attributes of wheat under different treatment

Treatment	Plant height (cm)	Number of tillers m^{-2}	Number of grains $spike^{-1}$	1000 grain wt (gm)	Grain yield (kg ha^{-1})
T1	83	147	41	38.2	617
T2	74	202	46	30.7	505
T3	80	198	31	23.7	790
T4	77	165	35	37.3	557
T5	90	198	39	38.5	2383
T6	93	186	42	39.1	2178
T7	76	193	29	36.5	499
T8	87	181	38	36.6	1379
T9	96	248	43	43.7	2393
F-test	**	ns	ns	**	**
LSD (0.05 %)	7.5	-	-	3.8	334.5
CV %	5.1	22.3	16.7	6.1	15.4

*** denotes significant at 1 % level of significance and ns denotes non-significant*

CONCLUSION

The results of this study indicate that there was very low wheat grain yield in all phosphorus missing treatments (T1, T2, T4, and T 7). This shows Phosphorus is one of the most limiting factors in wheat crop. Application of FYM @ 10 t ha^{-1} in long run or recommended dose of chemical fertilizer increased the wheat grain yield and weed population as well. Hence, balanced dose of organic manure or recommended dose of inorganic fertilizer along with effective weed management practices should be applied to increase the wheat grain yield.

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COMPATIBILITY STUDY OF TRICHODERMA ISOLATES WITH CHEMICAL FUNGICIDES

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ABSTRACT

Chemical use in agricultural farming in recent years has led to many threats concerning the environment and human health. Trichoderma spp. has been used as a biocontrol agent and is gaining popularity in recent years. Integrated use of Trichoderma with compatible chemicals is one disease management strategy which would aid in immediate action on plant pathogens and provide control over pathogens in long term as well. In vitro compatibility test of five Trichoderma isolates with thirteen different chemical fungicides at two different concentrations was carried out in the laboratory of Plant Pathology Division. The results showed that four of the tested chemical pesticides viz; Bavistin (Carbendazim 50% WP), Cryzole (Hexaconazole 5% SC), Benlate (Benomyl 50% WP) and Saaf (Carbendazim 12% Mancozeb 63% WP) exhibited complete inhibition of Trichoderma, irrespective of the isolates tested. Seven of them were compatible with all Trichoderma isolates and two chemicals Krilaxyl (Metalaxyl 8% + Mancozeb 64% WP) and Aver up (Chlorothalonil 75% WP) showed some degree of inhibition of two Trichoderma isolates, while the rest of the isolates were fully compatible. In all the chemical treatments it was noted that growth of Trichoderma decreased as the concentration of pesticides increased. Integration of safer and compatible chemical pesticides and Trichodermacan provide an effective and long-term solution against plant diseases in agricultural farming.

Keywords: Biocontrol, chemical pesticides, compatibility test, *Trichoderma*

INTRODUCTION

Trichoderma sp. is well established as a biopesticide, biofertilizer in agriculture and is the most exploited bioagent used for the control of various plant pathogens (Kumar et al., 2014). It can be used as seed treatment, seed biopriming, seedling treatment, soil applications, and foliar applications (Benitez et al., 2004).However, there are also findings, in which *Trichoderma* give excellent control of plant pathogens in greenhouse and pot trials while they fail to perform at the same level in fields. This may be primarily due to the time taken to adapt to new ecological niches with variable microclimate

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and interaction with several other microorganisms. Scientists have often explained of the lag phase of *Trichoderma* to provide control of plant pathogens as they would need time to colonise the root system or the diseased foliar parts of plants to provide ultimate benefit of plant protection (Mutawila et al., 2015). Hence the beneficial effect of *Trichoderma* may be exhibited in long term. Chemicals on the other hand act relatively very quicker than the biopesticides. But, the detrimental effect of chemical pesticides on environment and health is a serious issue. Most chemicals have short term effect and need to be applied continuously. Pesticide use in Nepal is low (0.396 kg a.i. perha) as compared to other countries (Sharma, 2015). However, the data for the use of chemical pesticides in Nepal in agricultural commodities suggests an indiscriminate use of the pesticides, particularly in vegetable farming (Bhandari et al., 2018; Gyawali, 2018).This also induces resistance in pathogens and therefore an integrated approach of using both chemicals and *Trichoderma* may enhance the effectiveness of disease control and provide better management of plant diseases (Madhusudhan et al., 2010).There are also many findings of effective disease control with combined use of *Trichoderma* species and chemical pesticides in seed treatment or when applied in field conditions (Venkateswarlu et al., 2008; Mahesh et al., 2010; Animisha and Zacharia, 2011). Several chemicals however have negative effects on *Trichoderma* growth and colonization (Sushir et al., 2015; Tapwal et al., 2012) and hence firstly safer chemicals compatible with *Trichoderma* must be tested. This study was conducted to select the chemical fungicides, which are compatible with different *Trichoderma* isolates for their potential to be used in integrated disease management approach. Differences in response of various *Trichoderma* strains have also been observed by several authors and resistant isolates have been identified, which can tolerate field concentrations of stronger chemical pesticides (Silva et al., 2018). Different isolates of *Trichoderma* were used in this *in vitro* test to find out if there were variable responses among the isolates to the chemicals under study.

MATERIALS AND METHODS

TRICHODERMA ISOLATES USED FOR THE STUDY

Five different isolates of *Trichoderma* were used for the study, which were Ts, Tv, T22, Th and T69. All isolates except T22 were the native isolates recovered from rhizosphere of vegetable crops in different places of Nepal. T22 was an isolate recovered from commercial Trichoderma product. Serial dilutions of the soils/commercial formulation were made in sterilized water and the suspension was spread on PDA plates for the isolation of *Trichoderma*. Plates were incubated at 25°C until the growth of *Trichoderma*. The colonies were observed under stereoscope and isolation of *Trichoderma*

was performed with the help of sterile needle onto PDA slants. The isolates T69, Th were identified as *T. harzianum*, Ts as *T. asperellum* and Tv as *T. viride* while T22 was not identified to species level.

CHEMICAL FUNGICIDES USED FOR THE STUDY

Thirteen commonly used chemical pesticides were tested for their compatibility with the *Trichoderma* isolates. These were AverUp (Chlorothalonil 75% WP), Aver Green (Mancozeb 64% + Cymoxanil 8% WP), Triazole (Tricyclazole 75% WP), Cryzole (Hexaconazole 5% SC), Sectin (Fenamidone 10%+ Mancozeb 50% WG), Antracol (Propineb 70% WP), Bavistin (Carbendazim 50% WP), COC(Copper oxychloride 50% WP), Nacrobat (Dimethomorph 69% WG), Uthane (Mancozeb 50% WP), Krilaxyl (Metalaxyl 8 % + Mancozeb 64% WP), Benlate (Benomyl 50% WP) and Saaf (Carbendazim 12% Mancozeb 63% WP). These were tested at two different concentrations of 50 ppm and 100 ppm of their active ingredients.

COMPATIBILITY TEST OF CHEMICAL FUNGICIDES AND TRICHODERMA ISOLATES

Chemical fungicides were mixed in sterilized PDA before pouring onto 8 cm plates. Five mm circular discs of 7 days old culture of *Trichoderma* were excised with sterile cork borer and placed at the centre of PDA plates under aseptic conditions. PDA plates without addition of chemical were treated as control. Each isolate of *Trichoderma* was tested in 3 replications of the test chemicals and control. The experiment was set in completely randomized design and plates were incubated at 26 ¤C. Colony diameter of *Trichoderma* in the treatments was measured every day for a week.

STATISTICAL ANALYSIS

M-Stat software was used for the statistical analysis of the data. The significance of differences between chemical treatments and the isolates used under study was tested at 1% level of significance.

RESULTS AND DISCUSSION

Four fungicides viz; Bavistin, Cryzole, Benlate and Saaf had complete inhibitory effect on all *Trichoderma*, irrespective of the isolates tested. Seven chemicals (Aver Green, Triazole, Sectin, Antracol, Blitox-50, Nacrobat, Uthane) were found to be compatible with all *Trichoderma* isolates (Figure 1a and 1b). These chemicals initially exhibited partial inhibition of the isolates as compared to control but eventually at the end of 7 days allowed for complete growth of the fungi. Sensitivity of the isolates TS and T22 was noted in the chemicals Aver up and Krilaxyl while the other *Trichoderma* isolates were compatible with these chemicals. Results (data of 3 and 7 days after *Trichoderma* inoculation) are presented in Table 1. Significant differences among the chemicals and between isolates in terms of colony growth could be seen from the study (Table 2 and Table 3).

Table 1. Colony diameter of *Trichoderma* isolates (cm) in different chemical fungicide treatment (50 ppm and 100ppm of active ingredients) at 3 and 7 days of inoculation

Chemical fungicides		Colony diameter (cm) of *Trichoderma* isolates									
		Ts		Th		T22		T69		Tv	
		3 days	7 days	3 days	7 days	3 days	7 days	3 days	7 days	3 days	7 days
Aver Up (Chlorothalonil 75% WP)	50 ppm	1.43	2.03	1.97	8.00	1.67	2.37	1.90	7.23	1.67	5.20
	100 ppm	1.20	1.87	1.73	8.00	1.43	2.20	1.67	6.57	1.63	4.23
Aver green (Mancozeb 64% + Cymoxanil 8% WP)	50 ppm	8.00	8.00	8.00	8.00	8.00	8.00	7.16	8.00	8.00	8.00
	100 ppm	6.37	8.00	7.37	8.00	6.30	7.70	4.70	8.00	7.57	8.00
Triazole(Tricyclazole 75% WP)	50 ppm	7.73	8.00	6.90	8.00	4.50	8.00	3.53	7.63	7.97	8.00
	100 ppm	4.80	8.00	2.77	5.23	8.00	8.00	3.10	6.30	5.30	8.00
Cryzole(Hexaconazole 5% SC)	50 ppm	0.50	0.50	0.50	1.27	0.50	0.50	0.50	0.50	0.50	0.50
	100 ppm	0.50	0.50	0.50	1.33	0.50	0.50	0.50	0.50	0.50	0.50
Sectin(Fenamidone 10%+ Mancozeb 50% WG)	50 ppm	6.10	8.00	7.60	8.00	6.70	8.00	5.20	8.00	6.90	8.00
	100 ppm	5.73	8.00	7.13	8.00	5.50	8.00	4.27	8.00	6.70	8.00
AntracolPropineb 70 % WP)	50 ppm	7.07	8.00	8.00	8.00	8.00	7.23	6.47	8.00	8.00	8.00
	100 ppm	6.97	8.00	8.00	8.00	8.00	8.00	5.70	8.00	7.93	8.00
Bavistin (Carbendazim 50% WP)	50 ppm	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	100 ppm	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
COC(copper oxychloride 50% WP)	50 ppm	6.90	8.00	6.07	8.00	7.07	8.00	5.43	8.00	6.50	8.00
	100 ppm	4.50	8.00	5.80	8.00	4.80	8.00	5.13	8.00	6.20	8.00

Nacrobat(Dimethomorph 69% WG)	50 ppm	7.30	8.00	7.07	8.00	7.20	8.00	7.23	8.00	6.85	8.00
	100 ppm	7.03	8.00	6.83	8.00	6.77	8.00	6.83	8.00	6.60	8.00
Uthane(Mancozeb 50% WP)	50 ppm	5.77	8.00	5.70	8.00	5.67	8.00	6.90	8.00	5.35	8.00
	100 ppm	5.30	8.00	5.37	8.00	5.27	8.00	6.53	8.00	5.15	7.70
Krilaxyl(Metalaxyl 8% + Mancozeb 64% WP)	50 ppm	2.90	6.60	5.20	7.80	2.80	6.37	6.30	8.00	6.20	7.90
	100 ppm	2.47	4.83	4.87	7.60	2.50	5.60	5.97	8.00	5.60	8.00
Benlate (Benomyl 50% WP)	50 ppm	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	100 ppm	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Saaf(Carbendazim 12% Mancozeb 63% WP)	50 ppm	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	100 ppm	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Control (PDA without chemical)		8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00

Table 2. Effect of different chemicals (50 ppm and 100 ppm concentration) on colony diameter of *Trichoderma* sp. at 3 days and 7 days after inoculation

Chemicals	Colony diameter of *Trichoderma* sp. (cm)			
	3 days 50 ppm	3 days 100 ppm	7 days 50 ppm	7 days 100 ppm
Aver Up (Chlorothalonil 75% WP)	1.71G	4.65C	1.54G	4.24D
Aver green (Mancozeb 64% + Cymoxanil 8% WP)	7.84AB	8.00A	6.40C	8.00A
Triazole(Tricyclazole 75% WP)	6.66D	7.95 A	4.04F	7.08B
Cryzole(Hexaconazole 5% SC)	0.50H	0.62D	0.50H	0.64E
Sectin(Fenamidone 10%+ Mancozeb 50% WG)	6.45D	8.00A	5.81D	8.00A
AntracolPropineb 70% WP)	7.51BC	8.00A	7.13B	8.00A
Bavistin (Carbendazim 50% WP)	0.50H	0.50E	0.50H	0.50F
COC(copper oxychloride 50% WP)	6.40D	8.00A	5.24E	8.00A
Nacrobat(Dimethomorph 69% WG)	7.51BC	8.00A	6.81B	8.00A
Uthane(Mancozeb 50% WP)	5.90E	8.00A	5.52DE	7.95A

Krilaxyl(Metalaxyl 8% + Mancozeb 64% WP)	4.54F	7.34B	4.12F	6.71C
Benlate (Benomyl 50% WP)	0.50H	0.50E	0.50H	0.50F
Saaf(Carbendazim 12% Mancozeb 63% WP)	0.50H	0.50E	0.50H	0.50F
Control (PDA without chemical)	7.95A	8.00A	8.00A	8.00A
Grand mean	3.82	4.71	3.40	4.60
Lsd	0.00	0.00	0.00	0.00
CV	3.14	2.08	2.93	2.40
P Value	***	***	***	***

Data are mean of three replicates. Figures followed by different letters along the column are significantly different ($p<0.001$)

Table 3. Variation in colony diameter of *Trichoderma* isolates in response to chemicals (50 ppm and 100 ppm concentration) at 3 days and 7 days after inoculation

Trichoderma isolates	Colony diameter of different *Trichoderma* isolates (cm)			
	3 days 50 ppm	3 days 100 ppm	7 days 50 ppm	7 days 100 ppm
Ts (*T. asperellum*)	3.72BC	4.41C	3.24B	4.28C
Th (*T. harzianum*)	3.96A	5.06A	3.57A	4.88A
T22 (Unidentified species)	3.84AB	4.45C	3.24B	4.37C
T69 (*T. harzianum*)	3.61C	4.88B	3.24B	4.75AB
Tk (*T. koningii*)	4.00A	4.75B	3.72A	4.67B
Grand mean	3.82	4.71	3.40	4.60
Lsd	0.00	0.00	0.00	0.00
CV	3.14	2.08	2.93	2.40
P value	***	***	***	***

Data are mean of three replicates. Figures followed by different letters along the column are significantly different ($p<0.001$)

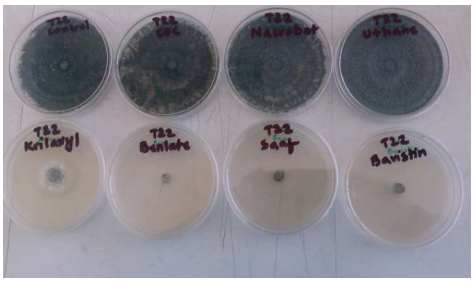

Figure 1a. Growth of *Trichoderma* isolate T22 in different chemical treated plates

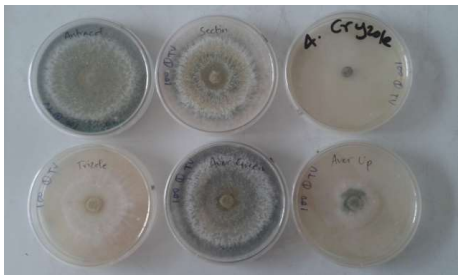

Figure 1b. Growth of *Trichoderma* isolate Tv in different chemical treated plates

Carbendazim, Benomyl, Hexaconazole even when tested at very low concentrations (<100 ppm) have been found to be inhibitory to *Trichoderma* growth by several authors (Sirohi et al., 2009; Bagwan, 2010; Madhusudhan et

al., 2010; Ranganathswamy et al., 2012; Kumar and Mane, 2017). Sushir et al. (2015) also found Benomyl as most toxic against *T. harzianum*. The fungicides seen as completely inhibitory in our study had the same chemicals as active ingredients. Variability of different *Trichoderma* strains in their response to chemicals has previously been explained by several authors (Chaparro et al., 2011; Silva et al., 2018). Hence it is of great significance to test the compatibility of bioagents and chemicals to be used in integration. There are also *Trichoderma* tolerant strains that can survive field concentrations of chemical fungicides and insecticides (Chaparro et al., 2011; Tang et al., 2009). Reports of mutant *Trichoderma* strains are also available, which are even resistant to strong chemicals, like benzimidazole (Mukherje et al.,1999; Mutawila et al., 2015).

The compatible chemicals seen in this study have also been reported as safer chemicals by previous authors (Bagwan, 2010; Gaur and Sharma, 2010; Madhusudhan et al., 2010). But Ranganathswamy et al. (2012)found Tricyclazole and Chlorothalonil as inhibitory to *T. harzianum* and *T. virens*contrary to our result. Sirohi et al. (2009) also found that chemicals copper oxycholride and metalaxyl at lower concentrations upto 100 ppm were compatible with *Trichoderma* but the same chemicals at higher concentrations exhibited inhibition of the bioagent. The chemicals at concentrations of 50ppm and 100 ppm were only evaluated in our experiment and hence it may be needed to test the chemicals at higher concentrations as well. Colony diameter of *Trichoderma* sp. was also seen to increase after 7 days of inoculation as compared to 3 days for most of the chemicals and the same pattern of increasing compatibility with time was reported by Khirallah et al. (2016).

The combined effect of *Trichoderma* along with chemicals has also been tested *in vivo* by several authors. Venkateswarlu et al. (2008) found that seed treatment with T. *virens* @ 4g and mancozeb @ 2g/kg seed was able to reduce the wilt incidence in tomato (caused by *F. oxysporum*f. sp. *lycopersici*) to greater extent than using the treatments alone. Similarly, Pandey and Upadhyay (1999) in their study found that seed treatment with *T. viride* and thiram gave maximum disease control of 81% in pigeonpea while combined use of *T. harzianum* and thiram provided 68% wilt control in pigeonpea. Sharma et al. (2003) reported the combined use of *Trichoderma* spp. and thiram as the most effective treatment in reducing linseed wilt caused by *F. oxysporum*f. sp. *lini*.

Trichoderma provides long term protection against pathogens and chemicals provide short term control. However, *Trichoderma* may take time to establish in newer ecological niches and colonise the roots to provide protection. Chemicals on the other hand act in shorter time (Mutawila et al., 2015) but

the disadvantages of excessive use of chemical pesticides is not new to anyone's knowledge. Hence combining *Trichoderma* and safer chemicals can be an effective tool for the management of diseases, where chemicals are needed in lesser doses and the threat of resistance development in pathogens can be minimized (Bhatnagar and Kumari, 2013). The compatibility of *Trichoderma* with the afore mentioned chemicals opens up probability for the integrated use of *Trichoderma* and chemicals for plant disease control so as to reduce chemical pesticide over exploitation in commercial farming.

CONCLUSION

The present finding shows that some chemical fungicides inhibit growth of *Trichoderma* spp. and some are compatible with *Trichoderma*. The chemicals compatible with *Trichoderma* spp. can be selected to be used in combination for the integrated disease management of agricultural crops. Variation among the *Trichoderma* isolates with regard to their response to chemicals is also possible and hence it is better to test the compatibility of individual *Trichoderma* spp. to be used in integration rather than generalize the effect of chemicals on *Trichoderma* growth. The combined use of bioagent and chemical can provide immediate control over pathogens and for a longer period of time. Field trials with combination of the *Trichoderma* spp. and compatible chemicals found in this study needs to be carried out to find out the effect on disease control.

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ECOLOGICAL LITERACY AMONG TECHNICAL AND NON-TECHICAL STUDENTS OF NEPAL

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ABSTRACT

Ecological literacy creates foundation towards betterment of environment and reducing negative externalities of human activity. A study was done to evaluate the level of ecological literacy among students pursuing technical and non-technical education in Nepal. Structured questionnaire was designed, pilot tested and administered to different students all over Nepal through Google form. Altogether 375 responses were obtained. Gender, type of education and ethnicity significantly affected ecological literacy. Female students, technical students and elite groups' students were 2.4%, 4.92% and 2.19% more ecologically literate than male students, non-technical students and marginalized group students respectively. Technical students have basic level and non-technical students have low level of ecological literacy. Though these groups of students are acquiring information from various courses they are studying, they were unable to relate what they learnt in class with their surroundings. Urgent and effective amendments and action is needed in developing sound scientific information about ecosystem, skills for critical thinking, positive attitude, creative and strategic problem solving to increase the rational action among the students to sustain the environment.

Keywords: Ecological literacy, environment, attitude, critical thinking

INTRODUCTION

A person's ecological understanding, thinking, habits and general knowledge about environment is termed as ecological literacy. Paul Risser used the term "ecological literacy" for the first time in 1986 while addressing the Ecological Society of America (Risser, 1986). Ecological literacy has been defined as "the ability to use ecological understanding, thinking and habits of mind for living in, enjoying, and/or studying the environment" (Berkowitz et al., 2005) and as focusing on the "key ecological knowledge necessary for informed decision-

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making, acquired through scientific inquiry and systems thinking" (McBride et al., 2013). (Meena & Alison, 2009) referred student's understanding about ecological concept as well as his/her place in the ecosystem as ecological literacy. Various factors impact personal environmental knowledge, attitudes, uses and concern. The widespread public awareness of and concern about environmental issues at that time is often attributed to the work of the distinguished naturalist and nature writer, Rachel Carson (Rothman, 1988).

Students are future of tomorrow. The way we shape them today will help them will affect the sustainability of future. For this, the entry point is to make them ecologically literate. It will change their dimension of attitude, behavior and concern as well as basic knowledge on ecosystem. However, there is limitation of such study in context of Nepal. In this regard, the present study was done to record the perception of students about general environmental issues as well to assess the level of ecological literacy among technical and non-technical students of Nepal and factors affecting it.

THEORETICAL FRAMEWORK

The vision for assessing ecological literacy in this study was crafted by overcoming the challenges of balancing brevity with comprehensiveness. An inclusive and adaptive analytical approach was needed to examine the perspectives of students was essential. Frameworks for ecological literacy generally prioritize that the knowledge about the environment is necessary for informed decision-making and they also emphasize systems thinking as they involve the identification of various biophysical and social components in the contextual environment. In this regard, the theoretical framework for the study was adapted and synthesized from numerous alternate frameworks previously used for ecological literacy as shown in table 1 as because , a widely accepted framework was not found which was also supported by (Knapp and D'Avanzo, 2010) and (Jordan et al., 2009).

In the study done by (Cherrett, 1989), ecological literacy was assesesed by top twenty ecological concepts in rank order viz; 1) the ecosystem, 2) succession, 3) energy flow, 4) conservation of resources, 5) competition, 6) niche, 7) materials cycling, 8) the community; 9) life history strategies, 10) ecosystem fragility, 11) food webs, 12) ecological adaptation, 13) environmental heterogeneity, 14) species diversity, 15) density dependent regulation, 16) limiting factors, 17) carrying capacity, 18) maximum sustainable yield, 19) population cycles, 20) predator-prey interactions.

(Klwmow, 1991) used eleven basic concepts for assesing ecological literacy which included the nature of ecological science, nature of ecological science, influences of physical and biological factors on organisms, species distribution, populations, communities, organism interactions, ecosystem

concept, energy flow through ecosystems, nutrient cycling in ecosystems, constant change in ecosystems and human impacts on ecosystems.

(Berkowitz et al.,2005) gave three overlapping components of ecological literacy; knowledge of key ecological systems, ecological thinking toolkit and understanding of the nature of ecological science and its interface with society. Similarly, (Jordan et al., 2009) formulated the three overlapping components of ecological literacy; ecological connectivity and key concepts of ecosystem, ecological scientific habits of mind for modeling and dealing with environmental uncertainty and lastly, links between human actions and their subsequent effects on ecosystems. The present study has used the framework stated above with some modifications. The modifications were with respect to attitude of concerns, behavior and actions, view towards sustainability of campus and general knowledge about environment and important issues in Nepalese context.

Based on the theoretical framework, concept of work was put forth for assessment of ecological literacy. The concept for analysis was based on the fact mentioned here under; an ecologically literate individual understands environmental realities by specifically identifying their cause and effect relationships. As such, the ecologically literate individual has a clear perception and understanding of an ecosystem dynamic, as well as its past and future outcomes. He or she understands the complexity of studied objects and phenomena, allowing for more enlightened decision-making and is also up to date about various issues taking place.

METHODOLOGY

After rigorous setting of appropriate questions structured survey method was followed. The survey questions were in part drawn from survey studies conducted in the past (Davidson, 2010; Morrone, et al., 2001; Bruyere, 2008) and were in part crafted by the principal author. The first section in the questionnaire included the basic and socioeconomic information about the respondents whereas, the second section reflected attitude of concern which included 16 statements each with five point Likert scale as suggested by Awadia and Esa (2013) showing various degrees of agreement to gauge the student's level of care about environmental issues. The statements used are given in appendix 1. The third section included five statements reflecting behavior and action of students towards certain environmental issues to judge student's practical competency. The fourth section was loaded with six statements to record their view for improving the sustainability in their campus whereas the last section was designed to access the general knowledge of students about various ongoing environmental issues. After the questions were devised, they were pilot tested for checking the length of

questions and clarity of statements. These questions were then loaded in Google form after subsequent corrections. The questionnaire was sent to students through Facebook and Google group. Snowballing was done so as to reach much of targeted group. 375 responses were obtained, out of which, 152 were non-technical and 223 were technical students. The responses thus obtained which were then coded and subsequently analyzed in Statistical Package of Social Science (SPSS) version 25.

Both descriptive and inferential analysis was done. Chi square test was done to test the level of significance for perception on ecological literacy, responsibility towards environment and activities to reduce the impact on environment with respect to gender, type of education and level of education.Independent sample t test was done to triangulate the score with gender, type of education and type of college. Moreover, ordinary linear regression was done to assess the role of gender, type of education, level of education, ethnicity and type of institution on ecological literacy percentage. The percentage grading was created as shown in appendix 2 by assigning percentage to each response in each heading. For general knowledge section the correct answer obtained full marks whereas wrong was assigned 0 marks. The grading scheme required at least 60% to be ecologically literate. This rating scale is based on the rating given by (Mcginn, 2014). From 60 percent to 100 percent the levels were broken up into 10 percent ranges just like a standard grading rubric as shown in Table 1. The reason of choosing this method was because of easiness in easy understanding not by only academia but also other personals.

Table 1: Standard grading rubric for ecological literacy

Percentage	Grade	Level of ecological literacy
60-70%	D	Low
70-80%	C	Basic
80-90%	B	Standard
90-100%	A	High

RESULTS AND DISCUSSION

GENERAL INFORMATION

Out of 370 respondents, 60.8% were male and 39.2% were female. Majority of the participants (71.2%) were pursuing bachelor's level of education, followed by intermediate (14.7%) and masters or above (14.1%). Moreover, 59.5% were from technical education, mostly agriculture. The detail is shown in table 1 below:

Table 2: Gender, education level and type of education of respondents

Variables	Percentage
Gender	
Male	60.8
Female	39.20
Education	
Intermediate	14.7
Bachelors	71.2
Masters and above	14.1
Type of education	
Technical	59.5
Non-technical	40.5

PERCEPTION ON ENVIRONMENTAL ISSUE AND SPECIES EXTINCTION

33.2% respondents perceived pollution as the most important environmental issue in their locality followed by deforestation (31.2%). Moreover, habitat loss was perceived to be the major cause of species extinction in the natural habitat followed by climate change, over harvesting and predation as shown in the table 3. (Sodhi et al., 2009) stated that habitat loss causes extinctions directly by removing all individuals and indirectly by facilitating the establishment of an invasive species or disease agent, improving access to human hunters, or altering biophysical conditions. They also suggested that the deforestation is currently, and is projected to continue to be, the prime direct and indirect cause of reported extirpations.

Table 3: Perception on Important environmental issues (left) and causes of species extinction (right)

Important environment issues		Causes of species extinction	
Particulars	Percentage	Reasons	Percentage
Climate change	11.5	Habitat loss	55.1
Pollution	33.3	Over harvesting	10
Over harvesting	11.4	Climate change	21.2
Deforestation	31.2	Predation	13.7
Others	12.6		

PERCEPTION ON THE LEVEL OF ECOLOGICAL LITERACY

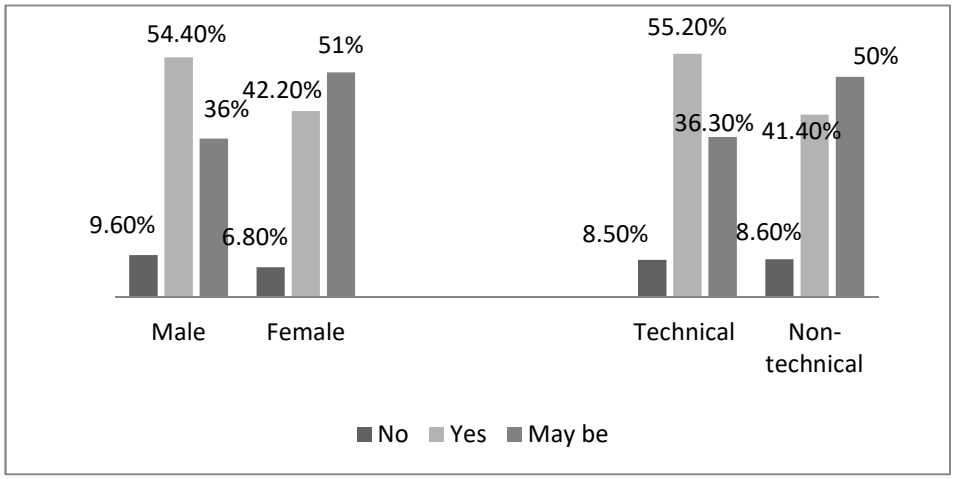

Figure 1: Ecological literacy with respect to gender (left) and type of education (right)

Significant difference was observed in the percieved level of ecological literacy with respect to gender (X^2=8.37, P<0.05) and type of education (X^2=6.66, P<0.05). 54.4% of male and 42.2% female said that they were ecologically literate. Similarly, 55.2% of technical students and 41.4% % of non-technical students said to be literate ecologically. The detail is shown in the Figure 1.

PERCEPTION ON RESPONSIBILITY

Technical students were found to be significantly more self-responsible than non-technical students in reducing waste generation in the environment (X^2=8.01, P<0.05), whereas no significant difference was noted with respect to education in this regard. Detail is shown in Figure 2.

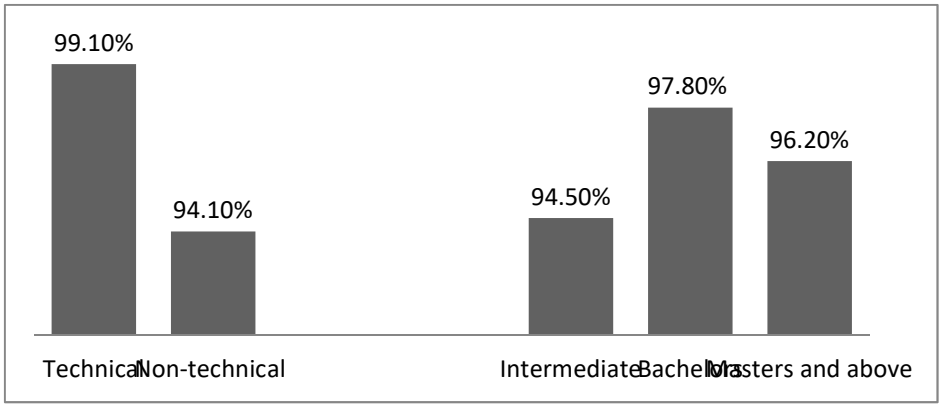

Figure 2: Responsibility to reduce waste with respect to type of education (left) and level of education (right)

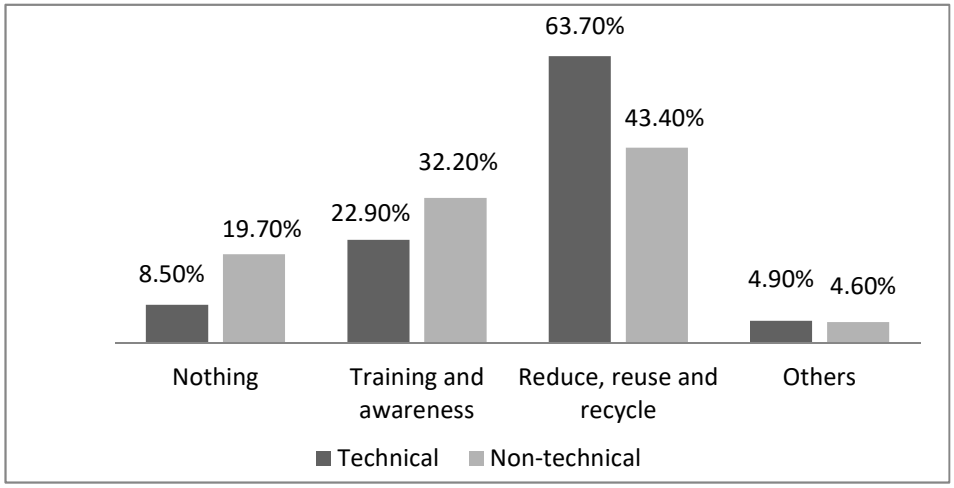

Figure 3: Activities doing by respondents to reduce the impact on environment

8.5% of technical students and 19.7% of non-technical students are not doing anything to reduce the impact on environment. Detail is shown in Figure 3. Both of these groups are focusing on reduce, reuse and recycle. Non-technical students are focusing more on training and awareness as compared to technical students because they are less acquainted with the impact of human activities on environment and the ways to reduce the impact. The finding is statistically significant (X^2 =18.38, P<0.001).

Moreover, when reasons of not doing any such activities, it was found that non-technical students focused on lack of idea and knowledge whereas technical students stressed on some other unseen factors Also, intermediate students had least idea or knowledge in this regard. Detail is shown in Figure 4.

Table 4: Reasons of not doing environment conservation and awareness activities with respect to type of education and level of education

	Type of education (%)		Level of education (%)		
	Technical	non-technical	Intermediate	bachelors	masters and above
It's not my duty	1.40	13.30	6.10	5.80	22.20
lack of idea and knowledge	23.60	42.20	48.50	29.80	27.80
I am not capable	11.10	16.90	12.10	12.50	27.80
others	63.90	27.70	33.30	51.90	22.20
Chi square value	23.20***		15.19*		

Note: *=P<0.05 & ***=P<0.001

FACTORS AFFECTING ECOLOGICAL LITERACY

Female were 2.4% more ecologically literate than male students. Moreover, non-technical students of Nepal are 4.92% less ecologically literate than technical students. The percentage obtained was not significantly different with respect to the level of education. Moreover, elite groups were 2.19 %more ecologically literate than marginal groups, probably due to more access to technical education. The model was also statistically significant. Detail is shown in the Table 5. (Tikka et al., 2000) found the significant variation in students' environmental knowledge, attitudes and activity levels respect to gender and education level.

Table 5: Simple linear regression estimates predicting the level of ecological literacy by characteristics of students (n= 375)

Independent variables	Regression coefficient
Gender (1=female)	2.40**
Education type (1=nontechnical)	-4.92***
Education level (1=intermediate)	2.26ns
Ethnicity (1=elite)	2.19*
Type of institution (1=governmental)	1.57ns
Intercept	68.12***
Model F	9.82***
Regression degree of freedom	5
Residual degree of freedom	365
Adjusted R square	0.107

Note: *=P<0.05, **=P<0.01, ***=P<0.001, ns=not significant (P>0.05)

LEVEL OF ECOLOGICAL LITERACY

The score obtained by female is significantly higher than male in terms of behavior, work towards campus sustainability and overall ecological literacy. Similarly, the type of education significantly affects their activities, attitude, behavior, work toward campus sustainability, general knowledge about environment and overall ecological literacy (Table 6). The score of students from private college was significantly higher than public college in terms of behavior and work towards campus sustainability. The detail about the level of scores in individual areas and overall ecological literacy is shown in Table 6.

Table 6: Independent sample t test showing the score obtained on different aspects of ecological literacy with respect to gender, education type and type of college

	Activities	Attitude	Behavior	Campus sustainability	GK	Total
Gender	Ns	Ns	**	*	Ns	*
Male	91.37	77.02	73.15	80.55	42.12	67.5
	±1.115	±0.89	±1.20	±1.23	±1.42	±0.60
Female	93.45	78.42	78.15	84.09	43.48	69.42
	±1.295	±1.19		±1.31	±2.04	±0.75
Education type	***	*	Ns	*	***	***
Technical	96.04	78.96	76.02	83.67	45.88	70.40
	±0.71	±0.76	±1.20	±1.20	±1.33	±0.48
Non-technical	86.5	75.5	73.76	79.38	37.88	65.08
	±1.71	±1.34	±1.50	±1.38	±2.09	±0.87
Type of college	Ns	Ns	*	*	Ns	NS
Governmental	92.60	77.61	73.62	80.64	41.41	67.88
	±1.07	±0.89	±1.18	±1.24	±1.36	±0.61
Private	91.41	77.5	77.83	84.3	44.92	68.91
	±1.37	±1.20	±1.51	±1.19	±2.20	±0.75

Note: *=P<0.05, **=P<0.01, ***=P<0.001, ns=not significant (P>0.05)

Based on the score secured by the participated students their level of ecological literacy was calculated based on criteria given by Mcginn (2014). Both male and female students have basic literacy with respect to attitude, behavior and work towards campus sustainability. They were however considered as illiterate with respect to their scores obtained in general information about environment and its allied problems. Technical students have only basic level of ecological literacy. Moreover, the level of ecological literacy of students both from government and private college is low. Detail is shown in the Table 7.

Table 7: Level of ecological literacy among students with respect to gender, education type and type of college

	Attitude	Behavior	Campus sustainability	GK	Total
Gender					
Male	Basic	Basic	Basic	Illiterate	Low
Female	Basic	Basic	Basic	Illiterate	Low
Education type					
Technical	Basic	Basic	Standard	Illiterate	Basic
Non-technical	Basic	Basic	Basic	Illiterate	Low
Type of college					
Governmental	Basic	Basic	Standard	Illiterate	Low
Nongovernmental	Basic	Basic	Standard	Illiterate	Low

Note: Illiterate<low<Basic<Standard<high (As given by rating of McGinn, 2014)

This supports the study of (Goldman et al., 2006) and (Negev et al., 2008) which was carried out at Israeli academic institutions. Several other studies have found that women show more positive attitude towards environment Previous studies have found that women and girls show more positive attitudes towards the environment than men (Yavetz, and Pe'er 2006; Engels and Jacobson 2007). However, all the sections seemto possess poor general knowledge with respect to environment. An ecologically literate person must have positive attitude, reflect it in behavior, thinks about campus sustainability and have sound general information about environment. The result is shocking in the sense that though the students have been getting acquainted with environmental education since their primary level but are unable to reflect it in their responses.The results suggested that the institutions have failed to attract students with a higher level of ecological literacy and highlighted the need of significant task to be done in this regard. This baseline data shows that there is significant work to be done to increase ecological literacy both for technical and non-technical students. This is a barrier to sustainability work in communities, across states, and at the federal level because if people do not know, care, or take sustainable actions, then issues such as climate change are more difficult to adequately address. (Orr, 2004) states that it is unacceptable that the students leave college without a strong concept of each aspect of ecological literacy.

CONCLUSION

The concept of ecological literacy is of great significance in today's world where numerous environmental hazards are kicking its way due to anthropogenic activities. However, the findings revealed that even technical students have only basic level of ecological literacy whereas non-technical students' ecological literacy is too poor. They were unable to relate what they learnt in class with their surroundings. There was difference in the student's attitude, behavior and knowhow of general issues which signified that there was limitation in scientific understanding and awareness the students are getting in the colleges. Gender and technical seem to have more effect on ecological literacy. Until and unless, the gapwith respect to attitude, behavior, action and general knowledge between technical vs non-technical, male vs female or governmental vs private college is reduced, the sustainability will only reflect in words.

In the wake of climate change and other growing environmental concern, students are not been able to reflect the actions with the knowledge they are gaining. In this context, an ecologically literate person will make wise decisions and take perfect actions to solve environmental issues which is an essential skill given the environmental issues facing the world today. Practical oriented and student friendly efforts are needed in enhancing the ecological literacy of students. Efforts to increase ecological literacy should be done because it incorporates not only a person's knowledge, but also their caring and the actions they take. The curriculum should be updated

accordingly giving more emphasis to citizen science and environmental ethics in orderto increase the rational action among the students to sustain the environment, Amendments and actions are to be utmost identified and implemented to develop base of scientific information about ecosystem as well as skills for critical thinking, positive attitude, creative and strategic problem solving and prompt decision making. The study is to be replicated to wider section of society and to identify effective interventions for increasing the ecological literacy of students and other individuals of society. In addition to it, the government should focus on the ecological literacy of policy makers and decision makers because it will enable them to think about the environmental consequences of their decisions as well as for developing the aspects of ecological literacy as a culture and also for reflecting it in our education system.

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TRADITIONAL CROPS FOR HOUSEHOLD FOOD SECURITY AND FACTORS ASSOCIATED WITH ON-FARM DIVERSITY IN THE MOUNTAINS OF NEPAL

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ABSTRACT

Traditional crops play an important role in household food security and livelihood needs of mountain communities, while at the same time safeguarding crop biodiversity for future generations. This study aims to analyse socioeconomic, farm-specificagro-ecological and market factors influencing cultivation and maintenance of crop diversity in Nepal. It used sample surveys of 328 households from mountains of Humla, Jumla, Lamjung and Dolakha districts in 2015. The sample survey was supplemented with participatory rural appraisals, field monitoring visits and local stakeholder consultations. Tobit regression model was used to assess factors driving household decisions to allocate area for production and maintenance ofon-farm diversity. Farm maintenance of crop diversity was related to household food sufficiency level of traditional crops. Factors influencing on-farm crop diversity and household food security varied with the crops, and mainly related with farmers' age, family size, farm size, agro-ecosystemand market factor. Future research and development interventions need to focus on diversity rich solutions and technologies tailored to specific crops, socioeconomic, market and farm-agroecology of the households enhancing household food security and management of mountain crop biodiversity.

Keywords: Crop biodiversity, food security, traditional crops, mountain agroecosystem

INTRODUCTION

The high mountain region of Nepal harbours globally important crop biodiversity of traditional crops such as buckwheat, naked barley, and different species of millet (finger, proso and foxtail), amaranth, bean and highland rice that have unique traits of cold and drought tolerance adapted to harsh risk prone marginal environments (UNEP GEF, 2013). These crops are cultivated over millennia by farmers and hence have helped to meet food security of marginalized communities even in the face of changing climate (Gauchan and Khanal, 2011; UNEP GEF, 2013). The intra-specific diversity of these crops is very high as most of these crops are either evolved or located

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at the center of diversity in Nepal Himalayas. Cold-tolerant rice is grown in Nepal (e.g. Chhumchaur, Jumla) at altitude 3030 masl, the highest in the world, with its very high cold tolerance ability. Buckwheat and naked barley are also grown at high altitudes near the snow line providing food and livelihood security to marginalized people living in harsh mountainous environments, where poverty incidence is the highest in Nepal (CBS, 2012; NPC, 2016). These traditional underutilized crops are intensively used by local mountain communities in many of the remote hills and mountainous regions, and contribute considerably to their site-specific food security, nutrition and adaptation (Joshi and Shrestha, 2018). They are nutrient dense and climate resilient crops, and provide food, fodder, nutrition, livelihood and ecologicalsecurities to smallholder farmers with potential for value chain development and income generation (Gauchanet al., 2019). Many of these crops (amaranth, finger millet, proso millet and foxtail millet) are gluten free; rich in micronutrients (calcium, iron), dietary fibers, rare amino acids, antioxidants and vitamins, and contain higher protein as compared to major food staples such as rice and wheat (DFTQC, 2012). Hence, they are considered Himalayan Superfoods[1] and also crops for the future. Furthermore, most of these crops (amaranth, finger millet, proso millet and foxtail millet) are C4 crops, thus resilient and fit on climate change adaptation as they are hardy and can be grown in harsh marginal lands with low inputs and water (Gauchanet al., 2019). These crops tolerate biotic and abiotic stresses; for example, escape drought and cold temperatureand ensure food availability in shorter period in lean seasons due to their short duration (e.g. buckwheat grown in 2-3 months) of production period. Considering their great value for nutrition, climate resilience and risk diversification, these traditional crops are considered “future smart foods” in the changing climate for site-specific food supply and adaptation (Li and Siddique, 2018; Joshi et al., 2019).

Even though the traditional mountain crops are considered minor crops at the national level, they happen to be the principal crops of high Mountain Himalayan districts of western and mid-western regions of Nepal and play important role in food and nutritional security of poor farmers and marginalized communities. For instance, present official statistics of Nepal (MoAD, 2016) show that millet is number one important crop in Humla and Mugu districts, while barley and millet are second important crops in Jumla. Buckwheat is number one crop in Mustang and Manang and second most important one in Dolpa district (MoAD, 2016).Therefore, despite the minor crops shared small proportion (6%) of area nationally (CBS, 2013), they are important for food security of farmers in high elevation areas of mid and

[1]www.himalayancrops.org

higher mountain regions of Nepal. However, very little research, development and investment have been done globally and nationally focusing on these crops from the perspective of breeding, processing, promotion and policies. Therefore, cropped area and varietal diversity of these crops are declining rapidly recently with climate change, migration, cultural change and commercialization. Previous studies in rice in middle mountainsof Nepal have shown various socioeconomic, market and agro- ecological determinants of farm maintenance of rice diversity (Gauchan et al., 2005). However, we have limited information about the factors influencing on-farm maintenance and management of the traditional crop diversities and their role in local and national food and nutrition security.

The main objectives of this study were (i) to document the status of traditional crop biodiversities and their relations with household food security and (ii) to analyse farm-household agro-ecological, socioeconomic and institutional factors influencing the crops' cultivationand diversity maintenance for food security and agrobiodiversity conservation in the mountains.

METHODOLOGY

The study used sample household survey combined with participatory rural appraisals and field trials to generate information on mountain agro-ecosystems of Jumla, Humla (western Nepal), Lamjung (central Nepal) and Dolakha (eastern Nepal) districts. A total of 328 farm households were surveyed in 2014-15 covering one village development committee (VDC) in each of the districts. The survey using proportionate random sampling covered 72 to 90 farm households from Chhippra, Hanku, Ghanpokhara and Jugu VDCs respectively in Humla, Jumla, Lamjung and Dolakha districts. The survey was supplemented with focus group discussions, field monitoring visits and consultation meetings with local communities and other stakeholders. The study focused on collection of farm household information regarding agricultural systems that mainly included household food sufficiency, and production, agronomy and market related features and diversity of traditional mountain crops. Data compilation, analysis and reporting were focused on important traditional crops grown by large number of farmers in the study sites. Food security is assessed from both secondary time series and survey data collected on household production and sufficiency level. Both qualitative and quantitative data were analyzed primarily with the use of descriptive statistics, such as mean, frequency and standard error of mean. Relationships among variables are tested using correlation analysis. Regression model (e.g. Tobit) is used to identify factors influencing farm choices and decisions maintaining intra-specific diversity of economically important traditional crops mainly cold tolerant rice, finger millet and bean. The data were analyzed using Microsoft Excel, Statistical Package for the Social Sciences (SPSS) 16 for descriptive analysis and STATA (10.0) for econometric analysis.

ANALYTICAL MODEL

There are various regression tools and techniques to analyse factors influencing farm maintenance of crop varieties. The Tobit (censored regression) model is used here to study the household specific socioeconomic and institutional factors influencing on-farm maintenance of traditional crop diversity as the data sets for on-farm diversity indicator (proportion of area allocation to specific crops) are continuous and censored at zero. Censored Tobit model is suitable when data are continuous and censored at zero (Maddala, 1983). Moreover, Tobit regression model is suitable here as it measures the extent of crop area allocation by specific households as a measure of on-farm diversity. It uses all observations, both growers and non-growers, that are at the limit, usually zero (e.g. non growers), and those above the limit (e.g. growers) to estimate a regression line (McDonald and Moffitt, 1980; Gauchanet al., 2005). Proportion of area allocated to specific crop is used as dependent variable. The general formulation for Tobit specification is usually given in terms of index function (Greene, 2000),

$$D_i^* = \beta' X + \varepsilon_i$$
$$D_i = 0 \text{ if } D_i^* \leq 0,$$
$$D_i = D_i^* \text{ if } D_i^* > 0.$$

where, D_i^* is a censored variable of the dependent variable, which is expressed as the share of traditional crop area (cold tolerant rice, finger millet, beans) under different varieties depending on the type of analysis. β' is a vector of parameters to be estimated and X, is a vector of explanatory variables which includes household variables (age, gender, family size, farm size, female involved in agriculture, agriculture income, working outside), farm agro-ecological variables (mountain agroecosystems western vs eastern) and institutional variables (market distance, access to training and tenancy) and ε is the disturbance term.

RESULT AND DISCUSSION

HOUSEHOLD SOCIO-DEMOGRAPHY

The socio-demographic information of the sample households is presented in Table 1. Sample households are dominated by middle age farmers (44 years) with average family size of 6 persons and average farm size of 10 ropani (0.5 ha). This indicates predominance of smallholder farmers with smaller farm size as compared to national average of 0.68 ha. Over half of the sample households have nuclear families and about one-fifth of them are female decision makers. About 50% of the sample households fall under disadvantaged groups (Dalit and Janajati), which is the highest in the study site of Lamjung (96%).

Table 1: Household socio-demographic information in study sites in 2014-15 (n=328)

Socio-Demography	Humla (n=72)	Jumla (n=83)	Lamjung (n=83)	Dolakha (n=90)	All(n 328)
Age of the respondents (years)	37.9	39.5	51.9	47.0	44.0
Farm size (Ropani)*	4.4	8.00	18.2	10.4	10.4
Family size (No)	5.3	6.0	6.4	5.8	5.9
Nuclear households (%)	68	61	42	60	58
Female members in the households (%)	28	46	37	59	46
Female decision makers (%)	6	24	28	38	23
Disadvantaged groups (Dalit &Janjati) (%)	15	45	96	31	48

Note: One Ropani =500 sq meter

ON-FARM DIVERSITY OF TRADITIONAL CROPS

On-farm diversity of traditional mountain crops is measured in terms of (i) proportion of farm households cultivating these crops, (ii) farm area allocation to these crops and (iii) number of varieties (varietal richness) grown by farmers at the households and community levels in the mountain agro-ecosystems. These are briefly discussed focusing on high altitude cold tolerant rice, fingermillet and common bean in following outlines.

Proportion of households growing crops

Finger millet, cold tolerant rice and bean are grown by large proportion (>50%)of the households in mountain agro-ecosystems of Jumla (2300-2700 msl), Humla (2200-2900 msl), Lamjung (1500-1800 msl) and Dolakha (1700-2000 msl) (Figure 1). Proso millet, foxtail millet, amaranth, naked barley and buckwheat are not common to Lamjung and Dolakha, but they are grown by larger proportion of the households in Humla. In Jumla, foxtail millet, proso millet, buckwheat and amaranth are grown by smaller proportion of the households, but barley in larger area by many households.

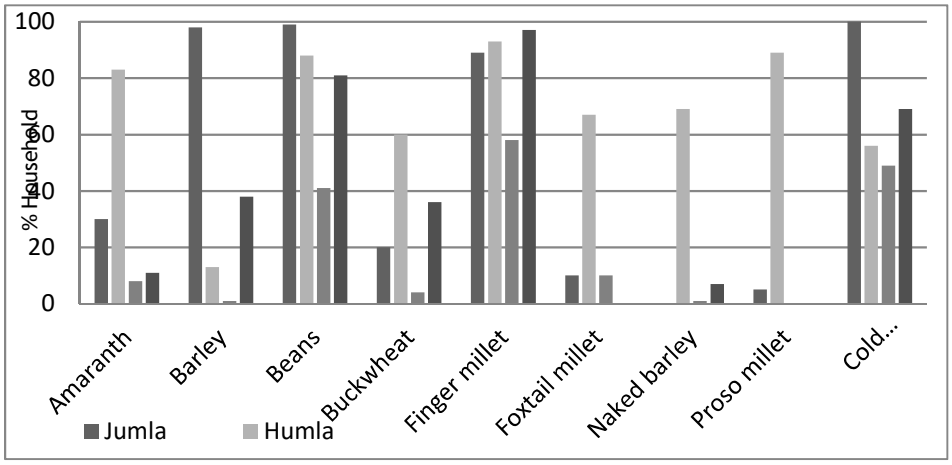

Figure 1: Percent households growing traditional mountain crops in study sites

Farm area allocation to traditional mountain crops

Since, farm households in mountain areas have small farm sizes (< 0.5 ha), they grow traditional crops in relatively smaller area. High altitude cold tolerant rice is grown in the largest area (33%) followed by finger millet (17%) in all the mountain study sites (Table 2).

Table 2: Average area allocations (Ropani) to different mountain crops in 2014-15

Crop	Jumla	Humla	Lamjung	Dolakha	Overall Average	Area share (%)*
Amaranth	0.027	0.12	-	-	0.06	0.57
Barley	2.20	0.39	-	1.1	0.80	7.70
Bean	1.88	0.48	0.38	0.026	0.35	3.4
Buckwheat	0.69	0.88	-	2.46	1.10	10.5
Finger millet	1.03	1.17	2.52	3.5	1.77	16.9
Foxtail millet	0.07	0.49	1.27	-	0.03	0.30
Naked barley	-	0.88	-	0.7	0.80	7.65
Proso millet	0.95	0.79	-	-	0.85	8.12
Rice	2.57	0.86	11.12	4.9	3.43	32.7
Farm size	8.06	4.29	18.22	10.44	10.46	100

Note: Area share includes percent share of specific crop area to total crop cultivated area by farmers*

The area share of different traditional crops to total cultivated farm area in the study sites ranges from less than 1% to 33% with the highest share for rice (33%) and the lowest share for foxtail millet (0.30%). Some of them are location specific such as proso millet, foxtail millet, buckwheat and amaranth in Humla and Jumla. Barley is grown mainly in Jumla and naked barley mainly in Humla. Buckwheat in Dolakha and foxtail millet in Lamjung are also grown in small area by few households.

Diversity of traditional crop varieties at community level

A high intra-specific diversity of traditional crops (rice, finger millet and bean) was found maintained at all four mountain agro-ecosystems. The varietal richness or number of varieties grown by farm households, an indicator of crop diversity, was found highest for rice in Dolakha, finger millet in Lamjung and bean in Dolakha and Jumla (Figure 2). Community level richness (number of crop varieties grown at the community level) is relatively high for rice, bean and finger millet. The level of varietal richness at the community level varied by specific crops in specific sites. For instance, the varietal richness (number of varieties) is relatively high for bean in Jumla and Dolakha, and finger and foxtail millet in Lamjung.

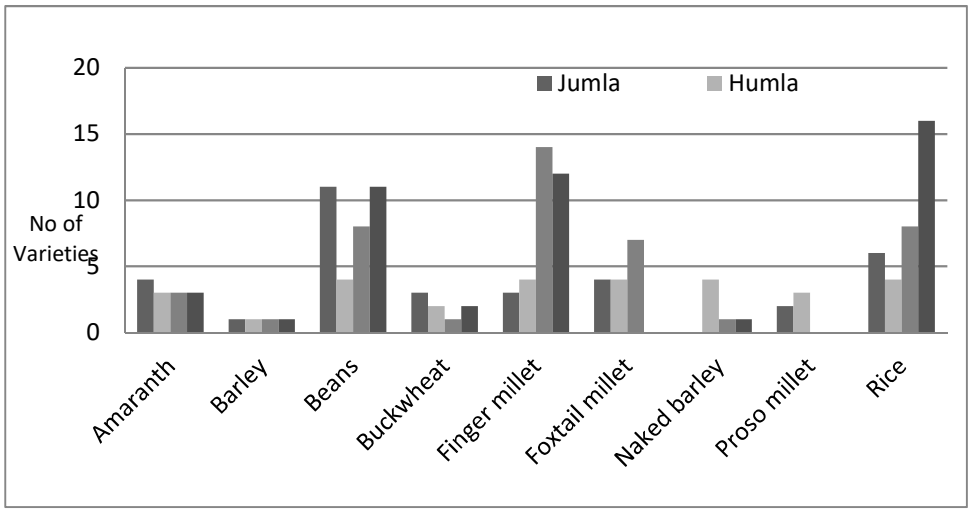

Figure 2. Crop varietal richness of traditional crops at community level

FOOD SECURITY STATUS

Food sufficiency in terms of cereals, pulses and vegetables production at farm level in aggregate was low and inadequate, which is not even adequate forabout six months (Figure 3). Farmers' annual production of food staples meet 7 months in Lamjung and Dolakha and only for 4-5 months in Humla and Jumla. The pulse sufficiency was relatively higher in Jumla for about 6 months, 5 months in Lamjung and only 4 months in Humla and Dolakha. The level of vegetable sufficiency was 5 months in Lamjung and Dolakha but less than 4 months in Humla and Jumla. The finding shows that study sites in far western high mountain (Jumla and Humla) have very low food sufficiency level, though this was also not adequate (not more than six months) in central mountain (Lamjung) and eastern mountain (Dolakha).

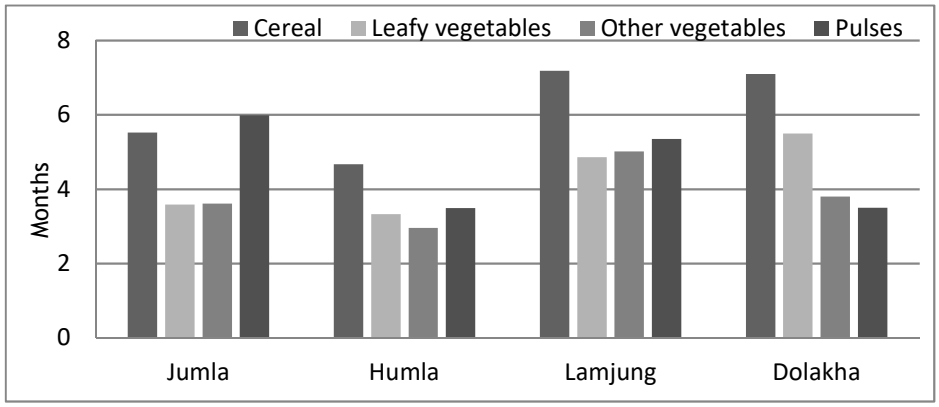

Figure 3: Status of household food and vegetable self-sufficiency (months) in study sites

Relationship between food security and crop diversity

Analysis on average period of food sufficiency (number of months) from farm production and its relationship with on-farm crop diversity (as measured by varietal richness or number of varieties grown by the households) is essential to get an idea about whether crop diversity had positive contribution on food security and livelihood of smallholder mountain farmers. The analysis was carried out for rice, finger millet and bean that are predominantly grown in all the high-altitude study sites (Table 3). Correlation analysis was carried out for key household socioeconomic variables with proportion of area allocated with traditional mountain crops and varietal richness. There is a positive and significant relationship between rice richness (rice varietal diversity of the households) and household food sufficiency in Humla, Jumla, Lamjung, and Dolakha and at the aggregate level. Similarly, there is positive relationship between finger millet richness and food sufficiency indicating finger millet is critical food staple in this high mountain district. Secondary data also indicate that finger millet is number one crop in term of its area coverage in Humla district (MoAD, 2016) contributing important role in food sufficiency. However, this relationship was not significant in bean in Humla, Jumla and Dolakha, probably due to production of this crop in small area in all the sites. The finding clearly indicates that on-farm diversity of high-altitude rice cultivars has positive role in food security of the households in all the mountain agro-ecosystems, while that of finger millet diversity has only in Humla contributing positive role in food security of the mountain households.

Table 3. Relationship between food security and on-farm traditional crop diversity

Crop Diversity	Jumla	Humla	Lamjung	Dolakha	All Sites
Rice richness	1.49 *	0.61**	0.572**	0.311**	0.4**
Finger millet richness	0.91ns	0.237*	-.017	0.161	0.066
Bean richness	1.78ns	0.85ns	-0.230*	0.029	-0.027

Note. ** Significance at P<0.01, and *significance at P<0.05 level.

Factors influencing on-farm crop diversity

Tobit (censored) regression model was carried out to analyse household specific socioeconomic, agroecological and institutional factors influencing on-farm diversity of rice, finger millet and bean. The results of the model for the selected crops with their significance level are presented in Table 4.

Table 4: Factors influencing on-farm diversity of selected traditional mountain crops

Socioeconomic groups	Rice Coefficient	Finger millet Coefficient	Bean Coefficient
Age (number of years)	0.0025**	0.003**	-0.003
Gender of decision makers (Female=1; Otherwise=2)	-0.0067	-0.007	-0.0153

Family size (Number)	0.026**	0.018**	0.0141**
Female involved in agriculture (Number)	0.066**	-0.0401	0.0121
Agri as main income source (Yes=1; Otherwise 0)	0.065*	-0.0431	0.0086
Farm size (Ropani)	0.013***	0.007**	-0.0002
Working outside (Yes=1; Otherwise= 2)	-0.056	0.003	-0.0673**
Mountain agro-ecosystem (Western=1; Otherwise=0)	-0.188***	-0.0215***	0.318***
Access to training (Yes=1; Otherwise=0)	0.0368	-0.0104	-0.0619
Tenancy (Share out/in =1 Otherwise= 2)	0.003	-0.007	-0.0159**
Market access (Distance to market, Km)	-0.0215***	0.004	-0.0174***
Constant	0.614	0.5800**	0.4652***
Number of observations	309	309	309
Likelihood ratio(LR chi2(11) and Prob (> Chi2)	99.70 ***	52.48***	199***

*Note ***, ** and * significant at p<0.01; 0.05 and 0.1 respectively.*

Dependent variable used in this analysis was proportion of area allocation to each crop. The independent variables were household specific socioeconomic, agro-ecological and institutional factors. The household socioeconomic factors included are age and gender of decision makers, female involved in agriculture, family type, family size, farm size, agriculture as main source of income and family members working outside. Mountain agro-ecosystem whether located in the eastern mountains (Lamjung and Dolakha) or western mountains (Jumla and Humla) was considered as a farm-specific agro-ecological factor. Institutional factors mainly include access to training, type of tenancy situation and market factors. The significant variables in explaining area allocation to rice include age of farmers, female members involved in agriculture, farm size, family size, market factors such as market distance in kilometer and agro-ecology (mountain agro-ecosystem). For finger millet, household specific factors such as family size, farm size, age and agro-ecological location were significant whilst market factor was not significant. For bean, family size, family members working outside village, tenancy, agro-ecological location, and market access are significant. Agro-ecological factors were significant in all the three crops due to important roles that agro-ecology (climatic and natural conditions) play in the study mountain locations. The factors such as access to training to production of these crops and gender of the decision makers did not have significant effect on the maintenance of on-farm diversity of all the important crops.

RESULT AND DISCUSSION

The findings showed that various socioeconomic status of the households such as farm size (proxy for wealth status), age (proxy for experience and knowledge), family size (proxy for farm labour availability), market distance (proxy for market access and demand) and agro-ecology (mountain locations and its environment) are the key factors that influence the farmers' decision and shapes the diversity of a crop. Age of the farmers and farm size are influencing factors for rice and finger millet but they are not important for bean. Age was found significantindiversified cultivation of rice and finger millet that requires specific knowledge on seedbed preparation, cultivation and crop management. Family size was important for all of these crops as these are labour intensive crops grown under traditional family farming system. Larger farm size provides spaces for growing different varieties of the crops in larger area resulting in more on-farm diversity of these crops. For bean, only family size was important but not the farm size and farmers' age as this crop is labor intensive for cultivation, threshing and handling where larger family size provides more labour sources for this. Since bean is grown in small area by all the farm households older or younger in similar proportion of the area, farm size and age were not important. Farmers' sources of agricultural income and female members working in agriculture are important factors for area allocation to rice but not for finger millet and bean, because rice tends to be preferred crop and area allocation to this crop increases with more income sources of the farmers. Female members in the households are important in rice production, post-harvest handling, processing and food preparation as their engagement and knowledge is higher in rice farming in Nepal.

Agroecological conditions and locations of mid-western mountain environments are positively driving allocation of area for bean but negatively on rice and finger millet production. This may be due to less suitability of lands for rice and finger millet cultivation under high altitude cold and harsh extreme environment of Karnali Mountains as compared to relatively mid altitude and better environment of central and eastern mountain agro-ecosystem such as Lamjung and Dolakha. In contrast, Karnali Mountain shows positive and significant effect on diversified cultivation of bean, because the crop is well adapted and suited to the high altitude environments, and Karnali high altitude bean fetches high demand in urban markets of Nepal. Market access (distance) factor was significant with negative sign for rice and bean but non-significant for finger millet. This indicates farm households located farther away from market are less likely to maintain rice and bean diversity, because recently rice and bean are cultivated nearby market are becoming more cash crops requiring inputs from markets and products to be sold in nearby market for generating cash income. Farmers working outside the

village seasonally for non-farm works showed negative effect for bean, but not for rice and finger millet. This is because family labour used in non-farm outside the village does not affect much for rice and finger millet cultivation prebaby because, they work seasonally outside during off-season and tend to come to village during peak cultivation and harvesting season of rice and fingermillet.Focus group discussion and field observations in the study sites also support this finding. However, for beans, this has some negative effect as its main planting and harvesting period contradicts with outside non-farm work and this crop is not much important for many of the farm households as compared to rice and finger millet.Tenancy situation (share cropping) variable is only significant for bean regression but with negative sign indicating that share croppers are less likely to maintain bean diversity than owner cultivators since bean is becoming more cash crops and owner cultivators tend to grow bean in their own area including in kitchen gardens than that of share cropping and those cultivators renting the land. For traditional mountain crops, factors such as access to training and gender of the decision makers in the households did not have significant effect on the maintenance of on-farm diversity, probably due to both men and women farmers' pre-existing good experiences and traditional knowledge on cultivation of these crops.

CONCLUSIONS

On-farm diversity maintenance of traditional crops namely finger millet, high altitude cold tolerant rice and bean is fair in the study sites, while that of barley, naked barley, prosomillet, foxtail millet and amaranth are specific to some mountain regions (mainly Humla and Jumla districts). Among the traditional crops, the diversity particularly of cold tolerant rice in all the mountain sites and that of finger millet in Humla play important role in farm production and food security of the mountain households despite current food sufficiency level of these crops is low in these marginal mountain environments. Factors influencing on-farm diversity of the three economically important crops namely finger millet, cold tolerant rice and bean varied by agro-ecological, farming system and socioeconomic conditions of the mountain locations. Agro-ecology of the mountain farming system has been a critical factor in influencing area allocation and diversity maintenance of rice, finger millet and bean in all the mountain agro-ecosystems. Farmers' socioeconomic factors such as farmers' age, family size and farm size play important role in on-farm maintenance of rice and finger millet diversity. Similarly, family size, tenancy and family members working outside are important for on-farm diversity of bean. Market factors play important role for rice and bean, since market demand for nutritious high altitude local organic *marshi* rice and bean is increasing in urban markets of Nepal. Therefore, market development in the mountain regions needs to consider

promoting on-farm diversity of high-altitude rice and bean.While other interventions on household-specific socioeconomic characteristics promoting on-farm crop diversities and farm household food security are essential for all the major traditional crops. Furthermore, crop-specific agro-ecological factors and the crops diversities should also be considered in such promotions. Future research and development interventions need to focus on diversity rich solutions and technologies tailored to specific crops and farm socioeconomic, agro-ecological conditions and institutional settings of the mountain households to enhance household food security and management of crop biodiversity of the mountain agro-ecosystems.

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THREATS, DRIVERS, AND CONSERVATION IMPERATIVE OF AGROBIODIVERSITY

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ABSTRACT

Agrobiodiversity underpins food, nutrition and livelihood security, ecosystem and environmental health, and climate change resilience but it is under threat of extinction. This paper highlights threats of agrobiodiversity, its drivers and conservation imperatives. Review shows prior to the green revolution, several crops and varieties were found in situ and on-farm but the number has declined since then. Extinctionis contributing to decline in crop productivity and resilience and consequently the long-term sustainability of human wellbeing. Extinctionis attributable to various natural and man-made factors. Various international and national level efforts are underway but not adequate to curb the loss. Therefore, further efforts are required to conserve and utilize agrobiodiversity, which will require concerted efforts in exploring agrobiodiversity, identifying drivers of loss and bolstering conservation efforts.This can be done through implementation of biodiversity-friendly legislations, actions and incentive mechanisms adhering to relevant global and national level policies, negotiations and conventions.

Keywords: Agrobiodiversity loss, drivers, in situ conservation, policy, sustainable use

INTRODUCTION

Biodiversity for food and agriculture or agrobiodiversity, a sub-set of biodiversity,[1] is the product of a continuous interaction of living things, land, technology and social systemsfor nearly 12,000 years (Partap and Sthapit 1998; Smale and Drucker, 2008). Throughout the history of mankind, a bounty of agrobiodiversity existed in nature,on-farm and *ex situ* condition. Worldwide, about 3,000 edible plant species are discovered, of which 30 crops account for 90% of plant-based calories and only three (rice, maize and wheat) fulfill two-thirds of food requirement (FAO, 2009a). Similarly, only 10

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species of cereal grains, legumes and oilseeds cover 80% of the world's cropland (Glover et al., 2007). Nearly 67% of global crop production (by mass) is directly consumed by humanand crops alone account for 55% of global calorie production and 40% of global plant protein production (Cassidy et al., 2013).

Agrobiodiversity is a vital element of human life and sustainability of mother earth since it underpins ecosystem functions, ecological health and human livelihoods (FAO, 2019). More specifically, it is considered to be the basis for sustainable food and nutrition security and human survival since human food, medicine, fiber, fuelwood and other resources come from agrobiodiversity (Brush, 2004; Frison et al., 2011). Extreme events such as droughts and floods push species to extinction (IPCC, 2007; Pascual et al., 2011) but rich on-farm biodiversity helps adapt to such climate change impacts (Frison et al., 2011) and reduce climate vulnerability and risks (Lobell et al., 2008; Galluzzi et al., 2011; Woods et al., 2015). For instance, planting different varieties at different times and the adoption of new varieties may decrease negative impact (Rosenzweig and Parry, 1994) and planting fast maturing and late maturing plant species can avoid short, irregular, uncertain and erratic rainfalls (Cavatassi et al., 2011).

Agrobiodiversity managed adopting eco-agricultural practices also underpin ecosystem and environmental health by generating positive co-benefits for production, biodiversity and local people (Scherr et al., 2008). Agrobiodiversity also enhances agroecosystem functioning when mixing of high yielding and pest resistance genotypes increases nutrient input and cycling (Jackson et al. 2007). Agricultural landscape provides us with various ecosystem services that support human and wildlife– provisioning (food, fiber, fuel), supporting (nutrient cycling, soil formation) and regulating services (climate, flooding, disease regulation, and water purification) (Pascual and Perrings, 2007). Despite their utmost importance to human being, various crops and varieties are rapidly eroding from their important habitats. A large number of genetic resources are on the verge of extinction while a large number of them have already extirpated from the agricultural system before their full utilization was made. The extinction is rapid, irreversible and irreplaceable in several cases due to various endogenous and exogenous factors including climate change (FAO, 2009b), which is leading to the erosion of important gene pools and associated knowledge (FAO, 1997). Global level efforts have been made to curb the loss but that has remained inadequate, further threatening the loss of agrobiodiversity and our livelihoods. Thus, concerted effort is required to protect agrobiodiversity for improving food security and resilience of agroecosystem. This paper discusses about agrobiodiversity loss, its drivers, current conservation efforts and future strategy to strengthen agrobiodiversity conservation efforts.

THEORETICAL FRAMEWORK

THREATS TO AGROBIODIVERSITY

Genetic erosion is a“loss of genetic diversity between and within populations of the same species over time, or reduction of the genetic base of a species” (Jarvis et al., 2000). In other words, it is the loss of species, varieties and alleles which affect species richness (Nabhan, 2007).The genetic erosion continues unabated worldwide. A wholesale loss of plant genetic resources, also known as “genetic wipe-out”, is also a continuous process and it is rampant worldwide (Harlan, 1975; Wilkes, 1993; Chhetri and Chaudhary 2011). International Centre for Agricultural Research in the Dry Areas (ICARDA) warns about two decades ago that, up to 60,000 (about 25% of the world’s total) plant species would be lost by the year 2025 if the trend continued (ICARDA, 1999).

Prior to the Green Revolution, some 30,000 landraces of rice were grown in India, but now 50 modern varieties predominate the rice growing environments (Hardon, 1996). In China, nearly 10,000 wheat varieties were believed to be grown in 1894, but the number reduced to only around 1,000 by the 1970s. The United States had lost over 90% of the local cultivars of cabbages, maize, and peas grown the past century toward the end of 20th century (FAO, 1996). Similarly, in Nepal about 50 % of local crop landraces or traits and 40% of total agrobiodiversity (crops, forage, livestock, aquatic agricultural genetic resources, insects and microbial genetic resources) are believed to be lost and many remained threatened mainly due to replacement by modern varieties, less use of local races in breeding and non-profit agricultural business (Upadhyay and Joshi 2003; Joshi et al., 2020).Chaudhary et al., 2004 have mapped varietal loss and genetic erosion of rice varieties in Bara district of Nepal using a few case studies and they revealed several social, economic and ecological drivers of varietal replacement. Sherchandet al., 1998 documented currently existing, threatened and lost varieties of rice, finger millet, sponge gourd, cucumber, taro, pigeon pea in Bara district, which is summarized in Table 1. Some introduced agricultural crops are invasive species that are spread beyond their planned range thus displacing native species and affecting ecosystem functioning (Mooney et al. 2005). According to Paini et al. 2016, Nepal is the third most affected country by plant invasion in agricultural system.

Table 1. Number of existing and lost landraces (LR) reported in different villages of Bara, Nepal

No.	Village	Existing cultivated LRs	Lost LRs
1	Amarpatti	5	9
2	Bachanpurwa	14	12
3	Bariyarpur	13	5
4	Chhatapipara	6	8
5	Dumarwana	6	6
6	Inarwasira	4	13
7	Jitpur	10	6
8	Kachorwa	24	2
9	Kolvi	4	5
10	Lipanimal	3	10
11	Mahendra Adarsh	6	4
12	Matiarwa	2	17
13	Parsurampur	2	14
14	Prastoka	2	21
15	Sapahi	11	7
16	Sinhasani	7	6

Source: Sherchand et al.,1998; Chaudhary et al., 2004

DRIVERS OF AGROBIODIVERSITY LOSS

Agricultural system, along with the refugia of agrobiodiversity, is continuously evolving as a result of natural selection and human selection, either deliberate or unintended, of desired crops and varieties (IPGRI, 1997; FAO, 2009). Some examples are given in Table 2 and further discussed below.

Natural drivers

Natural selection is affected by macro and micro environmental factors of the growing areas and surrounding. Climate variability and change have various effects on species through altering hydrological cycles, high temperature and variation in the length of growing season and increased frequency of extreme weather (Reilly and Schimmelpfenning, 1999). Scientists have pointed out climate change and variability as an increasing threat to agricultural yields and food security (Lobell et al., 2011).

Anthropogenic drivers

Various manmade activities also cause negative effect on agriculture. Modern techniques in agriculture exacerbates climate change when greenhouse gases are released by chemicals used in field, land clearing and other practices (Smith et al., 2007).A recent study done by Aryal et al. (2017) documented five anthropogenic drivers of crop diversity losses (Figure 1). The leading

cause of loss of crop genetic resources was found to be the availability of the improved and hybrid seeds (77%) followed by seasonal migration of the human force (56%). Human decisions on crop and variety selection are influenced by land ecology, environmental factor, sociocultural and economic factors, market institutions and government policies (IPGRI, 1997; Gauchan et al., 2003; Chaudhary et al., 2004; Rana et al., 2007).

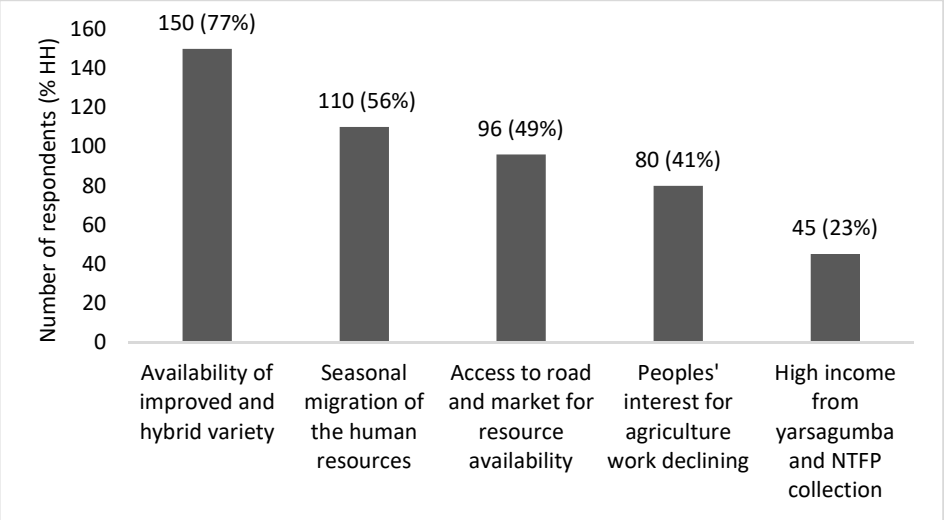

Figure 1: Drivers of agrobiodiversity loss (Adapted fromAryal et al., 2017)

Table 2. Examples of natural and anthropogenic drivers of agrobiodiversity loss and genetic erosion

Type of driver	Drivers of change	Nature of loss and extinctions	Reference
Natural	Natural selection	Biotic and abiotic stress tolerant species survive, and others go extinct	Sthapit et al. 2015; Solankey et al. 2015
	Land use change	Habitat for species is disturbed and turned out to be unsuitable The traditional agricultural land has been brought under cash crops Population growth and land fragmentation	Aryal et al. 2017; Jose and Padmanabhan, 2016; Upreti and Upreti, 2002; Maikhuri et al., 2001
	Climate change and disaster	Increase temperature, drought, diseases and pests result in the loss of poorly adapted crop species and cultivars	

Anthrop o-genic	Change in food choice, preferences	Local landraces replaced by modern varieties due to introduction of new varieties, alteration of food choice	Agnihotri and Palni, 2007; Rana et al., 2007; Aryal et al., 2017
	Market demand and value chain	Except a few well-known local varieties, others are not preferred by consumers due to lack of promotional activities Change in cropping pattern due to comparative economic advantage Access to road and market leading to easy availability of the fast foods and resulting in the loss of traditional crops Value chain of uniform and modern crops and varieties results in the loss of traditional diverse crops	Aryal et al., 2017; Nautiyal et al.. 2008; Gauchan et al., 2019
	Gene manipulation through breeding and non-breeding approaches	Gene manipulation introduces new genes at the cost of certain old genes, so the old one is lost Poor recognition of informal seed exchange and farmers network	Poudel et al., 2015; Hodgkin et al., 2006
	Human response to climate change and disasters	Local landraces replaced by modern varieties due to drying up of pond Farmers' perceptions on climate change risks on cereal crops	Katwalet al., 2015
	Seasonal and or out migration	Seasonal migration of the human resources to city areas and abroad Peoples' interest on agriculture work is declining	Aryal et al., 2017; Nautiyal et al., 2008
	Lack of transfer of traditional Knowledge	No systematic documentation of ethnomedicinal uses of traditional landraces, leading to poor knowledge transfer Younger generation is unaware of the distinct properties of the landrace diversity	Aryal et al., 2018; Nautiyal et al., 2008

AGROBIODIVERSITY CONSERVATION STRATEGIES ADOPTED WORLDWIDE

Agrobiodiversity conservation efforts have been made by government organizations and their allies worldwide for centuries. Farmers are also making intended and unintended efforts to conserve, manage and utilize agrobiodiversity. The effort has been further accentuated following the call to action of the Convention on Biological Diversity (CBD, 1992) for halting the current loss of plant and crop diversity while contributing to poverty reduction and sustainable development. Agrobiodiversity conservation strategies broadly include *exsitu* and *insitu* (Maxted et al., 1997; UNCED, 1992) and its promotion can be done, *inter alia*, by establishing living collection and germplasm banks and introducing varieties of species to agroecosystem (Long et al., 2003).Nepal has adopted four strategies (namely *ex situ, in situ,* on farm and breeding) separately for management of six components of agrobiodiversity (crop, forage, livestock, aquatic agricultural genetic resources, insect, and microbe) as summarized by Joshi and Upadhya(2019) and Joshi et al. (2020).

In situ conservation

In situ conservation means conserving diversity in the setting where it developed (UNCED, 1992). CBD (1992) defines "In-situ conservation' as the "conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties". It, along with on-farm conservation, is "the continuous cultivation and management of a diverse set of populations by farmers in the agroecosystems where a crop has evolved" (Bellon et al., 1997). Various *in situ* conservation methods have been adopted by different countries as summarized in Table 3. On-farm conservation encourages farmers to continue selection and management of local crop populations (Brush 1999). On-farm conservation has focused on *de facto* conservation in centers of origin (Qualset et al., 1997; Brush, 1991), but exceptionally valuable varieties are found outside their centers of origin (Vavilov, 1951). Resource-poor farmers in marginal environments often maintain large amounts of agrobiodiversity (Maxted et al., 2002; Wood and Lenne, 1997; Bellon, 1996).

Ex-situ conservation

Ex-situ conservation is about conserving diversity outside of natural habitats (UNCED, 1992) including genebank storage (seed and field), in-vitro storage, pollen storage, and DNA storage (Maxted et al., 1997). In globe, 4,362,100 accessions of Plant Genetic Resources for Food and Agriculture (PGRFA) are

maintained of which Nepal contributes about 23,600 accessions of plant genetic resources conserved in more than 12 countries (Joshi et al., 2016). *Ex situ* conservation is also the source of re-introduction and restoration of genetic diversity (van de Wouw et al., 2009) but the *ex situ* sites are not immune to genetic erosion which is mainly the result of the loss of accessions and alleles due to poor regeneration and storage practices (Parzies et al., 2000). The target 8 of Global Strategy of Plant Conservation (GSPC) 2010-2020 reveals at least 75% of the threatened plant species are in *ex situ* conservation and around 20% are available for restoration.

Table 3. Examples of in situ, ex-situ and on-farm conservation methods have been adopted by different countries

Conservation strategy	Growing condition (Habitat)	Examples of conservation methods	Characteristics
In situ	Wild habitat	Crop wild relatives Wild edible plants Uncultivated plants	Plants and animals available for food and agriculture that support human economy, livelihoods and wellbeing.
	On-farm	Farmers' field	Local landraces grown by farmers for generations, so co-evolved with natural, social, cultural, economic and environmental change
		Diversity block	A number of crop varieties found in local communities growing in a single plot for demonstration, multiplication, regeneration and awareness
		Community seed bank	Community-initiated seed conservation and distribution mechanism where seeds are stored in a locally constructed house
		Field genebank	Often biennial and perennial crops are grown in field to conserve them
		Participatory Crop Improvement (PCI)	A number of varieties are given to farmers to grow and choose the best from (also called basket of choice)
		Participatory Plant Breeding (PPB)	Crossing made between local germplasm and modern variety to retain desired traits from both
		Value chain and Market Development	Value addition, value chain and market development of underutilized and traditional crop biodiversity

Ex situ	Genebank & preservation centers	National genebank& International genebank	Genebanks equipped with high voltage cold storage where germplasms can be preserved for hundreds of years depending on the level of low temperature maintained
		Seed vault	Natural seed storage in perennial snow-covered polar region (permafrost), which are duplicate samples or spare copies of germplasms stored in genebanks
	Other *ex situ* sites outside genebanks	Botanical garden	A large number of flowering and non-flowering plants are grown for recreation purpose
		Parks	Protected areas from where people collect their wild food
		Research stations	Several local landraces are planted in research stations for research and development

GOING FORWARD – CALL FOR ACTION

Although several agrobiodiversity conservation strategie have been developed and practiced by farming communities, public and private organizations, the current efforts are not adequate. A complete picture of the total agricultural diversity worldwide is not knownhitherto. Information for wild relatives and wild edibles is even scarcer. It is thus important to further explore agrobiodiversity in different habitats along with social, cultural, economic and ecological information associated with them. Location-specific drivers of agrobiodiversity loss need to be identified for developing strategies tailoring to local needs and priorities.

It is important to integrate different conservation approaches. Article 9 of the Convention on Biological Diversity (CBD) emphasizes the complementarity of *ex situ* and *in situ* conservation of species through facilitating exchange of plant genetic resources between farmers and genebanks (Thormann et al. 2006). So, a multi-disciplinary conservation strategy that integrates *insitu* and *exsitu* management processes is necessary wherever appropriate (Conway 2007; Byers et al., 2013; Schwartz et al., 2017), which necessitates an adaptive management processes and a strong collaboration at all levels of conservation action including planning, implementation, monitoring and assessment (Schwartz et al., 2017).This will also require engagement of multiple actors with different complementary skills. Community seed banks and community field genebank have been developed to bridge gap between genebank and farmers. They play the role of facilitator and a platform for

knowledge exchange (Chaudhary, 2013). Generally, *ex situ* conservation for plant breeding involves collection, classification, evaluation and utilization of agrobiodiversity and community seed banks support genebanks in collecting, regenerating, and exchanging genetic materials (Vernooy, 2018; Joshi et al., 2018).

From a sustainable food system perspective, the diversity held in gene banks or *in situ* and on farm do not support and promote optimum conservation without their sustainable use in food and nutrition security and livelihood of the increasing global population. For instance, *ex situ* facilities represent tip of the ice bergs as gene banks have largely focused on conservation of major staple crops, while non-staple crops represent only 2% of materials stored and crop wild relatives are also poorly represented (Dulloet al., 2019). Furthermore, even diversity held in *ex situ* facilities can face genetic erosion due to inadequate management practices as a result of insufficient support, lack of duly trained staff and frequently overwhelmed and underfunded conservation programs. Value chain development of underutilized nutrient dense food crops can directly improve the livelihoods and nutrition security of poor farmers in marginal environments by increasing yields, managing marginal lands and improving income of the households (Gauchanet al., 2019).

Further policy gap analysis needs to be done to examine policy incentives and barriers and suggest formulation and revision of policies based on the identified gaps. It is also important to build strong network with global communities working on agrobiodiversity conservation in order to exchange knowledge, human resource and financial resources for sustainable management and utilization of agrobiodiversity. Using local crop varieties for future breeding can also curb genetic erosion asit can help retain useful genes from rare varieties. For this, participatory approaches such as participatory plant breeding and participatory crop improvement can be applied to develop locally acceptable and future climate-smart varieties. In addition, future smart crops, including neglected and underutilized species, need to be promoted to meet the future demand of nutritious and climate resilient crops so that people can be fed sustainably for several generations from now.

The Convention on Biological Diversity (CBD), Nagoya Protocol and International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) are important international instruments guiding conservation and use of agricultural biodiversity. However, current international attention to biodiversity focuses mainly on conservation of “globally-important” forest and wildlife biodiversity with less attention given to importance of agrobiodiversity to food security and livelihoods of the poor, and the vulnerable communities (Gauchanet al., 2017). This has resulted in loss of

agrobiodiversity. There are various economic, non-economic and indirect incentives that influence conservation and sustainable use of agrobiodiversity (Gauchan et al., 2005; 2016). The major gaps and challenges to be addressed include the formulation and implementation of biodiversity friendly legislative framework, action plans and incentive mechanisms (royalty, subsidy, value addition, property rights, benefit sharing, rewards, recognition etc.) supporting conservation, sustainable use and their integration in national development programs (Gauchanet al., 2017). However, experiences of incentive schemes for conservation and agri-environmental schemes indicate that incentives need to be carefully designed in order to avoid pitfalls and achieve the desired outcomes (Attwood et al., 2017).

CONCLUSIONS

Agrobiodiversity is important for food and nutrition security and climate change resilience of farming communities worldwide. Its conservation and proper utilization are thus necessary in order to sustain human live on earth. However, we have already lost precious agrobiodiversity from different households, farms and agroecosystems and extinction of remaining ones continues unabated. Various natural and man-made factors are attributable to extinction of agrobiodiversity. So, the ongoing loss of agrobiodiversity from farmers' fields or on-farm is of concern to global community. Proper strategies to promote agrobiodiversity are crucial in the future to cope with risks presented by climate change and non-climatic factors. Various strategies, *in situ, ex situ,* and on-farm, are adopted by farming communities, practitioners, NGOs and governments to conserve and promote valuable agrobiodiversity but the current efforts and strategies are not adequate to curb the ongoing loss of agrobiodiversity. It calls for national and global level efforts to conserve agrobiodiversity and harness its benefits now and in the long run. Therefore, breeding techniques combined with market-led approaches supported by national and international level policies are necessary to conserve valuable agrobiodiversity and increase its utilization for improving farmers' benefits, satisfying consumers' needs, and helping cope with changing social, economic, environment and climatic conditions in the long run.

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SCREENING OF MAIZE GENOTYPES AGAINST STALK ROT DISEASE IN RIVER BASIN AREA OF SURKHET, NEPAL

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ABSTRACT

Stalk rot of maize (Zea mays L.) is becoming a serious threat in tropical and subtropical maize growing regions of Nepal. To identify the sources of disease resistance in maize genotypes, a field experiment was conducted under natural epiphytotic condition during the summer season of 2016 and 2017 with thirty genotypes in a randomized complete block design in two replications. Statistical analysis showed that percent disease incidence (PDI) and grain yield were highly significant among the tested genotypes. Most of the maize genotypes were resistant to moderately resistant, only few were susceptible in both years, indicating good sources of resistance in the available genotypes. During 2016, the highest PDI was found in Arun 4 (33.17%) followed by Rampur 27 (20.10%) and Arun 2 (20.06%) whereas TLBRS07F14 and TLBRS07F16 showed no disease incidence. Similarly, the highest and least grain yielders were identified as Rampur Hybrid 6 (6.77 t/ha) and Arun-4 (2.15 t/ha) respectively. In 2017, highest PDI was observed in Arun-2 (24%) followed by Arun-4 (22%) and no disease incidence was seen in TLBRS07F14. Highest grain yield was found in RAMS03F08 (7.38 t/ha) followed by Manakamana-3 (7.37 t/ha) and the lowest was recorded in Arun 4 (2.60 t/ha). These resistant genotypes can be utilized in national breeding program to develop stalk rot tolerant high yielding maize genotypes in future.

Keywords: Disease resistance, genotypes, grain yield, percent disease incidence, stalk rot

INTRODUCTION

Maize (*Zea mays* L.) is the second most important cereal crop of Nepal after rice in terms of area (0.9 million ha), production (2.3 million tons), and productivity (2.56 t/ha) (MOAD, 2016). Diseases are the most important biotic constraints for maize cultivation in the country. Nowadays, stalk rot complex is becoming a more serious disease in tropical and subtropical maize growing regions of Nepal. Pre-flowering stalk rots are *Pythium* stalk rot caused by *Pythium aphanidermatum* and bacterial stalk rot caused by *Erwinia chrysanthemi* pv *zeae*. Post-flowering stalk rots are *Fusarium* wilt or

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late wilt caused by *Cephalosporium maydis,* which is more prominent to reduce maize yield and charcoal rot caused by *Macrophomina phaseolina* (Subedi, 2015). Stalk rot is cosmopolitan in distribution and mostly prevalent in hot and humid areas like Dang, Chitwan, Nawalparasi and Surkhet (Shah, 1968). *Pythium* stalk rot is common in hills and the valleys in Nepal (Diwakar and Payak, 1975). In Nepal, bacterial stalk rot of maize (*Erwinia chrysanthemi* pv. *zeae*) has been recorded to cause an average of 80% yield loss along with other fungal diseases in the Terai area (Burlakoti and KC, 2004). Most of the maize hybrids and open-pollinated varieties released in the country, as well as several local varieties, have been found to be susceptible to this disease. Selection of resistant genotypes is the best, long term and environmentally friendly approach for sustainable disease management. The breeding of new varieties and their cultivation is economically and ecologically reasonable method for controlling maize diseases. Therefore, the major objective of this research was to find out the sources of resistance against stalk rot disease in different maize genotypes.

MATERIALS AND METHODS

Field experiment was conducted with 30 maize genotypes under a natural epiphytotic condition at Agriculture Research Station (ARS), Dasharathpur, Surkhet (28°30' northern latitude to 81°47' eastern longitude with altitude of 500 masl), Nepal during the summer season of 2016 and 2017 in a randomized complete block design with 2 replications. Each plot consisted of 2 rows of 3 m length with 75 cm and 25 cm spacing between row to row and plant to plant, respectively. Sowing was done in the last week of June, fertilizers were applied at the rate of 120: 60:40 NPK kg/ha (Basal dose @ 60: 60: 40 NPK kg/ha, remaining nitrogen in two splits; one at knee high stage and other before tasseling). Different parameters, such as early plant stand, tasseling days, silking days, plant height, ear height, final plant stand, number of diseased plants and grain yield were recorded. Disease incidence was noted in the field and percent disease incidence (PDI) was calculated using the following formula:

PDI = (No. of diseased plants observed/Total number of plants) *100

Ms-Excel was used for data compilation and tabulation. Data analysis was done using R Studio software. Based on the PDI, maize genotypes were categorized into the following four categories:

S.N.	PDI	Resistance Category	Code
1	0-10	Resistant	R
2	10-20	Moderately Resistant	MR
3	20-50	Susceptible	S
4	>50	Highly Susceptible	HS

Source: Ahamad et al., 2015

RESULTS

The statistical analysis revealed that both PDI and grain yield among the maize genotypes were highly significant in both years 2016 and 2017. However, early plant stand, and final plant stand were non-significant in 2016. In the year 2017, there were significant differences in case of early and final plant stand (Table 1). During 2016, the highest PDI was found in Arun-4 (33.17%) followed by Rampur 27 (20.10%) and Arun-2 (20.06%). Also, no disease was recorded in the genotypes TLBRS07F14 and TLBRS07F16. The highest grain yield was found in Rampur Hybrid 6 (6.76 t/ha) and the lowest in Arun-4 (2.15 t/ha). In 2017, high PDI were seen in Arun-2 (24%) and Arun-4 (22%) than others. The genotype TLBRS07F14 had no disease appear. Similarly, highest yield was observed in the genotype RAMS03F08 (7.38 t/ha) followed by Manakamana-3 (7.37 t/ha) and the lowest yield was recorded in Arun-4 (2.59 t/ha) (Table 1).

Most of the tested maize genotypes were resistant to moderately resistant against stalk rot disease, whereas two genotypes Arun-2 and Arun-4 showed susceptible reaction and none of tested genotypes was found as highly susceptible disease reaction during both years. Similarly, the genotypes TLBRS07F16, Rampur 21, TLBRS07F14, RAMS03F08, BLBSRS07F10, RML 95/RML 96, R pop-4, ZM 627, Rampur 32, Rampur 24, Rampur Hybrid 4, ZM 401, Rampur Composite and Across 9331 RE were found resistant to stalk rot disease in both years (Table 2 and 3). Out of the 30 tested genotypes, 17 genotypes were resistant and 10 were moderately resistant and rest three genotypes Arun-2, Rampur 27 and Arun-4 were susceptible to the disease (Table 2). Likewise, in 2017, 19 maize genotypes were found resistant and 9 were moderately resistant while 2 genotypes Arun-2 and Arun-4 showed susceptible reaction to stalk rot disease (Table 3).

Table 1.Screening of maize genotypes for pre-flowering stalk rot resistance at ARS, Surkhet during 2016 and 2017

S.N.	Genotypes	2016				2017			
		EPS #	PDI	FPS #	GY (t/ha)	EPS #	PDI	FPS #	GY (t/ha)
1	Rampur Composite	20	7.50	19	4.12	23	4.50	22	4.88
2	Arun-2	23	20.06	18	4.00	21	24.00	16	4.26
3	Poshilo Makai 1	18	14.38	15	4.32	21	12.50	18	6.04
4	S99TLYQ-B	17	15.00	14	3.24	12	17.50	10	3.62
5	S99TLYQ-HG-AB	23	15.61	19	4.06	20	15.50	17	5.40
6	BGBYPOP	20	15.39	14	3.92	22	7.00	20	6.15
7	R pop-3	20	10.26	16	3.72	19	11.00	17	4.13
8	R pop-4	21	4.77	20	5.86	23	6.50	21	5.83

9	Rampur Hybrid 4	22	9.17	19	5.67	23	2.00	22	5.65
10	Rampur Hybrid 6	21	11.82	22	6.76	25	12.50	22	5.79
11	RML 95/RML 96	14	4.55	14	3.79	23	4.50	22	5.54
12	RAMS03F08	22	2.27	21	6.28	21	2.00	21	7.38
13	ZM 401	23	6.44	20	4.56	23	8.50	21	5.55
14	ZM 627	19	5.28	18	3.72	23	6.50	22	5.80
15	05 SADVI	22	16.23	20	4.83	27	9.50	24	5.10
16	07 SADVI	23	15.77	20	5.38	21	10.00	19	4.32
17	Rampur 21	16	6.51	13	2.38	24	2.00	24	4.13
18	Rampur 24	20	7.29	19	3.72	25	10.00	22	4.66
19	Rampur 27	18	20.10	14	3.43	21	17.00	17	4.61
20	Rampur 32	19	5.44	18	4.65	22	4.00	21	6.19
21	Rampur 33	19	7.89	18	4.84	23	13.50	20	5.50
22	Rampur 34	17	11.81	14	3.52	23	6.50	22	6.56
23	Rampur 36	21	14.64	17	4.73	21	9.50	19	4.39
24	TLBRS07F16	15	0.00	15	4.35	25	2.00	24	4.75
25	Across 9331 RE	21	9.55	16	3.99	19	8.00	17	5.43
26	Across 9942/Ac 9944	16	15.83	13	3.52	22	5.00	21	5.50
27	BLBSRS07F10	23	4.46	22	6.10	22	9.00	20	4.58
28	TLBRS07F14	17	0.00	17	4.18	20	0.00	20	3.96
29	Arun-4	20	33.56	14	2.15	21	22.00	16	2.59
30	Manakamana-3 (FL)	18	8.33	16	5.10	22	11.50	19	7.37
	Grand Mean	19	10.66	17	4.36	22	9.13	20	5.19
	F-test	ns	**	ns	**	*	**	**	**
	LSD (≤0.05)	-	4.91	-	0.86	4.953	4.032	4.66	1.48
	CV%	14.48	22.52	19.91	9.59	11.20	21.59	11.57	13.94

*FL- Farmer's local, EPS- Early Plant Stand, PDI- Percent Disease Incidence, FPS- Final Plant Stand, GY- Grain Yield, LSD- Least Significant Difference, CV- Coefficient of Variation, *- significant, **- highly significant, ns- non significant*

Table 2. Performance of different maize genotypes against stalk rot disease at ARS, Surkhet during 2016

S.N.	PDI	No. of genotypes	Genotypes	Resistance Level
1	0-10	17	TLBRS07F16, TLBRS07F14, RAMS03F08, BLBSRS07F10, RML 95/RML 96, Rampur 21, R pop-4, ZM 627, Rampur 32, Rampur 24, Rampur Hybrid 4, ZM 401, Rampur 33, Rampur Composite, Across 9331 RE, Manakamana-3 (FL) and R pop-3.	R

2	10-20	10	Rampur Hybrid 6, Rampur 34, Rampur 36, Poshilo Makai 1, S99TLYQ-B, 07 SADVI, S99TLYQ-HG-AB, BGBYPOP, 05 SADVI and Across 9942/Ac 9944.	MR
3	20-50	3	Arun-2, Rampur 27 and Arun-4.	S
4	>50	0	-	HS

Table 3.Performance of different maize genotypes against stalk rot disease at ARS, Surkhet during 2017

S.N.	PDI	No. of genotypes	Genotypes	Resistance Level
1	0-10	19	TLBRS07F14, TLBRS07F16, Rampur 21, RAMS03F08, Rampur Hybrid 4, Rampur 32, RML 95/RML 96, Rampur Composite, Across9942/Ac9944, ZM 627, Rampur 34, R pop-4, BGYPOP, Across 9331 RE, BLBSRS07F10, ZM 401, 05 SADVI, Rampur 36 and Rampur 24	R
2	10-20	9	07 SADVI, R pop-3, Manakamana-3 (FL), Poshilo Makai 1, Rampur Hybrid 6, Rampur 33, S99TLYQ-HG-AB, Rampur 27, S99TLYQ-B	MR
3	20-50	2	Arun-2 and Arun-4.	S
4	>50	0	-	HS

DISCUSSION

The weather data recorded an average temperature between 20-35°C, with RH more than 80% and around 550 mm average rainfall during the entire crop period in both years (Figure 1). Stalk rot disease is high at temperature of 30-35°C, with 80-100% relative humidity (Subedi, 2015). In addition, water logged, low-lying or poorly drained field conditions also favor disease development. Also, the rainfall was high during the month of July and August which was also a favorable condition for disease development (Figure 1). Stalk rot infectivity depends on environmental factors, the genotype, and genotype and environment interaction (G×E) (Szoke *et al.*, 2007). Diwakar and Payak in 1980 reported plant age (pre-flowering growth stage) and a large plant population (≥60,000 per ha) favor a high disease incidence. Stalk rot disease is observed commonly when there is a period of drought during or shortly after pollination and the 'stay green' character is associated with resistance to certain post-flowering stalk rots (Subedi, 2015). Resistance to stalk rot disease involves several traits including physiological, morphological and functional characters (Subedi, 2015). Both stalk morphology and abiotic stress factor determine the maize stalk strength.

The findings of this experiment are also supported by Subediet al. (2016), who found Rampur Composite, RamS03F08, Rampur 34, TLBRS07F16 and Rampur 24 as resistant genotypes against stalk rot disease. However, Arun 2 which was seen as resistant in their research showed susceptible reaction in both years in our study. The susceptibility of Arun 2 may be due to different races of the pathogen and the prevailing environmental condition in the area. The commonly cultivated and farmers preferred variety, Manakamana-3 which was used as check was also found tolerant to the disease with high yield in both years. Hence, Manakamana-3 could be further expanded in the disease prone areas during summer season. Ledencan et al. (2003) reported low disease in hybrids than inbreds and they differed significantly in terms of resistance and infection types. Our results were also in the same line with maize hybrids like Rampur Hybrid 4, Rampur Hybrid 6, RML 95/RML 96 and Across 9942/Ac 9944 being resistant to moderately resistant in both years. In India, resistance in some inbred lines, single crosses, and hybrids have been identified through artificial inoculations. Among these, CM 104, CM 600, hybrids Ganga Safed-2 and multiple disease resistant (MDR) populations MDR-l and MDR-2 are known (Sharma et al., 1993). Screening work against bacterial stalk rot has been conducted by several other authors. In 1970, Rangarajan and Chakravarti evaluated 20 maize varieties including 4 composite and 16 hybrids in field against *E. carotovora* pv. *zeae* (Strains M1 and M2) and found that all those varieties were resistant. Likewise, Sinha and Prasad in 1975 reported partial resistance in CM 600, CM 104 and CM 105 maize lines and their crosses in the field against bacterial stalk rot. Thind and Payak (1978) evaluated 32 maize entries consisting of 13 inbred lines, 9 hybrids, 6 composites and 4 open pollinated varieties against *E. chrysanthemi*pv. *zeae* and observed that two inbred lines CM101, CM-110 and two OPVs CM600, Basi were found tolerant against *E. chrysanthemi* pv. *zeae*. Hence, the resistant and moderately resistant genotypes identified from this study could be used as a good source of resistance for developing high yielding stalk rot tolerant maize varieties especially for river basin areas of Nepal.

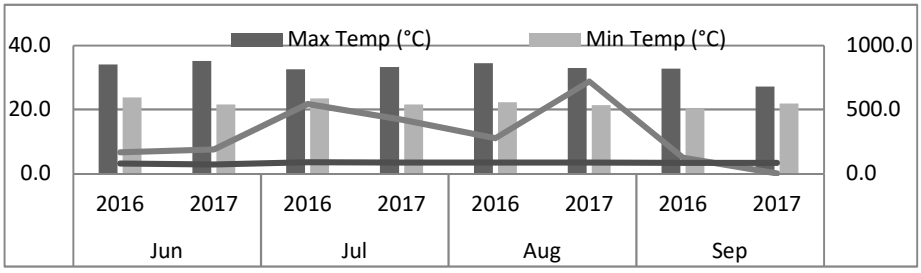

Figure 1: Prevailing weather of ARS, Surkhet during the cropping period in 2016 and 2017

CONCLUSION

Stalk rot disease of maize was prevalent during the summer season of 2016 and 2017 at ARS, Surkhet. Most of the maize genotypes were resistant (17 maize genotypes in 2016 and 19 genotypes in 2017) to moderately resistant (10 genotypes in 2016 and 9 genotypes in 2017), only Arun-2 and Arun-4 were observed as susceptible in both years. None of the tested genotypes were found highly susceptible to the disease in both years indicating good sources of resistance in the available genotypes. Therefore, sources of resistance to the disease are encouraging and these can be utilized in the national breeding program to develop stalk rot tolerant high yielding maize genotypes in future.

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GOVERNMENT INTERVENTION STRATEGY IN AGRICULTURE PRICE POLICY: A CASE OF MINIMUM SUPPORT PRICE IN NEPAL

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ABSTRACT

Price policies are used as important tools to enhance production, minimize the farmers' risks and stabilize the consumer price. Different price policies are being implemented in many countries since long. This paper tries to analyze the different price policies – especial focused with minimum support price, implemented by Nepal and comparative assessment of their successes.The different literatures have been reviewed and policies of Nepalese government at different periods have been analyzed and compared with the relative performances to draw the conclusion. Implementation of Minimum support price and deficit payment schemes for different crops have been recommended, while establishment of separate commission for price and cost of agriculture commodities may ease the implementation of price policy.

Keywords: Minimum support price, Deficit payments, Commission, Schemes, cost

INTRODUCTION

Many countries in the world have adopted minimum support price and other schemes for regulating price fluctuations in agriculture commodities (Lyu & Li, 2019; Guda, Rajapakshe, Dawande, & Janakiraman, 2019; Marcus & Modest, 1986; Rasmussen & Baker, 1979). Uncertainty in price has affected large number of farmers throughout the world and especially small farmers are more vulnerable to such fluctuations. Such price policy often causes significant income transfer(Lianos & Rizopoulos, 1988).Once the engine for all economic growth, now agriculture in most of the world remains a must protect sector. After industrial revolution in many countries, the share of agriculture sector has been decreasing constantly. Both price and income is being inelastic for agriculture produce (Brodeur & Clerson), 2015), the level of production of agriculture commodities has to be at controlled targeting the market demand. As large section of global population came out of agriculture sector, advanced technologies and high inputs were required to meet increased demand amid population growth and quality requirements.

Unlike many developing countries, Nepal's industrialization progress remained sluggish and major chunk of population is engagingin the agriculture sector. However, the liberalization after 1990 opened new avenues for foreign employment which resultedincreased absentee population from 0.6 million to 1.9 million during 20 years after liberalization (DoFE, 2014). It is estimated

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that such population to have surpassed 3.0 million in 2019. More than 90% of such absentee population is from rural areas; indicating much of the agriculture labor force is being dragged out of country. The foremost reason for such increased labor migration has been attributed to low profitability of agriculture sector because of lower productivity and low farm gate prices. The need for government intervention in price policy of agriculture commodities was realized long ago and some of the mechanisms are in place in Nepal too.

The debates on government interventions on agriculture prices have long been ongoing. The free market school advocates for border price to reflect their opportunity cost; while structuralist school argues that the border price paradigm for domestic price determination is misguided because of the different schemes and subsidies provided in huge amounts to decrease the cost of production by the developed world (Timmer, 1989). As a consequence, many donors and development partners in the third world including Nepal advocated for the free market approach; while many countries adopted the government intervention policies to protect their domestic production. India has been implementing Minimum Support price for major commodities since 1968; likewise, United States of America also provides price support for major commodities especially for exportable commodities which resulted increased in value of crops (Marcus & Modest, 1986). Albeit debates for using appropriate price policies, minimum support price and price supports are the basic tools used by most of the countries to stabilize price and diminish the risk of farmers.

India used the price intervention policy to increase the export of rice more prudently. India used to be the net importer of rice before 1970s. However, the MSP triggered during the same period and continued inspite of bumper production during green revolution, which encouraged the farmers to keep the production up. As price assured their minimum income, farmers were encouraged to use new technologies like high yielding varieties and high dose of fertilizer for increasing productivity and production (Kumbhar, 2011). As a result, India became one of the major rice exporters in the world and exports of Basmati rice accounting more than 3 billion USD in 2019.

Figure 1: International Trade of Rice in India

Source: Ricepedia.org/India, 2020

Nepal once exporter of rice during 1970s, started importing rice after 1980s where the export was booming in India.

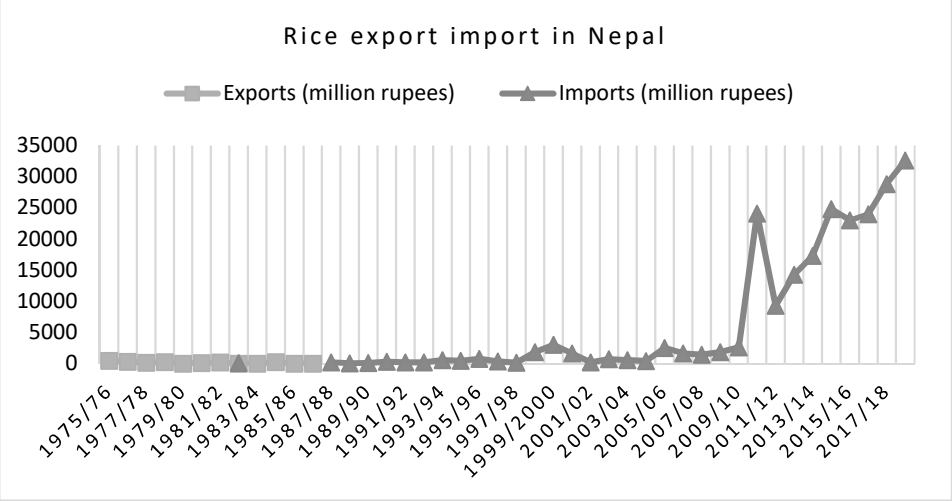

Figure 2: International Trade of Rice in Nepal

Source: Trade and Export Promotion Center, Nepal, 2019

The general objective of the study is to carry out a review about the price support mechanism around the world and to assess the suitability in case of Nepal. Furthermore, the study aimed to come up with best possible alternative for the price support in agriculture sector.

METHODOLOGY

Several approaches have been suggested for the literature reviews which includes systematic, semi-systematic and integrative (Snyder, 2019).Semi-systematic review approach has been adopted for the study. This model is found instrumental for theoretical perspective (Ward, House, & Hamer, 2017). A comprehensive review of published literature has been carried out for the study. The published peer-reviewed papers are the foundation of the study. However, government report in this regard is also considered to get insight in the process and the intention of the intervention. Moreover, several key informant surveys were conducted to validate the findings. Further, following guideline was adopted to assess the quality of a literature review (Snyder, 2019).

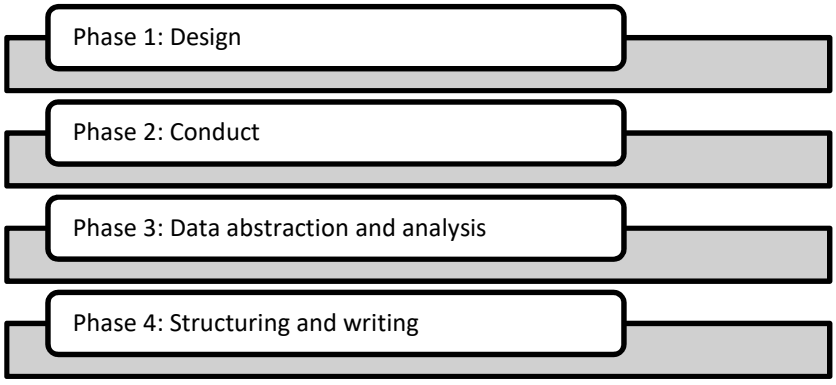

Figure 1: Guideline to assess the quality of literature review

RESULTS AND DISCUSSION

DIFFERENCES IN PRICE POLICIES BETWEEN INDIA AND NEPAL

In India major thrust of price policy implemented from 1965 was i) need to provide incentives to producers for adopting improved technology for maximizing production, ii) ensure the rational utilization of land and other resources, iii) the likely effect of the price policy on the rest of the economy, particularly on cost of living, wage levels and industrial cost structures (Bhalla, Randhawa, & Tyagi, 1989). As India faced lot of shortages of food and production inputs; the major emphasis of the price policy was to increase the production. Whereas in Nepal, from 1957 to 1981 the major objective of the price policy was to stabilize the consumer price. It did not really account on the production regime. As significant quantity of rice was being exported; the government tried to regulate consumer prices thereby disincentivizing the producers. It was only since 1981; the support prices were meant for

increasing the production. Moreover, mechanism for such support price were established differently for different crops such as rice and wheat; tobacco, jute and later on sugarcane.

In India, the price policy was successful for most of the cereals. The market price for most of the period operated in around the minimum support price. This was also possible due to strong public distribution system throughout the country. The recent study by NITIAyog suggests that most of the farmers sell their produce above the MSP; only 4% of total rice production in the country was purchased by the government agency to regulate the farm price (NITI Ayog, 2018). In case of Nepal, although declared; the MSP were never implemented for cereals. The market price for rice and wheat were far below the MSP in the main season in 2018 and 2019; which was even worse during 1976 to 1986.Lack of clear direction, weak infrastructures– especially storage and public distribution system, and poor coordination was responsible for failure of price policy in Nepal; which is even much difficult to handle due to open border with India; where major food basket of the country in the south adjoins with. One easy way to adopt price policy in Nepal is to maintain the MSP as par with Indian border price; however, this depends on the other support and subsidies schemes of the Indian government to their farmers. But it seems there is no choice than to fully implement the price support schemes to encourage the increased production in context of ever-increasing trade deficit in food grains.

DEFICIT PAYMENTS AGAINST MINIMUM SUPPORT PRICE: A POSSIBILITY IN NEPAL

Deficit payment schemes were brought to implement the hybrid model of government price policy; and are popular in United States for export commodities. In this scheme, the support price is directly paid to the farmers if the market price goes down from floor price. This process does not intervene the market on the one side but also protects farmers on the others side. In this aspect, it seems most plausible option to implement government price policy; however factually it is no different to direct payment; which in turn increases the government spending to insurmountable amount later on and cannot be affordable to the country like Nepal. Deficit payments can be applied to the limited high value commodities with higher scope for export markets. Similar support price is being implemented for Sugarcane in Nepal; where government direct transfer to farmers is more than 1 billion rupees in 2019 (DoA, 2019). The deficit payment system for cereal crops is not feasible economically in Nepal; while that for sugarcane also should be reviewed periodically. Farmers are complaining of difficulty in obtaining the price support due to lengthy bureaucratic process and could be simplified if the payments be made from local government.

INSTITUTIONAL STRUCTURES TO IMPLEMENT PRICE POLICY IN NEPAL

One of the main reasons for failure of price policy in Nepal is the establishment of many institutions in the process. There are at least three ministries involved in price determination and provision of cabinet to decide the minimum support price. It makes the price declaration a big hurdle due to ministry's own bureaucratic procedures and lack of coordination amongst ministries. Generally, MSP should be declared before the cropping season but interestingly in Nepal, it is declared after the harvest with exception in some years. Ministry of Agriculture and Livestock Development should be made solely responsible in price determination and cabinet to decide the price. Instead, a separate commission for price declaration can be established like Indian Commission for Agricultural costs and prices (CACP). The role of Ministry of commerce and supply should be limited in regulating the consumer prices. Likewise, different institutions are made responsible for implementing price support. Food Management and Trading Company limited (FMTCL); the government owned company is responsible for food supply in the rural areas. In doing so, it purchases the grains in the main season and supplies to remote areas. The major objective of the establishment of then Food Corporation of Nepal was to implement price support schemes of the government in food grains. However, it never operated in the way of price support, rather than benefit making by purchasing in low price and selling in prevailing market price. The clear guidance from the responsible authorities and lack of coordination between the agencies involved in price policy derailed the implementation. Likewise, Dairy Development Corporation is operating as market price regulator by purchasing the milk from farmers in the fixed price. This mechanism is somehow successful in stabilizing milk price both from producers and market perspectives. The increased commercialization of milk production can be credited to DDC operations where price is guaranteed for per unit of milk produced. The DDC price has served as minimum price of per unit of milk for other dairy industries. Farmers are benefiting by supplying milk to private dairy industries in lean season with higher prices while supplying to DDC in flush season in minimum prices. Fixing different prices for different season can solve the moral hazards in due process.

Tea and coffee Development Board is responsible for implementing appropriate price policy for tea and coffee. Likewise, Cotton Development Committee serves as implementation of cotton price policy. Tobacco price committee, Jute price committee, Sugarcane price committee were also established to determine the minimum support price for respective commodities.

POSSIBLE MODELS FOR IMPLEMENTING PRICE POLICY IN NEPAL

Price policy were implemented by many countries to solve the farm related problems especially after 70s, where non-agriculture sector became more lucrative and risk of falling production throughout the world became prominent(Mollett, 1988; Rao, 1992). Further, price policy also aims to maintain a buffer stock against potential shocks, and to maintain public distribution system at desired level of price focused to the vulnerable section of the country (Vyas, 2001). As new technologies have been developed to increase the production and high input use ensuring the better production; the question in the developed world has raised whether still farm related problems exist and need for government intervention still relevant (Brodeur & Clerson, 2015; Andonov, 2012). The case of Nepal is quite different, as small economy cannot support farmers directly in the form of subsidies and incentives. Although some efforts were made to decrease the cost of farmers by chemical fertilizer subsidies and other input subsidies in negligible amount. More importantly the price policy in Nepal could not be implemented in the proper way to raise the farmers' income and the consequence is a large section of population are forced for migration due to lack of domestic job opportunities including several other factors like conflict and natural disasters. The neighboring countries India; implementing the price policy since 1968 successfully with exception to certain commodities (Krishnaji, 1990; OECD/ICRIER, 2018) and China implementing controlled price policy throughout the country(Yang & Li, 2008), Nepal has no option but to implement appropriate policy successfully.

The nature of commodities defines the type of price supports needed, such as MSP can be implemented in cereal crops while deficit payments can be implemented in certain industrial crops. Likewise, price fixation model can be continued in milk like commodities. Similarly, export subsidy could be an option for some commodities, but WTO regime does not allow it. The possible models for different commodities are discussed hereunder,

a. Cereal crops

The non-perishable and high storability nature of cereal crops allows minimum support price can be the better way for price support. It requires caution to fix minimum support price as the market price varies significantly in season. To work for farmers welfare; the MSP should be fixed according to season like India fixes for Rabi and Kharif crops differently. Likewise, Australian Wheat Board also guarantees minimum support price scheme not only for consumer and producer net surplus but for more complete welfare (Fraser, 1988). The FMTCL poses the capacity to purchase the cereal crops and has mechanism of milling and supplying to rural areas. It requires additional infrastructures and

human resources to operate the MSP throughout the country and the company should be equipped with such requirements. Additionally, the scope of company should be broadened and also mandated to seek opportunities for exporting the additional purchase if met the domestic requirements. The government should regulate the dumping of cheap products from neighboring countries. Recently enacted Safeguard, Antidumping and Countervailing Act 2076 will play a vital role in this regard (GoN, 2019).The MSP for rice in India was higher in 2019 than in Nepal; sale of Indian rice from farmers in border side is automatically checked by the price difference; and only way of distorting the market is by dumping of buffer stocks; which need to be cautiously regulated.

One study suggested that after removal of price support policy in Malaysia, by 2020, domestic rice production was estimated to be declined by 13%, net rice import was anticipated to be increased by 23% and the paddy producer price was expected to be decreased by 20% (Suleiman, Abdullah, Shamsudin, & Mohamed, 2014).

b. Pulses and oilseeds

The production of pulses and oilseed crops is at decreasing trend in Nepal. Government should implement price policy immediately for lentil and mustard to stop the further slump of production. In this aspect, MSP can be implemented in both commodities. Lentil was the one of the most promising export commodities until few years back; however, its production and export both have faced repercussion. The FMTCL can be appropriate institution to implement the support prices; with buy back provisions.

c. Sugarcane

Existing deficit payment system may be modified for easy transfer of support prices to the farmers. The local government can act as appropriate institution to implement the support prices. The federal government may determine the mill and support prices and manage necessary funds for deficit payments, while local government should become responsible for cash transfer to the farmers. It will increase the ownership and credibility of the program. In long run, such schemes should be revisited and contract farming with floor price can serve as good alternatives.

d. Tea and Coffee

Tea and coffee are the two export promising commodities of Nepal. Nepalese orthodox tea is very popular in the international markets, while Nepalese coffee is also gaining momentum in export market. The price policy of these commodities should be harmonized with

international prices. National Tea and coffee Development Board (NTCDB) is working to implement the pricing policy however is not effective so far. Long demanded tea auction center was not materialized till the date which may bring fair price in the tea sector. Likewise, instead of continuous price hike in the coffee sector inconsistent with the international price, support to increasing productivity of coffee could stabilize farmers' income. The government may design price policy with the view of protecting farmers and also maintaining the international market price.

e. Milk

Dairy Development Corporation is implementing the government policies in dairy products. The price fixation mechanism is established; and DDC purchases the milk in the fixed price. As the share of DDC is high in milk market; the DDC price serves as base price for other private dairy industries too. This mechanism is working well till date; however, as the share of private industries increases in the milk market, this mechanism could be revised appropriately. Private industries may play further by purchasing the milk in higher prices in lean season while being reluctant to purchase in flush season; thereby increasing pressure on DDC functioning. DDC may use contract purchase for the whole year in definite price set by the government.

f. Vegetables and potatoes

Price policy for vegetables is the most difficult one to implement. Due to perishable in nature; the MSP at national level cannot be implemented however, the buy back guarantee could be emphasized. The buyback mechanism for vegetables could be different than other cereals. The provincial government may act as deciding entity for minimum price fixation in their territories; most possibly Agriculture Knowledge Center (AKC) under provincial ministrymight be an appropriate institution to recommend the price. As production cost and season differs significantly amongst the province; the floor price can be fixed by respective provincial government. Such pricing policy of provincial government should be implemented by the local government. The federal government should be responsible for managing appropriate funds necessary to implement the policies and make available to respective provinces and local governments. The local government may utilize the cooperatives as service providers to purchase and sell the vegetables from farmers if they cannot sell in market price. Thus, if support price is more than prevailing market price, then only cooperatives will come into market to support the farmers. However, the price compensation will be provided by the local governments to

the cooperatives for all transactions. This hybrid model will not distort the market while protecting the farmers' welfare; however, government may need to incur additional investments each year.

CONCLUSION AND RECOMMENDATION

The objectives of the price policy should ensure increased production and profitability of the producers along with providing choices to farmers whether to produce while also taking account of the consumer price. Nepal has ample opportunities to learn from the Indian experiences and implement in the best possible way. It demands the strong institutional mechanism to implement the price support. The good coordination amongst the ministries responsible for price determination and implementation of the schemes are most essential. Involvement of many authorities in decision making creates confusion and time taking, which ultimately affects the efficacy. The recommendations for effective implementation of price policy in Nepal are as following,

- Minimum support price should be implemented for major cereal crops like rice, wheat and maize; pulse crops- lentils and oilseeds- mustard. The Food Management and Trading Company Limited should be made responsible for implementing the support price. The infrastructures like storage house, drying floors, mills and selling outlets should be strengthened and further capacitated.
- Ministry of Agriculture and Livestock Development should be responsible ministry for determining the MSP and sending proposals to cabinet for approval. A separate commission for cost and price determination of agriculture commodities can be formed to recommend to the government.
- It is recommended to bring FMTCL under the direct management of MoALD instead of Ministry of Industry commerce and supply.
- It is recommended to continue the deficit payment mechanism for sugarcane for first three years. The local government should be made responsible for implementing the price support, while federal ministry managing the required funds. However, the schemes should be revisited after third year; possibly scrapped and replaced by other support schemes.
- The Dairy Development Corporation should continue implementing the floor price schemes, which serves as minimum price for other private dairy industries too. Contract buying of milk in the fixed price for throughout the year by the DDC is further recommended to regulate milk prices.
- Buyback arrangements are important for perishable commodities like vegetables. Production cost variation because of differences in location

and season implies that such price policy should be implemented at sub-national levels. The provincial government should be responsible for fixing support price within the respective provinces' domain, while local government should implement the scheme.

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EFFECT OF BIOCHAR APPLICATION IN COMBINATION WITH DIFFERENT NUTRIENT SOURCES ON CAULIFLOWER PRODUCTION AT KASKI NEPAL

S. Timilsina,[1] A. Khanal[1], S. P. Vista[2] and T. B. Poon[3]

ABSTRACT

Field experiments were conducted during the winter season of 2016/17 and 2017/18 to assess the effect of biochar application in combination with different nutrient sources on cauliflower (Brassica oleraceae var. botrytis) productionin sandy loam soil. The experiment was conducted using a Randomized Complete Block Design (RCBD) with ten different treatment viz., Farmer's practice as control treatment, Recommended dose of fertilizer (200:120:80 kg NPK/ha), Composted biochar @ 1t/ha, Urine Soaked biochar @ 1t/ha, Mineral fertilizer (200:120:80 kg NPK/ha) mixed biochar @ 1t/ha, Humic acid soaked biochar @ 1 t/ha, Composted biochar @ 2t/ha, Urine Soaked biochar @ 2t/ha, Mineral fertilizer (200:120:80 kg NPK/ha) mixed biochar @ 2t/ha andHumic acid soaked biochar @ 2 t/ha, each replicated for three times. The application of biochar in combination with mineral fertilizers significantly increased the yields of cauliflower in both consecutive years. Application of biochar @ 2 t/ha along with mineral fertilizer at recommended dose increased curd yield of cauliflower by 37 % compared to that of only mineral fertilizer application and by 59 % compared to that of control treatment. Biochar and inorganic sources of nutrition together in soil showed superiority over other practices and would be of immense value to increase the productivity of cauliflower.

Keywords: Biochar, cauliflower, nutrient sources, yield

INTRODUCTION

Biochar is the porous carbonaceous solid produced by thermo-chemical conversion of organic materials in an oxygen limited atmosphere that has physiochemical properties suitable for the safe and long-term storage of carbon in the environment and potentially soil improvement (Hammond et al., 2011). The agricultural use of biochar has been growing and attracting more research interest globally due to its potential benefits to crop production, soil fertility and carbon sequestration. Theuse of biochar enhanced crop yields; decreased the soil acidity, increased water and nutrient holding capacity, stimulates the nutrient uptake and reduce the greenhouse gas emissions from the soil (Sohi et al., 2009 and Quayle, 2010).

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The biochar has the high surface area and porosity as compared to other soil amendments which make the soil to retain the nutrient and water and also provide habitat to the soil microorganisms (Warnock et al., 2007). Biochar produced through pyrolysis of biomass have high content of carbon and may help to improve environmental quality by reducing soil nutrient leaching losses, reducing bioavailability of environmental contaminants, sequestering carbon, reducing greenhouse gas emissions and enhancing crop productivity in degraded soils (Ippolito et al., 2012). However, the benefits of biochar are influenced by the source of raw materials used for biochar preparation, amount of biochar applied and types of soil. Soils having good structure, porosity, hydraulic conductivity, bulk density and strength provide good medium for growth to beneficial microorganisms, better nutrient and water movement into the soil profile, higher nutrient and water retention and more root growth ultimately provide higher yield as compared to degraded soil having poor physical properties (Abdallah et al., 1998).

Cauliflower (*Brassica oleracea* L. var. *botrytis*) is one of the most important and profitable vegetable crops in Nepal. The total cultivated area of cauliflower in Nepal is about 34967 ha that is 13% of the total area under vegetable crops and it has the highest share in terms of production which is 550,044.8 tons followed by cabbage i.e. 484,036.8 tons (MoAD, 2016). The crop is very responsive to soil nutrients and climatic requirements (Nath et al. 1987). The agro-climatic conditions across the country favor the production of cauliflower even in summer season with export potentiality.

Biochar can be prepared from the various organic materials such as crop residues, forest litters, twigs and animal residues. In Nepal, the agricultural and forest wastes are available in surplus amount, but farmers have practice of open burning of these wastes which resulted in loss of nutrient resources from the soil. Also, Nepalese farmers have faced problem of the unavailability of quality and sufficient quantity of fertilizers on time and poor efficiency of inorganic fertilizers which are the main limiting factor for the crop production. The conversion of the agriculture and forest waste into the biochar could be one of the viable options to prevent the loss of resources and use of biochar as soil amendment help to improve fertilizers use efficiency and could solve the problem of fertilizer unavailability to the farmers. Although several researches have been conducted on the efficiency of biochar elsewhere in the world but there is limited information available in Nepal about the efficiency of biochar to improve the productivity of soil and crops. Hence, a field experiment at Sardikhola, Kaski, Nepal (1185masl) was carried out to assess the effectiveness of biochar on cauliflower production.

MATERIALS AND METHODS

Field experiment was conducted at farmer's field of Sardikhola, Kaski (Outreach site of RARS Lumle) with 28.33^0latitude, 83.97^0 longitude and 1185 meter above sea level. Treatment combinations consisting of different nutrient sources in combination with biochar application were as follows:

Treatment- 1: Control (only FYM were used as of farmer's practice)
Treatment- 2: Recommended dose of inorganic fertilizer @ 200:120:80 kg NPK/ha
Treatment- 3: Composted biochar @ 1t/ha
Treatment- 4: Urine soaked biochar @ 1t/ha
Treatment- 5: Mineral fertilizer (200:120:80 kg NPK/ha) mixed biochar @ 1t/ha
Treatment- 6: Humicacid soaked biochar @ 1 t/ha
Treatment- 7: Composted biochar @ 2t/ha
Treatment- 8: Urine soaked biochar @ 2t/ha
Treatment- 9: Mineral fertilizer (200:120:80 kg NPK/ha) mixed biochar @ 2t/ha
Treatment- 10: Humicacid soaked biochar @ 2t/ha

The experiment was laid out in randomized complete block design (RCBD) with three replications where, each treatment received 6 m^2 plot areas with the spacing of 60 cm between rows and 50 cm within row. Snow-mysticvariety of cauliflower were grown during November to Marchin two consecutive year (2016/17 and 2017/18).The benchmark soil of experimental field was sandy loam texture having pH 5.8, organic carbon 1.7%, total nitrogen of 0.19 % and available phosphorus (P_2O_5) 142.5 kg/ha. The biochar used in the experiment were prepared from various crop residues such as maize, soyabean, banmaraetc through thermal decomposition under oxygen limited condition using Kon Tiki (Vista S.P, 2015). The humic acid (6%) used in the experiment were collected from Soil Science Division Khumaltar which was prepared from manure as well as from peat soil in laboratory and that was completely soluble in water. Cattle urine (cattle urine and water @ 1:4) was collected from cattle of experimental farm owner and used to soak biochar for one week. The mineral fertilizer was used as per the recommended dose i.e. 200:120:80 kg NPK/ha and mixed with biochar at specified rate. The composted biochar were prepared by mixing farm yard compost with biochar and composted for one week.The experiments received uniform plant protection and cultural management practices throughout the period of crop growthThe necessary data for growth, yield and yield parameter were recorded and statistically analyzed using R studio.

RESULTS AND DISCUSSION

PLANT HEIGHT

The effect of biochar in combination with different nutrient sourcrs on plant height of cauliflower at harvesting time was found insignificant in first year of

experiment 2016/17 but statistically significant in second year of experiment 2017/18. The maximum plant height (54cm) was recorded from treatment with mineral fertilizer mixed biochar @ 2t/ha followed by treatment with mineral fertilizer mixed biochar @ 1t/ha whereas the minimum was recorded33.86 cm in control treatment during 2017/18.This may be due to the fact that relatively higher availability of nutrients as influenced by biochar application in combination with mineral fertilizers results in increase in cell size,elongation and enhancement of cell division which increases plant height of plant. Schulz and Glaser, 2012 also found increased oat heights when biochar was applied with fertilizer in tropical condition of Bangladesh. Timilsina et al. (2017) also reported that biochar application had increased plant height of radish at loamy sand soil of Nawalparasi Nepal.

CURD DIAMETER

Perusal of the data in table 1 revealed maximum curd diameter of cauliflower record from the treatment with mineral fertilizer mixed biochar in both years but statistically similar with other treatments. During 2017/18 the average curd obtained from the treatment with mineral fertilizer mixed biochar @ 2t/ha was 31.5 % more in diameter over the curd obtained from control treatment but only 12 % more in diameter as compare to curd obtained from the treatment with mineral fertilizer without biochar.

Table 1: Effects of biochar application in combination with different nutrient sources on yield attributing characters of Cauliflower at SardikholaKaskiduring 2016/17 and 2017/18

Treatments	Plant Height (cm)		Curd Diameter (cm)	
	2016/17	2017/18	2016/17	2017/18
Control(Farmer's practice)	48.33	33.86 ^{d}	16.00	12.46
Recommended dose of fertilizer	58.07	37.73 ^{bcd}	15.70	16.00
Composted biochar @ 1t/ha	50.67	36.06 ^{cd}	17.60	13.87
Urine Soaked biochar @ 1t/ha	57.30	44.13 ^{b}	18.60	15.50
Mineral fertilizer mixed biochar @ 1t/ha	57.70	44.14 ^{b}	20.30	18.56
Humicacid soaked biochar @ 1 t/ha	56.06	41.53 ^{bc}	19.30	15.20
Composted biochar @ 2t/ha	50.40	41.26 ^{bc}	17.30	16.60
Urine Soaked biochar @ 2t/ha	51.00	42.40 ^{bc}	14.35	15.73
Mineral fertilizer mixed biochar @ 2t/ha	55.40	54.00 ^{a}	20.60	18.20
Humicacid soaked biochar @ 2 t/ha	48.35	43.40 ^{b}	15.30	14.73
Mean	53.43	41.85	17.53	15.78
CV%	9.6	10.04	16.35	15.17
P Value	0.11	0.01	0.14	0.13
$LSD_{0.05}$	NS	7.20	NS	NS

CURD YIELD

The observation assembled on account of curd yield of cauliflower as influenced by various treatments have been presented in Table 2 and average curd yield from two years data after pooled analysis were graphically presented in Fig. 1. It is revealed from Table 2 that the yield of cauliflower was significantly affected due to application of different treatments and application of biochar in combination with mineral fertilizers. As a result, the curd yield was significantly increased in both consecutive years. Application of mineral fertilizer mixed biochar @ 2t/ha produced the highest curd yield (44.90 t/ha) followed by mineral fertilizer mixed biochar @ 1t/ha (38.01t/ha) during the first year of experiment where asthe lowest yield (18.97 t/ha) was observed in control treatment. During 2016/17, Application of biochar @ 2 t/ha along with mineral fertilizer treatments increase curd yield of cauliflower by 23% compared to that of only mineral fertilizer application and by 59% compared to that of control treatment and show synergistic effect between biochar and mineral fertilizers. Similar trend of producing high yields by mineral fertilizer mixed biochar application were observed in second year of experiment (2017/18) where significant higher yield (43.56 t/ha) of cauliflower were recorded from the treatment with mineral fertilizer mixed biochar @ 2t/ha followed by mineral fertilizer mixed biochar @ 1t/ha as compared to rest of the treatments.

Table 2: Effects of biochar application in combination with different nutrient sources on yield of Cauliflower at Sardikhola Kaski during 2016/17 and 2017/18

Treatments	Curd Yield (t/ha)	
	2016/17	2017/18
Control(Farmer's practice)	18.97 ^{d}	17.44 ^{e}
Recommended dose of fertilizer	34.33 ^{bc}	21.17 ^{de}
Composted biochar @ 1t/ha	28.79 ^{c}	23.92 ^{cd}
Urine Soaked biochar @ 1t/ha	29.77 ^{c}	28.22 ^{c}
Mineral fertilizer mixed biochar @ 1t/ha	38.01 ^{ab}	37.22 ^{b}
Humicacid soaked biochar @ 1 t/ha	32.75 ^{bc}	23.23 ^{d}
Composted biochar @ 2t/ha	29.03 ^{c}	27.98 ^{c}
Urine Soaked biochar @ 2t/ha	31.20 ^{bc}	33.12 ^{b}
Mineral fertilizer mixed biochar @ 2t/ha	44.90 ^{a}	43.56 ^{a}
Humicacid soaked biochar @ 2 t/ha	27.53 ^{c}	22.67 ^{d}
Mean	31.53	27.85
CV%	14.18	19.30
P Value	0.001	0.00
$LSD_{0.05}$	7.67	4.44

The two years data after pooled analysis revealed that the curd yield of cauliflower was significantly influenced by application of biochar in combination with different nutrient sources. Among different ten treatments, mineral fertilizer mixed biochar @ 2t/hayield significantly higher curd yield (44.23 t/ha) followed by mineral fertilizer mixed biochar @ 1t/ha (37.62 t/ha). In contrast, the lowest yield (18.2 t/ha) was recorded from control/ farmer's practice.Results obtained from combined analysis of two years data showed that application of biochar @ 2 t/ha along with mineral fertilizer at recommended dose increased curd yield of cauliflower by 37% compared to that of only mineral fertilizer application and by 59 % compared to that of control treatment.

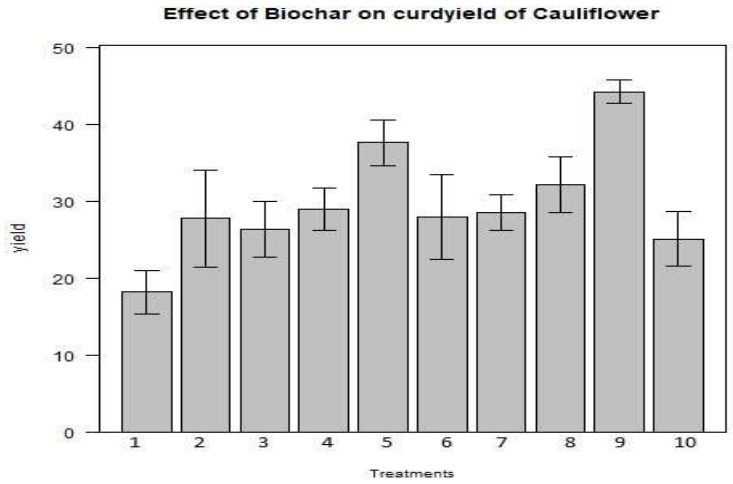

Figure 1: Two years combined effect of biochar application in combination with different nutrient sources on curd yield of Cauliflower at Sardikhola Kaski during 2016/17 and 2017/18

The biochar had capacity to increase nutrients availability in soil which increased the uptake of nutrients by plants resulting in the increase in yield of cauliflower. Chan et al., 2008 reported significant increase in radish yields from application of biochar and this increased yield was due to the biochar's ability to increase N availability to plants. Timilsina et al., 2017 also reported that biochar application had increased radish yield at loamy sand soil of Nawalparasi Nepal. Results of this experiment overall supports the fact that, biochar application was effective to increase plant height, and yield of crops.Hamdani (2017) reported highest (95%) recovery of fertilizers in wheat after application of 1% biochar in addition to 50% of the recommended fertilizer dose.

CONCLUSION

Results of study thus clearly indicated that various treatments significantly influenced the growth and yield of cauliflower. Application of biochar and inorganic sources of nutrition together showed superiority over other practices. It is found that application of mineral fertilizer mixed biochar @ 2t/ha gave maximum yield and showed superiority over other treatments for curd yield of cauliflower. It can be thus concluded that addition of biochar along with inorganic source of fertilizer to soil would be of immense value to increase soil fertility and yield of cauliflower.

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KANG KONG (*Ipomoea acquitica*): HIGH NUTRITIOUS SUMMER LEAFY VEGETABLE CROP FOR MID-HILLS OF NEPAL

S.L. Shrestha[1] and Y.K. Shrestha[2]

ABSTRACT

Kang kong (Ipomoea acquitica Forsk) is a green leafy vegetable belongs to convolvulaceae family. A varietal trial was conducted in Horticulture Research Division, Khumaltar with three cultivars; HRDKAN001 (Combodian), HRDKAN002 (Thai palungo as check cultivar) and HRDKAN003 (Bangladeshi); were collected through Hellen Kellar organization. Four weeks old seedlings of these three cultivars were planted in open field on first week of April in 2016 and 2017 consecutive years in Kathmandu valley (1300 masl) with spacing of 50 cmrow to row and 30 cm within the row distance in seven replications. Plants were fertilized with 200:150:120 kg NPK and 20 tons farm-yard manure per hectare and only neem was sprayed for controlling insects. The main objective of this experiment was to study the probability of cultivation and select suitable cultivars for green leafy vegetable during summer season when other leafy vegetables are not available. Data were recorded on vegetative growth, disease response, vegetative yield, qualitative parameter and consumer's preference. On the basis of overall characteristics, HRDKAN002 which had average consumable branch weight 18.4 g, yield 89 branches and 1620 g per plant, and 107.6 ton/ha, negligible insect pest and disease damage, higher; benefit cost ratio (3.13), iron (30 mg/100g), phosphorus (616 mg/100 g) and calcium (300 mg) content as compared to broad leaf mustard and superior taste, environmentally sound followed by HRDKAN003 were selected and recommended for cultivation in mid-hills of Nepal like Kathmandu valley and similar agro-ecological condition.

Keywords; Kangkong, leafy summer vegetable, Thai palungo, taste, yield

INTRODUCTION

Kang kong (*Ipomoea aquatica* Forsk.) which is also called water spinach is an important member of the Convolvulaceae family and it is supposed to be originated in China (Edie and Ho, 1969; Payne, 1956; Synder et al., 1981). *Ipomoea aquatica* Forsk., a commonly grown green leafy vegetable is a rich source of vitamins, minerals, proteins, fibers, carotenes and flavonoids with many health benefits (Prasad et al., 2018). It is native to Asia, Africa and south western Pacific Islands. Botanists are unsure where Kang kong originated, but it likely came from somewhere in eastern India to

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Southeast Asia. It was first documented in 304 A.D. with the Chin Dynasty in China. Currently it is found throughout tropical and subtropical regions around the world but is a common ingredient in Southeast Asian countries (Hai, 2015).

It is an herbaceous aquatic or semi-aquatic perennial plant of the tropics or subtropics. Since at least 300 A.D., it is used as a medicinal vegetable. In Southeast Asian medicine it is used against piles, and nosebleeds, as an anthelmintic, and to treat high blood pressure (Wart, 2018). Since 200 B.C. people started to cultivate it. With the arrival of Europeans in the late 1400s, they are aware about its medicinal uses and started carry around the entire world. It can be grown throughout the year if winter is not extreme. Water spinach has no relationship with common spinach but is closely related to sweet potato (*Ipomea batatas*) (www.plants.usda.gov, 2015).

It has different names according to language and dialect. Water convolvulus, Kang kong and Swamp cabbage are some alternative names in English. It is known in Mandarin as kongxincai (empty heart/stem vegetable), ongtsoi and wengcai (pitcher vegetable) in Cantonese, kangkong in Filipino and Malasian and in Japanese as Asagaona (morning glory leaf vegetable). In India it is locally known as "Karmatta Bhaji", "karmsagh" or "Kalmi Bhaji" (http://en.wikipedia.org/wiki/Ipomoea_aquatica, 2007).

It is grown year-round in the tropics. Flowering occurs under short-day conditions and commences from mid-summer onwards. It becomes perennial in warm climates, but an annual under cooler growing conditions. It tolerates very high rainfall, but not frost (www. http://agriculture.vic.gov.au/agriculture/horticulture/vegetables). It prefers full sun but where summer temperature is more than 100 ^{0}F, it is sometimes grown as a ground cover beneath climbing plants. It has long, jointed and hollow stems, which allow the vines to float on water or creep across muddy ground. Adventitious roots are formed at nodes which are in contact with water or moist soil (Packenpaugh, 2004).

Its stems are 2–3 meters (7–10 ft) or more long, rooting at the nodes, and they are hollow and can float. Narrow leaves are 1-2.5 cm wide and 20-30 cm long (http://agriculture.vic.gov.au/agriculture/horticulture/vegetables/vegetables-a-z/growing-water-spinach-kangkong). The leaves vary from typically sagittate (arrowhead-shaped) to lanceolate. Broad leaves are up to 5 cm wide and 15-25 cm long (Rubatzky, 1990). It has long, jointed and hollow stems, which allow the vines to float on water or creep across muddy ground (http://agriculture.vic.gov.au/agriculture/horticulture/vegetables/vegetables-a-z/growing-water-spinach-kangkong). In cool to cold locations, it can be grown as an annual or as a greenhouse plant. It grows so fast and easily, and tastes so good. Adventitious roots are formed at nodes which are in contact

with water or moist soil. The flowers are trumpet-shaped, 3–5 cm (1–2 in) in diameter, and usually white in colour with a mauve centre. The White type Kang kong is characterized as plants with green/white stems, green leaves with green/white petioles, and white flowers. (Cornelius et al., 1985).

Propagation is either by planting cuttings of the stem shoots that will root along nodes or planting the seeds from flowers that produce seed pods. It is not adapted to climates with mean temperatures below 10° C and the optimal temperature is around 20°C – 30°C (Gruben and Denton, 2004). Kang kong possess various amounts of Vitamin A, Vitamin C, Vitamin B, phosphorus, fiber, iron, amino acids, selenium and calcium (Umar et al., 2007). With these nutrients Swamp Cabbage provides massive health benefits. Practically all parts of the young plant are edible, although the shoot tips and younger leaves are preferred (https://www.nutrition-and-you.com/kangkong.html). The young terminal shoots and leaves of *I. aquatica* are eaten as green leafy vegetable and in salads (Ismail et al., 2004) and as fodder (Phimmasan et al., 2004).

The main objective of this study was to select suitable Kang kong cultivars in mid-hills especially Kathmandu valley condition for green leafy vegetables throughout the year except cold months.

METHODOLOGY

Four-week-old Kang kong seedlings of three cultivars; HRDKANOO1 (Combodian), HRDKAN002 (Thai Palungo) and HRDKAN003 (Bangladeshi) cultivars were transplanted in first week of May 2016 and 2017 at Horticulture Research Division, Khumaltar on open field condition. The experiment was laid out in randomized complete block design with seven replications with 50X30 cm row to row and plant to plant distance. Plants were grown with fertilizers 200:150:100 kg NPK and 20 tons compost per hectare during summer season. Pesticide (Nimbicidin) was sprayed as necessary to save plants from leaf damaging insects and copper oxychloride fungicide was sprayed one time at near to last harvesting stage to save from cercospora leaf spot disease. Hence, pesticide was used as organic production. Green soft branches were harvested frequently as new auxiliary branches grew with appropriate length. Plants of each cultivar were visually observed during their growth period for vegetative parameter, plant uniformity, plant vigor, plant height, insect pest and disease infection. Likewise, branch parameters; leaf characteristics, leaf quality, maturity and leaf yield in number and weight were recorded. Consumers' response was recorded on its plant appearance, taste and its tenderness in 1(unacceptable) to 5 (excellent) scales where taste was recorded after just after boiled.

Plant uniformity and vigor was recorded visually in 1 to 5 scale at the time of first harvest (35 DAT) where uniformity; unacceptable (1) to excellent (5) scale and vigor; poor (1) to vigorous (5) scale. As insect and disease scoring was done at the time of its symptom appeared in plant that was after 90 days (later stage) in 1 (noany symptom) to 9 (dead) scale. Calcium, Phosphorus and iron content was analysed by following the analytical method mentioned by Ranganna (1986) where Calcium content was analyzed with ward and Johnston (1962) protocol by precipitating calcium oxalate and the precipitate was dissolved in hot dilute H_2SO_4 and titrated with standard potassium permanganate and used the formula:

$$\text{Calcium (mg/100 g)} = \frac{\text{Titre x Normality of KMnO4 x 20 x total volume of ash solution x 100}}{\text{ml of ash solution taken for estimation x wt. of the sample taken for ashing}}$$

Phosphorus content was analyzed with King (1932) protocol where Phosphorus was reacted with molybdic acid to form a phosphomolybdate complex and then reduced with aminonaphtholsulphonic acid to the complex molybdenum blue which was measured colorimetrically following the formula:

Phosphorus mg per 100 g

$$= \frac{\text{mg of P in the aliquot of ash solution taken for estimation x total volume of ash solution x 100}}{\text{ml of ash solution taken for estimation x wt. of sample taken for ashing}}$$

Likewise, iron was determined by converting the iron to ferric form using oxidizing agents like potassium persulphate or hydrogen peroxide and treating thereafter with potassium thiocyanate to form the red ferric thiocyanate which was measured colorimetrically at 480 nm[1] by following the formula:

$$\text{Iron (mg/100 mg)} = \frac{\text{OD of sample x 0.1x total volume of ash solution x 100}}{\text{OD of standard x 5 x wt. of sample taken for ashing}}$$

Seedlings were prepared by sowing the seeds in plastic plug tray and it took 30 days to make ready for transplanting. Seeds were sown one in each hole of the tray. Around 150 gm seed is required per 500 m^2 area. Benefit cost ratio was calculated by following formula,

$$\text{Benefit cost ratio} = \frac{\text{Total income –Total expenditure}}{\text{Total expenditure}}$$

RESULTS AND DISCUSSION

VEGETATIVE CHARACTERS

Plant vigor ranged from 4.3 to 4.6 scores where cv. Thai spinach showed the maximum plant uniformity. As far as plant vigor is concerned, all the cultivars were vigorous (>4.0) where Thai spinach was most vigorous (4.7). All the cultivars produced numerous branches and in first year, HRDKAN003 had

significantly higher number of branches (9.4) and also the maximum number in 2017 (10.2) followed by HRDKAN002 (9.3). The tallest plant height (63.3 cm) was attained by HRDKAN002 followed by HRDKAN003 (59 cm) at the time of first harvest (35 DAT) (Table 1). In consequent harvesting time; cv. HRDKAN002 had fastest growth in the length of harvested branches. The growth of the plant was the highest in 2017. It grows so fast and easily.

Table 1: Vegetative characters of three Kang kong cultivars at Khumaltar in 2016 and 2017

Cultivar	Plant uniformity[x]			Plant vigor[y]			Branches/plant (no.) DAT			Plant height (cm) Before 1st harv		
	2016	2017	Mean	2016	2017	Mean	2016	2017	mean	2016	2017	Mean
HRDKAN 001	4.4	4.3	4.3	4.0	4.5	4.3	7.9	8.3	8.1	66.8	48.5	57.6
HRDKAN 002	4.4	4.8	4.6	4.4.	5.0	4.7	7.9	10.7	9.3	71.2	56.0	63.6
HRDKAN 003	4.4	4.3	4.3	4.4	4.7	4.6	9.4	10.9	10.2	70.8	47.3	59.0
CV%	16.8	13.5	4.6	16.8	10.71	2.4	12.61	21.58	9.25	9.32	23.39	4.93
F-test (0.05)	Ns	ns	Ns	ns	Ns	Ns	*	ns	ns	ns	ns	Ns
LSD (0.05)	0.84			1.04			1.57			9.45		

[x]Plant uniformity; 1: unacceptable, 5: excellent [y] Plant vigor; 1: poor, 5: vigorous

Leaf length was significantly varied among the cultivars in both the years. HRDKAN003 had broad leaf and HRDKAN001 had lanceolate leaf where as HRDKAN002 had in between them. The longest leaf length (20.5 cm) was obtained in cv. HRDKAN001 (20.5 cm) followed by HRDKAN002 (20.4 cm) whereas the wider leaf was noticed in HRDKAN003 (7.1 cm) followed by HRDKAN002 (6.6 cm) (https://ndb.nal.usda.gov/). In 2016, leaf width of HRDKAN003 was significantly wider (Table 2).

HRDKAN001 HRDKAN002 HRDKAN003

Fig 1. Branch and leaf of HRDKAN001, HRDKAN002 and HRDKAN003.

Hence, leaves are varied in shape depending on variety, from heart-shaped to long, narrow and arrow-shaped. Sharma (1994) had also mentioned the highly variable leaf shape.

HRDKAN002 had the shortest inter node length (6.2 cm). It has reflected on harvested branch length that the shortest harvested branch length (42.6 cm) was obtained in this cultivar. This result is similar to Chauhan (2016) who recorded internodes length ranged from 4.71 cm (IGWS-21) to 8.06 cm (IGWS-1). He also reported that the leaf length ranged from 5.58 (IGWS-17) to 10.69 (IGWS-2) and from small to medium size group. Leaf width ranged from 1.69 cm (IGWS-23) to 5.90 cm (IGWS-2). Similar result was obtained that ranged from 2.5 to 8.0 cm in breadth. As harvesting was 6-7 times, total length becomes 255 cm to 295 cm. This result also supports to Rubatzky, (1990) who has recorded up to 3 m length. Likewise, wikipedia.org. (2007) mentioned that, Kang kong leaves are alternate, simple, arrow simple, arrowhead shaped-lanceolate, and very variable in size from about 5-15 cm (2-6 inches) long and 2-8 cm (0.8-3 inches) broad. It is near to this result.The flowers are trumpet shaped, white and 3-5 cm (1-2 inches) in diameter maturing into oval or spherical, woody fruit 1 cm (1/2 inches) wide containing 1 to 4 grayish seeds.

Table 2: Vegetative characters of three Kangkong cultivars at Khumaltar in 2016 and 2017

Cultivar	Leaf length (cm)			Leaf width (cm)			Internode length (cm)	Av. harvested branch length (cm)	Nodes/ branch (No.)
	2016	2017	mean	2016	2017	mean	2017	2017	2017
HRDKAN001	21.8	19.2	20.5	5.6	6.5	6.1	7.2	48.8	6.2
HRDKAN002	23.8	17.1	20.4	5.5	7.8	6.6	6.2	42.6	6.8
HRDKAN003	18.6	16.4	17.5	7.2	7.0	7.1	7.3	44.6	6.8
CV%	5.12	7.28	9.04	14.0	14.08	13.42	18.62	14.6	13.75
F-test (0.05)	**	**	*	*	ns	ns	ns	ns	Ns
LSD (0.05)	1.598	1.693	1.64	1.242					

YIELD ATTRIBUTING CHARACTERISTICS

Noany disease was observed at the early stage up to 90 DAT (Table 3) but in later stage it was little bit higher in HRDKAN003 in first year. Insect damage was very little and was only by leaf eating caterpillar. Likewise, in disease, only the cercospora leaf spot was noticed in both the years, but it was negligible and do not have effect on market ability.

Number of harvested branches per plant was highest in HRDKANOO3 (91.2) followed by HRDKAN002 (89) however in first year, HRDKAN002 had higher number of harvested branches (95.3) (Table 3) but average weight of the individual branch was higher in HRDKAN001 (19.5 g). Likewise, harvested average branches yield per plant was recorded highest in HRDKAN002 (1620 g) followed by HRDKAN003 (1568 g) and HRDKAN001 (1529 g) respectively. In both the years, HRDKAN002 gave highest branch yield (g/plant) (Table 4). As far as harvested branches yield (ton/ha) is concerned, HRDKAN002 produced the highest consumable branches yield (107.60 Dton/ha) and HRDKAN001 gave the lowest yield (102.62 ton/ha) where HRDKAN002 gave superior yield in both the years (Table 3). It supports the statement of Yamaguchi (1990) that kang kong is easy to grow, has a high yield and considered nutritious.

Table 3: Yield attributing characters of three Kang kong cultivars at Khumaltar in 2016 and 2017

Cultivar	Insect damage (1-9)	Cercospora leaf spot (1-9)			Branch yield (ton/ha)			Branch yield (no./plant)		
	2017	2016	2017	mean	2016	2017	mean	2016	2017	mean
HRDKAN001	3.2	3.2	2.7	2.9	103.74	98.516	102.62	86.4	71.6	79.0
HRDKAN002	3.0	3.2	3.0	3.1	107.64	107.568	107.60	95.3	82.8	89.0
HRDKAN003	2.3	3.4	2.7	3.1	102.75	104.527	103.63	92.7	89.7	91.2
CV%	30.9	19.36	20.12	5.87	6.88	15.59	15.59	13.06	12.23	5.12
F-test (0.05)	Ns	ns	ns	ns	Ns	ns	ns	ns	*	ns
LSD (0.05)									12.80	

Table 4. Yield attributing characters of three Kang kong cultivars at Khumaltar in 2016 and 2017

Cultivar	Nodes/harvested branch (no.)	Branch yield (g/plant)			Av.branch wt.(g)		
	2017	**2016**	**2017**	**mean**	**2016**	**2017**	**mean**
HRDKAN001	6.2	1556	1502	1529	18.2	20.9	19.5
HRDKAN002	6.8	1615	1626	1620	17.2	19.6	18.4
HRDKAN003	6.8	1541	1595	1568	17.2	17.8	17.5
CV%	13.75	6.88	15.51	2.44	11.03	9.14	4.35
F-test (0.05)	ns	ns	Ns	ns	Ns	*	ns
LSD (0.05)						2.28	

MORPHOLOGICAL CHARACTERISTICS

All the three tested cultivars had spreading type of growth habit and color of vine and matured leaf color is green. Petiole length is also short. But internode length was medium (HRDKAN002) to long. Likewise, leaf outline of HRDKAN003 was ovobate that is different from other two tested lines having

triangular shape leaf. Leaf size is varied from small size (HRDKAN001) to big size (HRDKAN003) (Table 5). Chauhan (2016) from Indiragandhi Krishi Viswovidyalaya Raipur, India had collected twenty-five indigenous genotypes of water spinach and found variation in morphological characters among the genotypes.

Table 5. Morphological characterization of three Kang kong genotypes

Characters	HRDKAN001	HRDKAN002	HRDKAN003
Plant type	Spreading	Spreading	Spreading
Inter node length	long	Medium	Long
Vine colour	green	Green	Green
Leaf outline	Triangular	Triangular	Ovobate
Type of leaf lobes	No lateral lobes	No lateral lobes	No lateral lobes
No. of leaf lobes	1	1	1
Mature leaf size	small	Medium	Big
Mature leaf colour	green	Green	Green
Petiole length	Very short	Very short	Very short

QUALITY PARAMETER

Consumer's response showed that HRDKAN002 had been selected due to its very good in appearance, taste and good in tenderness. Even though HRDKAN003 had excellent appearance and tenderness, taste of HRDKAN002 was preferred by consumers. As far as quality content is concerned, HRDKAN002 had the highest crude fiber (18.5%) content. But, HRDKAN001 had the highest total ash percent (16.62), iron (57.7 mg/100g) and calcium; 1334 mg/100 g. However, HRDKAN003 had higher phosphorus content (679 mg/100 g). All the nutrient content i.e. total ash, crude fiber %, iron, phosphorus and calcium were found higher in kangkong as compared to broad leaf mustard (Table 6) except Nepalese taste. Hence, leaves of Kangkong are very nutritious, being rich in vitamins and minerals. Lin *et al*. (2009) has also mentioned medium calcium and iron content in Kang kong leaf. The most important fact is that there are many winter leafy vegetable crops; broad leaf mustard, cress, spinach, mustard for winter season consumption but these crops give flower and become not consumable during spring and summer season but Kangkong is a spring and summer season crop and consumable from March to November until temperature not goes down below 10 ^{0}C.

Table 6. Consumers' response and quality content of three kang kong cultivars at Khumaltar in 2016 and 2017

Cultivar	Consumers response (1-5)			Quality content				
	Appearance	Taste	Tenderness	Total ash (%)	Crude fiber (%)	Iron (mg/100g)	Phos-phorus (mg/100g)	Calcium (mg/100g)
HRDKAN001	Good	Good	Good	16.62	14.43	57.70	528.03	1334.3
HRDKAN002	Very good	Very good	Good	14.83	18.50	30.01	616.12	300.58
HRDKAN003	Excellent	good	V. good	14.86	14.70	53.71	678.96	718.40
Mean				15.44	15.88	47.14	607.7	784.43
BLM*				13.24	9.33	17.32	390.13	242.07

1: unacceptable, 2: fair, 3: good, 4: very good, 5: excellent. * Broad leaf mustard

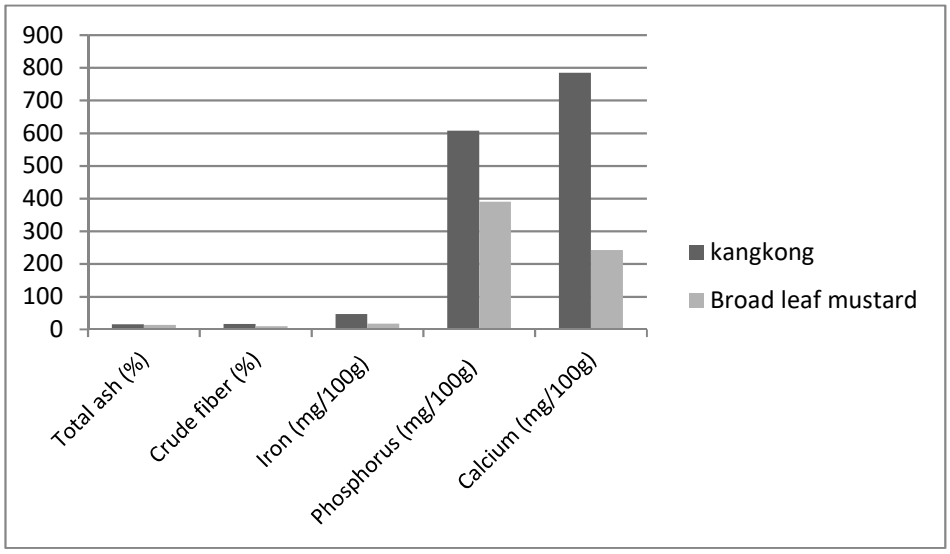

Figure 2: Quality content of kangkong and broad leaf mustard

ECONOMICAL PARAMETER

All the three cultivars had same cost of cultivation in Kathmandu valley condition. It was recorded NRs. 26225 in 500 m^2 land and on their productivity basis it comes NRs 107604.00 income per 500 m^2 land and becomes NRs 81379.00 from HRDKAN002 and benefit cost ratio equivalent to 3.13. Hence, Kangkong cultivation is beneficial vegetable crop from income generation and nutritional security perspective.

Table 7. Economic benefit from three Kang kong cultivars at Khumaltar 2016 in 2017 (in 500 m^2 land)

Cultivar	Cost of cultivation (Rs./ropani)	Production /ropani (kg)	Selling rate (Rs./kg)	Income (Rs.)	Net benefit (Rs.)	Benefit cost ratio
HRDKAN001	26225	5056	20.0	101128	74903	2.86
HRDKAN002	26225	5380	20.0	107604	81379	3.13
HRDKAN003	26225	5182	20.0	103638	77413	2.95

CONCLUSION

On the basis of overall characteristics, HRDKAN002 (Thai palungo) which had average consumable branch weight 18.4 g, yield 89 branches and 1620 g per plant, and 107.64 ton/ha, negligible insect pest and disease damage superior taste and higher benefit cost ratio (3.13) followed by HRDKAN003 was selected and recommended for cultivation in Kathmandu valley and similar agroecological condition of Nepal.

Kang kong can be easily grown during summer and rainy season without use of chemical pesticide. But most of the other leafy vegetables cannot be grown easily during this season commercially without chemical pesticide. Hence, it is an environment friendly and economically viable vegetable crop.

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DISASTER LOSS ASSESSMENT ON AGRICULTURE SECTOR IN NEPAL

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ABSTRACT

A study to document the impact of disaster on agriculture sector was carried out by using the secondary source of information. Five years data (2015 to 2019 A.D.) related to the loss of crop, livestock and fisheries due to disaster were taken for the study purpose. Study was also focused to overview institutional, legal and organizational setup in Nepal, established to deal with the natural disaster. Simple bar diagram was used to compare the financial loss in agriculture sector due to occurrence of disaster.The decrease on AGDP (Agriculture Gross Domestic Product) was calculated. Data revealed that the total financial loss during the five years period in agriculture sector, accounting crops, livestock and fisheries, was more than NPR 42.57 billion. Average annual financial loss was found to be NPR 8.5 billion. The crop loss was highest in 2015 while in 2017 livestock sector suffered the most. The average loss was estimated to be about 1.2 percent of AGDP in five years period while in the year 2017 and 2015 the loss was about 2.3 percent of AGDP, signifying a considerable loss from disaster. Integration of disaster risk reduction into the planning and programming process and establishment of early warning system and making ease access of agriculture insurance in harmony with the sub-nationals government is indispensable in Nepal to protect the agriculture sector and farm families.

Keywords: Agriculture, disaster, livelihood, sub-national government

INTRODUCTION

Nepal is a hotspot for geophysical and climatic hazards. It stands at the top 20th list of most multi-hazard prone countries in the world. In a global comparison, Nepal ranks 4th in terms of the impact of climate change, 11th in terms of risk of earthquake occurrence and impact, and 30th in terms of flood occurrence and impact (UNDRR, 2019). Furthermore, about 80 percent of the total population of Nepal is risk form natural hazards (MoHA, 2017). Its geographical structure, rugged topography, high reef, active tectonic process and intense monsoon rain has made this fragile land and environment vulnerable to various types of disaster. According to UNDP (2008) natural disaster risk is believed to be increasing very rapidly in Nepal due to growth

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of population, lack of a favorable policy and legal environment commensurate with the present-day situation, needs, opportunities and resource availability.

FAO (2017a) states that agriculture sector absorbs 23 percent of the total damage and losses in developing countries. Further, flood, drought and other climatologically disasters along with disease pest have 37%, 19% and 44 % respective contributions to the loss on agriculture and livestock production.

According to MoHA (2017), disaster erodes about two percent of national GDP annually. A devastating earthquake of April 2015 alone made NPR 25.5 billion loss in agriculture, with maximum losses (86%) in mountains and hills of central, eastern and western regions (Gauchan et al.,2017)). Majority of the farmers being marginal and having less capacity to adapt are the people to suffer the most. The disaster dramatically increases threat to food security, particularly for subsistence farmers and their vulnerable families. The main objective was to study the impact of natural disaster in agriculture sector in Nepal.

METHODOLOGY

Secondary source of information was used in assessing the impact of natural disaster in agriculture sector of Nepal. Information was mostly collected from the publication of Ministry of Home Affairs, National Planning commission and Food and Agriculture Organization. The loss data used in this study were obtained from the official web portal of Sendai framework for disaster risk reduction and Ministry of Agriculture and Livestock Development. Simple bar diagram was used to observe the trend of loss pattern in agriculture sector. Due to the lack of information, only the five years data were taken into consideration for the study purpose. Regarding the crop entity, the data includes the loss of paddy and maize in the given year.

RESULTS AND DISCUSSION

DISASTER STATUS IN NEPAL

Nepal, exposed to multitude of hazards is among the most vulnerable countries in the world for disaster. According to MoHA (2019 b) the country is at risk of number of geological, hydro-meteorological along with the other human induced hazards and 6 thousands 3 hundred and 81 various disaster have been occurred within a period of 2017 to 2018. Floods and landslides are the most frequently recurring hazards, and floods are the source of the greatest economic loss and highest casualty rate (WB, 2012).

Table 1: Types of Natural and Human-Induced Hazards in Nepal

S.N.	Types of Hazard	Prevalence
A	**Natural Hazards**	
1	Earthquake	All of Nepal is a high-hazard earthquake zone
2	Flood	Terai (sheet flood), Middle Hills
3	Landslide and landslide dam breaks	Hills, Mountains
4	Debris Flow	Hills and Mountain, severe in areas of elevations greater than 1700 m that are covered by glacial deposits of previous ice age
5	Glacier Lakes Outburst Floods (GLOF)	Origin at the tongue of glaciers in Higher Himalayas, Higher Mountains, flow reach down to middle Hill regions
6	Avalanche	Higher Himalayas
7	Fire (forest)	Hills and Terai (forest belt at foot of southern-most Hills)
8	Drought	All over the country
9	Windstorms	All over the country
10	Lightening	All over the country
11	Hailstorm	Hills
B	**Human-Induced Hazards**	
1	Epidemics	Terai and Hills, also in lower parts of Mountain region
2	Fire (settlements)	Mostly in Terai, also in mid-Hill region
3	Road Accidents	Urban areas, along road network
4	Industrial/Technological Hazards	Urban / industrial areas
5	Soil erosion	Hills
6	Social Disruptions	Follows disaster-affected areas and politically disturbed areas

Source: Nepal Country Report: ISDR Global Assessment Report on Poverty and Disaster Risk 2009.

As per the table above (Table 1) earthquake, fire, drought, windstorm and lightening disaster is prevalence all over the country. Flood and fire hazard is mostly observed in terai and mid hills of Nepal. In the hill and mountains landslides, debris flow and Glacier Lake Outburst Floods (GLOF) are the major disaster. Hailstorm and soil erosion are experienced as major hurdles in the Hills of Nepal. Similarly, Kafle (2017a) has identified flood, landslides, earthquake, epidemic, GLOF, avalanche, fire as the key hazards of Nepal.

EFFECT OF MAJOR NATURAL DISASTER IN AGRICULTURE

Drought

FAO (2017b) states that drought affects a significant proportion of the global population and it has consequences of reversing gains in food security and poverty reduction, hampering efforts to reach SDG 1 and 2. Change in magnitude and frequency of droughts will have severe impacts on agriculture, especially crop production, cropping system and livestock (Karl et al., 2009). According to MoHA (2018) every year drought impacts agriculture, environment and ecosystem negatively in the Terai and Western hills of Nepal and it has been identified as the most hazardous for agriculture. The droughts happened in 1972 and 1979 were the most seriously damaging and harmful to the people, livestock and crops and that of 1994 was the worst drought in its history that affected 35 districts of western hilly and terai regions (NDRRP, 2019). Similarly, there was severe decline in food production all over the country due to lack of rainfall in the winter of 2008 and production of wheat and 14 and 17 percent, respectively.

Flood

Monsoon carries more than 70 percent of South Asia annual precipitation in a brief of four-month period. A good monsoon brings strong harvests and financial security, but a poorly timed monsoon, can result in human suffering and economic loss due to either flooding or drought (WB, 2012). According to FAO (2017b), total share of flood to damage and loss in agriculture about 17% of the total loss. The largest recorded impact over the past decade was caused by the Myanmar floods in July and August 2015, amounting to USD 240 million in subsector damage and loss. Nepal is also extremely vulnerable to water-related hazards. Nepal's hydrology is highly variable, with the monsoon bringing 80 percent of Nepal's rainfall in less than three months during the summer (WB, 2012). The flood water has wiped out 79.8 million USD worth of crops, as the massive floods inundated huge tracts of land in 31 districts of Nepal (Upreti, 2018). According to MoHA (2018), 42,995 hectares of agriculture land had been affected by heavy rainfall, landslides and flood in various years. Furthermore, this has damaged the irrigation system and rural roads and other physical infrastructure.

Earthquake

Although the frequency of earthquakes, in Nepal is low, it has affected the maximum number of people and has destroyed the country's economy among all disasters that occurred between 1990 and 2015 (Kafle, 2017b). Earthquake has a significant effect on the agriculture production system. As per the Post Disaster Need Assessment Team (PDNA), the devastating 2015 earthquake in Nepal destroyed stockpile of stored grains and devastate the livestock sector

NPC (2015). The loss of over 17000 cattle and about 40000 smaller domesticated animals has resulted in the downward revision of the projected growth in agriculture from 2.2 to 1.8 percent. The total effect of the disaster in agriculture was NPR 28,366 million.

Landslides

Landslide is one of the very common natural hazards in the hilly region of Nepal. Natural and human factors such as steep slopes, fragile geology, high intensity of rainfall, deforestation, unplanned human settlements are the major causes of landslide (Dahal, 2012). In between 1971 to 2015, Nepal hasto bear more than 2000 landslides and this has destroyed irrigation system, roads, bridges and other infrastructure, causing great economic loss.

Hailstorm and Windstorm

Hailstorm is another most critical factor causing crop damage. Thunderstorms usually occur during the monsoon season; and hailstorms at the beginning and end of the monsoon season, causing potential damage to property and crops and increasing vulnerability to food insecurity, for instance (MoHA & DPNet-Nepal, 2015).

EXISTING POLICIES AND INSTITUTIONAL FRAMEWORK FOR THE DISASTER RISK MANAGEMENT IN NEPAL

Government of Nepal has promulgated various acts, regulation, policies, standard, action framework and codes related to the management of natural disaster. For the first time the Constitution of Nepal (2015) has spelled out in its Directive Principles, Policies and Obligations of the State (Clause 51) about disaster management as to make advance warning, preparedness, rescue, relief and rehabilitation in order to mitigate risks from natural disasters. It has identified disaster management as one of the key priorities of all tiers of government in the list of concurrent powers of federal, provincial and local levels. Disaster management is enlisted as sole responsibility of local level and shared responsibilities of three level of government in schedule-8 and 9 of the constitution respectively.

In Nepal, disaster management is focused mainly on early preparedness, rescue, relief and rehabilitation. The Local Government Operation Act (LGOA) 2017, which has replaced Local Self Governance Act (LSGA) 1999, empowers local bodies to govern themselves. It recognizes that local people and local bodies as the most appropriate points of entry to meet the disaster management needs at the local level.

1. *Legislative provisions for disaster risk management*

   Soil and Watershed Conservation Act 1982; Water Resource Act 1992; The Forest Act 1993; National Building Code 1994; National Building

code act 2004; Prime Minister Relief Fund Regulation 2007; Local Government Operation Act 2017; Disaster Risk Reduction and Management Act 2017 and Environment Protection Act 2019 are the major legal arrangements dealing with the disaster risk management in Nepal.

2. *Policies promulgated for the disaster risk management*

Various policy are been promulgated for the disaster risk management.Agriculture Policy 2004; Forestry Sector Policy, 2000; Water Resources Strategy 2002; National Water Plan 2005; Water Induced Disaster Management Policy 2006, Sendai Framework for Disaster Risk Reduction 2015-2030; National Climate Change Policy 2011, National Framework on Local Adaptation Plan of Action (LAPA), 2011; The National Disaster Response Framework, 2013; Local Disaster Risk Management Planning Guidelines (LDRMP) 2012; National Strategic Action Plan on Search and Rescue 2013 and National policy for disaster risk reduction 2018 are the major policy approved and enacted. In periodic plan Disaster Management was first included in the 10th plan (2002-2007) and the emphasis has gone to ascending order. Realizing the importance, in the fifteenth periodic plan of Nepal disaster risk reduction and management strategies have been mentioned on separate chapter (NPC, 2020).

3. *Institutional and Organizational Structure*

The Disaster Risk Reduction and Management Act 2017 has provisioned National Council for Disaster Risk Reduction and Management (NRRM) led by the prime minister as the apex body for the policy guidance on DRRM issue. The Executive Committee (EC) led by the Home Minister is provisioned for executive functions. The National Disaster Risk Reduction and Management Authority (NDRMA) is envisioned to function on behalf both the council and EC.

At the provincial level, there is provision of Province DRRM Council and Province DM committee. There is provision of District Disaster Management Committee (DDMC) in the leadership of Chief District officer, whose mandate is to coordinate and cooperate with respective Province and local government. In each local level disaster management committee has been established. The local governments are mandated to take both the sole responsibilities and concurrent responsibilities to DRRM in their territory (MoHA, 2019 a).

Ministry of Home Affair is the focal ministry for the overall disaster management and risk reduction in Nepal. In province level, Ministry of Internal Affairs and Law has been mandate to function as nodal ministry for DRRM. Under the MoHA, 77 district disaster management

committee, (formerly District Disaster Relief Committee) which has been chaired by Chief District Officer are directly involved in disaster management. Besides, there are various organizations within and outside the government that have been working in the sector (NPC, 2020). These organization help the victims get relief at the time of disaster, though their effort seems inadequate. Recently, the government of Nepal has established National Disaster Risk Reduction and Management Authority which is supposed to act as the central authority in the disaster management.

INSTITUTIONAL SET UP FOR THE DISASTER MANAGEMENT IN AGRICULTURE SECTOR

Federal Ministry of Agriculture and Livestock Development is the leading organization to deal with the disaster management in agriculture in the country. Among the 11clusters identified by the Disaster Preparedness Response Plan (2019), MoALD is the leading organization for the food security cluster. Agriculture loan, Insurance and Disaster Management section under the Agriculture and Livestock Business Promotion Division is the focal section to coordinate, plan and prepare the disaster related programs and policies. In the provincial level, agriculture biodiversity and climate change section has been assigned to look after this subject. At local level, the agriculture section has the sole responsibility to deal with the entire agriculture related tasks including disaster.

Although, institution is set up in all three tiers of government, the flow of information is poor. Due to this poor linkage mechanism among the sub-national government, collecting and sharing information regarding the impact of disaster on agriculture and its timely management is obstructed. Lack of manpower in one hand and the apathy of decision makers in this issue on the other hand is further exacerbating the situation. Some risk management strategies like insurance scheme, early forecast and warning of the weather is established but its coverage is limited.

Damage and losses caused by Disaster in Nepal

According to ADB (2019) Nepal has to suffer a huge amount of financial and economic loss annually. The following table (Table 2) shows the damage and losses caused by disaster in Nepal in various years. The table also depicts the loss amount proportion to GDP.

Table 2: Damage and losses caused by Disaster in Nepal (2008- 2017 A.D.)

Year	Damages and Losses (NRs million)	Proportion of GDP (%)
2008	3,774	0.39
2009	947	0.10
2010	1,789	0.15
2011	1,452	0.11
2012	1,294	0.08
2013	192	0.01
2014	15,143	0.77
2015	706,893	33.19
2016	432	0.02
2017	60,717	2.34.

Source: Asian Development Bank, 2019

From the table above we can see the fact that there is considerable setback in the national GDP due to disaster in every year. In the year 2015 the loss was highest and seen as 33 percent of GDP.

Loss pattern of agriculture crops and livestock from 2015 -2019 A.D. in Nepal

Annually, from both natural and human induced hazards the agriculture sector too has to suffer a lot. Increased frequency of natural hazards makes the already –fragile farming and livestock sector all the more vulnerable to losses (ADB, 2019). Due to this, many farmers have to suffer from both physical and economic crisis. Many remote farming communities are left completely devastated with the series of disaster. The disaster not only have direct impact on crop and livestock but also dismantle the infrastructure like farm shed, irrigation cannel etc. making the management cost higher.

Due to the dearth of data on various sub sectors, the total financial loss in agriculture sector was carried out in terms of loss in Crops, livestock and fisheries. It does not include the loss in infrastructure, machinery and other fixed assets. Figure 1; presented below shows the total financial loss in agriculture sector due to the disasters in given year.

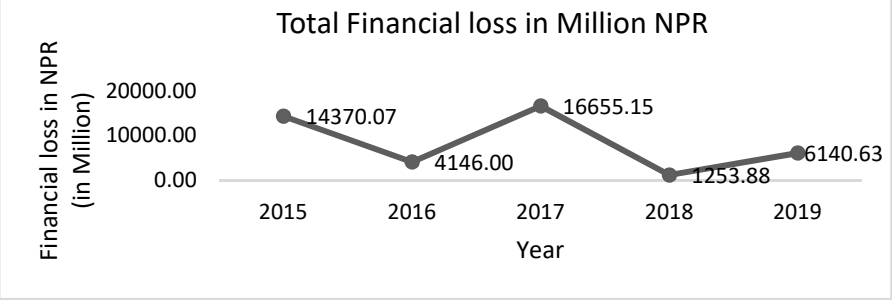

Figure 1: Total Financial loss due to natural disaster in agriculture sector (2015-2019 A.D.)

Figure 1, reveals that every year there is considerable amount of financial loss in agriculture sector due the various natural disasters. Though the nature of disaster and its magnitude may differ, loss value cannot be ignored. On an average, there were more than NPR 8513 million financial losses per year. The total financial loss was maximum in 2017 A.D. which was about NPR 16655 million. The total loss in agriculture sector in five years was found to be NPR 42565.73 million.

According to NPC (2017) the total damage caused by the floods in 2017 was NPR 61 billion, which amounts to almost 3% of Nepal's GDP. Of the total, the damage to the agriculture sector was estimated at NRR 7.2 billion or 11.9% of the overall damage, while losses to the livestock subsector were estimated at NRs10.7 billion.

According to FAO (2017a) between 2005 and 2015 natural disasters cost the agricultural sectors of developing country economies a staggering $96 billion in damaged or lost crop and livestock production.

Total Crop Loss Due to Natural Disaster from 2015-2019 in Nepal

The following graph (Figure 2) shows the crop loss in terms of area and financial terms from 2015 to 2019 due to the various disasters in Nepal.

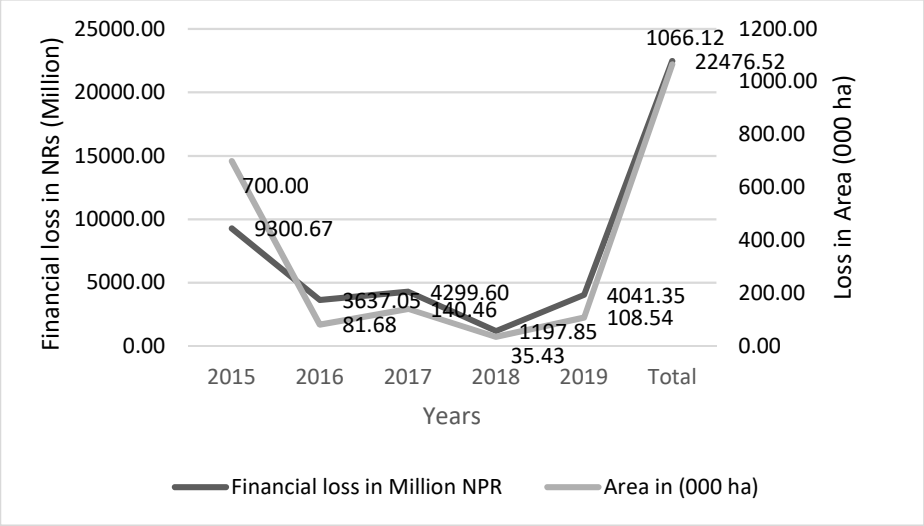

Figure 2: Crop loss due to natural disaster from 2015-2019 in Nepal

Figure 2, revels that the crop loss was highest in 2015 and was about NRs 9300.67 million. This was due to the devastating earthquake in the country in this year. The average crop loss per year from 2015 to 2019 was found to be

around 4495 million. Similarly, per year average crop loss in terms of area was found to be about 213 thousand hectares. The total financial loss from 2015-2019 was found to be 42565.73 million.

Loss in Livestock due to Natural Disaster from 2015-2019 in Nepal

The loss in the livestock sector is mainly due to flood, land slide, snow slide and earthquake in Nepal.The following graph (Figure 3) shows the loss in livestock sector in different years.

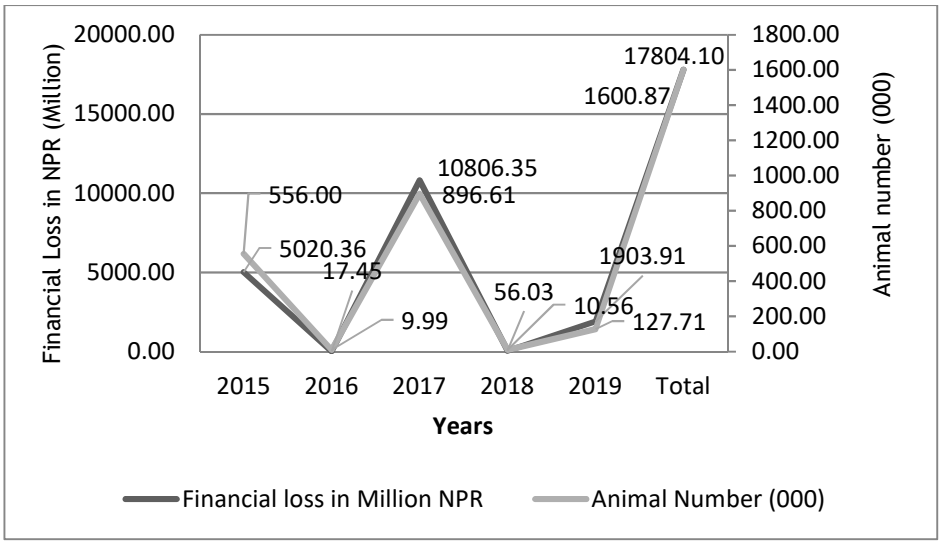

Figure 3: Loss in livestock due to natural disaster from 2015-2019

The total financial loss in livestock during the year 2015-2019 was about NPR 17804 million. Similarly, the average economic loss per year from 2015 to 2019 was 3560.8 Million. The graph shows that the maximum loss in terms of both finance and number was in the year 2017 A.D., accounting about NRs 10806 million financial and about 896 thousand losses in number. NPC (2015) has estimated the losses and damages to the livestock sector to be NPR 10.12 billion.

Loss in fisheries due to natural disaster from 2015-2019 in Nepal

All type of natural disaster can have varying effects on fisheries and aquaculture depending on the exposure and intensity of hazard and flood is major natural disaster to cause loss in the fishery sector (FAO, 2017a). In Nepal, Fish farming is mainly concentrated in the terai region. This region is the most vulnerable region for the impact of flood. In fish farming considerable amount of loss is observed annually by the disaster in Nepal.

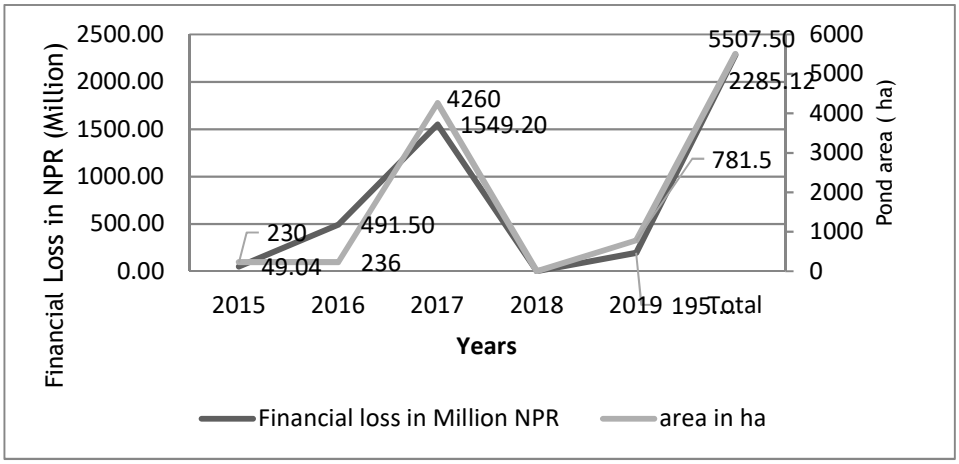

Figure 4: Loss in fishery due to natural disaster from 2015-2019

Regarding the fisheries sector loss amount was highest in year 2017. In 2017, the loss was about NRP 1549 million. Similarly, the total economic loss in fishery 2015 to 2019 was approximately NRP 2285 million. The total destruction area of the fish farming was 5507.50 ha.

TOTAL LOSS AND AGRICULTURE GROSS DOMESTIC PRODUCT

Data regarding the AGDP and the total loss in agriculture sector (plotted in the Figure 1) was considered to observe the percentage contribution it would have been to AGDP, if loss has not been occurred. The total AGDP of five year was around NPR 3548906 Million. This indicated that on an average about 1.2 percent setback on AGDP was due to the natural disaster. In the year 2015 and 2017 percentage decrease on AGDP due to natural disaster was found to be 2.3 and 2.37 percent, respectively.

Table 3: Total loss and Agriculture Gross Domestic Product

year	Agriculture Gross Domestic Product (AGDP) in Million	Total Financial loss in agriculture sector, in Million	Percentage of total loss in comparison to AGDP
2015	625900	14370.07	2.30
2016	655571	4146.00	0.63
2017	702757	16655.15	2.37
2018	738670	1253.88	0.17
2019	826008	6140.63	0.74
Total	3548906	42565.73	1.20

STRATEGIES FOR THE DISASTER RISK REDUCTION AND MANAGEMENT IN AGRICULTURE SECTOR

Planned land use with crop rotation, rainwater harvesting, drought monitoring, using recycle water, developing irrigation system, water rationing are some of the strategies which help to minimize impact of drought (Koirala, 2014). Not withstanding the importance of agriculture to Nepal's economy, the country has limited crop and livestock insurance coverage. According to ADB (2019) the impact of natural hazards on farmers in Nepal would be significantly mitigated by the use of insurance scheme. This calls for the crop and livestock insurance scheme to be extended and made ease access to all farmers.

In Nepal, federalism is still in fledgling stage. The capacity and experience of the sub national government to manage disaster is poor. The institutional and organizational setup according the NDRRM act 2017 is still to be completed. There are skills and capacity gaps in the newly formed municipal and weak incentives for local governments to include Disaster Risk Reduction in development activities (FRA, 2019). So, the capacity of the local and provincial government in dealing with the natural disaster needs to be enhanced.

Many municipalities do not have systematic process to integrate disaster risk management into their planning and programming despite the high level of risk. Planning and budgeting for disaster risk in wider development investments such as infrastructure and agriculture is increasingly important. Although some local governments have considered such components in their development activities, it is on an ad-hoc basis without any systematic procedure (WB, 2019). So, integrating the disaster risk management in annual budget from all the tiers of government is becoming fundamental to secure the livelihood of majority of the people.

Early warning system (EWS) is recognized in both the Hyogo Framework for Disaster Reduction (2005-2015) and the Sendai Framework for Disaster Risk Reduction (2015-2030) as an important element of disaster risk reduction (UNDRR, 2005 and UNDRR 2015). According to kafle (2017b) Disaster Early Warning Systems are an infancy stage in Nepal and no effective multi-hazard early warning systems at national and local levels have been established. Though, Some hazards specific alerts generation and dissemination mechanisms have been established and response capabilities of local communities have been built, however these are project specific and cover a few hundred village. So, it prudent to establish EWS. The system should be established in such a way that all the farmers have access to such information and strong coordination mechanism between department of hydrology, MoALD and other concerned agencies is utmost.

According to Torani et al. (2019) disaster education is a functional, operational, and cost-effective tool for risk management. It is important for vulnerable people to learn about disasters. Though, there are different methods to educate vulnerable people, but no method is better than others. In this regard, planning and designing comprehensive country specific educational programs are necessary.

Farmer's awareness program about the adaptation strategy to adverse climatic condition must be conducted in large scale (FAO, 2014). For this local government should be made responsible and Physical infrastructure should be built in such a way that it can hold the setback created by disaster.

CONCLUSION

Natural disaster has significant negative impact on economic sector. The impact is more visible on agriculture. Annually a huge amount of loss is being observed in this sector. Despite the several efforts made by national and international to rebuild the agriculture resilient, the profound effect is yet to be seen. Insurance coverage and early warning system is still in fledgling. Inadequate of disaster preparedness, poor coordination among various actors, poor resource allocation for disaster management and the apathy of concerned people to address the situation are the major hurdles to put the agriculture in risk of disaster. Strengthening the institutional set up in the three tiers of government, establishment of information flow system and early warning system along with incorporation of disaster risk management in annual plan, programs and budget are essential to prevent and address the impact of natural disaster in agriculture sector of Nepal.

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EVALUATION OF CUCUMBER (*Cucumis sativus* L.)VARIETIES FOR QUALITY TRAITS AND YIELD

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ABSTRACT

Seven cucumber varieties (Bhaktapur Local, Karma, Shalini, Kamini, Sahini-2, Chadani and Manisha) were tested on an open field to evaluate their performance for quality traits including yield and yield components in 2019 at Banepa-4, Kavre, Nepal. The research was conducted on Randomized Completely Block Design (RCBD) with three replications. Green and white skin colored cucumber was included in the research. Among the green skin-colored varieties, Sahini-2 was observed as precocious. Besides, it is superior in terms of number of harvests, fruit length, fruit breadth, fruit weight and pericarp thickness. This variety had non-significant difference in yield compared to the variety Kamini. Among the white skin-coloredvarieties, Shalini performed better as it had a greater number of harvests, number of fruits per plant, yield per plant and per hectare, fruit weight and larger pericarp thickness.

Keywords: Precocious, qualitative, reproductive characters, traits, vegetative characters.

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is an important commercial vegetable which is also used as salad belongs to the family cucurbitaceae. It comprises of 117 genera and 825 species and is cultivated in warmer parts of the world (Nagamaniet al., 2019). Cucumber is widely cultivated in China, Camerron, Russian Federation and Turkey (Aminet al., 2018). Mainly three types of cucumber (i.e., slicing, pickling and seedless) are cultivated across the world. It is mainly grown in the summer season and is popular for its soft and tender juicy fruit.

The fruit consist of more than 90% of water (Loy, 1990; Maynard, 2001). It is also considered as an important fruit from the medicinal point of view as it provides cooling effect to human body when consumed. People also use it on skin and face for relaxation when physically stressed. It is also considered as helpful fruit to prevent and cure jaundice and constipation. Seeds of this fruits contains essential oil which is helpful for brain development and body smoothness (Bhagwat etal., 2018). It aids in weight loss and rehydration

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(Shetty and Wehner, 2002) as it contains low calories (16 calories per cup) and more fiber on the skin (Bhagwat et al., 2018). Therefore, it is also known as versatile food for its countless number of health benefits (Ngouajio et al., 2006).

In recent years, hybrid varieties of cucumber have drastically changed the productivity pattern, cultivation practices, and production area. Genetic improvement and application of modern technologies in cultivation practices (better management) are key factors for achieving maximum yield. This attracted and empowered commercial and non-commercial farmers to grow cucumber nowadays. There is a constant demand for cucumber fruits in the market throughout the year. The fruit-bearing precocity of cucumber attracts farmer for early economic return.This is why, a field trial was conducted at Nala, Kavre district to evaluate seven cucumber varieties in order to identify the best variety of cucumber based on quantitative and qualitative traits and to study the yield and yield attributing traits of hybrid cucumber varieties.

THEORITICAL FRAMEWORK

In Nepal, cucumbers are mainly grown during warm and rainy season. However, in some southern plain parts (terai), it is grown even in the winter season. In most of the cases, non-availability of suitable and well-adapted varieties, lack of varietal information on commercial traits and better management practices to the local farmers or farming communities are some of the major problems associated with cucumber cultivation.

The commercial fruit relies on quality appearance such as colour, size, shape, texture, shelf-life etc. which determines consumers' acceptability of fruit in the market. Harmony between quality production and consumers' preferences need to meet to its excellent level for good profit. Hence, pre-requisite for variety selection for specific agro-climatic area should base on vegetative, floral, yield and fruit traits. Thus, the present study was undertaken to identify appropriate varieties to meet farmers' and consumers' preference, quality traits and good growth for better yield.

METHODOLOGY

This research was conducted at the Karma Innovative R&D Center, Ugrachandi Nala, Banepa - 4 of Kavre district of Nepal (Figure 1) from June to September 2019. The experimental site is situated at 27°39" N latitude and 85°31" E longitude with an elevation of 1500 masl.

The experimental site has mild and generally warm and tropical climate. In winter, there is much less rainfall than in summer. During the research period average temperature was 23.3° C and precipitation was 1258.33 mm (Figure 1). Composite soil sample was taken from the top (0-30 cm) layer of

the experimental plots before transplanting cucumber seedlings. Soil analysis was carried out in the laboratory of the Karma Group of Companies at Sitapila, Kathmandu to determine soil pH, soil EC and soil texture.

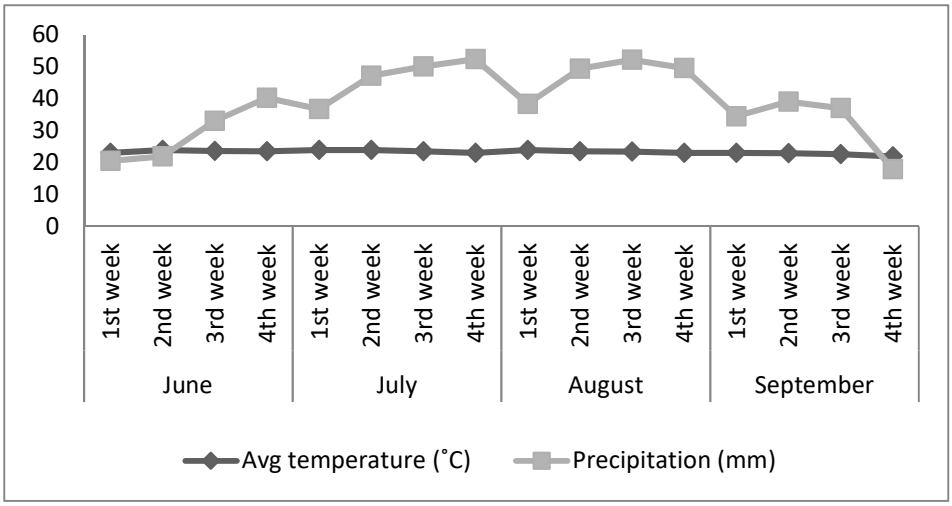

Figure 1: Weekly average temperature and precipitation during the research period at Nala, Kavre during 2019.

The experiment was laid out on Randomized Complete Block Design (RCBD). The experiment consisted of seven varieties of cucumber (Bhaktapur Local, Kamini, Sahini-2, Chadani, Manisha, Shalini and Karma) as treatments. The size of the individual plot was maintained at 2 m^2. Ten plants were planted in each plot. The crop was planted at the spacing of 0.5 m x 0.4 m. One-meter distance was maintained between two adjacent replications. Similarly, distance between two adjacent plots was maintained at 0.5 m. Randomization of treatments was done by lottery method. The treatments were replicated three times.

The field was cultivated with potato before the start of experiment. After harvesting potato, the experimental field was deep ploughed and leveled, a week before the date of transplanting cucumber seedlings. The field layout and plot arrangement were done prior to transplanting. Akanee (21.7% OM, 4.1% N, 0.9% P, 2.3% K, 4.2% Ca, 1.5% MgO and 0.28% S) @ 31.18 gm/m^2, urea @ 6.18 gm/m^2, DAP @ 10.20 gm/m^2, MOP @ 0.8 gm/m^2 was applied as basal dose at the time of final land preparation. Additional dose of fertilizer was applied at fortnight interval (i.e., 19.02 gm/m^2 urea on first topdressing, and 9.98 gm/m^2 urea, 4.5 gm/m^2 DAP, 5.56 gm/m^2 MOP were applied on subsequent topdressing). Topdressing was done for 5 times during cropping season. Seedlings at two leaves stagewere transplanted in the experimental plots on 9th June 2019. In each plot, plant to plant distance was maintained at 40 cm and row to row distance was maintained at 50 cm (Figure 2). A light

irrigation was provided just after transplanting to soften the soil crust for better anchorage of cucumber seedlings. The gap filling was done within a week after transplanting. Protector ZN (Chlorothanil 75% W.P. @ 2 g/lit water) as preventive measures of fungal disease was applied at the interval of 15 days for 2 times and Kingmill 72 % W.P. (Mancozeb 640 g/kg + Cymoxanil 80 g/kg @ 3 g/liter water) water was applied after infection of downy mildew as curative measure at weekly interval for 3 times.All the intercultural operations like weeding and hoeing were carried out when necessary. Irrigation was provided through drip irrigation system at 2-3 days interval. Regular manual harvesting was done at every 5-6 days intervals.

Three randomly selected plants from each plot were observed for nineteen characters i.e., vine length (cm), number of nodes, internodal length (cm), number of primary branches (n), days to first male flower appearance (d), days to first female flower appearance (d), nodal position of first male flower, nodal position of first female flower, days to first fruit harvest (d), number of fruits per plant (n), number of harvest (n), yield (kg plant^{-1}), yield (t ha^{-1}), fruit length (cm), fruit diameter (cm), fruit weight (gm), pericarp thickness (cm), and shelf-life (d). Likewise, qualitative data such as plant vigor, fruit color and stripe length were also recorded based on visual observations.Bitterness was recorded through organoleptic taste. Scoring guidelines from Chia Tai Seeds Co. Ltd. was used for recording qualitative traits like bitterness, fruit color and stripe color and viral disease scoring. All observed, measured and calculated data were encoded in Microsoft excel (MAC version 16.16.15) for data curation and management. R-program (version 3.5.2) was used for data analysis. Statistical tools such as One-way ANOVA was used to check significant differences between treatments and Least Significance Difference (LSD) at 0.05 significant level ($¤_{0.05}$) was used to compare differences between treatment means.

RESULTS AND DISCUSSION

The soil test results showed that the experimental plots had silty loam soil texture with 6.1 pH value and 0.49 mS/cm electrical conductivity (EC).It is evident from Table 1 that the cucumber varieties are significantly different ($P \leq 0.001$) from each other in terms of vine length. The variety Chadani had the highest vine length (4.5±0.2 m), followed by Bhaktapur local (3.8±0.1 m) which was not significantly different ($P \leq 0.05$) from the variety Manisha (3.5±0.2m). The shortest vine length was observed on the variety Kamini (3.2±0.1 m) but it was not significantly different ($P \leq 0.05$) from the variety Karma (3.2±0.2m), Shalini (3.2±0.2m) and Shahini-2 (3.4±0.2 m). Likewise, number of primary branches was highest on the variety Chadani (8.2±0.4) which was statistically at par ($P \leq 0.05$) with the variety Shahini-2 (7.7±0.8), Bhaktapur local (6.5±0.4), Kamini (5.3±0.7) and Manisha (5.3±1.3), while the

lowest number of branches were found in the variety Karma (3.4±1.4) which was not significantly different (P≤0.05) from the variety Shalini (3.6±1.7), Kamini, Manisha and Bhaktapur local. The number of nodes was found statistically at par (P≤0.05) on all varieties. While, internodal length of variety Chadani was found highest (11.0±0.1cm) and was not significantly different (P≤0.05) from the varieties Bhaktapur Local (10.2±1.5cm) and Sahini-2 (9.4±0.1cm).These two varieties were also at par (P≤0.05) with remaining varieties. Among remaining varieties, lowest internodal length was found on the variety Karma (8.6±0.1 cm), followed by Shalini (8.9±0.1 cm), Manisha (8.8±0.1 cm) and Kamini (9.1±0.2cm) and all these were at par (P≤0.05).

Vegetative characters i.e., vine length, number of primary branches, number of nodes, internodal length and stem diameter determines plant vigour and the area (space) it requires for cultivation. In most cases it is also related to yield and yield-related traits, but it doesn't mean vigour always determines yield and yield related traits. Variation in these traits are similar with the finding of Soleimaniet al., 2009; Palet al.,2017; Ranjan et al., 2015; Bhagwat et al., 2018; Kumaret al., 2019 and Mekap, 2016.

Table 1: Vegetative attributes of cucumber varieties observed at Nala, Kavre, 2019

Varieties	Vine length (m) ± S.E.	Number of primary branches ± S.E.	Number of nodes ± S.E.	Internodal length (cm) ± S.E.
Shalini	3.2±0.2^{c}	3.6±1.7^{b}	36.4±0.9^{a}	8.9±0.1^{b}
Sahini-2	3.4±0.2^{c}	7.7±0.8^{a}	36.6±3.0^{a}	9.4±0.1^{ab}
Bhaktapur Local	3.8±0.1^{b}	6.5±0.4^{ab}	37.4±2.5^{a}	10.2±1.5^{ab}
Chadani	4.5±0.2^{a}	8.2±0.4^{a}	40.8±1.4^{a}	11.0±0.1^{a}
Karma	3.2±0.2^{c}	3.4±1.4^{b}	37.4±0.7^{a}	8.6±0.1^{b}
Kamini	3.2±0.1^{c}	5.3±0.7^{ab}	37.6±4.7^{a}	9.1±0.2^{b}
Manisha	3.5±0.2^{bc}	5.3±1.3^{ab}	39.6±0.3^{a}	8.8±0.1^{b}
Mean	3.6	5.7	38.0	9.4
P(>F)	0.0006 ***	0.043 *	0.84	0.11
LSD	0.5	3.3	7.3	1.8
CV (%)	8.1	32.7	11.0	10.9

It is observed from table 2 that the variety Karma initiated male flower earlier (15.6±0.2 days) than other mentioned varieties. And this variety was statistically at par (P≤0.05) with the varieties Sahini-2 (15.8±0.5 days), Shalini (16.1±0.2days) and Manisha (16.6±0.6 days). Variety Bhaktapur Local took

longer days (21.3±0.1 days) to initiate male flower which was significantly different (P≤0.001) from all other varieties, followed by the varieties Kamini (19.2±0.4 days) and Chadani (18.7±0.5 days). The varieties were not significantly different (P≤0.05) regarding the nodal position of male flower. Similarly, days to initiation of female flower had very significant role in determining precocity of varieties. Here, varieties Karma (14.9±0.1 days), Shalini (14.9±0.2 days), Sahini-2 (15.1±0.4 days) and Manisha (15.8±0.3 days) were found as early varieties as these varieties had the shortest duration for the first female flower appearance as shown in table 3, while Bhaktapur Local (31.9±1.2days) was found as the late flowering variety which was significantly different from Kamini (22.7±0.2 days) andChadani (20.6±0.7 days). Bhaktapur local variety had the first female flower setting at the highest nodal position (7.1±1.2) which was significantly different (P≤0.001) from the varieties Kamini (3.7±0.2), Chadani (3.6±0.7), Sahini-2 (2.6±0.4), Manisha (2.3±0.3), Shalini (2.3±0.2) and Karma (2.3±0.1) (i.e. beside Bhaktapur local, all other varieties were statistically at par).

Among the horticultural traits' days to first male flower appearance, nodal position of male flower, days to first female flower appearance, nodal position of female flower and days to first fruit harvest determine the earliness of a variety. In our study, results of such traits were in harmony with the finding of Ene et al., 2016; Bhagwat et al., 2018; Pal, 2014 and Sharma et al., 2018.

Table 2: Flowering attributes of cucumber varieties observed at Nala, Kavre, 2019

Varieties	Days to first male flower appearance ± S.E.	Nodal position ± S.E.	Days to first female flower appearance ± S.E.	Nodal position ± S.E.
Shalini	16.1±0.2^{c}	1.9±0.4	14.9±0.2^{d}	2.3±0.2^{b}
Sahini-2	15.8±0.5^{c}	2.0±0.1	15.1±0.4^{d}	2.6±0.4^{b}
Bhaktapur Local	21.3±0.1^{a}	2.4±0.0	31.9±1.2^{a}	7.1±1.2^{a}
Chadani	18.7±0.5^{b}	2.3±0.1	20.6±0.7^{c}	3.6±0.7^{b}
Karma	15.6±0.2^{c}	1.7±0.1	14.9±0.1^{d}	2.3±0.1^{b}
Kamini	19.2±0.4^{b}	2.3±0.1	22.7±0.2^{b}	3.7±0.2^{b}
Manisha	16.6±0.6^{c}	2.1±0.1	15.8±0.3^{d}	2.3±0.3^{b}
Mean	17.6	2.1	19.4	3.4
P(>F)	0.00000 ***	0.1472	0.00000 ***	0.0005 ***
LSD	1.2	0.5	1.7	1.8
CV (%)	4.0	14.2	5.0	30.1

Table 3: Yield and yield attributes of cucumber varieties observed at Nala, Kavre, 2019

Varieties	Days to first harvest	Number of harvests ± S.E.	Number of fruits/plant ± S.E.	Yield (kg/plant) ± S.E.	Yield (t/ha) ± S.E.
Shalini	35.3±2.6^{c}	12.8±0.6^{a}	14.8±0.6^{bc}	5.8±0.2^{b}	290.9±10.3^{b}
Sahini-2	37.8±1.6^{bc}	12.4± 0.1^{a}	16.2±1.5^{abc}	6.5±0.5^{ab}	325.6±24.4^{ab}
Bhaktapur Local	47.3±1.6^{a}	10.3±0.3^{c}	12.8±1.4^{c}	5.6±0.4^{b}	280.7±18.8^{b}
Chadani	41.8±1.8^{b}	11.4±0.1^{b}	16.0±1.9^{abc}	6.8±0.5^{ab}	339.7±24.3^{ab}
Karma	38.3±0.7^{bc}	12.2±0.4^{ab}	13.6±1.1^{c}	5.3±0.4^{b}	263.8±19.8^{b}
Kamini	39.3±0.8^{bc}	12.4±0.1^{a}	19.7±2.0^{a}	7.6±0.7^{a}	380.6±35.5^{a}
Manisha	35.9±0.9^{c}	12.6±0.1^{a}	18.8±1.5^{ab}	6.4±0.7^{ab}	318.5±36.0^{ab}
Mean	39.4	12.0	16.0	6.3	314.3
P(>F)	0.001 **	0.0008 ***	0.0418 *	0.0834	0.0836
LSD	4.7	1.0	4.5	1.6	77.7
CV (%)	6.8	4.5	16.0	14.1	14.1

Table 3 shows the mean comparison for yield and yield related traits. Sahini-2 (35.3±2.6days) and Manisha (35.9±0.9days) had the shortest duration forthe first harvest (less than 36 days) which were at par (P≤0.05) with Sahini-2 (37.8±1.6 days), Karma (38.3±0.7 days) and Kamini (39.3±0.8days). The variety Bhaktapur Local (47.3±1.6 days) had the longest days to first harvest which was followed by Chadani (41.8±1.8 days), Shalini (12.8±0.6 days), Manisha (12.6±0.1 days), Kamini (12.4±0.1 days), Sahini-2 (12.4±0.1 days) and Karma (12.2±0.4 days). The lowest number of harvests was observed on variety Bhaktapur Local (10.3±0.3) followed by the variety Chadani (11.4±0.1) which were significantly different from each other and from all other varieties except Karma (12.2±0.4) which was at par(P≤0.05) with the variety Chadani. More number of fruits per plant were harvested on the variety Kamini (19.7±2.0), followed by the variety Manisha (18.8±1.5), Shahini-2 (16.2±1.5) and Chadani (16.0±1.9) but these varieties were not significantly different (P≤0.05) from each other and the lowest numbers of fruits were harvested from the variety Bhaktapur Local (12.8±1.4), followed by varieties Karma (13.6±1.1), Shalini (14.8±0.6), Chadani and Sahini-2 which were not significantly different (P≤0.05) from each other. Likewise, yield of variety Kamini was highest (7.6±0.7kg/plant i.e., 380.6±35.5ton/hectare) which was not significantly different (P≤0.05) from varieties Shahini-2 (6.5±0.5 kg/plant i.e., 318.5±36.0 ton/hectare), Chadani (6.8±0.5 kg/plant i.e., 339.7±24.3 ton/hectare) and Manisha (6.4±0.7 kg/plant i.e., 318.5±36.0 ton/hectare).

Lowest yield was observed on the variety Karma (5.3±0.4 kg/plant i.e., 263.8±19.8 ton/hectare) which was at par (P≤0.05) with the varieties Bhaktapur Local (5.6±0.4kg/plant i.e. 280.7±18.8 t/ha), Shalini (5.8±0.2 kg/plant i.e., 263.8±19.8 t/ha). Wide variation between cultivars were observed while comparing number of harvests, number of fruits per plant, yield per plant and yield per hector. These results are similar to the results obtained by Nagamani et al., 2019; Pal, 2014; Khan et al., 2015; *Bhagwat et al.*, 2018; Pal et al., 2017; Bhangu and Singh,1993; Prasad and Prasad,1979 and Ahmad et al., 2017.

Table 4: Fruit traits of cucumber varieties observed at Nala, Kavre, 2019

Varieties	Fruit weight (gm) ± S.E.	Fruit Length (cm) ± S.E.	Fruit breadth (cm) ± S.E.	Pericarp thickness (cm)± S.E.
Shalini	558.0±43.5^{ab}	26.7±1.4^{a}	5.7±0.2^{a}	1.5±0.0^{a}
Sahini-2	562.9±41.9^{ab}	26.3±0.1^{ab}	5.6±0.1^{a}	1.3±0.1^{b}
Bhaktapur Local	554.9±30.5^{ab}	26.7±0.6^{a}	5.7±0.2^{a}	1.4±0.1^{ab}
Chadani	542.2±39.3^{abc}	25.5±0.2^{ab}	5.7±0.2^{a}	1.3±0.0^{b}
Karma	577.8±49.6^{a}	26.8±1.2^{a}	5.8±0.1^{a}	1.5±0.0^{a}
Kamini	443.8±60.0^{bc}	24.4±0.4^{b}	5.5±0.2^{a}	1.3±0.0^{b}
Manisha	420.0±15.4^{c}	20.3±0.3^{c}	5.7±0.2^{a}	1.3±0.0^{b}
Mean	522.8	25.2	5.7	1.4
P(>F)	0.097	0.0003 ***	0.784	0.023 *
LSD	127.7	2.3	0.5	0.2
CV (%)	14.0	5.2	4.9	6.4

Table 4 describes morphological traits of cucumber fruit, where highest fruit weight was observed on the variety Karma (577.8±49.6 gm) but is not significantly different (P≤0.05) from the varieties Shahini-2 (562.9±41.9 gm), Shalini (558.0± 43.5 gm), Bhaktapur Local (554.9±30.5 gm) and Chadani (542.2±39.3 gm), while the lowest fruit weight was found on the variety Manisha (420.0±15.4 gm) not being significantly different (P≤0.05) from varieties Kamini (443.8±60.0 gm) and Chadani (542.2±39.3 gm). Similarly, the longest fruit was also observed on the variety Karma (26.8±1.2 cm) which was at par (P≤0.05) with the varieties Shalini (26.7±1.4 cm), Bhaktapur Local (26.7±0.6 cm), Shahini-2 (26.3±0.1 cm) and Chadani (25.5±0.2 cm) followed by the variety Kamini (24.4±0.4 cm) and Manisha (20.3±0.3 cm) where Manisha was significantly different (P≤0.001) from all other varieties and Kamini was at par (P≤0.05) with varieties Chadani and Shahini-2. All varieties were statistically the same in terms of fruit breadth although variety Karma

had highest breadth (5.8±0.1 cm) and variety Kamini had the lowest breadth (5.5±0.2 cm). Comparing the means for pericarp thickness, variety Shalini had the highest pericarp thickness (1.5±0.0 cm) which was at par (P≤0.05) with the varieties Karma (1.5±0.0 cm) and Bhaktapur local (1.4±0.1 cm). Lowest pericarp thickness was observed on the variety Kamini (1.3±0.0 cm) and was not significantly different (P≤0.05) from the varieties Manisha (1.3±0.0 cm), Shahini-2 (1.3±0.1 cm), Chadani (1.3±0.0 cm) and Bhaktapur local (1.4±0.1cm).Mekap, 2016; Ahmad et al., 2017; Nagamani et al., 2019; Singh and Tiwari, 2018; Sharma et al., 2018 also observed great variation on the morphological traits of fruit such as fruit length, fruit breadth, fruit weight, pericarp thickness.

Table 5:Comparison of cucumber varieties for qualitative traits at Nala, Kavre, 2019

S.N.	Variety	Germination%	Bitterness	Stripe color	Fruit color	Viral disease
1	Shalini	100	Not bitter	Yellow	Green	9
2	Sahini 2	100	Not bitter	Yellow	Dark green	9
3	Bhaktapur Local	100	Not bitter	white	Light green	1
4	Chadani	100	Not bitter	Yellow	Green	9
5	Karma	100	Not bitter	Green	Light green	9
6	Kamini	100	Not bitter	Yellow	Dark green	9
7	Manisha	100	Not bitter	Yellow	Dark green	9

Scoring guidelines from Chia Tai Seeds Co. Ltd. was used for recording qualitative traits like bitterness, fruit color and stripe color (Table 5). Germination was excellent in all varieties. None of the varieties were bitter in taste. But the varieties were different in terms of stripe color. Varieties Shalini, Sahini-2, Chadani, Kamini and Manisha had yellow colored stripe whereas variety Karma had green colored stripe and Bhaktapur Local had white. Varieties Kamini, Manisha and Sahini-2 had dark green colored fruit while variety Chadani had green colored fruit, and Bhaktpur Local, Karma and Shalini had light green colored skin. Chia Tai Seeds Co. Ltd. guideline (1-9 ranking scale) was also used to score viral disease. It was found that variety Bhaktapur local was most susceptible to squash leaf curl virus (Table 5).

CONCLUSION

Among green skin segment, variety Chadani was vigorous as it had longer vine length, higher number of primary branches, higher number of nodes, better stem diameter and the highest internodal length. But, more vigor doesn't necessarily mean more productivity. Here, higher number of fruits, yield per plant and yield per hectare was observed on the variety Kamini not being

significantly different than variety Sahini-2. Besides, Shahini-2 had longer fruit length, higher fruit weight, fruit breadth and pericarp thickness. Male and female flower setting and days to first fruit harvesting was earlier in the variety Sahini-2 with fruit setting on a lower node. Considering earliness, good fruit quality and productivity variety Sahini-2 is found better compared to the other green skin colored varieties.

Among white skin segment, variety Shalini had a greater number of harvests, higher number of fruits per plant, yield, fruit weight and larger pericarp thickness than Karma and Bhaktapur local. Early flowering and fruit setting on the lowest node were observed on the variety Shalini.

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EVALUATION OF ASPARAGUS BEAN (*Vigna unguiculata* spp. sesquipedalis (L.) Verdc.) GENOTYPES IN THE MID WESTERN HILLS OF NEPAL

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ABSTRACT

A study was conducted to evaluate morphological traits, yield potential of Asparagus bean genotypes at Horticulture Research Station, Dailekh in 2016 and 2017. Six genotypes of asparagus bean, namely HRDASB007, HRDASB008, HRDASB009, HRDASB010, Malepatan Meter Long and Khumal Tane (check variety) were planted in Randomized Complete Block Design with four replications. The averaged results of two years' experiments showed that the longest pod (66.03cm) was recorded in genotype HRDASB010 that was followed by HRDASB008 (64.19 cm) and HRDASB007 (63.5 cm). Similarly, the highest pod weight (38.72 g) was recorded in the genotype HRDASB008. The highest yield (37.43 t/ha) was recorded from HRDASB009 followed by HRDASB007 (35.45 t/ha), Malepatan Meter Long (35.32 t/ha), HRDASB008 (35.19 t/ha) and HRDASB010 (33.25 t/ha) and the lowest in Khumal Tane (26.50 t/ha). The further validation on farmer's field for the determination of yield potential of such genotypes is suggested for the mid western hill of Nepal.

Keywords: Asparagus bean, genotypes, pod, yield

INTRODUCTION

Asparagus bean (*Vigna unguiculata* spp. *sesquipedalis* (L.) Verdc.) is known as vegetable cowpea, yard long bean, chinese long bean, string bean, snake bean, snake pea, snap pea, bodi, bora and sitao. Its origin is possibly in the Middle West Africa or in Southern China. Asparagus bean is widely grown in Southeast Asia, South China and West Africa for immature pods which are used as a vegetable (Sarutayophat, 2008). It is a vigorous climbing annual, producing 9 to 12 feet indeterminate vines. It is rich in protein, calcium, iron, riboflavin, phosphorus, potassium, and vitamin A. In addition, it is a very good source of vitamin C, folate, magnesium, and manganese (former Asian Vegetable Research Development Center/World Vegetable Center (AVRDC), 2015; Yamaguchi, 1983; Hugqe et al., 2012).

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Asparagus bean is a warm-season crop. The optimum growth temperature range is 27-30°C. It tolerates heat and dry conditions better than common field or lima beans (Rubatzky and Yamaguchi, 1997). It is considered as having relatively low pod productivity because it is quite sensitive to unfavorable environmental conditions, such as high temperature, dry weather, and even cloudy sky or heavy rain (Sarutayophat et al., 2007).

In Nepal only two varieties of Asparagus bean namely Khumal Tane and Sarlahi Tane have been released and only few varieties have been registered. The production and productivity of released variety is very low (4.5-7 t/ha) as compared to other registered imported seeds of asparagus bean (35 t/ha) (SQCC, 2018). The productivity of asparagus bean in mid western hill is about 9 t/ha and productivity in mid-western Terai is 14 t/ha. The area, production, and productivity of asparagus bean in Nepal is 4426 ha, 41096 t and 9 t/ha, respectively (ABPSD, 2017).

Different types/varieties of asparagus bean have been imported in the country from abroad and thus it is of great opportunities to evaluate, select and recommend, the suitable high yielding variety for a particular location of the country. Considering the facts, the study was conducted to select the high yielding asparagus bean genotypes for the climate representing Dailekh district and similar locations.

MATERIALS AND METHODS

The experiment was conducted in HRS, Dailekh to evaluate the yield and yield attributing characteristics of asparagus bean genotypes. Six genotypes namely HRDASB-007, HRDASB-008, HRDASB-009, HRDASB-010, Malepatan Meter long and Khumal Tane were planted in March 2016 and 2017. The plot size was 1.8x1.5 i.e. 2.7m^2 and there were two rows having five plants in each row. The spacing of Asparagus bean was 120x30 cm. Two seeds per hill were sown. Chemical fertilizers (NPK) were applied @ 40:60:40 kg/ha along with compost 20 t/ha. The experiment was laid out in randomized complete block design with four replications. The observations were taken on plant establishment (no), plant height (cm), pod number, pod weight (g) and yield (t/ha) were recorded. The data were analyzed by using statistical software R-statistics.

RESULTS

FLOWER COLOR, POD TEXTURE AND POD COLOR

Flower color, pod texture and color of different genotypes was found to be different (table 1). Pod color variation was observed in different genotypes which vary from light green to dark green. Pod texture was smooth in all genotypes. The color of flower was different in HRDASB010 i.e. yellower than other genotypes having creamy white colored flower.

Table 1: Descriptions of asparagus bean genotypes grown at the Horticultural Research Station, Kimugaun, Dailekh in years of 2016 and 2017

Genotypes	Flower color	Pod color	Pod texture
HRDASB007	Creamy White	Light green	Smooth
HRDASB008	Creamy White	green	Smooth
HRDASB009	Creamy White	green	Smooth
HRDASB010	Yellow	Dark Green	Smooth
Malepatan Meter Long	Creamy White	Light green	Smooth
KhumalTane	Creamy White	Light green	Smooth

YIELD AND YIELD ATTRIBUTING CHARACTERISTICS

The results of the different genotypes of asparagus bean on yield and yield attributing characters have been given in table 2. In the first year of experiment, statistical analysis of variance for pod length, individual pod weight and yield differed significantly among the genotypes. The longest pod (66.81cm) was recorded in the genotype HRDASB 010 followed by HRDASB009 (65.68 cm), HRDASB008 (63.55 cm), Malepatan Meter Long (62.64 cm) and HRDASB007 (62.47 cm) while the shortest pod (50.07 cm) was recorded in the variety Khumal Tane.

The highest individual pod weight (33.77 g) was recorded in the genotype HRDASB008 followed by HRDASB009 (33.14 g), Malepatan Meter Long (32.88 g), HRDASB07 (32.52g), and HRDASB010 (29.96 g) while the lowest pod weight (22.37 g) was recorded in the variety Khumal Tane.

The highest yield (35.29 t/ha) was recorded in HRDASB008 followed by Malepatan Meter Long (34.48 t/ha), HRDASB009 (33.89 t/ha), HRDASB010 (32.31 t/ha) and HRDASB007 (31.61 t/ha). The lowest yield was obtained in variety Khumal Tane (23.93 t/ha). The numbers of pod per plant were found non-significant among the genotypes tested.

Table 2: Yield and yield parameters of asparagus bean at HRS, Kimugaun, Dailekh, during years of 2016 and 2017

Genotypes	No. of pods per plant			Length of pod (cm)			Weight of individual pod (g)			Yield (t/ha)		
	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean	2016	2017	Mean
HRDASB 007	39.56	70.69	55.13	62.47 ^{b}	64.55	63.50 ^{a}	32.52 ^{ab}	32.95^{a}	32.74 ^{a}	31.61 ^{a}	39.28 ^{ab}	35.45 ^{a}
HRDASB 008	38.72	63.59	51.16	63.55 ^{b}	64.83	64.19 ^{a}	33.77 ^{a}	43.68^{a}	38.72 ^{a}	35.29 ^{a}	35.09 ^{ab}	35.19 ^{a}

HRDASB009	43.25	85.19	64.23	65.68 ab	58.75	62.22 a	33.14 ab	32.95 a	33.05 a	33.89 a	40.97 a	37.43 a
HRDASB010	39.82	70.50	55.17	66.81 a	65.25	66.03 a	29.96 b	35.60 a	32.78 a	32.31 a	34.20 ab	33.25 a
Malepatan Meter Long	45.04	68.44	56.75	62.64 b	64.10	63.37 a	32.88 ab	38.85 a	35.86 a	34.48 a	36.15 ab	35.32 a
Khumal Tane	35.19	80.33	57.76	50.07 c	40.60	45.34 b	22.37 c	13.21 b	17.79 b	23.93 b	29.07 b	26.50 b
Grand Mean	40.26	73.12	56.69	61.87	59.68	60.77	30.77	32.87	31.82	31.92	35.79	33.85
SEM(±)	28.34	206.58	61.92	4.15	171.93	43.20	5.15	100.73	33.31	22.68	40.32	14.66
$LSD_{0.05}$	3.62	NS	11.85	3.07	NS	9.91**	3.42	15.13*	8.69**	7.17	NS	5.77*
CV (%)	13.22	19.65	13.87	3.3	21.97	10.81	7.4	30.52	18.14	14.92	17.74	11.30

Means within the column followed by the same letter are not significant different at 5 % level of significance by DMRT

The experiment in 2017, the statistical analysis of the recorded data revealed that individual pod weight differed significantly among the six different tested genotypes. However, the numbers of pod per plot, individual pod length, were observed with non-significant difference among the tested genotypes. The total yield was found significant between HRDASB009 and Khumal Tane.

Individual pod weight of the genotype HRDASB008 were weighted significantly the highest (43.6 g) which was statistically at par with the genotypes Malepatan Meter Long (38.9 g), HRDASB010 (35.6 g), HRDASB007 (9.3 g) and HRDASB009 (9.3 g) respectively. In contrast, the weight of individual pod was the lowest on Khumal Tane (13.2g). The highest yield was observed for the HRDASB009 (40.97 t/ha) while the lowest yield was observed for the Khumal Tane (29.07 t/ha).

When we evaluate the average results of the two years experiment, statistical analysis of variance for pod length, individual pod weight and yield differed significantly among the genotypes. The longest pod (66.03cm) was recorded in the genotype HRDASB010 which was followed by HRDASB008 (64.19 cm), HRDASB007 (63.50 cm), Malepatan Meter Long (63.37 cm) and HRDASB009 (62.22 cm) while the shortest pod (45.34 cm) was recorded in the variety Khumal Tane.

The highest individual pod weight (38.72 g) was recorded in the genotype HRDASB008 followed by Malepatan Meter Long (35.86 g), HRDASB009 (33.05 g), HRDASB010 (32.78 g), and HRDASB007 (32.74 g) while the lowest pod weight (17.79 g) was recorded in the variety Khumal Tane.

The mean yields were statistically similar for the tested genotypes except check variety Khumal Tane. The highest yield (37.43 t/ha) was recorded in HRDASB009 followed by HRDASB007 (35.45 t/ha), Malepatan Meter Long (35.32 t/ha), HRDASB008 (35.19 t/ha) and HRDASB010 (33.25 t/ha). The lowest yield was obtained in the variety Khumal Tane (26.50 t/ha). The numbers of pod per plant were found non-significant among the genotypes tested.

DISCUSSION

Several factors may have contributed to the difference in two years result for the different parameters. The sowing date was a little different in March for two years and the climatic condition might be different. The plot was different for the two years trials of asparagus bean in each year. Such types of variations among genotypes were recorded in different research station of Nepal Agricultural Research Council. Evaluation of seven genotypes of asparagus bean at HRS, Malepatan in the year 2016 shows that the longest pod was recorded from the genotype HRDASB009 (68.13 cm) and the highest weight of ten pods (393 g) and yield(30.41 t/ha) was recorded in the genotype HRDASB008 while in the year 2017, HRD ASB010 produced the longest pod(69.3 cm) and HRDASB 008 produced the highest (27.06 t/ha) fresh pod yield (Annual Report, 2016 and 2017, HRS, Malepatan).The variation in genotypes is the characteristics of gene present in individuals. Agbogidi and Ofuoku (2005) reported that plants respond differently to environmental factors based on their genetic makeup and their adaptation capability indicating that variability among species.

Pod length is one of the major criteria to select better variety of cowpea for its higher yield and preferable pod size. The longer pods produce more weight than short pods, but final yield depends on the number of pods per plant as well as weight of individual pods. Farmers preferred green color, big and long size with tender and fibreless pods for home consumption and, also consumer's preferred characters for the market (Pandey et al., 2006).

CONCLUSIONS

From the two years experiment on the varietal trial of the asparagus bean, the highest mean yield was obtained from genotype HRDASB009 (37.43 t/ha) followed by HRDASB007 and Malepatan Meter Long. The yield and yield attributing characters of tested genotypes like HRDASB009, HRDASB007,

HRDASB008 and Malepatan Meter Long are promising for the variety registration and release for the commercial cultivation. These tested genotypes were superior to check variety Khumal Tane. The superior genotypes have to be further evaluated in farmers' field trials for the confirmation and validation for mid-hill regions of Nepal.

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RESOURCE USE EFFICIENCY OF KIWI PRODUCER FARMERS IN DOLAKHA DISTRICT OF NEPAL

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ABSTRACT

Kiwi is recently introduced fruit crop in Nepal and being widely popular among hill farming population. Kiwi yield in Nepal is low as compared to other kiwi growing countries, and such lower yield might be attributed to different resource use inefficiencies at farmer's level. This study was conducted to evaluate the resource use efficiency of the kiwi producer farmers in Dolakha district where Kiwi is popularly grown. Eighty Kiwi growers were randomly selected from purposively selected two municipalities during June 2019 and Cobb-Douglas production function is used as analytical tool. The functional analysis shows, input factors such as training-pruning, irrigation and manure were rationally utilized however human resource is under utilized. Economic utilization of inputs on kiwi farming resulted in increasing return to scale.

Keywords: Cobb-douglas, cost, marginal value product, regression co-efficient, resource use efficiency

INTRODUCTION

Kiwi is a temperate fruit of Nepal, which is cultivated on 322 hectares productive area with production of 2188 mt and productivity 6.8 mt/ha (MOALD, 2017/18). Kiwi fruit is a native plant of China, known as a Chinese gooseberry and now commonly known as a kiwi fruit all over the world. Kiwi fruit can be consumed as a fresh fruit, juice, jam, wine, ice-cream etc. Kiwi fruit can grow in mountain region of Nepal, it require 800 to 2900 meters altitude and proper irrigation system in dry season to grow best quality fruit. Kiwi fruit is cash crops increasing demand globally; it helps to improve the economic condition of farmers. Moreover, poor and middle-class farmers face an additional disadvantage in accessing technical support. Though kiwi requires less labor than traditional field crops, complicated cultivation techniques are needed to produce high quality and yields. The young vineyards face obstacles such as hailstorms, plant disease, animal pests, and volatile markets. Despite these obstacles, many farmers have rushed to plant kiwi as this is new and comparatively profitable crop.

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Kiwi farming has emerged as a lucrative agri-bussiness in Dolakha district of Nepal. Presently, 1252 farmers are engaged in commercial kiwi fruit production and it is cultivated in 450 ha of land with the average productivity of 10 mt/ha. It is reported that 600 mt of fresh kiwi fruit was produced in Dolkha district during FY 2076/77, out of which 300 mt was exported outside the district with the net worth of 35 million rupees (PMAMP, PIU-Dolakha, 2076/77). Though kiwi fruit is being cultivated in all rural areas of Dolakha district, maximum area of kiwi is being cultivated in Sailung, Bhimeshowor and Jiri municipality with 33.24, 32.25 and 20.45 ha of land respectively (PMAMP, PIU-Dolakha, 2076/77).

A number of management factors such as timeliness and method of sowing, transplanting, irrigation and application of right doses of inputs and input mix play an important role in influencing inter-farm variation in crop productivity (Selvarajan et al., 1997). In some situations, as farm size increases, factor productivity also decreases even though the marginal as well as large farmers are generally less productive than the small and medium farmers (Sen and Bhatia, 2004; Haque, 1996). So, the identification of optimal level of factor productivity and farmers' efficiency in resource use are very important at national level for restoring its increasing trend. One way of approaching this problem is to investigate into farmers' efficiency in resource use with available technology as land and other capital items are very limited. So, in the case of inefficiency in resource use, the kiwi production can be increased or at least can be restored its increasing trend by making adjustment in the use of factors of production in optimal direction. With scarce resources, there is a high national demand for careful exploration of production possibilities and ways for increasing the efficiency of resource use on kiwi farms. So, the study has been designed to evaluate the resource use efficiency of the kiwi farmers of Dolakha district of Nepal. The objective of the study was to evaluate the resource use efficiency of the kiwi producer farmers in Dolakha district of Nepal.

METHODOLOGY

DATA COLLECTION

Dolakha district was purposively selected for the study based on area coverage by kiwi fruit. The required data for this study were collected through household survey method from a sample of 80 farmers from two areas; Bhimeshowor and Jiri municipality of Dolakha district. Eighty farmers were randomly selected taking 40 from each study site. The survey was carried out in June 2019. The secondary data were collected from the various publications of related organizations like National Center for Potato, Vegetable and Spice Crops Development, Ministry of Agriculture and Livestock

Development (MOALD), Prime minister Agriculture Modernization Project, Project Implementation Unit (PMAMP-PIU), Agro-Enterprise Center (AEC) etc.

ANALYTICAL MODEL

Cobb-Douglas production function was chosen to estimate the kiwi fruit production function of kiwi fruits producers. The choice of the functional form was based on its theoretical fitness to agriculture and its computational manageability. Further, most production studies in agricultural sector have used this function (Sahota, 1968; Dhawn and Bansal 1977; Barman 1993; Barman and Chaudhary, 2000). The model specified and used was represented by $Y = \alpha X_1^{b1} X_2^{b2} \ldots\ldots\ldots X_n^{bn}$,where Y was dependent variable and X_1through X_n were the explanatory variables. 'A' was the constant and X_1through X_n were factors of production, respectively. The production function was converted to logarithmic form so that it could be solved by least squares method

i.e. $\text{Log } Y = \text{Log } \alpha + b_1 \text{Log } X_1 + \ldots\ldots\ldots\ldots\ldots + b_n \text{Log} X_n$

Mathematically, the Cobb-Douglas production function can be expressed as:

$$Y = \alpha X_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5}$$

In log linear form the above model can be expressed as follows

$$\text{Log } Y = \text{Log } \alpha + b_1 \text{Log } X_1 + b_2 \text{ Log } X_2 + b_3 \text{ Log } X_3 + b_4 \text{Log } X_4 + b_5 \text{ Log } X_5$$

Where,

Y = Gross return (Rs/*ropani*)
X_1 = Human labour cost (Rs/ *ropani*)
X_2= Irrigation cost (Rs/*ropani*)
X_3 = Training and pruning cost (Rs/*ropani*)
X_4= Manure cost (Rs/*ropani*)
X_5= Pesticide cost (Rs/*ropani*)
α = coefficient

Land fertility and its productivity is important factor which was not included in this model due to lack of appropriate information on it.

Definition and measurement of variables

Gross return (Y): It was the product of per *ropani*estimated yield of kiwi fruit and per unit price at the farm level.

Human labour cost (X_1): It was product of ongoing wage rate and total human labour hours spent on different operations in kiwi fruit production, such as land preparation, manuring, and pesticide application etc. In costing the family labours, their opportunity cost were considered at ongoing wage rate and taken into account.

Irrigation cost (X_2): The irrigation cost was calculated from the product of ongoing wage rate and total human labour hired for the irrigation canal management – maintenance operation.

Training and pruning cost (X_3): Itis the sum of total labour hired for training and pruning of kiwi fruit and depreciation cost of initial construction of pillar/staking for kiwi fruit farming.

*Manure cost (X_4)***:** The cost of manure was calculated from direct cash expenditure and imputed value of home supplied quantity of manure and converted into per *ropani* basis for analysis.

Pesticide cost (X_5): The direct expenditures on pesticides used in kiwi fruit production for preventing insects and checking diseases was considered in costing and converted into per *ropani* basis for analysis.

Area

1 Hectare = 30 *Kattha* = 19.66 *Ropani*

MULTI-COLLINEARITY

Production analysis with cross sectional data sometimes may lead to the problem of multi-collinearity which is the linear relationship between variables. However, in this study, a thumb rule was applied to visualize the magnitude of multi-collinearity, i.e. "The correlation coefficient between a pair of explanatory variables was treated serious if it was greater than 0.8" (Heady and Dillon, 1961). To ascertain the problem of multi-collinearity, a zero order correlation matrix for all explanatory variables was obtained for this production function.

MARGINAL VALUE PRODUCT (MVP)

Technically the marginal productivity of a particular resource is defined as the addition to the gross return caused by an addition of one unit of that resource while other inputs are held constant. The most reliable and useful estimation of MVP is obtained by taking the inputs (Xi) as well as gross return (Y) at their geometric means (Dhawan and Bansal, 1977). The MVP was computed by multiplying the regression coefficient of the given resource with the ratio of geometric mean of gross return to the geometric mean of the given resource i.e.

$$MVI \frac{\bar{Y}(GM)}{\bar{X}i(GM)}$$

Where, i = 1,2…..n and GM represents the geometric mean. The marginal value product for all variable inputs was measured in terms of Rs.

ECONOMIC EFFICIENCY OF RESOURCES

The economic efficiency of the kiwi fruit farmers as the users of resources can be measured by comparing marginal value products of inputs to their marginal cost in acquisition. Since the variables used in analysis were

expressed in terms of a value, 11 percent rate or interest was charged for the cost of all used variable inputs and considered for the period of seven months only and were expressed in Rs. So, the cost of Rs was Rs. 1.064 represented as the cost of acquisition of inputs. The ration of MVP of different inputs to their respective acquisition cost was calculated. A ratio equal to unity indicates the optimum use of that factor. A ratio more than unity indicates that the return could be increased by using more of that resource and a value less than unity indicates the unprofitable level of resource use which should be decreased to minimize the losses.

RESULTS AND DISCUSSION

PRODUCTIVITY AND RESOURCE USE EFFICIENCY

Regression analysis was done for the whole sample with the specified functional model i.e. Cobb-Douglas production function. The coefficients and estimated values of different parameters in the model were given in Table 1. The coefficient of variable X_3training-pruning application was 0.599 and found to be highly significant at 1 percent level which implied that expenditure on training-pruning is useful. The expenditure on training-pruning may be useful for controlling disease and insect pest incidence and creating favorable environment for more fruiting for next year. The regression coefficient of irrigation and manure were 0.246 and 0.238 which were significant at 5 percent level indicating that if irrigation cost and manure cost were increased by 1 percent, other inputs remaining the same, there would be an increase in gross return by 0.246 percent and 0.238 percent, respectively. However, regression coefficient of pesticide application was found non-significant. Similarly, the production coefficient for human labour was also non-significant.

Table 1: Parameter estimates of regression models for gross return of kiwi fruit production with different explanatory variables

Independent Variables	Un-standardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
Constant	1.908	0.273		7.012	0.000**
Log human labour cost (X_1)	0.097	0.075	0.143	1.299	0.199
Log irrigation cost(X_2)	0.246	0.114	0.282	2.167	0.034*
Log training and pruning cost (X_3)	0.599	0.128	0.661	4.670	0.000**
Log manure cost (X_4)	0.238	0.095	0.214	2.142	0.032*
Log pesticide cost (X_5)	0.007	0.013	0.040	0.452	0.654

Dependent Variable: Gross return SE = Standard Error.

R = 1.409, R^2 = 0.789, Adjusted R^2 = 0.774 and Stand error of estimate = 0.0872,

Durbin- Watson test = 2.412 and F statistics = 54.922**

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

The sum of production coefficient was 1.409. This was more than unity, which indicated that there was increasing return to scale in kiwi fruit production. Coefficient of multiple determination (R^2) being 0.789 and indicated that the explanatory variables used in the model specification were important and 78.9 percent variation in the kiwi fruit production was explained by them. The F statistic was observed to be 54.922 and highly significant at 1 percent level implying a good fit of the model. Obviously, the larger the R^2 value is the more important the regression equation is in characterizing the dependent variable (Gomez and Gomez, 1984).

Table 2: Regression coefficients and test statistics of the kiwi fruit producers in study area

Parameters	Regression coefficients	MVP of factors of production	Geometric mean (Rs.)	Ratio of MVPs to their costs
Constant	1.908	-	93942.41	-
Human labour	0.097	0.92	16740.50	0.857
	(0.199)			
Irrigation	0.246*	5.06	2900.00	4.749
	(0.034)			
Training and pruning	0.599**	7.94	9860.80	7.459
	(0.000)			
Manure	0.238*	3.53	4875.45	3.428
	(0.032)			
Pesticide	0.007	1.67	430.97	1.562
	(0.654)			

It was also found that the inter correlation between independent variables was also low i.e. no correlation coefficient between explanatory variables was greater than 0.80. Thus satisfying the criterion for non - seriousness of multi-collinearity (Table 3).

Table 3: Zero order correlation matrix of variables for studied kiwi fruit farmers

Variables	Gross return	Human labour cost	Irrigation cost	Training and pruning cost	Manure cost	Pesticide cost
Gross return	1.00	0.465	0.740	0.773	0.300	0.667
Human labour cost	-	1.00	0.558	0.552	0.742	0.512
Irrigation	-	-	1.00	0.709	0.439	0.719
Training and pruning	-	-	-	1.00	0.432	0.773
Manure	-	-	-	-	1.00	0.374
Pesticide	-	-	-	-	-	1.00

CONCLUSIONS

Overall functional analysis showed that the kiwi fruit farmers were rational in making expenditures on training–pruning, irrigation and manure as the ratios of MPVs of these resources to their costs were significantly greater than unity, indicating optimum level of resources use. Less than unity ratio of MPV to factor cost as found in human labour indicated that the expenditure on this input was greater than their contribution and used not at an optimal level. These observations of the study were based on statistical estimations made through a production model specified with five explanatory variables. Similarly, due to perennial nature of kiwi tree only variable costs were included for this study and all the plants taken for the study are in the productive phase and examine single year of production. Encouragement and support towards mechanization in kiwi farming, use of improved cultivation technology, use of drip irrigation will make kiwi farming much profitable in Dolakha districts of Nepal.

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WHEAT VARIETAL DEVLOPMENT FOR INCREASING PRODUCTIVITY IN HILLS OF NEPAL

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ABSTRACT

Wheat is one of the most important cereal crops of Nepal. The research was conducted to identify the high yielding wheat varieties for Mid and High Hills (MHH) of Nepal. Coordinated Varietal Trial (CVT-MHH) was conducted during 2014/15 and 2015/16 wheat season at five different locations in Randomized Complete Block design with three replications. In 2014/15, highly significant difference among the genotypes was observed for the days to heading (DH), days to maturity (DM), plant height (PH), spikes/m2, grains per spike, Thousand Grain weight (TGW) and Grain Yield. NL 1153, BL 4520 and WK 2286 were the high yielding genotypes with the grain yield of above 4 tons/ha. In 2015/16, highly significant difference ($p<0.01$) was observed for the DH, DM, PH, Grains per spike, TGW and grain yield. NL 1226, WK 2430, WK 2422 and NL 1179 were the high yielding genotypes with good yield attributing traits. There is an option to select the better genotypes like WK 2286, NL 1226, WK 2430, NL 1179 and WK 2422 for grain yield and other associated traits as variety.

Keywords: Genotypes, hill, productivity, traits, wheat

INTRODUCTION

Wheat is the crop of global importance. Nepal as a mountainous country the development of the wheat variety for the hill is very important. Wheat is grown from Terai to high mountain region and consumption of wheat is increasing day by day. Wheat is the third major cereal crop after rice and maize in Nepal. The Mid-hills and high hill represent the 32% of the total production and 43% of the area.The area under wheat production under mid

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and high hills was 317458 ha and produced 598243 metric tons with the average productivity of mountain and hills was 2047 kg/ha (MOAD, 2017). The low level of productivity is mainly due to difficulty in availability of improved varieties on one hand and occurrence of different wheat disease on the other. Since there is little scope for increasing land area under wheat, the major challenge will be to break the yield approaches (Chatrath et. al, 2007).There is a need of increment in grain yield to meet the current and future demands of food.

Wheat grain yield potential, high water-use efficiency with end-use quality are continued to complement with durable resistance to all three rusts and other diseases or pests to achieve more productive, climate-resilient, farmer-friendly wheat varieties. Despite these limitations, Dahal et al. (2015) reported that the there is an increment in production and productivity of wheat with the advancement of new varieties and market expansion.

Varietal improvement is a continuous process, which helps to suppress the biotic and abiotic factors and, also improves the production and productivity by developing and disseminating new high yielding wheat varieties. The factors responsible for low yield are lack of suitable high yielding varieties, improper seed flow system, lack of tolerance to sterility and low level of resistance to leaf rust, yellow rust and loose smut diseases in these agro-ecological zones of hills. Abiotic factors like drought, snow fall, hail stone and poor soil fertility are also equally responsible for low yield of wheat in hilly areas of Nepal. Therefore, there is a need to develop many numbers of varieties with location specific. Also, it is necessary to develop early maturing wheat varieties to fit in rice-wheat, maize-wheat and millet-wheat cropping system in addition to leaf rust, stripe rust, loose smut resistance and sterility tolerance. Among the biotic stresses, leaf rust, stripe (yellow) rust and foliar blight are major yield limiting factors. Stripe epidemics during the 1980s, mid 1990s, and in 2004-05, caused yield losses of 50-80%. Leaf rust epidemics are sporadic and less damaging and has been under control since 1985 and no yellow rust epidemics have been reported since 2005 (Bhatta et al., 2012).

National Wheat Research program is following the improvement of wheat by using modified selected bulk method in early generations for achievement of adequate to high levels of durable resistance through pyramiding of minor, slow rusting, or partial resistance genes and single plant method at late generations (NWRP, 2014). After the introduction of modern semi dwarf high yielding wheat varieties: Sonalika (RR21), PasangLamhu, WK 1204, Dhaulagiri and Gaura responding to high inputs, the area under wheat in Nepal has been increased significantly (NWRP, 2014). Some of the wheat varieties like Danphe (NL 1064) and Sworgadwari (BL 3629) which were advanced to the next level in Coordinated Varietal Trial for mid and high hill (CVT-MHH)

during 2011/12 have been released (Gautam et al., 2013). Thus, to develop high yielding and disease resistance wheat varieties for hilly region, Coordinated Varietal Trial was conducted at different locations representing hill environments of the country.

MATERIALS AND METHODS

RESEARCH DESIGN

The multilocations testing of wheat germplasm was done at five different agricultural research stations. Planting was done in normal planting season of 2014/15 and 2015/16 in Agriculture Botany Division, Khumaltar; Horticulture Research Station, Dailekh; Agriculture Research Station, Pakhribas; Hill Crop Research Program, Dolakha and Agriculture Research Station, Jumla(Table 1). Both the exotic germplasm and newly developed genotypes through hybridization at Bhairahawa and Agricultural Botany Division, Khumaltar were used. Twenty genotypes including two check varieties, Dhaulagiri and WK 1204 were used in the experiment. Randomized Complete Block (RCB) design with three replications was used. The spacing between the rows was 25 cm. The plot size was eight rows of three meters length (6 m^2). In CVT-MHH, twenty genotypes

DATA RECORDING AND ANALYSIS

Observations on quantitative characteristics like days to heading (DH), days to maturity (DM), plant height (PH), Grains per Spike (GPS), thousand grains weight (TGW) and Spikes per meter square (SPMS) and grain yield (GY) were measured and collected. Data was analyzed utilizing ANOVA technique on CROPSTAT program.

Table 1: Details of the trial conducted locations

S.N.	Research Stations	Address	Geographical Position	Altitude (meters above sea level)
1	Agriculture Research Station (ARS)	Bijayanagar, Jumla	29º17' N 82º10'E	2300
2	Agriculture Research Station (ARS)	Pakhribas, Dhankuta	27º05' N 87º14'E	1889
3	Hill Crop Research Program (HCRP)	Kabre, Dolakha	27º38' N 86º08'E	1733
4	Agriculture Botany Division (ABD)	Khumaltar, Lalitpur	27º39' N 85º19'E	1321
5	Horticulture Research Station (HRS)	Kimugaun, Dailekh	28˚50.83' N 081˚43.3' E	1255

RESULTS AND DISCUSSION

DAYS TO HEADING

Reduced photo period has major effects on the adaptability of bread wheat to specific environments (Wilhelm et al, 2013). Therefore, the selection for the early heading genotypes is important in the breeding program. In this research also a highly significant difference among the genotypes for the days to heading was observed in 2014/15. Twelve genotypes have the early heading than the mean (115 days). WK 2415 and WK 2422 were the early genotypes with 110 days for the heading (Table 2). Similarly, in NL 1179, WK 2286 and WK 2123 heading days of 116, 118 and 119 respectively was observed. In 2015/16 also highly significant difference among the genotypes was found. WK 2422 with 101 days to heading was the earliest heading genotype. That was followed by NL 1179, NL 1226, WK 2430 and WK 2286 up to 107 days. WK 2395 was the late among the tested genotypes (Table 3). The days to heading ranged from 111 days to 119 days in the year 2014/15 and 103 to 115 days in 2015/16. Simillar finding has been reported by Pant et al, (2019) and Thapa et al., 2009)

DAYS TO MATURITY

A significant difference among the genotypes was observed for days to maturity in both years 2014/15 and 2015/16. WK 2415 was the earliest maturing genotype of 152 days followed by WK 2422 with 153 days in 2014/15 (Table 2). Seven genotypes had the earliest maturity day than both of the check varieties. In 2015/16 also the genotype WK 2422 showed the earliest maturity of 145 days. Similar kind of maturity days was observed in WK 2422 and WK 2432. The days to maturity ranged from 152 to 163 days with mean value of 157 days in 2014/15 and 145 to 153 days in 2015/16. The result is in conformity with the finding of Pant et al. (2020) and Thapa et al. (2009). Early heading and early maturing variety WK 2422 showed hopes for the wheat growers to get climate resilient wheat genotypes. This suggests that the WK 2422 varieties could be used as a genetic resource for developing early genotypes thereby intensifying the agriculture cropping system in the hills.

Table 2: Summary of combined analysis of different traits in CVT- MHH across five locations (Jumla, Pakhribas, Khumaltar, Kabre and Dailekh), 2014/15

Genotypes	DTH (days)	DTM (days)	PH (cm)	NGPS	SPMS	TGW (g)	GY (kg/ha)
NL 1153	111	156	94	53	319	49	4254
NL 1156	116	156	87	49	272	55	3224
NL 1159	119	162	85	52	231	50	3619
NL 1178	117	156	86	53	272	52	3837

NL 1179	116	155	83	48	277	51	3526
NL 1183	115	162	78	48	250	47	3348
NL 1217	114	159	77	49	299	44	3709
NL 1218	113	155	71	49	279	44	3108
WK 2123	119	159	78	50	307	44	3261
WK 2218	113	157	99	45	299	43	3492
WK 2249	115	154	95	49	275	47	3762
WK 2286	118	163	83	53	293	47	3853
WK 2414	112	153	82	49	296	42	3536
WK 2415	110	152	82	55	307	43	3382
WK2422	110	153	77	40	276	49	3509
BL 4520	112	156	82	53	287	50	4043
BL 4541	118	158	100	45	299	46	3449
BL 4566	112	154	103	45	301	48	3226
WK 1204(check)	118	159	80	51	273	46	4011
Dhaulagiri(check)	112	154	89	51	270	47	3753
Grand Mean	115	157	85	49	284	47	3595
Genotype (*p*)$^{\Psi}$	<0.01	0.03	<0.01	>0.05	>0.05	<0.01	<0.01
Location (*p*)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Genotype X Location (*p*)	>0.05	>0.05	>0.05	>0.05	0.04	<0.01	<0.01
LSD value	9.2	24.4	13.1	27	130.6	6.7	1534
CV (%)	4	7.8	7.7	17.8	13	7.1	12.3

Where, DTH=days to heading, DTM=days to maturity, PH=plant height, NGPS=no. of grains/spike, SPM= spikes/mete square, TGW=thousand grain weigth, GY=grain yield. LSD=least significant difference and CV=coefficient of variation.

$^{\Psi}$ *Indicates significant difference among the tested genotypes (where, p is> 0.01 to <0.05), highly significant difference among the tested genotypes (where, p is <0.01) and non-significant difference among the tested genotypes (where, p > 0.05).*

PLANT HEIGHT

Significant difference among the genotypes was observed for plant height in both year 2014/15 and 2015/16. Ten genotypes were shorter in plant height than both checks. The genotype NL 1218 had shortest height (71 cm) followed by NL 1217(77 cm) and WK 2422(77 cm) (Table 2). In 2015/16, shortest plant height was observed in WK 2422 (77 cm). Similar height was observed for WK 2123, WK 2430 and NL 1183 (Table 3). The plant height ranged from 71 cm to 103 cm. This finding was found similar to the previous findings obtained by Gautam et al. (2013) and Pant et al. (2020).

NUMBER OF SPIKES PER SQUARE METER

There was no significant difference among the genotypes for the number Spikes per square meter. However, the highest number of spikes was observed in the NL 1153 followed by WK 2415 and WK 2123 in 2014/15. A significant difference was observed in 2015/16 but no interaction according to the location was observed for this parameter. The highest spikes per square meter was found in WK 2123(248) followed by WK 2430, NL 1227 and NL 1229(Table 3). The spikes per square meter ranged from 231 to 319 in 2014/15 and 174 to 248 in 2015/16. This is similarto the previous findings obtained by Thapa et al., 2013 and Gautam et al., 2013. The tiller number as counted per square meter is correlated to the yield. The highest correlated response was expressed by grain yield with tillers number. The correlation between spikes per square meter and the grain yield was high (r=0.85), suggesting that the grain yield is associated with the spikes. In a similar study, the author indicated the possibility of improving wheat genotypes through selection utilizing existing variation in these traits (Joshi et al., 2016).

Table 3: Combined analysis in CVT- MHH across five locations (Jumla, Pakhribas, Khumaltar, Kabre and Dailekh), 2015/16

Genotypes	DTH (days)	DTM (days)	PH (cm)	NGPS	SPMS	TGW (g)	GY (kg/ha)
NL 1178	106	148	80	41	199	47	2824
NL 1179	104	146	79	33	208	46	3098
NL 1183	103	147	77	37	195	49	2500
WK 2123	108	149	77	39	248	40	3079
NL 1217	104	147	73	40	184	44	2696
WK 2286	107	151	79	42	231	42	3039
WK 2422	101	145	77	38	231	46	2671
BL 4621	106	148	83	38	207	40	2782
BL 4622	107	148	85	42	196	38	2818
NL 1226	105	148	80	40	223	44	3348
NL 1227	107	149	79	42	234	41	2975
NL 1229	104	145	81	45	234	41	2864
NL 1231	104	146	78	42	183	44	2730
NL 1232	104	148	81	37	226	48	3059
WK 2375	111	152	85	41	207	42	2737
WK 2395	115	153	78	49	174	46	2116
WK 2432	100	145	81	40	203	47	3144
WK 2430	106	148	77	41	239	41	3174

WK 1204 (Check)	108	151	80	42	225	45	3322
Dhaulagiri (Check)	101	148	83	39	205	54	2504
Grand Mean	106	148	80	41	199	47	2824
Genotype(*p*)$^{\Psi}$	<0.01	<0.01	0.04	<0.01	0.03	<0.01	0.02
Location (*p*)	0.03	0.02	>0.05	0.02	0.04	<0.01	0.03
Genotype x Location (*p*)	>0.05	0.03	>0.05	0.02	>0.05	<0.01	>0.05
LSD Value (5%)	4.9	3.8	9.0	6.9	76.0	2.4	1476
CV (%)	2.9	1.6	6.9	10.5	18.9	3.3	14.5

Where, DTH=days to heading, DTM=days to maturity, PH=plant height, NGPS=no. of grains/spike, SPSM= spikes/mete square, TGW=thousand grain weigth, GY=grain yield. LSD=least significant difference and CV=coefficient of variation.

$^{\Psi}$ *Indicates significant difference among the tested genotypes (where, p is> 0.01 to <0.05), highly significant difference among the tested genotypes (where, p is <0.01) and non-significant difference among the tested genotypes (where, p > 0.05).*

GRAINS PER SPIKE

In 2014/15, Non-significant difference among the genotypes was observed for the tested genotypes. The genotypes WK 2415, NL 12153, NL 1178, WK2286 and BL 4950 had more numbers of grains than both of checks. Highly significant difference for grains per spike was observed in 2015/16. The Seven Genotypes has produced more numbers of grains per spike tham mean value (41). The WK 2395 produced highest grains per spike (49) followed by NL 1229 (45). The number of grains per spike ranged from 45 to 53 with mean value of 49 in 2014/15 and 33 to 49 with mean value of 41 in 2015/16. This result is similar to result obtained by Thapa et al., 2013 and Gautam et al., 2013.

THOUSAND GRAINS WEIGHT (TGW)

Highly significant difference among the genotypes was observed for thousand grains weight in both 2014/15 and 2015/16. In 2014/15, Nine genotypes had highest thousand grains weight than the mean value. The highest thousand grains weight was observed in NL 1156 (55 g) followed by NL 1179, WK 2422 and WK 2286 with the thousand grains weight of 51 g, 49 g and 47 g respectively. Dhaulagiri showed the highest TGW over the all tested entries in 2015/16. The genotypes NL 1183 and WK 2432 had the higher thousand grain weight than the mean value. GXE interaction in TGW was observed. The thousand grain weight ranged from 42 g to 45 g with mean value of 47 in 2014/15 and 38 to 54 with mean value of 47 in 2015/16. This result is similar to result obtained by Pant et al., 2020 and Gautam et al., 2013.

GRAIN YIELD

The highly significant difference among the genotypes was found for grain yield in both 2014/15 and 2015/16. The highest grain yield was produced by NL 1153 (4254 kg/ha) followed by BL 4520 (4043 kg/ha), WK1204 (4011 kg/ha), and WK 2286 (3853 kg/ha) and NL 1178 (3837 kg/ha) in 2014/15 (Table 2). In 2015/16, highest grain yield was observed in NL 1226 with 3348 kg/ha followed by WK 2430, NL 1179, WK 2123 and WK 2286. Greater yield advantage from new varieties over local checks was reported from rainfed environments and areas where old local varieties were used (Joshi et al., 2017). The grain yield ranged from 3108 to 4254 kg/ha in 2014/15 with mean value of 3595 and 2116 to 3348 kg/ha with mean value of 2824 kg/ha in 2015/16. The range is in accordance with the finding by Pandey et al., 2019; Thapa et al., 2013 and Gautam et al., 2013 for mid hill environment of the country.

CONCLUSION

Genotypic variation was found among all the tested genotypes for different agronomic traits. Based on the grain yield and yield attributing traits, the genotypes WK 2286, NL 1226, WK 2430, NL 1179 and WK 2422 were found promising and can be released as varieties for mid and high hill region of the country after testing in farmer's field.

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EVALUATION OF INDIGENOUS AND IMPROVED CULTIVARS OF POTATO AGAINST LATE BLIGHT (*Phytophthora infestans* L.) IN OKHALDHUNGA, NEPAL

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ABSTRACT

A two-factor field experiment was conducted in randomized complete block design with ten cultivars of potato; six indigenously cultivated and four improved varieties in two blocks; one with management against late blight of potato (protected) and the other without any management (unprotected). Highly significant (p≤0.01) effect on yield (tha^{-1}) ranging from 3.23 to 9.839 was observed among tested cultivars. The highest yield was observedin cultivar Pasang Alu (9.839t ha^{-1}) followed by BhotangeSeto (8.622t ha^{-1}), Local RatoGolo (8.036t ha^{-1}), KufriJyoti (6.056t ha^{-1}), Namjeli SetoLamcho (5.742), Namjeli SetoGolo (5.475t ha^{-1}), Desiree (4.453t ha^{-1}), KhumalSeto (3.586t ha^{-1}), and Khumbule Rato (3.394t ha^{-1}) while the lowest yield was found in cultivar Janakdev (3.231t ha^{-1}). Mean yield in the protected plots (6.502t ha^{-1}) vs. unprotected plots (5.185t ha^{-1}) and that of the tested cultivars was found to be highly significant (p≤0.01) for both protected and unprotected blocks but cultivar Pasang Alu was indifferent to the treatment.

Keywords: Indigenous cultivars, late blight, potato

INTRODUCTION

Potato occupies fifth position in area coverage, second in total production and first in productivity among the food crops grown in Nepal (MOALD, 2019/20). It covers 195,173 ha of total cultivated land, with the production of 2,881,829tons and the productivity of 14.76 metric tonha^{-1} in Nepal (MOALD, 2019/20).

Late blight, a devastating disease, caused by *Phytophthora infestans* L.(Mont.) De Bary, is the most important biotic constraint of potato production throughout the world claiming upto complete destruction of the crop.

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Late blight is an important and widely spread disease throughout the potato growing areas of Nepal (Sharma et al., 2011). In high hills, the losses have been encountered more than 75 percent (Shrestha and Kharel, 1996) and interai losses have been recorded 50-90 percent in some years (Shrestha, 2000). In mid hill valleys like Kathmandu and Panchkhal, where potatoes are grown twice a year (autumn and spring season), late blight has become severe.

The late blight pathogen was apparently originated from Central Mexico (Zimnoch-Guzowska et al., 2003).Thegenus, *Phytophthora*, belongs to oomycetes, which are unrelated to true fungi (Shaw and Khaki, 1971). The disease, well known for causing historic Irish famine during mid-19th century, is major constraint in potato production in different parts of the world (Fry and Goodwin, 1997; Elansky, et al., 2001). It affects potato foliage in the field and tuber in storage, causing yield loss up to 100 percent (Tsedaley, 2014). It is the most important disease of potato worldwide (Sharma et al., 2013) and is best known, highly studied and still the most devastating of all potato diseases (Jones, 1998). It is probably, the single most important disease of potatoes and tomatoes for huge economic loss worldwide (Sonet al., 2008). Losses due to *P. infestans* have been estimated to € 12 billion per annum, of which the losses in developing countries have been estimated around € 10 billion per annum (Haverkortet al., 2009). Due to the ability of pathogen to cause huge yield loss it is regarded as a potential threat to global food security (Latijnhouwers et al., 2004). In addition to economic losses, the disease also possesses a threat for food security, human health and environment (Kromann et al., 2009) as it demands a lot of fungicide applications in the field (Haverkort et al., 2009). According to Ghimire *et al*. (2003), late blight of potato was first reported in between 1883 and 1897 and appeared as an epidemic since mid-1990s in Nepal. Shrestha (1976) reported that heavy losses due to the late blight disease on potato in hills during summer and in Kathmandu valley during winter. Nation-wide crop failure in Nepal due to late blight occurred in 1996 (Dhital and Ghimire, 1996).

Due to long-term economic benefits for farmers, host resistance is a major component in integrated management of the disease. It also minimizes changes in the population structure of the pathogen, decreasing the likelihood of fungicide resistance (Hakiza 1999; Mukalazi et al., 2001). Breeding activities and use of biotechnological tool for resistance to *P. infestans* started in the 19th century and has continued at a slower rate. Variations in resistance to late blight among different potato varieties have been demonstrated by several researchers (Njulaem et al., 2001).

Considering the importance of host resistance in late blight disease management, the experiment was conducted to determine resistant/tolerant

local or improved potato cultivars to late blight with better yield in the given location.

MATERIALS AND METHODS

A two-factor field experiment in a randomized complete block design (RCBD) was conducted with ten cultivars of potato with three replications in two blocks; one with management against late blight disease of potato (protected) and the other without management (unprotected) at Siddhicharan 7, Okhaldhunga. Of the ten cultivars kept under trial six of them (Namjeli SetoLamcho, Namjeli SetoGolo, Bhotange Seto, Khumbule Rato, Pasang Aalu and Local RatoGolo) were collected from locally preserved and multiplied seeds by potato farming households in Okhaldhunga and Solukhumbu districts which were locally named and distinguished for different morphological characteristics (including tuber). Four of the varieties used (Desiree, Janakdev, Khumal Seto and KufriJyoti) were third generation basic seed obtained from National Potato Research Program, Khumaltar, Lalitpur. The experimental site represents mild temperate climate at an altitude of 1810 masl with sandy loam soil.

Field trial in both blocks were laid out with application of farm yard manure at the rate of 20 $tonha^{-1}$ and chemical fertilizers 100:100:60 $kgha^{-1}$ in the form of N_2:K_2O:P_2O_5 through urea, di-ammonium phosphate and muriate of potash during the planting time but late blight disease was completely managed in protected block only by application of fungicide Krilaxyl (metalyxil 8% + mancozeb 64% WP) with four sprays of the fungicide applied at the rate of 2 gl^{-1} water at the rate of 800 lha^{-1} starting from 50 days after planting (DAP) followed by 57, 64 and 71 DAP, respectively. While another block (unprotected) was allowed for natural infection without application of any control measures. Disease scoring was done in unprotected plots at one week interval starting from 75 days after planting (DAP) for three times using 0-9 scale (Henfling, 1987) on whole plot basis.The area under disease progress curve (AUDPC) was calculated with the formula as given by Campbell and Madden(1990); Madden and Hughes (1995).

$$\mathrm{AUDPC} = \sum_{i=1}^{n-1} (Y_{i+1} + Y_i)\ 0.5\ (T_{i+1} - T_i)$$

Disease severity was estimated on percentage basis with the formula (Kranz, 1988)

Disease Severity (%) = [sum (class frequency × score of rating class)]/[(total number of plants) × (maximal disease index)] x 100%

GenStat fifteenth edition (v.15.1.0.8035) package was used for analysis of the data.

RESULTS

DEVELOPMENT OF LATE BLIGHT AND RESPONSE OF POTATO CULTIVARS

Cultivars of potato tested in unprotected plots showed differential response to late blight (Table 1). Appearance of symptoms first started 47 DAP on cultivar Namjeli SetoGolo, which was statistically at par with cultivar Namjeli SetoLamcho (49 DAP) followed other cultivars (Table1). Plots with fungicide application (protected) were disease free.

In unprotected plots, cultivars differed significantly ($p \leq 0.01$) in maximum disease severity (%) 71 DAPon foliage (Table 1). Significantly highest disease severity was observed on cultivar Namjeli SetoGolo (88.89%), which was statistically at par with cultivars Namjeli SetoLamcho (85.19%) and Namjeli SetoGolo (85.19%). Pasang Alu showed least disease severity (25.93%) among all the tested cultivars. In protected plots, weekly sprays of fungicides starting at 50 DAP kept all the tested cultivars free from the late blight.

Table 1: Days to appearance of disease after planting and maximum severity of late blight on 10 potato cultivars during December 2016 to May 2017 at Bigutar, Okhaldhunga, Nepal

Cultivar	Days to disease appearance (DAP)		Maximum severity (%)	
	Unprotected	Protected	Unprotected	Protected
NamjeliSetoLamcho	49^{ab}	0.0	85.19^{ab}	0.0
NamjeliSetoGolo	47.67^{a}	0.0	88.89^{a}	0.0
Janakdev	49.67^{b}	0.0	59.26^{d}	0.0
BhotangeSeto	50.33^{b}	0.0	74.07^{bc}	0.0
KhumbuleRato	50.67^{b}	0.0	74.07^{bc}	0.0
KufriJyoti	50.67^{b}	0.0	85.19^{ab}	0.0
PasangAalu	57.33^{d}	0.0	25.93^{e}	0.0
KhumalSeto	56.33^{d}	0.0	55.56^{d}	0.0
Local RatoGolo	51^{b}	0.0	66.67^{cd}	0.0
Desiree	53.33^{c}	0.0	55.56^{d}	0.0
F Value	**		**	
LSD	1.902		12.33	
CV	1.2		2.5	
Grand mean	51.60		67	

Protected plots - fungicide (Krilaxyl) @2 gl^{-1}, Unprotected plots – No fungicide

DAP= Days after planting, LSD= Least significant difference, CV= Coefficient of variation

DISEASE SEVERITY PROGRESS

On different dates of disease scoring i.e. 57, 64 and 71 days after planting (DAP) significantly highest disease severity was observed on all estimations of severity viz. disease severity 1, 2 and 3 in cultivar Namjeli SetoGolo 29.63, 59.26 and 88.89, respectively while cultivars Pasang Alu and Khumal Seto were found to have no disease severity in first scoring (Figure 1).

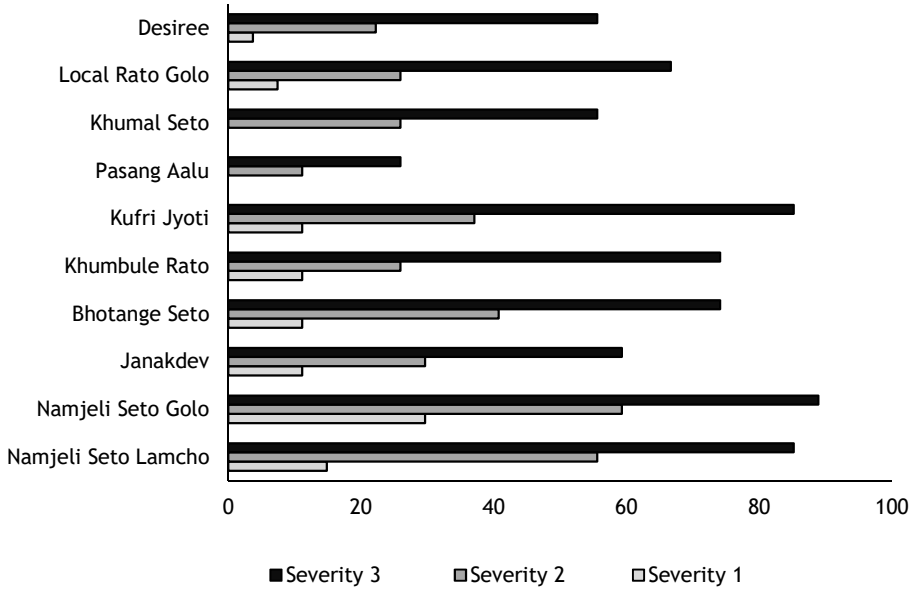

Figure 1: Disease severity progress in different cultivars of potatoes during December 2016 to May 2017 in Bigutar, Okhaldhunga, Nepal

AREA UNDER DISEASE PROGRESS CURVE (AUDPC)

AUDPC 1 varied significantly ($p \leq 0.01$) among the cultivars. The highest AUDPC 1 was observed in cultivar Namjeli SetoGolo (222.2) followed by other cultivars as in table 2. Least AUDPC 1 was observed in cultivar Pasang Alu (27.8).

AUDPC 2 also varied significantly ($p \leq 0.01$) among the cultivars (Table 2). Highest AUDPC 2 was observed in cultivar Namjeli SetoGolo (370.4) which was statistically at par with cultivar Namjeli SetoLamcho (351.9) followed by other cultivars as in table 2. Least AUDPC 2 was observed on cultivar Pasang Alu (92.6).

Mean AUDPC varied significantly ($p \leq 0.01$) among the cultivars (Table 2). Highest mean AUDPC was observed in cultivar Namjeli SetoGolo (296.3) followed by other cultivars as in table 2. Least AUDPC 2 was observed on cultivar Pasang Alu (60.2).

Table 2: AUDPC values of late blight on 10 cultivars of potato under protected and unprotected conditions during December 2016 to May 2017 at Bigutar, Okhaldhunga, Nepal

Cultivar	AUDPC 1		AUDPC 2		Mean AUDPC	
	Unprotected	Protected	Unprotected	Protected	Unprotected	Protected
NamjeliSetoLamcho	175.9^{b}	0	351.9^{a}	0	263.9^{b}	0
NamjeliSetoGolo	222.2^{a}	0	370.4^{a}	0	296.3^{a}	0
Janakdev	101.9^{cde}	0	222.2^{de}	0	162de	0
BhotangeSeto	129.6^{c}	0	287^{bc}	0	208.3^{c}	0
KhumbuleRato	92.6^{def}	0	250^{cd}	0	171.3^{d}	0
KufriJyoti	120.4^{cd}	0	305.6^{b}	0	213^{c}	0
PasangAalu	27.8^{g}	0	92.6^{f}	0	60.2^{f}	0
KhumalSeto	64.8^{f}	0	203.7^{e}	0	134.3^{e}	0
LocalRatoGolo	83.3^{ef}	0	231.5^{de}	0	157.4d^{e}	0
Desiree	64.8^{f}	0	194.4^{e}	0	129.6^{e}	0
F-value	**		**		**	
CV%	6.8		2.6		3.1	
LSD (=0.05)	30.28		40.39		31.8	
Grand mean	108.3		250.9		179.6	

Protected – Fungicide applied Unprotected – Fungicide not applied

AUDPC= Area under disease progress curve, LSD= Least significant difference, CV= Coefficient of variation

YIELD AND YIELD PARAMETERS

Mean yield (tonha^{-1}), total number of tubers, number of tubers >50 g (large sized tubers), number of tubers <25 g (small sized tubers) were found highly significant ($p \leq 0.01$) between the protected and unprotected plots however the number of average sized tubers (25-50 g) were not significant ($p \leq 0.01$) (Table 3).

Table 3: Comparison of yield and yield parameters on protected and unprotected plots during December 2016 to May 2017at Bigutar, Okhaldhunga, Nepal

Treatments	No. of tubers			Total No. of Tubers	Yield (tonha^{-1})
	<25g	25-50g	>50g		
Unprotected	65.669	31.6	1.7	98.967	5.185
Protected	58.6	43.9	4.267	107.233	6.502
F Value	**	NS	**	**	**
Mean	62.13	37.75	2.98	103.1	5.83
LSD	2.462	0.974	0.227	2.484	0.076
CV%	7.58	10	29.5	4.61	2.51

Protected plot – Fungicide (Krilaxyl applied) Un-protected plot – Fungicide not applied

Mean yield (t ha^{-1}) for tested cultivars in protected and unprotected plots are given in figure 2. Among the tested cultivars Pasang Alu did not differ between protected and unprotected plots while cultivar Bhotange Seto showed maximum difference statistically at par with NamjeliSetoLamcho (Figure 2).

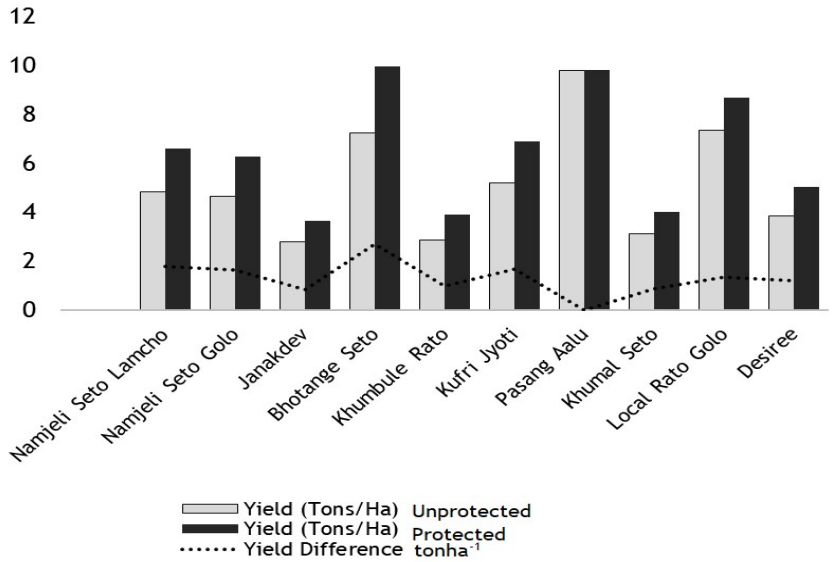

Figure 2: Tuber yield of different cultivars of potato in protected and unprotected plots at Bigutar, Okhaldhunga in May 2017

Tested cultivars of potato significantly differed on number of tubers less than 25 g (33 to 106) between 25 to 50 g (17 to 56), greater than 50 g (0.5 to 7) and total number of tubers (73 to 150). Highest number of tubers less than 25 g was found on Local RatoGolo and Desiree while lowest number was found in Janakdev. Similarly, highest number of tubers between 25 to 50 g was found on Pasang Alu while lowest number was found in Janakdev. In case of number of tubers greater than 50 g, the highest number was found on Pasang Alu while lowest number was found in Namjeli SetoGolo, Desiree and Janakdev. The highest number of tubers was found on cultivar Local RatoGolo while lowest number of tubers was found in cultivar Janakdev.

DISCUSSION

Appearance of symptoms started earliest on Namjeli SetoGolo from 47 DAP and lately on cultivar Pasang Alu 57 days after planting. The late appearance of late blight Pasang Alu may be associated with relatively smoother and

narrower leaves less suitable for holding of moisture resulting in unfavorable conditions for the germination of sporangia, oospores or zoospores of *Phytophthora infestans*. The late appearance of late blight in experimental site is associated with longer duration for germination taken by potato tubers due to climatic conditions of the region, no rainfall during earlier period of crop growth and lower relative humidity. The most important factor resulting variability of disease course is found to be the cultivars of potato which is confirmed by the results of Namanda et al., 2004, Douches et al., 2001, Li et al., 2010; Gebhardt et al., 2007; 2011.

Significant difference in disease severity on foliage was observed in cultivars observed. Highest disease severity was observed on cultivar Namjeli SetoGolo. Attainment of maximum disease severity at first in cultivar Namjeli SetoGolo may be associated with leaf morphology and angle of attachment with peduncle i.e. rough lamina with depressed veins allowing holding of more moisture for longer duration creating favorable environment for germination of zoospores, oospores or sporangia of pathogen. Pasang Alu showed least maximum disease severity among all the tested cultivars which may be credited to the leaf characteristics described above. Black (1970) and Yuen and Forbes (2009) have described about the relation of foliage morphology on non-race specific resistance of potato cultivars to late blight disease.

Highest AUDPC 1, AUDPC 2 and mean AUDPC were observed in cultivar Namjeli SetoGolo followed by cultivars Namjeli SetoLamcho. Least AUDPC 1, AUDPC 2 and mean AUDPC was observed in cultivar Pasang Alu. Account of AUDPC is mathematically related with disease severity so the plant characteristics responsible for the disease severity are responsible for the AUDPC 1 AUDPC 2 and mean AUDPC (Campbell and Madden, 1990).

Significant difference on number of tubers of different sizes observed suggest that individual difference among the cultivars innumber of tubers less than 25 g can have an avenue for genotypic properties of the individual cultivars responsible for the difference observed. Genotypic relationships in different tuber related performance i.e. yield and yield attributing characteristics of potato genotypes which has also been described by Li et al., 2010; and Gebhardt et al., 2007; 2011.

These results also suggest that protection against late blight of potato can reduce the number of smaller sized tubers which can be conversely stated that exposure to late blight which reduces size of tubers and vice-versa affecting total tuber yield in terms of mass. Highly significant difference in mean yield (t ha^{-1}) in protected plots in contrastto unprotected plots of the tested cultivars can be a basis for suggesting the farmers to apply the measures for disease control. Significant decrease in yield of potato in late

blight infected fields has been described by Tahtjarv et al., 2013; Haverkort et al., 2009. Yield of potato was observed far lesser compared to the yield potential of the released improved cultivars Janakdev, KhumalSeto, Desiree and KufriJyoti which can be accounted for the lesser national productivity of potato (14.03 tha^{-1}) (ABPSD, 2015/16), lesser productivity at Okhaldhunga district for years 2014/15, 2015/16 and 2016/17 (ranging 10-11 tha^{-1}) (DADO Okhaldhunga, 2017).

Productivity of potato is higher in the lower elevations and lower at the higher elevations. Also, the rocky terrain responsible for low moisture retention in soil causing moisture stress in crop and poor soil fertility status of the region may also have been responsible for the lower yield performance. Relationship of environmental, biological and socio-economic differences for yield gaps in various locations has been described by Crissman et al., 1991; CIP (2010); Luitel et al., 2017.

CONCLUSION

Indigenous cultivars of potatoes found in eastern high hills of Nepal, especially the Pasang alu, Bhotane Seto and Local ratogolo, have a great scope for further exploration and exploitation to utilize in varietal improvement programs of potato in Nepal. The local cultivar Pasang Aalu was found the best among the tested cultivars with least disease severity and highest tuber yield even without fungicide application.

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STATUS OF PESTICIDE RESIDUE IN VEGETABLE AND FRUIT SAMPLES COLLECTED FROM KALIMATI WHOLESALE MARKET OF KATHMANDU, NEPAL

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ABSTRACT

Pesticide residue analysis were carried out to examine the status of carbamate and organophosphate insecticide in vegetable and fruit samples collected from Kalimati wholesale market. The primary and secondary information were obtained from rapid bioassay of pesticide residues analysis laboratory using reagent kit method for the period of five fiscal year. The recent study showed that majority of samples collected had the enzyme inhibition percentage below 35. Of the total positive sample tested, tomato (21.88%) followed by cowpea (18.75%) were found to be more sub-standard sample. It was also found that the samples from Sarlahi district (29.69%) followed by Kavre district (17.19%) showed more than 35% enzyme inhibition by carbamate and organophostphate. Present study revealed that there is a huge scope for reducing the high residue risk in vegetables and fruits through the regulation procedure that can sort out the residue free product from pesticide residual product.

Keyword: Analysis, bioassay, carbamate, enzyme, health, inhibition, pesticide, sub-standard, organophosphate

INTRODUCTION

Nepal possesses a great opportunity in the production and marketing of vegetable crops throughout the year. The productivity and quality of vegetables greatly depend on the level of insect pests attack. Pesticides were widely used in agriculture to increase the yield, improve the quality, and extend the storage life of food crops (Fernandez and Reyes, 2008). So, farmers were frequently using broad-spectrum synthetic chemical insecticides to manage insect pests due to their quick knock-down effect on targeted insects, easy availability and relatively cheaper. After application of particular insecticide, farmers hardly care prescribed waiting period to harvest crop (Maharjan et al., 2004). Farmers harvest the crops at close frequency, and pesticide residues remained in vegetable produce cause toxic problems in human health as the produce is being consumed immediately or within few days of harvest.

The production of vegetables nowadays depends heavily on new technologies, and pesticide usage is almost unavoidable especially in the subtropical and

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tropical regions, where vegetable production confronts with serious insect and disease problems. Although new safety-concerned pesticides have been developed in the past two decades, many pest problems still remain unsolved and rely heavily on hazardous pesticides, particularly, the neurotoxic Organophosphate and Carbamate groupsof insecticides (Fukuto, 1978). Both Organophosphate and Carbamate groups ofinsecticides are acetyl-cholinesterase enzyme (AChE) inhibitors and most pesticides of these groups belong to toxicity category I or II.

It has always been the serious concern regarding the presence of pesticides in food (Sharma et al., 2012). In Nepal, Food Act 1967 and Food Regulation 1970 have established and implemented MRLs for pesticides in food products. Department of Food Technology and Quality Control (DFTQC) constantly monitorspesticide residues level in food products (Koirala and Tamrakar, 2008). The level of pesticide residues in food stuffs are generally legislated so as to minimize the exposure of the consumers to harmful or unnecessary intake of pesticides (Zorka and Serder, 2009). Pesticide study shows that more than 85 percent of imported pesticides are used only in vegetable crops in Nepal (Sharma, 2015).

Therefore, constant monitoring of fruits and vegetables for these dangerous pesticide residues is feasible, and to carry out the control action is absolutely needed for consumer protection. Therefore, Nepal has initiated to analyze residues of vegetable in the vegetable wholesale market by applying rapid bioassay residue analysis technology. The Rapid Bioassay for Pesticide Residue (RBPR) developed in Taiwan in 1985 and since then it has been successfully adopted as a supplement to sophisticated chemical pesticide analysis. In order to protect local consumers from contaminated vegetables, it is a low-cost alternative to chemical analysis to achieve quick test results for pesticide residues. It is practical for use in screening large samples so that contaminated produce can be withdrawn from the farm gate or local market before they reach the consumers. Rapid Pesticide Residue Analysis Laboratory established in the Kalimati fruit and vegetable wholesale market regularly follows monitoring and provides results on theuse of organophosphate and carbamate groups of pesticides in the vegetables and fruits. Rapid Bioassay of Pesticide Residue Laboratory test possible residue of chemicals in vegetables by using the RBPR analysis technique which is based on inhibition of acetylcholine esterase enzyme which can detect residues of organophosphate (OP) and carbamate (Carb) group of insecticides as stated on Standard Operating Procedure of RBPR laboratory (PPD, 2017). With its success, Government has established 6 more Rapid Pesticide Residue Analysis Laboratories in the different cities of Nepal.

The main objective of the study was to determine persistence residual level of Organophosphate and Carbamate groups of insecticidesin vegetables and

fruit samples collected from Kalimati wholesale market of Kathmandu during the period of five fiscal year from 2014/15 to 2018/19 using quantitative method.

METHODOLOGY

The study was conducted at Rapid Bioassay of Pesticide Residues Analysis (RBPR) Laboratory, Kalimati, Kathmandu as it is the first RBPR Laboratory established in Nepal. An alternative and cheaper solution was to rely on the Rapid Bioassay for Pesticide Residues (RBPR) method, a test developed by the Taiwan Agricultural Research Institute in 1985 used in this study as quantitative measure. RBPR has also been adopted by the Republic of Korea, Vietnam, Philippiness, Panama and many Southeast Asian countries and 11 international RBPR training workshops were held during 1993-2010 (Kao et al., 2010). Although not as reliable as GC-MS, the RBPR is considered sensitive enough to meet the FAO–WHO regulations for pesticides in vegetables (Chiu et al., 1991). This test assesses the toxicological effect of two common types of insecticides (carbamates and organophosphates) by measuring the percentage of inhibition of the acetylcholinesterase (AChE), a key enzyme in the nervous system of animals. More than 65% of the most dangerous pesticides (i.e., WHO toxicity class I or II) used in the research area belongs to these categories (Bosch et al., 2005). The RBPR is able to measure the toxicological effect but not to distinguish if this is ascribable to the presence of excess of pesticides or to the use of forbidden and extremely toxic pesticide formulations.The study was conducted on the vegetable and fruitsamples collected regularly from wholesale market of kalimati, Kathmandu for the period of five fiscal year starting from F.Y.2014/15 to 2018/19 AD. The primary and secondary information was obtained from the RBPR unit, Kalimati, Kathmandu. This study was done on the sample collected on an average of almost 8 samples per working days as a regular inspection procedure and insecticide residue on the collected sample was assayed quantitatively using RBPR method.

PROCEDURE FOR INSECTICIDE RESIDUE ASSAY

Sample preparation, sample processing and extractionto obtain analytical portions before visible deterioration occurs and incubation/analysis of sample extract were done usingStandard Operating Procedure(SOP)developed for Rapid Bioassay of Pesticide Residues Analysis (RBPR) by Taiwan Agriculture Research Institute in 1985 and later Nepal has developed its Standard Operating Procedure for RBPR Laboratory (Plant Protection Directoriate, 2017).

Calculation of Enzyme inhibition percentage

The reduction of absorbance for the sample to control (blank) test was compared and inhibition percentage of enzyme was calculated and grouped as follows:

$$\text{Enzyme inhibition (\%)} = \frac{\text{Absorbancechange(control)} - \text{Absorbancechange(sample)}}{\text{Absorbancechange(control)}} \text{X } 100$$

Below 35%	Approved for sell and consumption as pesticide residue was found low.
35%-45%	Kept at Quarantine for minimum 2 days as presence of pesticide residue was found in considerable amount that may be degraded with holding for certain period. After the sample was hold for certain period, test was repeated and as the inhibition percentage was found less than 35%, then sample was allowed for sale.
Above 45%	It was not suggested for sale and consumption purpose since significantly high amount of pesticide residue was found in the sample. As a result, such sample were destroyed and dumped.

RESULTS AND DISCUSSION

ENZYME INHIBITION PERCENTAGE OF COLLECTED SAMPLE

Majority of the fruit and vegetable sample had the enzyme inhibition percentage below 35 during the period of five fiscal year. Most of the sample tested was found safe for consumption and approved for sale. It was clear from the study that the enzyme inhibition percentage between 35 and 45 was found in the order of decreasing. While sample having enzyme inhibition percentage above 45, i.e. not safe for consumption was found highest, i.e. 23 samples in the fiscal year 2016/17 and found decreasing in preceding fiscal year (Table 1).

Fiscal Year (in AD)	Enzyme Inhibition			TotalSample Tested
	<35%	35%-45%	>45%	
2014/15	1473	14	3	1490
2015/16	1840	8	9	1857
2016/17	1650	5	18	1673
2017/18	1507	1	2	1510
2018/17	1812	2	2	1816

There was variation in the total tested sample in different fiscal year which may be due to many factors. Fiscal year 2014/15 and 2017/18 had the lowest totaltested samples, which was due to the limited amount of reagent kits. The reason behind the decrease in the enzyme inhibition percentage of the samples tested in the preceding fiscal year may be due to increase in the knowledge of pesticide residue among farmers or may be farmers were using

other insecticides alternative to carbamate and organophosphate groups of insecticides.

COMPARISION OF ENZYME INHIBITION PERCENTAGE BY CARBAMATE AND ORGANOPHOSPHATE

Enzyme inhibition percentage greater than 35% by organophosphate was 85.94% of total tested positive samples, as compared to carbamate, i.e.14.06% of total positive samples tested (Figure 1). It was found that 6 samples having 35-45% enzyme inhibition by carbamate (66.67% of total carbamate positive samples) were kept in quarantine and released after showing inhibition percentage below 35 while 3 samples with inhibition percentage more than 45% by carbamate were disposed. Similarly, out of 55 organophosphate positive samples, 24 samples (43.64 %) were found having 35-45% enzyme inhibition while 31 samples (56.36%) were found higher than 45% enzyme inhibition.

Majority of the samples (50% of total samples showing 35-45% enzyme inhibition by carbamate) and 100% of total samples i.e. 3 samples with more than 45% enzyme inhibition by carbamate were found in the Fiscal year 2015/16. Similarly, 12 samples having 35-45% enzyme inhibition by organophosphate in FY 2014/15 had been reduced to 5 samples in preceding FY 2015/16 and to 4 samples in FY 2016/17. In contrary, 3 samples having >45% enzyme inhibition by organophosphate in FY 2014/15 increased to 9 and 15 samples in the preceding two years respectively and then declined by 86.67% in the FY 2017/18 and FY 2018/19.

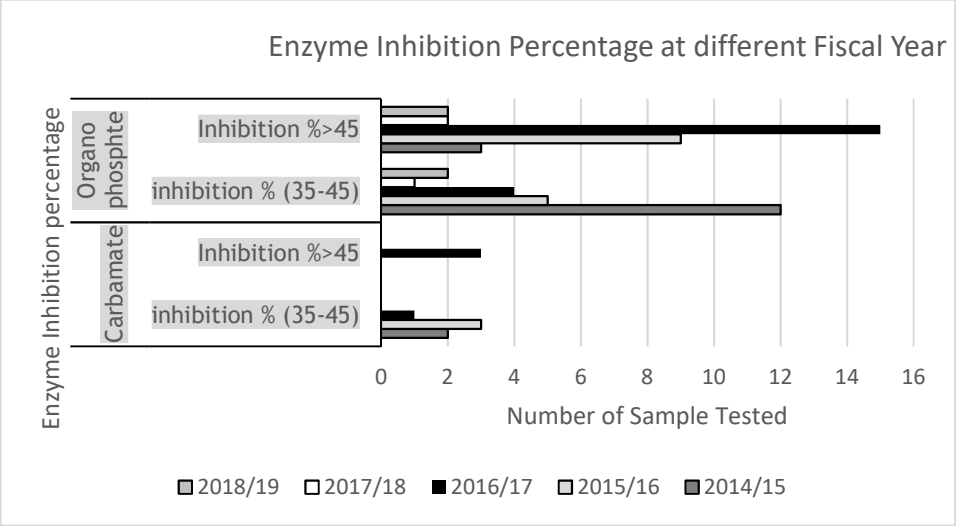

Figure 1: Figure showing enzyme inhibition percentage of pesticide during study period

According to Pesticide safety education program(PSEP)2012, chlorpyrifos pesticides was widely used because of its effective in controlling a variety of insects in crops.The reason behind the presence of organophosphate group of insecticide in more sample than carbamate was due to the availability of more registered insecticide under the group of organophosphate as compared to carbamate. The common insecticide of carbamate group are mainly soil applicators which is not commonly practiced in Nepal (Plant Quarantine and Pesticide Management Center, 2018).

DISTRICT AND SAMPLE-WISE ENZYME INHIBITION PERCENTAGE

The study revealed that out of total sample collected within the study period, tomato samples dominated in number, i.e. 14 samples, showing enzyme inhibition by carbamate (1 sample) and organophosphate (13 samples) followed by cowpea (12 samples) showing enzyme inhibition by only organophosphate. While brinjal, Potato, okra and broccoli lowest number, i.e. 1 each, showing enzyme inhibition percentage by only organophosphate (Figure 2). It was clear from the figure that sample showing the 35-45% enzyme inhibition by carbamate were bean (3 samples), tomato (1 sample), cauliflower (1 sample) and pointedgourd (1 sample) while by organophosphate were cowpea (9 samples), tomato (4 samples), bean (4 samples), cauliflower (2 samples), cucumber (2 samples), pointed gourd (1 sample), brinjal (1 sample) and potato (1 sample). Similarly, cauliflower (1 sample) and bottlegourd (2 samples) were found showing >45% enzyme inhibition by carbamate while sample showing >45% enzyme inhibition by organophosphate were tomato (9 samples), cauliflower (6 samples), bean (4 samples), bottlegourd (3 samples), cowpea (3 samples), cucumber (2 samples), capsicum (2 samples), okra (1 sample) and broccoli (1 sample). Nearly 50% of samples (48.44%) showed >45% enzyme inhibition by organophosphate followed by 35-45% enzyme inhibition 37.5%, while 35-45% and >45% enzyme inhibition by carbamate were 9.38% and 4.69%, respectively.

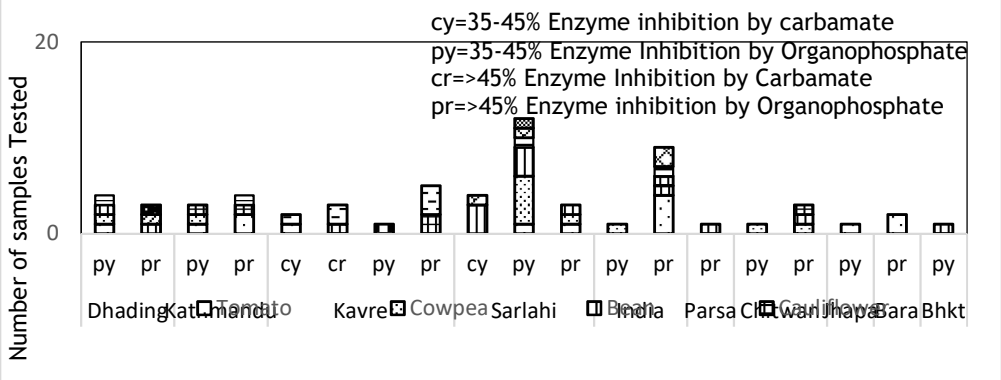

Figure 2: Figure showing district and sample-wise inhibition percentage during study period

Majority of the samples from the Sarlahi district (29.69%) showed more than 35% enzyme inhibition by carbamate and organophostphate followed by kavre district (17.19%) and samples from India (15.63%). WhileBhaktapur, Rautahat and Jhapa districts had least sample i.e. 1 sample each, showing more than 35% enzyme inhibition by carbamate and organophostphate. From the study it was found that more samples of Sarlahi district (4 samples) showed 35-45% enzyme inhibition by carbamate followed by Kavredistrict (2 samples), while samples of Sarlahi district (12 samples) was found more followed by Dhading district (4 samples) and Kathmandu district (4 samples) showed 35-45% enzyme inhibition by organophosphate. Similarly, samples only from Kavre district (3 samples) had shown >45% enzyme inhibition by carbamate while sample showing >45% enzyme inhibition by organophosphate of India (9 samples) was found more followed by Kavre district (5 samples).

Pesticide use, however, is much more in areas with intensive commercial farming of vegetables. The trend of pesticide use is increasing in Nepal by about 10-20 percent per year and expenses on pesticide in market-oriented vegetables and fruit production has been a major cost factor (Jasmine et al., 2008). Studies have shown that more than 90 percent of the total pesticides are used in vegetable farming (Atreya and Sitaula, 2010).Busindi (2012) reported on the tendency of tomato growers/farmers to harvesttomatoes one day after spray instead of seven days waiting period to increase tomato shining. Limited observation of pesticide withdrawal period causes residues in food and influence pesticide dietary exposure (Ayres et al., 2010). Pesticides use in tomato result in occurrence of resistant pests and diseases (Hossain et al., 2013). All these reports as well the eruption of new pest i.e. *Tuta absoluta* in Nepal support the result of the study that vegetables showing higher portion of samples >35% enzyme inhibition.

According to the Plant Protection Directoriate (PPD) 2015, the use of chemical pesticides was higher (31.9 % of the total use) in the central development region and the lowest (6.4 %) in the far western development region in 2001/02. On ecological basis, the highest average pesticides use was in terai (0.995 a.i.kg/ha) followed by valley (0.470 a.i.kg/ha), hill (0.314 a.i.kg/ha) and high hill (0.085 a.i.kg/ha) (PPD, 2015). A study showed that chemical pesticides were used by 25% of Terai households, 9% of mid hill households and 7 % of mountain households (Central Bureau of Statistics, 2003). The pesticide use is considerably high in certain mid hill pockets close to urban markets, (Sharma et al., 2012).Districts like Kavre, Morang, Chitwan, Siraha, Sindhuli, Dhading, Makawanpur, Parsa, Bara, Rautahat, Kaski, Dang, Banke, Kailali, and Kanchanpur, with the commercial vegetable production area use more pesticides as compared to other districts (GC, 2012), which support the result of the study that samples of Sarlahi and Kavre district showing positive carbamate and organophosphate inhibition percentage.

MONTH-WISE ENZYME INHIBITION PERCENTAGE (>35%)

Majority of samples tested showed higher inhibition percentage (>35%) in two seasons i.e. rainy season and winter season. It was clear from the figure 3 that the trend of samples showing enzyme inhibition percentage (>35%) was found increasing from June and reached the highest (12 samples) in the month of July (average of study period) and found decreasing in August. In winter season, trend of samples showing enzyme inhibition percentage (>35%) was found increasing from the month of November and reached the highest (13 samples) in Januaryand found least in the month of February (Figure 3).

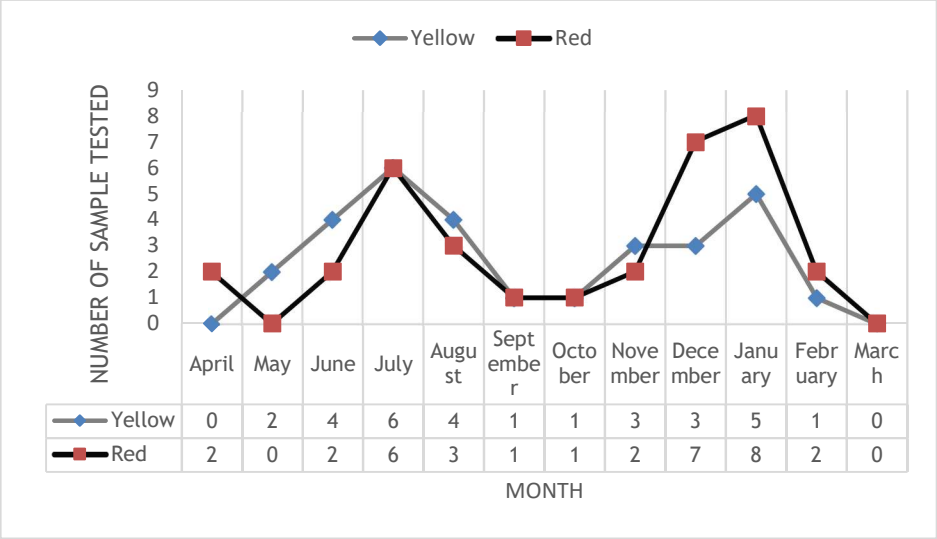

Figure 3: Figure showing month-wise enzyme inhibition percentage (>35%)

When insecticides are applied in September, all the insecticides persisted for longer than when applied in May. Degradation was slower during the winter while following spring rapidly increased the rates of degradation of some insecticide residue (Suett,1975).Observedseasonal concentration of pesticides are likely a result of seasonal application and weather patterns (Terry, 2000). According to Maharjan et al., 2004 summer and winter vegetable had higher number of pesticide sprays as compared to off-season vegetable. Thus finding supports the result of the study that the month of rainy season had increasing number of samples showing enzyme inhibition percentage (>35%) due to the frequent application of insecticide by farmers as persistent of insecticides are shorterand presence of highest number of sample showing enzyme inhibition percentage (>35%) in winter season due to the fact that degradation of pesticide is slow in winter.

CONCLUSION

Pesticide residue in vegetables especially tomato and cowpea seem to be serious issue. This study concludes that 21.88% of tomato and 18.75% of cowpea samples collected from wholesale market of Kalimati were found to be sub-standard. Similarly, it is concluded that 85.94% of the sample tested showed >35% enzyme inhibition by organophosphate and by carbamate was only 14.06%. The findings from this study indicates poor pesticide handling practices, especially when there is an eruption of new pests, repeated pesticide application and spraying mixtures of pesticides may be highly linked with risk of exposure to pesticide in fresh vegetables. In this regard, strengthening of foods safety control services to protect public health against pesticides is recommended as well even to include synthetic pyrethroid analysis in the future.

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EFFECT OF DIFFERENT LEVELS OF WATER HYACINTH (*Eichhornia crassipes* (MART.) SOLMS) INCLUSION IN BASAL DIETS ON PRODUCTIVE PERFORMANCE OF GOATS

M. R. Tiwari[1], D. Rawat[2] and L. N. Pandey[3]

ABSTRACT

An experiment was carried using 16 growing female goats at Goat Research Unit of Regional Agriculture Research Station, Khajura, Banke, Nepalto evaluate the possible inclusion of water hyacinth in goat diet during 30 March 2019 to 27 June 2019 covering 90 days after adaptation period of 7 days. Female goats of 5-6 months old age with average body weight of 12-13 kg were divided into 4 groups by using Completely Randomized Design (CRD) and one animal as one replicate. Four types of diets were composed: goatsof T1 group were fed concentrate mixture @ 1% of body weight + 50% oat +50% berseem, T2 group were fed concentrate mixture @ 1% of body weight +20% water hyacinth +40 % oat +40% berseem; goats under T3 group were provided concentrate mixture @ 1% of body weight +30% water hyacinth +35 % oat +35% berseem, and T4 were fed with concentrate @ 1% of body weight +40% water hyacinth +30 % oat +30% berseem. The findings revealed that concentrate feed along with forage supply performed highly significant (p<0.001) feed intake among the treatments whereas the effects were in decreasing trend with increment of water hyacinth level in diet. FCR was highest for T2 (1:6.26 kg) followed by T3 (1:6.88 kg) and T4 (1:7.48 kg). Highest body weight gain was observed in T2 followed byT1 and T3 (6.46, 6.38 and 5.96 kg, respectively) but the difference was non-significant (p>0.05) among diet groups. Thus, the result suggested that water hyacinth can be incorporated in goat diet only up to 20% without any adverse effect on growth performance.

Keywords: Feed intake, goat, growth performance, Nepal, water hyacinth

INTRODUCTION

Goat in recent years has been recognized as one of the most important livestock commodities that have widely been adopted in programs for poverty reduction, livelihood enhancement, and food and nutrition security in Nepal. Goats form an integral part of the mixed crop/livestock farming system and contribute substantially to farmers income, thus to the national economy.

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They provide meat, manure, and leather and even draft power as pack animals in high hills of Nepal. Furthermore, they are a valuable source of income for small resource-poor farmers, particularly women, and rural poor. Nepal has a goat population of 11.64 million and producing 73556 MT goat meat per annum (MoALD, 2018). There is a close integration between crops, livestock and trees in Nepalese agriculture (Dhakal et al., 2005). In Nepal, farmers use more than 180 species of trees, shrubs and vines as fodder and among them almost 50 are traditionally cultivated (Khanal and Subba, 2001). Leaves of fodder tree is particularly important for goat feeding especially during dry winter from mid-January to mid-June when there is very less availability of other feeds and fodder. The leaves and twigs of tree fodder and fodder tree act as good supplement of protein to poor quality cropresidues (Khanal and Upreti, 2008).

Water hyacinth is one of the most noxious weeds in tropical and subtropical regions and can be used as a fodder, green manure, compost and mulch for soil improvement. Several researcheshave been carried out to its use as a feed material for different classes of livestock. In South-East Asia, integrated fish-pig-water hyacinth farming systems have been developed in order to increase global animal production: Water hyacinths grown in fishponds have higher nutritive value and can be fed to fish and pigs in different forms. Fish and pig manures fertilize fishponds and provide nutrients to water hyacinth (Yang Huazhu et al., 2015). Animals are usually fed the leaves and stems without the roots or only the leaves. Water hyacinth can be fed fresh, ensiled or dried, but many other processes are used or have been tried, including cooking and fermentation (Yang Huazhu et al., 2014).

Moreover, water hyacinth has received much attention in recent years due to its potential benefits as animal fodder, aqua feed, water purification, fertilizer, biogas production, etc. Numerous studies have evaluated water hyacinth as a feed source to ruminants (Baldwin et al., 1975; Abdalla et al., 1987; Agarwala, 1988; Islam et al., 2009; Sophal, 2010), fish (Okoye et al., 2002; Abdel-Fattah, 2003) and other animals (Dey et al., 1983; Men et al., 2006).

Due to shortage of feed or fodder, goats sufferfrom malnutrition, and lose their productivity in Nepal. To mitigate this shortage, unconventional feed stuff such as water hyacinth can be used as goat feed. During natural calamity, especially during in the summer seasonwhen feed scarcity becomes severe, water hyacinth could be one of the potential sources of green fodder for goats. A high nutrient content such as crude protein (15.27%), moisture (90.39%), total ash (16.79%) and crude fibre (14.41%); has made water hyacinth as fodder to cattle, goats, pigs, ducks and tilapia fingerlings (Tham, 2015).

Sunday (2002) observed that feed efficiency of goats with 40% water hyacinth inclusion was superior ($p<0.05$) to the corresponding goats fed diets with 30% water hyacinth inclusion. Similarly, Mako (2013) conducted an experiment on goats and concluded that in diet based on green grass the maximum level of sun cured water hyacinth in diets for growing goats was 30%. However, specific research on the use of water hyacinth as goat feed has not been carried out so far in Nepalese context. Therefore, this study was done to assess the effect of different levels water hyacinth inclusion in the basal diet on feed intake and the growth performance of goats.

MATERIALS AND METHODS

EXPERIMENTAL SITE, ANIMAL SELECTION AND MANAGEMENT

This experiment was carried out using 16 growing female goats at Goat Research Unit of Regional Agriculture Research Station, Khajura, Banke, Nepal during 30 March to 27 June 2019 for 90 days after adaptation period of 7 days. Female goats of 5-6 months old age with average body weight of 12-13 kg were divided into 4 groups by using Completely Randomized Design (CRD). They were drenched with Fenbendazole at the rate of 5 mg/ kg body weight against internal parasites in the beginning of the experiment.

DIET COMPOSITION

The dry matter (DM) requirement of experimental animals was calculated at the rate of 5 kg DM /100 kg body weight. The feeds were formulated containing 16% crude protein. Concentrate mixture was procured from a Feed Industry locally. Water hyacinth was collected from nearby communities' ponds whereas green forage– oat and berseem were cultivated in the field allocated by Regional Agriculture Research Station for forage cultivation for Goat Research Unit.

EXPERIMENTAL DIET

Four experimental diets were composed for experimental animal as presented in the Table 1.

Table 1: Experimental diets composed to feed the goats

Treatments	Diet
1	Concentrate feed @ 1% of body weight + 50%oat +50%berseem
2	Concentrate mixture @ 1% of body weight + 20% water hyacinth + 40 % oat + 40% berseem
3	Concentrate mixture @ 1% of body weight + 30% water hyacinth + 35 % oat + 35% berseem
4	Concentrate mixture @ 1% of body weight + 40% water hyacinth + 30 % oat + 30% berseem

FEEDING REGIME

Concentrate mixture and specific forage was provided to the experimental animals individually in plastic vassal twice a day (morning and evening). Experimental animal had free access to drinking water.

CHEMICAL ANALYSIS

The samples of concentrate mixture, water hyacinth, oat and berseem were sent to the Animal Nutrition Division, NARC, Khumaltar, Lalitpur for proximate analysis. Representative samples were analyzed for Dry matter (DM), Crude Protein (CP), Crude Fibre (CF), Ether Extract (EE) and Total Ash (TA). The DM was determined by oven drying at 100°C for 24 hrs. Crude protein of the samples was determined using the Kjeldahl method. Ether extract was determined by using Soxhlet apparatus. Ash content was determined by ashing at 550°C in a muffle furnace for 16 hours (AOAC, 1980). Crude fibre of the samples was determined by using the Van Soest method (Goering H.K. and van Soest, 1970).

DATA MEASUREMENT / RECORDING

Concentrate mixture and forage (water hyacinth and green forage was mixed after chopping as mentioned in Table 1) offered to the individual experimental animal were recorded daily and that of the refusal was recorded the next morning. The body weight gain of individual goat was measured in 15 days interval in the morning before feeding.

DATA ANALYSIS

Data of feed intake and body weight gain were analyzed by using "One-way Annova" test for every measurement using statistical package SPSS, version (16)

RESULTS AND DISCUSSION

CHEMICAL COMPOSITION OF FEEDSTUFFS

The results of chemical analysis of feedstuffs is presented in the Table 2

Table 2: Nutrient content of feedstuffs (%)

S/N	Feedstuffs	DM	OM	TA	CP
1	Water hyacinth	33.2	84.48	15.52	9.26
2	Oat	28.74	86.75	13.25	10.35
3	Berseem	14.08	87.49	12.51	20.36
4	Concentrate mixture	88.65	88.6	11.4	16.04

Table 2 showed that CP content of water hyacinth was lower (9.26%) than that of oat (10.35%) and berseem (20.6%). Similarly, DM content was found highest in concentrate

mixture (88.65%) followed by water hyacinth (33.2%) and oat (28.74%). Likewise, OM was noted highest also for concentrate mixture (88.6%) followed by berseem (87.49%) and oat (86.75%). The TA content was recorded highest in water hyacinth (15.52%) than that of oat (13.25%) and berseem (12.51%).

FEED INTAKE OF THE EXPERIMENTAL ANIMALS

The daily feed intake of experimental animals has been presented in Table 3.

Table 3: Feed intake of experimental animal

Parameters	T1 (control)	T2 (20%WH)	T3 (30% (WH)	T4 (40% WH)
Feed intake (g)	275.18±	246.78±	244.24±	232.96±
	43.02^{bcd}	39.02^{ad}	48.38^{ad}	40.321^{abc}
Forage intake (g)	1498.72±	969.36±	958.2±	974.91±
	263.87^{bcd}	387.03^{ad}	377.86^{ad}	273.54^{abc}
Daily dry matter (g)	564.81	449.17	455.56	461.23
Total dry matter intake (kg)	50.83	40.43	41	41.51
Feed conversion ratio (FCR), kg	1: 7.97	1: 6.26	1: 6.88	1: 7.48

Feed intake of experimental animals was found to be highest in T1 followed by T2 and T3 (275.18, 246.78 and 244.24 g /animal/ day, respectively) which was highly significant ($p<0.001$) with T2, T3 and T4 groups. Feed intake between T2 and T1group, T2 and T4 group was also highly significant ($p<0.001$) whereas it was non-significant between T2 and T3. Similarly, feed intake between T3 and T1 group was highly significant ($p<0.001$), and between T3and T4 group it was noted significant ($p<0.05$) while between T3 and T2 group was foundnon-significant. Likewise, feed intake between T4 and T1group and between T4 and T2 group wasfound to be highly significant ($p<0.001$), between T4 and T3 group noted significant ($p<0.05$). Similar type of trend was also observed for forage intake among the diet groups. FCR was observed highest for T2 (1:6.26 kg) followed by T3 (1:6.88 kg) and T4 (1:7.48 kg). However, it was not significant ($p>0.05$) among diet groups. Feed intake of experimental animals was found to be decreased with increment of water hyacinth level in the diet.

BODY WEIGHT GAIN OF EXPERIMENTAL ANIMALS

The trend of average body weight gain of the experimental animals is given in Table 4

Table 4: Body weight gain of experimental animal, kg (Mean ± SD)

TRT	Treatment			
	1 (Control)	2 (20% WH)	3 (30% WH)	4 (40% WH)
Initial body weight (kg)	13.12±1.65	12.87±2.17	12.87±3	12.87±1.25
Initial metabolic weight (kg)	6.89	6.79	6.79	6.79
Final body weight (kg)	19.5±1.73	19.33±4.16	18.83±2.75	18.37±2.49
Final metabolic weight (kg)	9.28	9.22	9.04	8.87
Total weight gain (kg)	6.38±1.37	6.46±1.52	5.96±1.73	5.55±1.47
Total metabolic weight gain (kg)	4.01	4.05	3.81	3.61
Average daily gain (g)	70.88±15.29	71.77±16.97	66.22±19.34	61.66±16.35

Initial body weight of experimental animals ranged from 12.87 to 13.12 kg which reached 18.37-19.5 kg by the end of the experiment. Highest total body weight gain was obtained in T2 followed by T1 and T3 (6.46, 6.38 and 5.96 kg, respectively) which were non-significant among diet groups. Similarly, highest average daily gain was observed in T2 followed by T1and T3 (71.77 g, 70.88g and 66.22 g, respectively) which were quite higher than national average 55 g (DLS, 2018). In the beginning, metabolic weight of the experimental animals were almost similar (6 kg) but in the end of the experiment metabolic weight of the animals was different which ranged from 3.61 kg to 4.05 kg that was nonsignificant among diet groups. The highest metabolic weight was recorded T2 followed by T1 and T3 (Table 4)

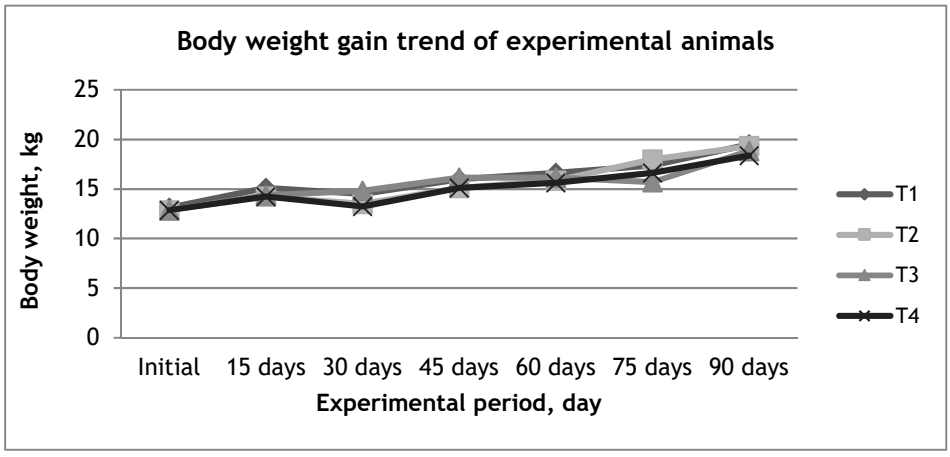

Figure 1: Body weight per experimental animals

This experiment was designed with the aim of to evaluate the effect of different proportions water hyacinth inclusion in basal diet and on feed intake and growth performance of the goats. Table 3 showed that feed and forage intake of experimental animals was highly significant ($p<0.001$) among diet groups, however, it was shown that increasing rate water hyacinth inclusion in diet reduced the feed and forage intake of experimental animals. Brij and Murdia (2002) examined the performance of goats feeding on 0%, 15% and 30% water hyacinth with dry feed and the dry matter and crude fiber digestibility of the 15% water hyacinth group was the highest. They also found that addition of water hyacinth had no significant effect on the digestibility of crude protein, crude fat, and nitrogen-free extract. The dry matter intake, digestible crude protein, and daily weight gain of the treated group were not significantly different from those of the control group.

Shigdaf et al. (2018) reported that wilted water hyacinth leaves reduced the intake and digestibility of some nutrients, however, its use for concentrate replacement could be economically advantageous for sheep feeding in areas with great availability of this aquatic plant. They had also mentioned that wilted water hyacinth leaves can safely substitute concentrate mixture up to 75% and result in the optimum growth of sheep. Since CP content in water hyacinth is satisfactory (Table 2), it can be concluded that wilted water hyacinth leaves can be used for protein supplementation for rice straw-based diet in the dry season.

Similarly, in our experiment, highest total body weight gain was obtained in T2 followed by T1 and T3 (6.46, 6.38 and 5.96 kg, respectively) which were non-significant among diet groups. It showed that water hyacinth can be included in goat diet up to 40%. Similar type of results was obtained by different researchers.

Sunday (2002) conducted an experiment on growing goats by feeding water hyacinth; cowpea pod and groundnut stubbles in following respective proportions: 30:40:30 (T1); 30:30:40 (T2) and 40:30:30 (T3), respectively. At the termination of the study (35 days) the mean final weight of goats fed T3 (6.87kg) was significantly ($p<0.05$) higher than the weights of goats fed T1 and T2 which were 6.80 and 6.76kg, respectively. The result indicated that utilization of sundried *E. crassipes* by growing goats at up to 40% dietary level of inclusion is beneficial.

Huang et al., 2014 investigated the effect of water hyacinth slag and wheat bran mixed silage on the growth performance of goats. The results showed that adding 30% of water hyacinth slag mixed silage to feed does not affect the growth performance of goats.

Nguyen (2016) also reported that ensilaged water hyacinth could be used to feed growing sheep without adverse effects on rumen parameters and the replacement level of 30% to Para grass in diet gave good results in term of growth performance and utilization of water hyacinth as a feed resource.

Amit (2019) conducted an experiment on growing bull calves and reported that water hyacinth can be used as an alternative feed source for growing dairy bull calves at 10-20% inclusion rate to ensure its optimal utilization. Several studies reported that an inclusion level of fresh water hyacinth should not exceed 30% to avoid problems of bloat and a long adaptation period to fresh water hyacinth should be managed. Water hyacinth at 40% inclusion rates caused increased DM intake in calves but did not affect body weight gain.

CONCLUSIONS

Water hyacinth is abundantly available across the terai and mid hills of Nepal which is not being used in animal feeding till date. This experiment revealed that water hyacinth can be incorporated in goat diet only up to 20% without any adverse effect on growth performance. However, for wider dissemination it should be verified in the farmers' field. Moreover, research should be carried out to determine the optimum level of water hyacinth inclusion in goat diet in mid hills condition also where major feeding resources are tree foliage and very less available during dry winter from mid-January to mid-June.

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RETROSPECTIVE ANALYSIS OF FOODBORNE PATHOGENS IN NEPALESE FOODS

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ABSTRACT

This paper garners the published information on foodborne microorganisms to identify the major pathogens present in the foods of Nepal. Data were collected from PubMed, NepJol online databases and from the physical libraries. A meta-analysis of prevalence quantified the estimated overall pooled prevalence of the bacteria as 49.2% (95% CI: 42-56.5%). The least prevalent was Salmonella at 22.6% (95% CI: 15.3-29.9%) and the highest was Enterobacteriaceae at 71.4% (95% CI: 63.9-79.0%). The food item with the least prevalence of bacteria was ready to eat foods (average pooled prevalence: 34.8%) whereas the food item with the highest prevalence of bacteria was raw liquid milk (average pooled prevalence: 69.8%). It is concluded that the food items produced and consumed in Nepal are contaminated with a number of hygiene indicator foodborne pathogens. This rightly justifies the need for novel perspectives for formulating policies on microbiological food safety surveillance and risk mitigation.

Keywords: Enterobacteriaceae, Foodborne pathogens, Nepalese food, Prevalence, Salmonella

INTRODUCTION

The developing countries are challenged by two simultaneous quandaries. First, they continue to struggle with the issue of food security (the volume of food enough for consumption by the exponentially growing population) and second is the issue of food safety (either food hygiene or the pathogenic organisms in food) (Grace, 2015). In one report, World Health Organization estimates that more than 200 types of human diseases are caused or spread by food, most importantly causing chronic problems to vulnerable populations

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such as the elderlies, the pregnant and the infants (WHO, 2015). The food sector of least developed countries like Nepal is generally comprised of heterogeneous, highly fragmented, small scale producers, which are difficult to monitor by government regulatory authorities and few large enterprises who have incentives to escape or capture regulations (Grace, 2015). A similar condition has been described as being composed of 'elephants and mice' in China (Alcorn and Ouyang, 2012).

In Nepal, the general public is not very much aware offood safety. In our neighbouring country China, a report showed that food safety was regarded as the second greatest risk after the earthquake (Alcorn and Ouyang, 2012). As a signatory of multiple international treaties and a member of the World Trade Organization (WTO), it is imperative that Nepal maintains its standards of food safety for international competitiveness and trade opportunities. It is expected that the incidences of foodborne diseases will increase in the least developed and developing countries due to the longer value chains in such resource-limited conditions (McMichael and Schneider, 2011). Available evidence on effective, sustainable and scalable interventions suggested that improvement in food safety at national or local markets are very scanty and show very little optimism unless where such good practices are linked to eligibility for export (Grace, 2015).

In contrast to the developed countries where studies on the pathogenic organisms such as *Listeria*, *Salmonella*, and *Campylobacter* are of primary concern, the studies on sentinels of hygiene and sanitation such as *E. coli*, *Staphylococcus*, *Streptococcus*, and *Enterococcus* are more common in developing countries (Odeyemi et al., 2019). Prevalence of foodborne pathogens is not well documented due to poor monitoring and surveillance in underdeveloped countries thus leading to a paucity of literature and statistical data to estimate the associated economic loss (Akhtar et al., 2014). Contaminating microbial pathogens are thought to be responsible for the larger portion of the burden of foodborne diseases in developed countries where they are attributed in 20%–40% of intestinal disease and a similar or probably even higher burden due to non-intestinal manifestations such afflictions (Grace, 2015).

Like other least developed countries, the studies on foodborne pathogens and sentinels organism of food hygiene are scanty and fragmented in Nepal. There are very few publications available in the global databases and those available are confined to only the national journals and databases. These publications have large variations in terms of sampling frames, sample size, methods used, results obtained, and interpretations made even for similar kinds of food items. In order to provide reliable, uniform quantitative estimates on the prevalence of microbial pathogens or sentinels of hygienic standards in Nepalese food items, we used a meta-analytic approach by using

data accumulated from published literature after descriptive analyses of the same for some key variables. The key benefit of this meta-analytic approach is the aggregation of available information to a more robust estimate at a 95% confidence interval (Paudyal et al., 2018). This method is commonly used to calculate a precise estimate of disease frequency (Barendregt et al., 2013). The obtained results would deliver a better estimate of the prevalence of various pathogens/sentinel organisms on different food items which could pose public health hazards or indicate the ineffectiveness of cleaning and sanitation procedures.

The objective of this study was to identify the major foodborne bacterial pathogens and quantify a best reliable estimate of their prevalence, especially in the foods of animal origin and other various food products, consumed in Nepal.

METHODOLOGY

LITERATURE SEARCH

A comprehensive literature search for the publications on Nepalese foods and the reported prevalence of foodborne pathogens was made in the physical libraries of Tribhuvan University (TU), Agriculture and Forestry University (AFU), Nepal Agricultural Research Council (NARC), Himalayan College of Agricultural Sciences and Technology (HICAST), Institute of Agriculture and Animal Sciences (IAAS), and Tri-Chandra Multiple Campus. The manual search was assisted by the librarians of the respective institute to locate and find out the relevant publications.

Simultaneously, an electronic search was made in the global databases of PubMed and NepJol for any publications made in the international journals on the same topic and available on the world wide web, using different search-strings of (i) 'Nepal' and 'foodborne pathogens'; (ii)'Nepal' and 'pathogens in food'; (iii) 'foodborne pathogens' and 'Nepalese foods'; (iv) 'Nepal' and 'food' and 'pathogenic bacteria' and (v) 'bacteria' and 'food' and 'Nepal'. These keywords were formulated so that they could retrieve multiple publications.

PRIMARY SCREENING

For the retrieved publications, primary screening was made on the basis of title whereas a secondary screening was made on the basis of abstract. The necessary data from the retained publications were entered into an excel spreadsheet formatted for the purpose to accumulate, arrange, synthesize and sort out the relevant information.

STATISTICAL ANALYSIS

Once arranged, a descriptive analysis was made in the GraphPad Prism vs 8.1 (GraphPad Software Inc., California, USA) on a Windows platform. For all the studies in the descriptive analysis, inclusion-exclusion criteria, as mentioned in Table 1 was made to select the publications suitable for the meta-analysis. The meta-analysis of prevalence and subgroup analysis was made in the DerSimonian Laird random-effects model, using the open-source freeware OpenMeta[analyst](http://www.cebm.brown.edu/openmeta/index.html; Brown University, Providence, RI 02912, USA). The cumulative figures of the meta-analysis were also made in GraphPad Prism vs 8.1 on a Windows platform.

Table 1: Inclusion-exclusion criteria for data selection for meta-analysis

Inclusion Criteria	Exclusion Criteria
Published by researches from Nepal/abroad on food samples of Nepal.	Publications related to commodities other than foods, for example, animal feeds, live animals etc.
Published in English or Nepali in journals.	Publications related to human health.
Includes the grey literature.	Publications related to the hygiene and sanitation (e.g. mentions only the CFUs).
Published before or until 2017.	Publications made as ephemeral literature such as newspapers and magazine.
Related to the food of any types consumed in Nepal.	Reports made by various NGOs, INGOs and other agencies.

RESULTS

LITERATURE SEARCH

During the literature review, we retrieved a total of 295 publications published between 1994 and 2017 AD. Among these 163 were from the PubMed database while 77 were from NepJol database. A manual search of libraries at IAAS-TU, AFU, TU Central Library, HICAST library, TC Campus library and NARC library retrieved 55 publications. The retrieved papers were screened and then either accepted or rejected (Figure 1) on the basis of the afore mentioned selection criteria

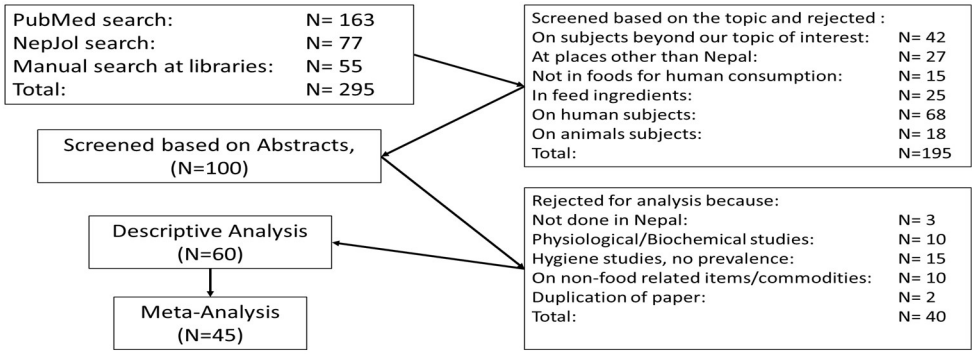

Figure 1: Numbers of publications collected and selected

DESCRIPTIVE ANALYSIS

Eventually, 60 publications were used in the cumulative descriptive analyses whereas only 45 publications were used for data extraction to be used in meta-analysis. Fifteen publications were not included because they primarily dealt with the hygiene indicator bacteria and presented their data only in terms of colony-forming units rather than the prevalence or proportion of the positive samples out of the total samples studied.

The publications suitable for use in the descriptive analyses were analyzed for their publication year. The earliest paper included in our analyses dated back to 1994. The frequency distribution of the paper published according to the various years is given in Figure 2.

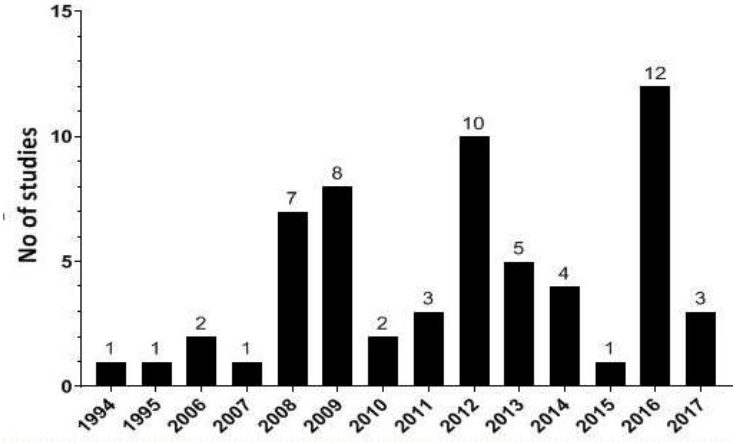

Figure 2: The number of studies according to the years of publication and included in our analyses

DATA ANALYSIS

The extracted data were categorized according to the sampling sites for the analyses. Not surprisingly, most of the studies were those done on samples collected from Kathmandu followed by Chitwan and some did not mention their sampling sites. Only a few geographical locations were encompassed by these studies as shown in Figure 3.

The data extracted from the included studies were analyzed for the types of the foods and the organisms isolated from such foods. The results showed that raw chicken meat, pasteurized liquid milk, ready to eat (RTE) dairy products and raw buffalo meat were the top four food items most commonly studied for the hygienic standards and the presence of pathogenic bacteria (Figure 4). The figure also shows that some food type such as drinking water, RTE foods, fruits and vegetables, goat milk, miscellaneous meats were the items with the least number of samples and seldom studied for foodborne pathogens.

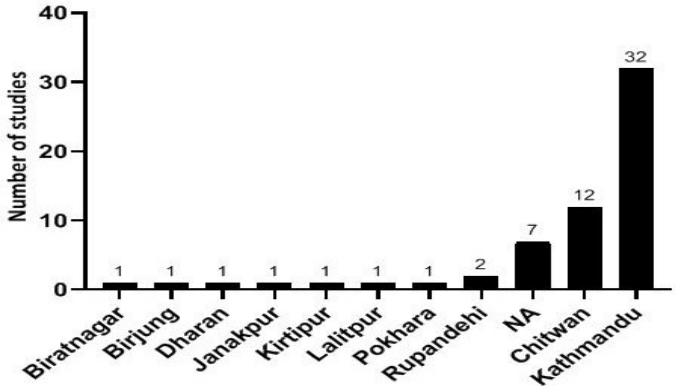

Figure 3: Sampling sites and the number of studies from each site, NA indicates that the study did not mention the specific site

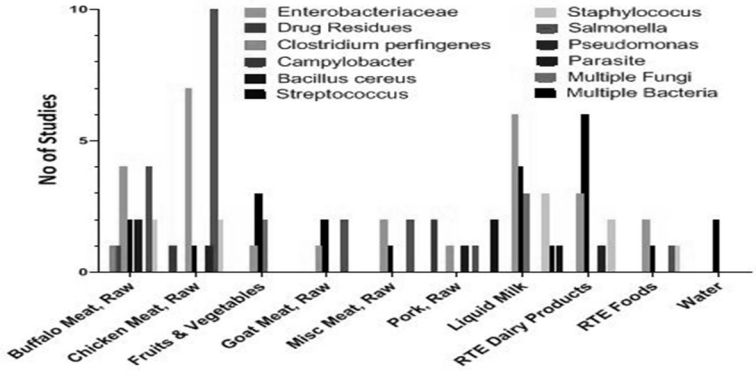

Figure 4: The number of studies on various food types and organisms

The bacteria mentioned in the selected publications were broadly categorized for the ease of analysis. Important pathogens such as *Salmonella* and *Campylobacter* were indicated as individual groups whereas the pathogens used commonly as sentinels of hygiene and sanitation were grouped as one single category of Enterobacteriaceae (e.g. *E. coli*, *Shigella*, and *Proteus*). *Staphylococci* which were reported in a higher number of studies could being indicative of human contamination of food (Aa et al., 2014). For other microorganisms such as *Pseudomonas*, *Clostridium*, *Enterococcus* and *Bacillus*, pathogens were grouped into broad categories depending on their occurrence with other co-inhabiting bacteria (for example, the bacteria like *Pseudomonas* and *Clostridium* were frequently mentioned simultaneously while *Enterococcus* and *Bacillus* were mentioned simultaneously). Meta-analysis showed that the overall pooled prevalence of the bacteria (pathogenic or sentinels of hygiene) was 49.2% (95% CI: 42-56.5%). Among these, the least prevalent was *Salmonella* at 22.6% (95% CI: 15.3-29.9%) and the highest was of the mixed genus of the family Enterobacteriaceae at 71.4% (95% CI: 63.9-79.0%). The prevalence of other bacteria is shown in Figure 5. The heterogeneity estimate (I^2) for this analysis was equal to 99.51%, which clearly indicates the presence of significantly huge methodological variation among the studies included for analysis.

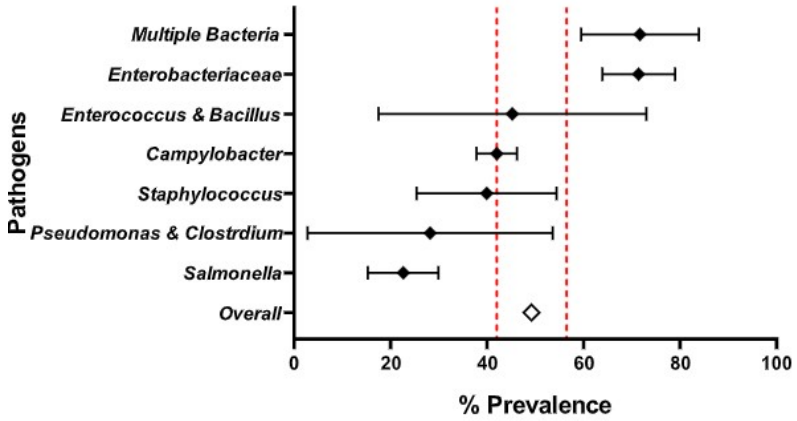

Figure 5: Forest plot of the summary data, of a meta-analysis of the prevalence of pathogens.

Solid black diamonds give the average value of prevalence of individual pathogen mentioned on the YY' while the error bars indicate 95% CI (upper & lower limits) of the estimated average (XX'). The red broken lines indicate the 95% CI (lower & upper limits) of the estimated overall pooled prevalence of bacteria (given by empty diamond). Multiple bacteria refer to a mixture of one or more of *Citrobacter*, *Serratia*, *Enterobacter*, *Morganella*, and *Streptococcus*.

With regards to the food types, different kinds of foods studied in the individual publications were grouped into broad categories for the ease of analysis. Because milk was studied more than the meat samples in the selected publications, the milk was categorized as liquid milk and ready to eat dairy products. Similarly, meat was categorized according to the animalsource. When the specific meat-type was not mentioned or differentiated, it was categorized as miscellaneous raw meat. All the food products available as ready for consumption, raw, cooked or reheated were categorized as ready to eat (RTE) foods. Meta-analysis showed that the food item with least prevalence of bacteria (hygiene indicator or pathogenic) was the RTE foods (average pooled prevalence was 34.8%, 95% CI: 22.2-47.3%) whereas the food item most commonly associated with the presence of bacteria was liquid milk (average pooled prevalence was 69.8%, 95% CI: 62.8-76.8%) (Figure 6).

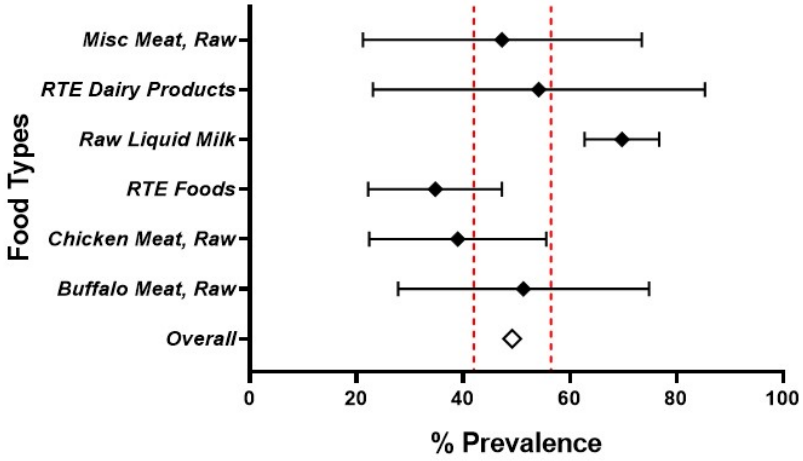

Figure 6: Forest plot of the summary data, of a meta-analysis of prevalence in foods of various types.

Solid black diamonds give the average value of prevalence of individual food category mentioned on the YY' while the error bars indicate 95% CI (upper & lower limits) of the estimated average (XX'). The red broken lines indicate the 95% CI (lower & upper limits) of the estimated overall pooled prevalence in food (given by empty diamond).

DISCUSSION

Among the 295 publications aggregated during the initial search, only 60 were found to be suitable for descriptive analysis while only 45 were included in the meta-analysis. In the descriptive analysis, we included all the publications that dealt with the pathogens present on foods, either as bacterial load in terms of CFUs or prevalence of pathogenic bacteria. We excluded the

publications dealing with antibiotic residues, parasites, and fungi. During the analysis, it was revealed that all the publications used classical microbiological techniques (including enrichment, culture, biochemical tests, and Gram's staining and microscopy) for the laboratory procedure. Use of PCR and other advanced tools was almost nil. This is because most of our data were synthesized from the grey literature and publications in Nepalese journals and very few from international peer-reviewed journals. The grey literature (primarily the undergraduate and postgraduate thesis) used for partial fulfilment of the degree requirements has some inherent features (such as not being produced for commercial publication, not available through standard distribution means, no standard bibliographic controls, not peer-reviewed, ephemeral and historically difficult to find) which can influence the outcome variable (Mahood et al., 2013).

This corroborates the fact that studies on foodborne pathogens are not a priority in the broader research scenario in Nepal (Budhathoky and Shrestha, 2015). Regarding the temporal distribution of study in the selected publications, the first included study was of the year 1994 while the last one was of 2017. However, it does not imply the total absence of studies before or after the selected time frame. There were some studies on hygienic standards of foods before 1994 too, but they have been excluded. In the recent years (after 2017 AD) too, there are some publications on Nepalese foods, but we did not include them in this analysis as they were published after the completion of our activity on data collection and extraction. After 2008, there have been few yet regular publications regarding foodborne pathogens which also reveals the renewed interest tothis sector in our Nepalese context.

On the spatial distribution, most of the publications were done in the samples collected at Kathmandu and Chitwan. This is not surprising because these two places are the locations with high numbers of various higher education institutions including colleges and universities. Most of the available publications in our data extraction were the undergraduate or postgraduate thesis (grey literature). In the past, academic institutes did not oblige the students to have their research works published in peer-reviewed journals, these academic works are generally confined within the boundaries of the university/college libraries. The other sites as seen in Figure 3, also represent the urban areas of Nepal while rural areas are not represented in any publications, which shows the huge urban-ruraldisparity on studies and the sampling framework and site selection for studies on issues of foodborne pathogens in Nepal.

We excluded the publications which focused on hygiene studies (for e.g. those studying the colony-forming units (CFUs), total viable count (TVC) or

Total plate count (TPC) of coliforms. That way our analyses could accurately estimate the prevalence and be devoid of any misinterpretations on the prevalence of other microorganisms. The prevalence of other bacteria in foods were grouped using broad categories of food. Some of these groups were raw meat of various animals, fruits and vegetables, liquid milk, RTE dairy products, miscellaneous RTE foods and water. The largest number of studies were related to chicken meat followed by milk and buffalo meat. Furthermore, most of the samples were collected from studies conducted in Kathmandu, where the consumption of buffalo meat is high (Maharjan et al., 2006) and Chitwan, with the highest density of poultry population (Osti et al., 2016), this outcome is a true representation of the local circumstances. The least number of studies and therefore the least pathogen prevalence was seen inthe water, which is generally regarded as a complement to the main food course rather than the food itself. The major the drinking water in developing countries is the presence of the coliform bacteria (indicates some kind of faecal contamination) rather than the pathogenic bacteria (Apruzzese et al., 2019).

People in the least developed countries have limited knowledge and quite unaware of food safety. However, if we see on the continent basis, then the situation of food safety is slightly betterfor the countries in Asia as compared to the countries in Africa (Odeyemi et al., 2019). Ineffective enforcement of legal scrutiny, little or lack of knowledge about the foodborne pathogens in the food handlers and poor personal hygiene and sanitation of the people are some of the primary causes of contamination of food, especially those of animal origin in Nepalese context (Khanal and Poudel, 2017).

While the overall cumulative prevalence of pathogens (irrespective of the genus) was 49.2% (95%CI: 42.0-56.5%) in Nepalese foods, the highest prevalence was that of the bacteria of the genus Enterobacteriaceae at 71.4% (95% CI: 63.9-79.0%). As our analyses included *E. coli*, *Shigella*, *and Proteus* into a single category of Enterobacteriaceae, its prevalence could have been obtained at the highest level. On the other hand, due to the unhygienic condition during production, transportation and sale of food products (a common sight in developing countries) (Grace, 2015), this must have been true in our context too.

The highest rate of contamination by bacteria was seen in liquid milk at 69.8% (95% CI: 62.8-76.8%). Various studies in Nepal show varying rates of mastitis in cattle and sub-clinical mastitis due to coliforms or *Staphylococci* (Dhakal et al., 2007). Improperly cleaned or unhygienic milking procedures and the mixing of milk from healthy and sick animals for sale by farmers could have resulted in a higher prevalence of bacteria in the liquid milk (Ng et al., 2010). The least contamination is seen in the RTE foods at 34.8% (95% CI: 22.2-47.3%). Nepalese RTE foods unlike the western kinds of foods are well cooked

in heat using a cocktail of various herbs and spices. It is generally accepted that the presence ofnatural compounds in herbs and spices could be an alternative to synthetic additives associated with minimizing the pathogenic load in those foods (Rodriguez-Garcia et al., 2016). On the other hand, contamination of raw meat (either the buffalo or the chicken) is the consequence of unhygienic slaughtering practices done in filthy and dirty areas and faecal contamination in Nepal (Devleesschauwer et al., 2013) thus leading to contamination of the carcass and the raw meat. Contamination during preparation, cooking, and handling procedures could greatly contribute to the unacceptable microbiological quality of the foods (Manguiat and Fang, 2013).

The prevalence of Salmonella at 22.6% (95% CI: 15.3-29.9%) was least among the bacteria which further highlights the assumption that maintaining hygiene and sanitation is of primary concern as compared to controlling pathogenic bacteria in Nepalese foods (Thapa and Shrestha, 2012). A larger range ofconfidence interval for pathogens like *Pseudomonas*, *Clostridium*, *Enterococcus* or *Bacillus* represents a greater degree of variability in the prevalence of these pathogens which can be attributed to either endogenous or exogenous contamination (Paudyal et al., 2017). A very high percentage of I^2 also helps us to infer that, the studies included in our analysis had a very large variability among them, either in methodological part or in the sampling part (Churchill et al., 2019). This warrants for some unified and harmonized protocol for these kinds of studies in our context. The high heterogeneity between studies indicates that use of global summary prevalence estimates for risk assessments are generally ambiguous. Public awareness on possible risk and its determinants such as foods, or pathogens are relevant for education and further risk assessment.

CONCLUSIONS

Though Nepalese people are vulnerable to foodborne pathogens, foodborne pathogens are still not in a priority in the research sector. The foods of Nepal are contaminated with numbers of zoonotically important pathogens, majorly with the Enterobacteriaceae family. This indicates that the foods are either produced and processed or consumed unhygienically. Thus, all food producers, processors and consumers must understand their respective roles for protecting their personal and public health. In addition, the food production chain from farm to fork must be governed by the concerned government authorities to ensure food safety and curb the potential of outbreaks in the wake of new and emerging epidemics of various origins globally. Existing food control system including food safety regulatory system needs to be revamped to embody all relevant stakeholders in the food chain safety assurance system.

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VARIETAL PERFORMANCE AND YIELD ATTRIBUTES OF DIFFERENT RICE GENOTYPES AT BAITADI DISTRICT

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ABSTRACT

To elucidate the varietal performance of 11 rice genotypes a field experiment was conducted in Gokuleshwor Agriculture and Animal Science College, Baitadi during May-October of 2018 in RCBD with 3 replications. Traits like plant height, leaf area index, panicle length and panicle weight, grain per panicle, thousand kernel weight, grain yield and straw yield were observed. All studied traits significantly differed among the genotypes except leaf area index and straw yield. Highest grain yielding genotype were Hardinath-3 (5.34tha-[1]) and Ram Dhan (4.89 tha-[1]). The highest thousand kernel weight was obtained from the genotype Radha-4 (29.73gm). Grain yield has positive correlation with all the studied traits. Heritability was highest for plant height, grain/panicle and thousand kernel weight. Genetic advance is higher for traits panicle length and grains per panicle. Hardinath-3 and Radha-4 can be used as parents for improvement of yield and yield related traits.

Keywords: Correlation, genotypes, heritability, performance, rice, varietal

INTRODUCTION

Rice (*Oryza sativa*L.) is a major staple foodand mainstay for the rural population and their food security. It is a self-pollinated crop growing in tropical or warm climate. Maize, wheat and rice are considered as major crops grown in Baitadi District. Out of 1,552,469 hectare (ha) cultivated area with production 5,230,327 metric ton, Far western province covers cultivated area of 1,76,560 ha with production of 5,93,327 metric tonwhereBaitadi district contributes cultivated area of 8,000 ha and 18,540 metric ton (MOAD, 2018). A total of 2,63,079 population has requirement of 52,879 metric ton food. However, Baitadi produces 44,331 metric ton of edible food with a shortfall of 8548 metric ton(MOAD, 2018), which is not sufficient to fulfill the growing demands of local people.Under Food Security Phase Classification most of the rural municipalities in Baitadi district are minimally food insecure and some rural municipality are moderately food insecure (NeKSAP, 2017). Droughts, poor transportation facilities, lack of irrigation facilities and access

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to market are behind the continuing food insecurity in Bajhang and Baitadi district (The Kathmandu Post, 24 Nov, 2019).To fulfill this demand, huge amount of cereals, pulses and many more products are imported from Dhangadi and Mahendranagar. Population growth with the increase in demand for food and insufficient growth in farm productivity is leading world to food insecurity. The food problem will be as important as environmental issues. With human's, food crisis becoming an issue in the future (Schwartz, 1991). Therefore, to meet the over increasing demand of food grains, higher production emphasis should be given to genetic improvement of existing varieties of rice. Using molecular markers, research concluded that Nepalese rice landraces have unique gene pool (Sharma and Leung, 2002; Bajracharya et al., 2004). The genetic improvement helps in selecting efficient breeding system and identifying desirable parent in hybridization program. This would depend largely on the knowledge of genetic variation and genetic system controlling the yield and yield associated traits. The goal of this research is to study the overall performance (yield and yield attributing) of different rice genotypes in Baitadi district and help in crop improvement programmes.

METHODOLOGY

The experiment was conducted in the research field of Gokuleshwor Agriculture and Animal Science College (GAASC), which lies in Far western province of Nepal in Dilasaini rural municipality of Baitadi District and the elevation of research site, is 811 metre above sea level. During the research period, maximum temperature was 32^0C and average temperature was 26^0C with an average rainfall of 130 mm. The structure of soil was silty loam. The experiment was carried out during fourth week of May to third week of October laid out in Randomized Complete Block Design with 3 replications and 11 treatments. The treatments are given in Table (1). The individual plot size of 0.9 m*1.20 m (1.08 m^2) was used. The row to row distance was maintained 20 cm and plant to plant distance was maintained 15 cm. The seeds were first treated with Bavistin @ 2gm/kg of seeds, 24 hours before sowing. Farm yard manure@6tha^{-1} was mixed in soil two weeks before transplanting and chemical fertilizers applied were @100:30:30NPK kg/ha (Krishi Diary, 2018).Transplanting of seedlings was done manually on 28 days after sowing.

Table 1: List of different genotypes used during research.

S.N.	Genotypes	Release Status
1	G-60	Unreleased
2	Chaite-5	Released
3	DRR-42	Unreleased
4	Hardinath-3	Released
5	Kedar Basmati	Unreleased

6	Radha-4	Released
7	RamDhan	Released
8	Ciherang Sub-1	Released
9	Sukkha Dhan-3	Released
10	Sukkha Dhan-4	Released
11	Sukkha Dhan-5	Released

Different phenological traits such as plant height, leaf area index and panicle length were observed. Also, the yield and yield attributing traits such as grain per panicle, filled grains, unfilled grains, panicle weight, thousand kernel weight, grain yield and straw yield were taken in consideration. The data was collected for different parameters with the help of scale, measuring tape and weighting machine. Data entry was done on MS-EXCEL 2016 and processed into R version 3.4.2 and R studio for analysis of variation at 5% level of significance. SPSS was used for the correlation analysis.

RESULTSAND DISCUSSION

PHENOLOGICAL AND YIELD ATTRIBUTING TRAITS

Different phenological traits such as plant height, leaf area index and panicle length were observed for different genotypes and the results were tabulated in Table (2).

The genotypic effect for the plant height was highly significant ($p<0.001$) and was significant ($p<0.01$) for the panicle length. Similarly, the genotypic effect for leaf area index was non-significant. The height ranges from 58.4 cm to 114.33 cm where lowest height was seen in G-60 whereas the highest was in local genotype Kedar Basmati followed by Sukkha Dhan-3 (101.27 cm). The length of panicle ranges from 16.73 cm to 23.23 cm. Genotype G-60 had the smallest length of panicle and RamDhan had the longest panicle followed by Hardinath-3 (23.03cm) as shown in Table (2).

Similarly, the yield and yield attributing traits were tabulated after observation in Table (2). The genotypic effect for grain per panicle and unfilled grain was highly significant ($p<0.001$) and the genotypic effect was significant ($p<0.05$) for filled grains as shown in Table (2). The number of grains per panicle ranges from 61 to 169. Sukkha Dhan-4 has the lowest no of grains per panicle and Chaite-5 has the highest number of grains per panicle followed by Radha-4 (127). The range for filled grains varies from 255 to 698. The lowest number of filled grains were observed in genotype G-60 and the highest number of filled grains per 5 panicles was in Chaite-5, followed by Sukkha Dhan-3 (553). The number of unfilledgrains ranges from 46 to 165. The lowest numbers of unfilled grains on sample panicle were seen on Sukkha Dhan-4 and the highest number of unfilled grains per 5 panicles were seen on Ram Dhan followed by Chaite-5 (146).

Similarly, the genotypic effect was significant for panicle weight ($p<0.01$) and grain yield ($p<0.05$). The genotypic effect was highly significant ($p<0.001$) forthousand kernel weight whereas non-significant for the straw yield as shown in the Table (2). The weight of panicle ranges from 1.55 gm to 3.05 gm. Genotype G-60 has lowest panicle weight and Chaite-5 has the highest panicle weight followed by Sukkha Dhan-3 (2.87gm). The thousand kernel weightvary from 18.15 gm to 29.73 gm. The thousand kernel weight obtained highest was from the variety Radha-4 followed by DRR-42 (28.06gm) and the lowest was obtained from local genotype Kedar Basmati.

Table 2: Yield and yield attributes shown by different rice genotypes.

Significant traits are denoted * for $p<0.05$, ** for $p< 0.01$ and *** for $p<0.001$ and NS for non-significant.

	GPP	FG	UFG	PW	TKW	GY	SY	Pht	LAI	PL
G-60	77.17^{de}	255.00^{c}	80.33^{c-e}	1.55^{d}	27.61^{ab}	2.50^{d}	3.95^{b}	58.4^{f}	19.65^{b}	16.73^{b}
Chaite-5	168.67^{a}	697.33^{a}	146.00^{ab}	3.05^{a}	20.72^{de}	4.38^{a-c}	6.17^{ab}	92.4^{c}	33.57^{ab}	21.23
DRR-42	105.23^{b-d}	371.00^{bc}	49.33^{e}	1.95^{cd}	28.06^{ab}	4.69^{a-c}	6.02^{ab}	92^{c}	35.22^{ab}	22.03^{a}
Hardinath-3	115.47^{bc}	391.33^{bc}	109.67^{bc}	2.56^{a-c}	26.02^{bc}	5.34^{a}	6.54^{a}	100.73^{b}	40.13^{a}	23.03^{a}
Kedar Basmati	101.23^{b-d}	476.00^{a-c}	92.67^{c-e}	1.83^{cd}	18.15^{e}	3.18^{cd}	5.25^{ab}	114.33^{a}	21.64^{b}	22.17^{a}
Radha-4	126.70^{b}	466.33^{a-c}	68.00^{c-e}	2.81^{ab}	29.73^{a}	4.29^{a-c}	5.65^{ab}	89.93^{c}	41.41^{a}	21.83^{a}
RamDhan	99.47^{cd}	430.33^{bc}	165.00^{a}	1.96^{cd}	23.41^{cd}	4.81^{ab}	6.11^{ab}	79.6^{e}	35.23^{ab}	23.23^{a}
Ciherang Sub-1	81.40^{de}	305.00^{c}	102.00^{b-d}	1.79^{cd}	27.26^{ab}	4.17^{a-d}	6.51^{ab}	82.27^{de}	33.46^{ab}	21.47^{a}
Sukkha Dhan-3	121.47^{bc}	553.00^{ab}	54.33^{de}	2.87^{ab}	24.66^{bc}	4.75^{a-c}	6.98^{a}	101.27^{b}	41.05^{a}	22.57^{a}
Sukkha Dhan-4	60.93^{e}	258.67^{c}	46.00^{e}	1.40^{d}	26.73^{a-c}	4.32^{a-c}	6.48^{ab}	89.13^{cd}	28.56^{ab}	22.17^{a}
Sukkha Dhan-5	97.13^{cd}	382.00^{bc}	103.67^{b-d}	2.04^{b-d}	26.64^{a-c}	3.67^{b-d}	6.42^{ab}	89.07^{cd}	33.38^{ab}	21.22^{a}
Mean	104.99	416.99	92.45	2.17	25.36	4.19	6.01	89.92	33.03	21.61
CV	14.42	31.93	28.00	22.30	7.33	22.42	20.21	4.76	25.74	7.21
LSD	24.93	219.12	42.61	0.79	3.06	1.39	-	7.04	-	2.56
FTest	***	*	***	**	***	*	NS	***	NS	**

(GPP: Grain Per Panicle, FG: Filled Grain, UFG: Unfilled Grain, PW: Panicle Weight, TKW: Thousand kernel Weight, GY: Grain Yield, SY: Straw Yield, Pht: Plant height, LAI: Leaf Area Index, PL: Panicle Length).

The grain yield of different genotypes ranges from 2.50 *tha-1* to 5.34 *tha-1*. The highest grain yielding genotype was Hardinath-3 followed by Ram Dhan (4.81*tha-1*) and the lowest grain yielding genotype was G-60. The straw yield among the rice genotypes ranges from 3.95 *tha-1* to 6.98 ton/ha. The highest straw yield was obtained from Sukkha Dhan-3 followed by Hardinath-3 (6.54*tha-1*) and the lowest grain yield was obtained from genotype G-60 (3.95*tha-1*).

CORRELATION

The correlation helps to know how any characters are controlled by genes and help the breeder in the selection for effective crop improvement. The correlation among the traits was evaluated the result on correlation study suggested that grain yield showed the positive significant association with straw yield (0.80**), leaf area index (0.85**) and harvesting index (0.76**). All other association like grain per panicle (0.35), panicle weight (0.49), filled grain (0.2), unfilled grain (0.12), plant height (0.38) and thousand kernel weight (0.11) has shown positive association with grain yield. The further correlation among the traits is shown in the Table (3).

Table 3: Relation among different traits

	GY	SY	LAI	GPP	Panicle weight	Filled grain	Unfilled grain	Plant height	TKW	HI
GY	1	0.80**	0.85**	0.35	0.49	0.29	0.12	0.38	0.11	0.76**
SY		1	0.72*	0.20	0.37	0.27	0.03	0.49	0.01	0.22
LAI			1	0.49	0.70*	0.37	0.03	0.29	0.33	0.61*
GPP				1	0.92**	0.93**	0.37	0.37	-0.35	0.37
Panicle wt					1	0.84**	0.20	0.39	-0.14	0.40
Filled grain						1	0.38	0.50	-0.58	0.19
Unfilled grain							1	-0.11	-0.48	0.15
Plant height								1	-0.52	0.06
TKW									1	0.20
HI										1

Nandan, Sweta and Singh (2010) has found strong positive association of yield with days to 50% flowering, plant height, number of grains per panicles, number of spikelets per panicle and spikelet fertility. Also, Madhavilathaet

al., 2005 reported that the yield was positively associated with days to 50% flowering, plant height, number of effective tillers per plant, panicle length, numbers of grains per panicle, harvest index and 1000-grains weight. Janardhanam, Nadarajan and Jebaraj (2001) observed that grains per panicle was the only character which was directly and positively associated with grain yield per plant. Yolanda and Das (1995) observed that the grain yield had positive correlation with the 1000 grain weight. Similar results were reported by Prasad et al., 2000 and Iftikharuddaula et al., 2002.

GENOTYPIC AND PHENOTYPIC COEFFICIENT OF VARIATION

The values for phenotypic variance were higher than those of genotypic variance for all traits. The relative magnitudes of the phenotypic as well as genotypic variances between the traits were compared based on the phenotypic and genotypic coefficient of variation and tabulated as Table (4). Phenotypic coefficient of variation was highest for panicle length (35.41) followed by panicle weight (31.63), leaf area index (30.38) and grains per panicle (29.84) exhibited moderate high phenotypic coefficient of variation. Lowest magnitude of phenotypic coefficient of variation was exhibited by plant height (16.25) and thousand kernel weight (14.75). Grains (25.30) and straw yield (22.93) considerable values of phenotypic coefficient of variation. The difference of PCV and GCV is lower for plant height, thousand kernel weight and grain per panicle which shows there is less environmental effect on a gene. Afzal Zahid et al. (2006) also reported grain per panicle and grain yield with higher GCV values. Similar results were obtained by Anjaneyulu et al. (2010).

HERITABILITY AND GENETIC ADVANCE

The heritability was highest for plant height (91.42%) followed by grain per panicle (76.64%) and thousand kernel weight (75.26%). Estimates of genetic advance as percentage of mean was highest for number of grains per panicle (47.11) followed by panicle length (35.12). Lowest genetic advance was observed for straw yield (2.08) as shown in the Table (4). The results for heritability were observed similar to Saravanan and Senthil (1996) for days to 50% flowering, plant height, and 1000 kernel weight (Ali et al., 2000). Similar results for GAM were observed by Sabesan et al. (2009) for grain yield per plant, 1000 kernel weight and number of effective tillers. Also Anjaneyuluet al. (2010) has reported high PCV and GCV values for the number of grains per panicle. Khan (1990) suggested that high heritability and high genetic advance might be due to mainly additive gene action. High heritability of some traits show that the expression for a particular traitis genetic and have less environmental effects. The traits with higher values for GCV, PCV, heritability and genetic advance as percent of mean are observed in grain per panicle followed by panicle length that shows the dominance of additive gene

action and these traits can be further used for genetic improvement of crop through selection.

Table 4: Variability parameters for different quantitative traits

Traits	GCV	PCV	H %	GAM
Pht	15.53	16.25	91.42	30.60
LAI	16.11	30.38	28.13	17.60
GPP	26.12	29.84	76.64	47.10
PW	22.52	31.63	50.71	33.04
PL	24.57	35.41	48.14	35.12
TKW	12.79	14.75	75.26	22.85
GY	15.34	25.30	36.80	19.17
SY	4.81	22.93	4.40	2.07

(GCV: Genotypic Coefficient of Variation, PCV: Phenotypic Coefficient of Variation, H%: Heritability, GAM: Genetic Advance as Percentage of Mean)

CONCLUSION

The traits like grain per panicle, thousand kernel weight, grain yield and straw yield was found highest in Hardinath-3 and grain yield is highly significant and positively correlated with straw yield, LAI, harvesting index. The genotypes Hardinath-3, Radha-4 had lowest difference between genotypic and phenotypic variation and higher heritability and GAM for panicle weight grain yield, panicle length and thousand kernel weight. Similarly, Sukha Dhan-3, Sukha Dhan-4 has considerably lower values for the traits. Thus, Hardinath-3 and Radha-4 genotypes can further be used in breeding programmesfor similar environmental condition/location as Baitadi district.

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EVALUATING THE FERTILIZER POTENTIAL OF LIGNITE AMENDED DAIRY COMPOST BARN

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ABSTRACT

Although dairy compost barn is an important source of fertilizer, the GHG emission and the N loss reduces its potentiality. Soil amendments like lignite with dairy compost barn are effective in N loss control. But very less is known about the agronomic potential of the nutrients preserved by it. A study was done to explore fertilizer potentiality of lignite amended dairy compost barn by growing Silverbeet plant in glasshouse pot experiment at Burnley campus, University of Melbourne, Australia. The growth parameters like plant height, number of leaves/plants, dry plant biomass and the chemical properties viz pH, EC, inorganic N (NO_3-N, NH_4-N), total C, N, and C:N ratio were studied and analyzed. Research showed that there was a significant difference ($p<0.05$) in terms of the dry plant biomass, height, NH_4-N, and total N % in the soil substrate. But the simultaneous Tukey's test revealed that the significant difference was between the treatments with and without additional chemical fertilizers applied to the treatments. Likewise, there was no significant difference in NO_3-N availability ($p>0.05$). The results suggest lignite amended barn material cannot act as a fertilizer supplement alone and fertilizer addition is required to obtain optimum plant growth.

Keywords: Dairy compost barn, Lignite, Fertilizer potential.

INTRODUCTION

A compost bedded pack barn, commonly known as compost dairy barn, is an alternative loose housing system for the dairy livestock. It is being adopted mostly in the countries like the USA, Israel, the Netherland, New Zealand etc. This system is being increasingly used because it provides better comfort, dryness and special needs for the lactating cows (Barberg, Endres, & Janni, 2007).It is preferred over the free stall barns due to less labor requirement, cleaner cows and lower bedding cost. The bedding material, typically straw from wheat, soya bean and rice, wood chips and sawdust etcused in for housing cattle is composted to get as manure. This composted manure along with chemical fertilizer is used in agricultural farming. However, the GHGs emission and the Nitrogen loss via N cycle are the two issues associated in fertilizer management. The N fertilizer use efficiency is very poor and recovery in the soil-plant seldom exceeds 50% of the applied nitrogen (Raun

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et al., 2002). The low N use efficiency is due to the leaching, denitrification and volatilization (Fageria & Baligar, 2005). The loss of soil organic matter is increasing due to more dependency on chemical fertilizers in farming. This has impacted on crop productivity and studies show that loss of organic matter (OM) in soil reduces the capacity to buffer changes in pH and salinity and other chemical stressors which often weakens to hold the adsorbed N and exchangeable NH_4^+(Saha & Patti, 2016).

There are very few studies being done in GHGs emission, N loss control and efficient management of nutrients available from composted dairy barn. Some researchers have found in revealing the capability of amendments like lignite, if amended in cattle manure to control the loss of N via volatilization and leaching(Chen et al., 2015; Sun et al., 2016). Yet, still, there is lack of study on how additives like lignite effect in releasing the nutrients to the soil. There isn't a single research being done in exploring the agronomic potential of lignite amended diary compost barn till date.Thus, this research was a key step to explore the effect of lignite when amended with dairy compost barns to release the nutrients in the soil-plant system, thereby enhancing the nitrogen use efficiency (NUE) to increase crop production and productivity.

The objectives of the research project were:

- To investigate the capacity of lignite amended dairy compost barn material to release nutrients to the soil through glasshouse pot experiment.
- To compare the nutrient availability from the lignite amended and non-amended dairycompost barn material.

LITERATURE REVIEW

Nitrogen in the soil is available either internally (via N cycle) or supplied externally (viaorganic or in-organic fertilizer). However, due to the dynamic nature of N, the propensity for loss from the soil-plant system, creates a challenging environment for its efficient use and management (Fageria & Baligar, 2005). The amount of N supplied from the fertilizers is not received by the plant root system as it gets lost away due to the various factors like N cycle processes, rainfall surface run-off, erosion and leaching.. The N loss ranges from the very negligible amount to almost 50% depending upon the fertilizer practice and environmental conditions (Peoples, Freney, & Mosier, 1995). Likewise, loss of OM is of particular interest, as it is vital for retaining the physical structure and stability of soils, as well as energy source for the micro-organisms that play key role in soil ecological process (Little, Rose, Jackson, Cavagnaro, & Patti, 2014). As a result, use of organic manure, mostly cattle manure, is increasing.

Despite several researches being conducted on the significance of cattle manure, the livestock industry faces the two major challenges viz N loss management from the compost and the control of GHGs emission like nitrous oxide and methane that comes from it. As the livestock industry is increasing globally, the contribution to GHG emission is also likely to increase. This necessitates better management practices to reduce the GHGs emission as well as increase the efficiency of the nutrients available in the manure. Very few works have been done to reduce the loss of N by adding soil amendments like lignite.

Lignite, also called as brown coal, is formed from plant material and contains higher moisture content than black coal, and act as a sorbent in soil contaminated with heavy metals (Król-Domańska & Smolińska, 2012). Humic acid, one of the major constutuent of lignite, is a suitable organic materialthat could be used as soil amendment. It has potential to play vital role in f N loss due to ammonia volatilization and nitrification as well as retain it from leaching and runoff(Hao, McAllister, & Wang, 2007; Sun et al., 2016). A recent study showed that use of lignite in the surface of the cattle feedlot reduced the ammonia (NH_3) loss by 30% compared to feedlot without lignite (Sun et al., 2016). Likewise, the addition of lignite even in the diet and feed of the cattle has reduced the loss of ammonia emission (Hao et al., 2007) from urine and manure. Because lignite has low pH and high cation exchange capacity (CEC), it has the capacity to minimise ammonia emission.

Despite theresearches on use of lignite to reduce N loss from barn systems, there are no researches being done on how the preserved nutrients due to additives like lignite could release in the plant-soil system. As emphasized by Sun et al.(2016) that the extra nitrogen persevered in manure by lignite can be applied to substitute for chemical fertilizer in the field.There is no research being done to support this claim yet.This is a pertinent research gap in the composted dairy barn materials which aroused this research to be conducted at Burnley Campus of Melbourne University, Australia in 2018.

METHODOLOGY

The research work was carried out at the Burnley Campus of the University of Melbourne, Australia. A glasshouse pot experiment was conducted under the polyhouse. Silverbeet plant (Ford hook Giant Variety) was selected for the study due to its early harvest within 10 months. Due to the time constraint; the nursery for the Silverbeet was not prepared. Instead, two weeks seedlings were purchased and transplanted into the pots for the study purpose.

For the substrate to grow Silverbeet plant, a sandy, slightly acidic topsoil (Brown Podosol) was collected from Boneo, Grassland road, Southern part of Victoria (38°23´13.8“S, 144°54´28.2“E), Australia. The soil, collected from

the top 20 cm depth, were taken from 5 different spots. The soil amendment used in the experiment was the lignite. The lignite amended, and non-amended dairy compost barnsmade readily available from Dookie campus of Melbourne University, Australia were the part of previous research project on mitigating the N losses from compost bedded dairy barns using lignite.

EXPERIMENT SET UP

The experiment was started on 6th June 2018. The soil collected from the field was air dried for about one week in room temperature. The sieving of the soil sample was done by using 4 mm mesh sieve. The soil was mixed with different treatments as listed in Table 1. The mixing of the soil to the dairy compost barn was done on 10% v/v basis (i.e. 9-litre volume soil was mixed with 1-liter volume lignite amended and non-amended compost barn materials) in 1 litre volume plastic pot.There were five treatments with four replications for this experiment (Table 1). Treatments were pre-incubated for 2 weeks and the planting of Silverbeet was done on 25th June 2018. About 2 weeks old seedling were transplanted to the pots. The treatment pots were placed using a randomized complete block design method under the poly-house.

Table 1: Details of the treatments

Treatments	Description	Symbol
Treatment 1	Soil only (Control)	T1
Treatment 2	Dairy compost barn with lignite + soil	T2
Treatment 3	Dairy compost barn without lignite + soil	T3
Treatment 4	Dairy compost barn with lignite + soil + fertilizer	T4
Treatment 5	Dairy compost barn without lignite + soil + fertilizer	T5

IRRIGATION AND FERTILIZER APPLICATION

The Silverbeet plants in each treatment were irrigated twice a week to maintain at field capacity (FC). The moisture content of the treatments at FC was determined by saturating the treatments and letting them drain under gravity for 24 hours. Each pots /treatment were weighted twice a week and the amount of water loss from the pot was then added to each of the treatments based on the FC calculation. A basal rate of the mineral form of micronutrients (Mg, S, Fe, Mn, Zn, Cu,) at rates equivalents to 30,25,2,5, 4, 3 kg ha^{-1} and weekly rates of N (NH_4NO_3), P (KH_2PO_4) and K (KH_2PO_4 and KCl) 89,33,39 kg ha^{-1}, respectively, was applied to treatments T4 and T5(Kaudal & Weatherley, 2018).

MEASUREMENTS

The measurement of the chemical properties and plant nutrients available in the study sample was done both prior to planting and after harvesting of the

Silverbeet plant. All the chemical properties analysis of the soil and plant samples was done at Trace Analysis for Chemical, Earth and Environmental Science (TrACEES) lab of Melbourne University, Parkville.The difference was analyzed accordingly. Some of the process used for the measurements were as below.

PH AND ELECTRICAL CONDUCTIVITY (EC)

The samples for determining pH and EC was prepared by mixing samples to deionized water at the ratio of 1:5. For the process, 5 gm of samples were mixed with 25 ml of deionized water and were shaken for an hour in an electric shaker at the speed of 60 rpm. After 30 minutes, samples were removed from the shaker. The pH and EC reading were determined by using TPS Conductivity Sensor and results expressed in millisiemens per cm (mS/cm).

INORGANIC NITROGEN (NO_3-N, NH_4-N)

For the extraction of inorganic N (NO_3-N, NH_4-N), the sample to the solution was prepared at the ratio of 1:10, i.e. 4 gm of sample was mixed with 40 ml of 2 M KCL solution. The samples were shaken for 1 hr, in a reciprocating Shaker at the speed of 100 rpm. The solution was then filtered with Whiteman 42 filter paper. The amount of NO_3-N, NH_4-N were determined on Skalar San++ SFA (Flow Access V3.2)(Pathan, Aylmore, & Colmer, 2002) and expressed in mg/l. The quantification was further expressed in g/l for the analysis and result interpretation.

TOTAL C AND N

The samples of shoot and root of the Silverbeet plants and the soil substrate used for growing plants were fine grinded for homogenization using Tissue Lyser. The result of the total nitrogen (N) and carbon (C) were determined by Dumas Combustion - LECO Trumac CN at a furnace temperature of 1350°C.

PHYSICAL GROWTH PARAMETERS MEASUREMENT

The growth of the plants was closely monitored, and the observations made were recorded accordingly. The fresh weight of the plant was measured in the lab immediately after harvest. The shoots and roots detached were washed with deionized water and the weight was recorded using electric balance.
The detached shoots and roots were dried in an oven at a temperature of 40^0 C for four days. The soil substrates were dried at an oven temperature of 60^0 C for the same period as shoots and roots. Then after the weight of the dried shoots, roots and soil substrates were measured using electric balance. The

total weight of the plant biomass was calculated by addition dry weight of shoot and root of each plant grown in different treatments.

PLANT HEIGHT AND NUMBER OF LEAVES

The effect of treatments on the growth and development of the Silverbeet plant was studied in the project. The numbers of leaves per plant were counted once a week during the vegetative growth phase. Likewise, the height of the plant in each treatment was measured (cm) using the measuring scale.

All statistical analysis was done by using Minitab Software (Minitab 17). The test of significance of the difference between the treatments for the various responses were tested using one-way ANOVA. The difference between the values was considered significant at $P<0.05$. Where there was a significant treatment difference, Tukey's test was applied to separate the differences between the treatment means at $P<0.05$.

RESULTSAND DISCUSSION

CHEMICAL PROPERTIES OF TREATMENT SUBSTRATE

The selected chemical properties of the substrates and the samples used for the treatment mixes are present in Table2. The compost barn without lignite had higher pH (8.4) in contrast to pH 6.2 of compost barn with lignite. When the compost barn material with lignite was added to soil sample collected for the study, it decreased the pH from 6.2 to 5.9. This may be due to the fact that the lignite, as a humic substance has higher pH buffering capacity (Maciejewska & Kwiatkowska, 2000).Likewise, the Electrical Conductivity (EC) of the treatment substrate after the experiment was reduced compared to before the start of an experiment for the lignite amended compost barn materials. TheCarbon: Nitrogen(C: N) ratio of the lignite amended, and non-amended dairy compost barn had a ratio of 28 and 21% before experiment. This ratio decreased to 14 and 13% after the growth of silver-beet plants. However, as suggested by academic literatures, the optimum ratio of C:N for the micro-organism to decompose the organic material should be around 24:1 (USDA, 2011).There is decrease in total N (%) of the media after the experiment. This might be due to the nutrient uptake by the plant which can be supported by the fact that the total Nitrogen (N) in the plant tissue is increased after the experiment (Table4). One of the most important factors for plant's growth and yield is the soil organic carbon percent in the soil. From the lab analysis, the dairy compost barn material with lignite amended and non-amended had a C % of 46 and 41 respectively (Table 2).

Having the ANOVA analysis, it shows that there is a significant difference for pH, NH_4-N, Total N, EC and C:N between the treatment ($p<0.05$). However,

the Tukey's test shows that the difference for the all these values was between the chemical fertilizer added (T4, T5) and non-added (T1, T2, T3) treatments. There was no significant difference ($p>0.05$) for the NO_3-N between the treatments.

Table 2: Selected chemical properties of the treatment mixes before and after the experiment. Numbers in the brackets indicate the standard error of the mean (n=4). Values with the treatment are significantly different ($p<0.05$) if they do not share a common letter

Treatments	NO_3-N (g/kg)	NH_4-N (g/kg)	C: N	Total N (%)	Total C (%)	EC (mS/cm)	pH
Soil amendment material							
Barn with lignite	0.62 (0.00)	0.09 (0.00)	28 (0.00)	1.65 (0.00)	46.59 (0.00)	8.28 (0.04)	6.21 (0.00)
Barn without lignite	0.20 (0.00)	0.07 (0.00)	21 (0.00)	1.94 (0.00)	41.06 (0.00)	7.69 (0.02)	8.46 (0.01)
			Start of experiment				
T1	0.003 (0.00)	0.07 (0.00)	12(0.00)	0.33 (0.00)	4.04 (0.00)	0.09(0.00)	6.01(0.07)
T2/T4	0.021 (0.00)	0.0 6(0.00)	13.(0.00)	0.33 (0.00)	4.47(0.00)	0.33(0.02)	5.93 (0.04)
T3/T5	0.009 (0.00)	0.07 (0.00)	12(0.00)	0.39 (0.00)	4.89 (0.00)	0.29(0.01)	6.10 (0.02)
			End of experiment				
T1	0.002 (0.000) **a**	0.02 (0.00) **b**	13 (0.08) **c**	0.39 (0.01) **a**	5.01 (0.16) **a**	0.08 (0.00) **c**	5.75 (0.03) **ab**
T2	0.002 (0.000) **a**	0.02 (0.00) **b**	15 (0.24) **a**	0.27 (0.01) **c**	4.07 (0.04) **b**	0.17 (0.01) **a**	5.82 (0.03) **a**
T3	0.002 (0.000) **a**	0.01(0.0 1) **b**	14 (0.35) **ab**	0.31 (0.02) **bc**	4.39(0.12) **b**	0.12 (0.00) **ab**	5.82 (0.01) **a**
T4	0.020 (0.017) **a**	0.10 (0.02) **a**	14. (0.18) **bc**	0.32 (0.01) **b**	4.38(0.13) **b**	0.39 (0.14) **bc**	5.59 (0.07) **b**
T5	0.020 (0.002) **a**	0.13 (0.01) **a**	13. (0.13) **c**	0.34 (0.00) **b**	4.39(0.07) **b**	0.21 (0.01) **c**	5.73 (0.02) **ab**

(ANOVA at $p<0.05$)

PLANT GROWTH PARAMETERS

Dry shoot and root weight

The ANOVA analysis for the dry shoot weight of the Silverbeet plant grown in different treatments showed significant differences ($p<0.05$) as illustrated in Table 4 and Figure

1. Similar result is for the dry root weight between the treatments too. There is a significant difference between the means of treatments with chemical fertilizer (T4, T5) and treatments without chemical fertilizers (T1, T2, T3) as revealed by Tukey's pairwise comparison. However, there is no difference within T1, T2, T3, which shows that there was no significant effect of lignite on plant biomass. The difference of treatment (T4, T5), from (T1, T2, T3) probably might be due to additional nutrients supplied from the fertilizer added on them.

Plant height and numberof leaves/plant

The plant height parameter was analyzed using ANOVA. There is a significant difference between the treatments for the plant height parameters. Having Tukey'stest shows that the difference between the fertilizer added (T4, T5) and fertilizer not added treatments (T1, T2, T3). The growth parameters for the numbers of leaves showed no significant difference between the treatments ($p>0.05$). A research conducted by (Rose et al., 2016) on exploring the N uptake of lignite blended urea and conventional urea fertilizer in wheat found that there was no significant difference in N uptake between the two fertilizers treated plants. However, they anticipated the preserved N due to lignite would be available to the plants in the long run and suggested that 6 weeks' time was not enough to observe the N uptake result. This might be applicable to this study too.

Similarly, the C:N ratio has direct impact on residue decomposition and also N cycling in our soil (USDA, 2011). In the experiment, the C: N ratio of the dairy compost barn (with and without lignite) decreased almost by 50% compared to before experiment to after experiment. Although, the final C:N ratio (approximately 14% mean value in all treatments T1, T2, T3, T4, & T5) in the soil was above the C:N ratio requirement of micro-organism (8:1), yet it was below the optimumC:N ratio for the micro-organism(24:1) to conduct the decomposition process of organic material present in the soil.This might be one of the reasons of lignite amended dairy compost barn material to not reveal its fertilizer potentiality within the study period.

Table 3: Silverbeet plant growth parameters (Fresh and dry weight (g), plant height (cm). Numbers in brackets denote the standard error of the mean (n=4). Values with the treatment are significantly different ($p<0.05$) if they do not share a common letter

Treatments	Average dry weight(g)		Av. total biomass	Plant height	No of
	Shoot	Root	weight (g)	(cm)	leaves/plant
T1	0.26	0.60	0.86	6.47	5.88
	(0.05) b	(0.35) c	(0.37) **b**	(0.79) **c**	(0.44) **a**
T2	0.82	2.03	2.85	11.31	7.75
	(0.07) b	(0.17) bc	(0.19) **b**	(1.13) **b**	(0.37)**a**
T3	0.84	2.79	3.63	9.38	7.56
	(0.13) b	(0.59) ab	(0.71) **b**	(0.84) **bc**	(0.26)**a**

T4	5.20	4.33	9.53	18.41	9.13
	(1.30) a	(0.79) a	(1.93) **a**	(0.99) **a**	(1.64)**a**
T5	4.52	3.33	7.85	19.31	9.75
	(0.11) a	(0.23) ab	(0.26) **a**	(0.82) **a**	(1.30)**a**

ANOVA analysis at P <0.05

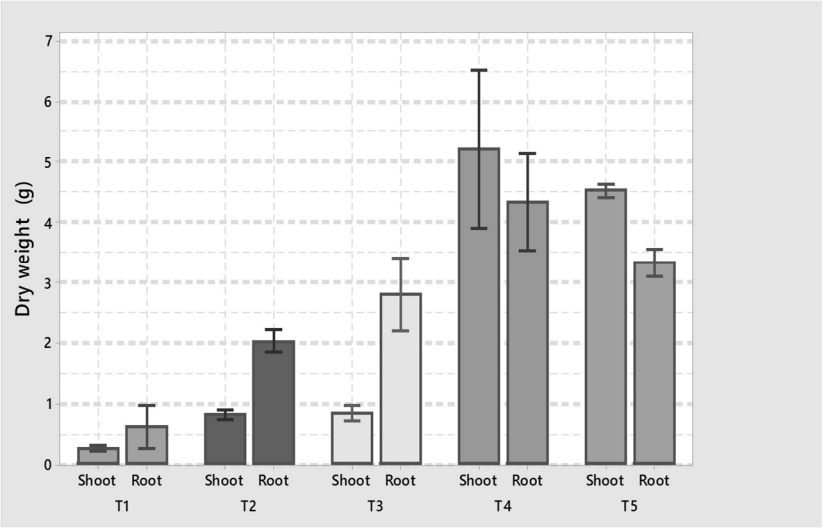

Figure 1: Shoot and root dry weight for Silverbeet plants grown for 10 weeks on all treatment substrate

Plant tissue analysis

The Table 4 shows that the total N and C of the plant's shoot and root grown in all treatments. By having ANOVA analysis, it revealed that there was a significant difference ($p<0.05$) to the N content in both root and shoot part of the plants. This is opposite to C content as it showed no significant difference ($p>0.05$) in both shoot and root plant tissue. However, the Tukey's test shows that the significant difference is between the fertilizer added treatment (T4, T5) and non-added treatments (T1, T2, T3). There is no significant difference in total N content in plant tissue between the lignite amended and non-amended dairy compost barn material. One of the reasons to have no significant difference in N content in plant shoot might be due to the reason that nitrogen present in lignite could be slowly released, therefore not available to the plants during that short-termperiod of study (10 weeks).This slow release theory could also explain lower N content in the shoots of both treatments T2& T4 (i.e. lignite amended compost barn without and with chemical fertilizer) compared to treatments T3& T5 (i.e. Lignite unamended compost barn without and with chemical fertilizer) (Table 4). Research has shown that this slow N release properties of lignite is due to its extensive

reactive surface area and humic acid content (Rose et al., 2016; Sun et al., 2016).

Likewise, If the N content in the plant tissue is less than 2.8% in Silverbeet it is regarded as the nitrogen deficit condition and fails to meet the normal range of 3.5-5% (Wade, 2009). Since thedairy compost barn material, with and without lignite and the soil material has N content of just 1.71, 1.99 and 0.39% respectively, it suggests that sufficient N is not available to see the differential impact. On the other hand, treatments (T4, T5) had N content of 4.72 & 4.84 % respectively and this was because of fertilizer added to these treatments.One of the reasons that we could not see the difference between lignite amended and non-amended treatment for the N content might be that enough time was not available to mineralize the organic N into a mineralform.This is true as evidenced in a research conducted by (de Boer, 2014) which showed that the compost bedded barn's fertility is observed until 10 years after application due toits initial low mineral N and slow N mineralization rate.

Table 4: Nutrient analysis of plant and root tissue of silver-beet plant grown in different media at the end of the experiment. Numbers in the bracket denote the standard error of the mean (n=4)

Treatments	Nitrogen, N (%)		Carbon, C (%)	
	Shoot	root	Shoot	root
T1	2.22(0.28) **b**	0.98(0.09) **b**	36.11(0.73) **a**	28.02(6.81) **a**
T2	1.71(0.10) **b**	0.81(0.04) **b**	36.90(0.45) **a**	23.65(1.61) **a**
T3	1.99(0.02) **b**	0.92(0.05) **b**	35.50(0.46) **a**	23.56(2.65) **a**
T4	4.72(0.15) **a**	1.41(0.11) **a**	36.04(0.88) **a**	27.71(2.28) **a**
T5	4.84(0.20) **a**	1.60(0.09) **a**	37.00(0.53) **a**	24.95(1.71) **a**

Values within the column significantly differ if they do not share a common letter.

CONCLUSION

The research hypothesis was that lignite amended dairy compost barn material increases the plant growth by increasing the nutrients (N) availability in the soil. However, there were no significant differences between the treatments T2 & T3 showing that lignite amended barn alone had no effect on the plant growth parameter. On the other hand, treatments with fertilizer addition (T4, T5) were significantly different from treatments without fertilizers (T1, T2, T3). The difference between, T1, T2, T3 on one hand and T4, T5 on the other was due to the fertilizer being applied to T4 and T5. This suggests lignite amended dairy compost barn material cannot act as a fertilizer supplement and fertilizer addition is required to obtain

optimum plant growth. As the normal range for the N content in plant tissue for Silverbeet is 3.5-5 %, the N available in control (T1), lignite amended compost barn + soil (T2), and lignite unamended compost barn + soil (T3) was below the normal range which might have made difficult to observe the growth impact. Likewise, the treatment with lignite amended dairy compost barn has higher organic N content and may be there was not enough time to mineralize this N to make available to the plants. So, if this research in the future is conducted for a longer period, we could differentiate the impact of lignite amended compost barn with non-lignite compost barn material. Moreover, the soil to compost barn materials ratio could be tried for a higher percentage on v/v basis in the future research too.

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SYSTEM OF RICE INTENSIFICATION (SRI): BOON OR BURDEN?

J. J. Gairhe[1] and S. Thapa[2]

ABSTRACT

Several studies have confirmed the claims of SRI in increasing the yield by two to three times the current global average. Increased yield in SRI includes both straw and grain yield. This increased biomass production entails higher amount of nutrient removal from the soil. Concern arises regarding the plant nutrient requirement and nutrient balance of the soil. These nutrients will be drawn from soil indigenous nutrient pools if not given through any external source. Concerning Nepalese agricultural system, even if there are no short-term effects observed, soil fertility and productivity could be seriously hampered in long term. Nutrient sustainability aspect of SRI has been overlooked, with most research being focused on the applicability of SRI in different agro-climatic and soil conditions. A balanced supply of nutrients using nutrient management approach must be combined with SRI to ensure high yields and maintain soil fertility.

Keywords: Nutrient balance, Nutrient mining, Soil, Sustainable agriculture, System of rice intensification

INTRODUCTION

Agriculture sector is under eminent pressure to increase food production, with global population hitting 7.7 billion and the figure to be increased by 28% till the end of 2050 (PRB, 2019). Researchers are in a constant look out for new ways to increase food production and productivity. Keeping pace with the increased population, yields in both irrigated and rain-fed lowlands rice needs to be increased by 60-70% within next 30 years (Dobermann and White, 1999). In an attempt to achieve it, green revolution hasled to a practice of using improved varieties and high amount of external inputs to increase agricultural output (Uphoff, 2003). Although these practices have raised production and helped to reduce imminent food scarcity problems, their sustainability is still questionable. Whether it be regarding their dependence on fossil fuel to operate machineries, fertilizer, and pesticide industries orin terms of the ill effect they possess to agricultural land in the long term.

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System of rice intensification (SRI), developed by Father Henry de Laulanie, is an agro ecological approach that modifies certain management practices (Dobermann, 2004). These modifications are believed to unlock the untapped potential of rice, producing more productive phenotypes from existing genotypes (Doni et al., 2019). Increase in yield up to15ton ha^{-1} is reported by Malagasy farmers under this system (Toriyama and Ando, 2011), which is more than three times the global productivity of 4.54 ton ha^{-1}(FAO, 2018). SRI is a labour intensive approach that increases the yield using few external inputs. Though intensive on labour use at the transplanting stage, the practice claims to increase both labour and water productivity.

Since its development in Madagascar during the 1980s and 1990s to recent years, SRI has been tested in different agro-climatic conditions. Despite the criticism of this practice like Sheehy et al.(2008) describing it as having no inherent advantage over conventional system and terming the initial report of high yield as a consequence of measurement error. Similarly, Sinclair and Cassman (2004) also describe the yield from SRI as agronomic UFOs (Unconfirmed field Observations), supporters like Ceesay et al. (2006) support it on increasing yields. This paper calls attention to the soil nutrient balance system under SRI and its possible effects under Nepalese agriculture system. Different research paper regarding SRI, conference and workshop proceedings, government reports regarding soil management and SRI were consulted.

PRINCIPLES OF SRI

The modifications of SRI include: Raising the seedling in carefully managed garden like nursery; transplanting seedlings at young age, 10-12 days old (not more than 15 days); planting single seedling per hill in a square pattern at a distance of 25 to 30 cm; mechanical weeding to eliminate weed and aerate the soil; Using Organic manure instead of mineral fertilizers; intermittent irrigation by alternate wetting and drying of the paddy field (Doni et al., 2019; Stoop et al., 2002). The synergy between different components is believed to increase nutrient availability to the plants and create a superior growing condition, hence, enhancing the physiological development and grain yield (Ceesay et al., 2006).

SRI practices were initially used with chemical fertilizers, before the Madagascar government removed fertilizer subsidies in the late 1980s. As a result, laulaine started using organic fertilizers with SRI (Sato, Yamaji and Kuroda, 2011).

A deeper root system is observed with concomitant profuse tillering of individually planted rice seedling, increasing the rhizosphere area that exploits nutrient from deeper layer of soil. SRI decreases the amount of water used in flooding rice cultivation. Less amount of seed and fertilizer requirement makes it a better approach over the conventional. Challenginggreen revolution as yield being a function of high external inputs and input responsive varieties, this system is more focused toward optimizing the available resources. Though, we have seen SRI being practiced with use of mineral fertilizers, the original idea of SRI advocates to sustain on solely organic manure. Uphoff (2003) summarized that the use of manure is recommended, not required, and considered best when applied on preceeding crop. Higher yields with SRI can be observed without any nutrient amendments (Dobermann, 2004). This system has increased the yield of rice to a level which even green revolution, with all its chemical and mechanical inputs and high yielding varieties, could not.

Rice is not an aquatic plant(Uphoff, 2003), the formation of *aerenchyma* (air pockets) in the roots of rice plant is rather an adaptive character whichis beneficial for survival in flooding rice cultivation but has no significance it terms of yield. The formation of those air pockets are at an expense of disintegration of cortex around the central stele(the xylem and phloem) to allow oxygen to diffuse into root tissue, which impair the ability of older roots to take part in nutrient uptake later in the grain filling stage (Uphoff, 2003).

SRI enhanced the root activity during the entire growth period, especially during the late growth stage (Wang et al., 2002). Massive root growth in SRI has been reported by Barison and Uphoff (2011). Individual SRI plant requires 8 times more resistance per plant to uproot as compared to conventional (55.2 v/s 6.9 kg force per plant) (Barison and Uphoff, 2011). Both root proliferation and penetration also increases. Younger seedlings produced greater root length density under both flooded and non-flooded soil conditions (Mishra and Salokhe, 2011). Two to three times greater root growth was recorded in SRI below 30 cm as determined by root length density (RLD) measurement at different soil depth. Thus, increasing the total soil volume exploited by the root system. Hence, access to deeper soil nutrients.

Moreover,planting the seedlings early (at second or third phyllochron) prevents the hindering of the rapid growth beginning at fourth phyllochron stage. Unlike standard cultivation practices where “maximum period” of tiller production occurs before the paincle intiation (PI), it conicides in SRI(Berkelaar, 2007).

NUTRIENT AVAILABILITY

Nitrogen is the limiting nutrient for rice production worldwide (Khan et al., 2002). The alternate wetting and drying of the soil significantly increases the mineralization process, increasing N availability. Plant uptakes nitrogen in the form of ammonium(NH_4^+) in anaerobic lowland soils and nitrate(NO_3^-) in aerobic upland soil. Ammonium requiring less energy to metabolize may be more beneficial to the plant. However, studies show that a combination of both $NH_4^+$and NO_3^- leads to 40-70% higher yields, as compared to giving the same amount of N in the form of ammonium. Alternate creation of aerobic and anaerobic condition makes both forms of N available to the plants (Ceesay, 2006).

Tsujimoto et al.(2009) mentioned that the increase in yield was linear to mineralizable nitrogen, deep ploughing increased the mineralizable nitrogen and facilitated the development of roots. A flush of humus decomposition and nitrogen mineralization occurs after every successive drying and rewetting of the soil, also termed as the 'birch effect', increases nitrogen availability (Birch, 1958). Aerobic phosphorus solubilizing microbes activity is increased in the system (Zhao, 2011). Deeper root system made the otherwise unavailable subsoil P available to the plants, indicating greater uptake and more efficient use of P for grain production (Barison and Uphoff, 2011).

Hengsdijk and Bindraban (2001) assert that the crop and soil scientists may have possibly over estimated the plant nutrient requirement. They argue that a very small amount of nutrients can give substantial growth results, provided that the nutrients are well balanced and include sufficient micronutrients. Barisonand Uphoff (2011) also stated that the difference in both nutrient uptake and output in SRI can be a combined result of greater root activity, longer functioning with deeper and more extensive proliferation, resulting in greater and more balanced nutrient uptake.

REASREACH EVIDENCES

According to Barison and Uphoff (2011), accumulation of above ground nutrients were enhanced considerably by management practices under SRI. The uptake of N and K was increased by 91% whereas P by 66%. At maturity, SRI plants had accumulated more nutrients in their major organs than the conventional and translocated greater amounts of nutrients to the grain (Zhao et al., 2011). On an average of 6.0 to 8.4 t ha^{-1} grain yield was reported on farmers' field with SRI (Khadka, Acharya and Uphoff, 2014). Biomass production was also reported to be higher in SRI management (Ceesay et al., 2006) with harvest index (HI) being increased by 30%. Kumari et al., (2015) reported 20.3 and 21.0 percent increase in grain and straw yield respectively. Sato et al., (2011) reported 78% increase in yield with 40% reduction in water

use and 50% reduction in chemical fertilizer application. Similar results were observed by Kabir (2007), Lin et al.(2011), Sinha and Talati(2007),Zhao et al. (2011), and so on.

SRI IN NEPAL

SRI was first introduced in Nepal in 1998 with some initial trials in Khumaltar in collaboration with USAID collaborative research support program (ICIMOD, 2015). It gained attention after a farmer field school produced an average of 8 t $h^{-1}$of grain yield with SRI (Dahal, 2014), more than double the current productivity of 3.2 t ha^{-1} (Tripathi, Bhandari, and Ladha, 2018).SRI is reported to be practiced in 35 districts of Nepal in 1000 hectare of land (Uprety, 2017). Only 9.25% of the district farmers produced more than 6 ton ha^{-1} yield while this increase was observed in 40% of SRI farmers, increasing the average district productivity to 4.1 t ha^{-1}(Uprety, 2015). Uprety (2015) reported a yield increase to 6.3 t ha^{-1}in farmers field by SRI which approximates to about double of the yield of 3.1 t $ha^{-1}$with conventional. Yield was reported maximum with 8-days-old seedling and 25×25 cm^2 spaced seedling respectively (Dahal, 2014). Similar results were observed by (Rajbhandari, 2007).

Uprety (2010) reported 55% increase in yield with 50% less seed requirement. Farmers reported 40-50% increase in grain yield and 20-25% greater biomass production with SRI in Jhikku khola watershed area (Dhakal, 2005). Dhital (2011) reported 51% increase in the grain yield and 40% increase in straw yield. Radha-4 was reported to yield maximum.

DISCUSSION

Since SRI appears to be producing higher grain yield in the same soil conditions as that under conventional systems, concern arises regarding plant nutrient requirement, the least amount of nutrient that should be added to the soil to ensure good crop growth. On one hand, significant increase in the yield, both grain and straw, is observed in this system. But on other hand, fertilizers use is cut down on and/or replaced by organic manure. Maintenance of soil fertility is important to improve and sustain yields. Plant growth removes nutrients from the soil which depletes the soil nutrient pool, if organic and chemical fertilizer inputs are not sufficient (Brown et al.,1999).

NUTRIENT BALANCE IN SRI: POSITIVE OR NEGATIVE?

According to IRRI (2007), 15-20 kg N, 2-3kg P_2O_5 and 15-20 kg K_2O uptake is required by rice crop to produce a ton of grain per hectare. Landon (2014) stated that a rice crop producing 3.36 t h^{-1} of rice grain and an equal amount of straw per hectare approximately removes 54 kg N, 26 kg P and 46 kg K. Rice-rice cropping system removed on average about 94.6kg N, 18.8 kg P and 97.3 kg K from unfertilized plot per year. This demand was largely met from

indigenous nutrient supplying ability of soil (Sridevi and Ramana, 2016). For production of 1 ton of paddy, crop absorbs an average of 20 kg N, 11 kg P_2O_5, 30 kg K_2O, 3 kg S, 7 kg Ca, 3 kg Mg, 675 g Mn, 150 g Fe, 40 g Zn, 18 g Cu, 15 g B,2 g Mo and 52 kg Si (FAO, 2006). Greater vegetative growth requires greater amount of nutrient in SRI(Barison and Uphoff, 2011).

20-ton compost or farmyard manure, on fresh-matter basis, supplied 78 kg N, 17 kg P and 116 kg K. Organic manure is reported to mineralize 40% in first year, 25% in second year and 15% in third year (Brown, Schreier, Shah, and Lavkulich, 1999). Dairymanure that is commonly used in Nepal contains 0.7%N, 0.1%P and 0.5% K by weight while the more fertile poultry manure contains 1.6%N, 0.5%P and 0.8%K by weight (Landon, 2014). From the above data, we can observe that the nutrient supplied by organic manure might not be enough to sustain a huge amount of production. Further addition of organic manure can slow down the decrease or tend to increase the soil organic matter content, but yield increment is less likely to occur. Dawe, et al. (2003) concluded application of manure does not improve the grain yield, the manure can be used only as a complement to inorganic fertilizers. Application of manure is not a complete alternative to mineral fertilizers. Manuring promotes an internal flow of nutrients within the farm rather than adding nutrients from outside (Bationo, et al., 2001). Moreover, the financial profitability from the organic amendments also needs to be considered. The feasibility of adding enough organic manure to meet the nutrient requirement as demanded by grain yield in SRI in a large area on a long-term basis is impractical.

The overwhelming increase in yield has led researchers to focus more on the applicability of this practice on a range of climatic conditions and soil, however, the effect of such practice on environmental components like soil is over shadowed. Soil degradation has become a challenge in sustainable intensification of the crop system, where poor quality and low nutrient input leads to decline in soil productivity (Bationo et al., 2001). Practices like SRI exhausts the soil by uptaking a great amount of nutrients, which needs to be replenished to the soil. As mentioned earlier, if not supplied through any external source, these nutrients will be extracted from soil indigenous nutrient pools. Especially in a country like Nepal where sub-optimal fertilizer use is a phenomenon rather than an exception. Larger root system implies that a greater amount of nutrients will be removed from a deeper soil layer. While showing little to no effects on yield in the short term,the effect of this negative nutrient balance in long term could make the soil unproductive. Hence, Long term effect of SRI practice on soil physical, chemical and biological properties needs to be explored.

SUSTAINABILITY OF SRI IN NEPAL

Fertilizer recommendation for rice in Nepal is 100:30:30 kg NPK h^{-1} for irrigated and 60:20:20 NPK $ha^{-1}$for rainfed with 6 t ha^{-1} organic manure (MOALD, 2019). However, the average use of fertilizer throughout the country is reported to be 46:26:10 NPK kg ha^{-1}as shown in figure 1, which is lesser than that of recommended dose for rainfed rice (Bhandari, Bhattarai, and Bista, 2017), with an approximately productivity of 3.2 t ha^{-1}. Maximum fertilizer is reported to be used in the terai region, concentrated mostly on central development region, is still not in sufficient amount (Bhandari, 2017). Although it is reported that every harvest of paddy takes away a large amount of nutrients from the soil (Thapa, 2010). SRI has reported to increase the yield of rice to more than double but the amount of fertilizer applied was the same as that in conventional methods. Increase in yield entails extraction of huge amounts of nutrients from the soil that previously had a negative nutrient balance.

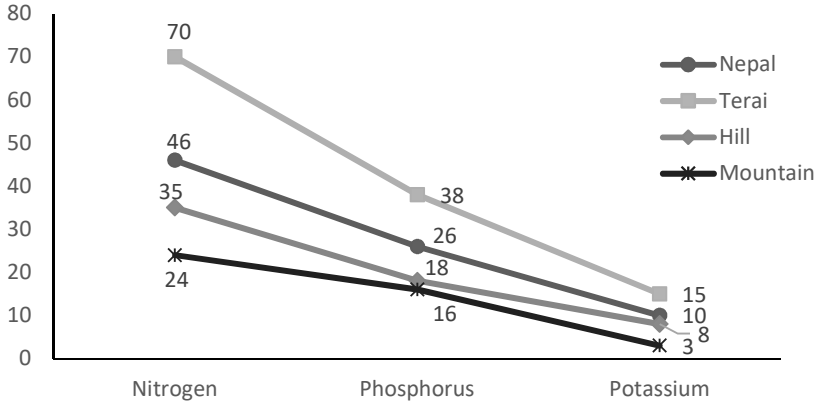

Figure 1: Nutrient use in rice in different ecological zones of Nepal (Bhandari, 2017)

Nutrient mining in SRI is also mentioned by Barison (2011), SRI is advantageous for increasing the yield in the short term. However, In the medium to long-term, nutrient inputs are required to offset the increased nutrient export. As observed by in his study Barison (2011), doubling of N uptake was seen with the SRI in comparison to conventional methods even though the soil had similar fertility, which again brings us to consider the possible mining of organic-N pool of the soil.

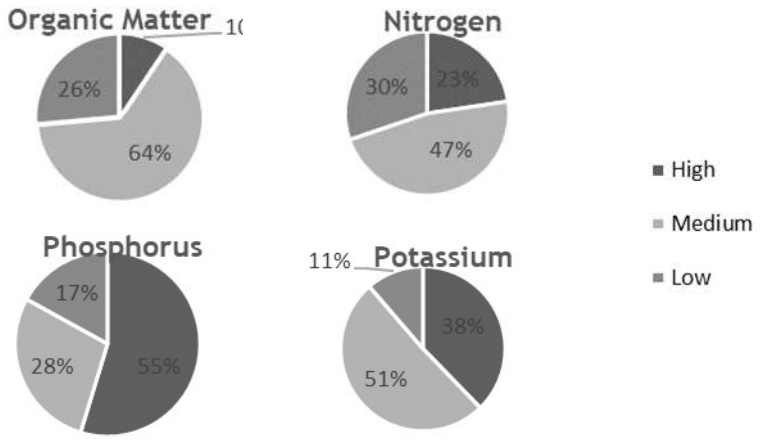

Figure 2: Nutrient content of soil in Fifty-four districtsof Nepal(MOALD, 2017)

Figure 2 shows the nutrient content of soil in fifty- four districts of Nepal according to MOALD report (2017). Most of the districts showedlow to medium amounts of nutrient.

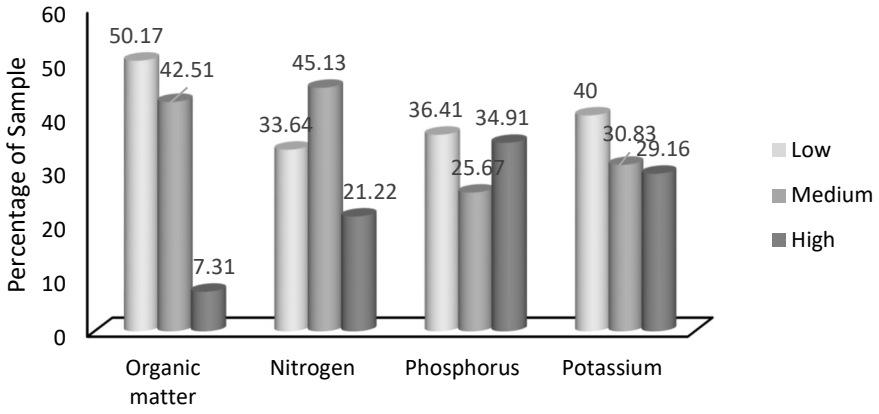

Figure 3: Results of the soil sample tested Under different laboratory under Soil Development Directorate in 2017 (MOALD, 2017)

As illustrated in Figure 3, thirty-three hundred soil samples tested throughout the country in fiscal year 2017/2018, 50.17% showed low organic matter content, 33.64% of the sample showed low nitrogen level, 36.41% was low in phosphorus while 40% showed low potassium level. Negative soil nutrient balance of all three major nutrients has been reported in Nepal (Tan, Lal, and

Wiebe, 2005). Nutrient balance analysis in a twenty year rice-rice-wheat experiment in Nepal, the N, P and C pools were either maintained or increased but K showed a negative nutrient balance in conventional system. Regmi et al., (2002) also reported depletion of soil K and inadequate K fertilization as a possible reason for yield decline. Usage of straw as forage or fuel contributes for the massive nutrient removal from the soil with each harvest (Dobermann and White, 1999).

Now the questions might arise on the benefits of adoption of this system in Nepal. High-yielding systems like SRI as shown by different experiments areundeniably beneficial. However, the increase in the yield with SRI should be accompanied with improved nutrient availability (Ceesay, Reid, Fernandes, and Uphoff, 2006). The depleted nutrient pool should be expanded through nutrient cycling by soil microorganisms (Barison and Uphoff, 2011). Adaptations in the practice of SRI are necessary to suit the soil of Nepal (Sato, Yamaji, andKuroda, 2011).Ahsan et al., (2007) through his experiment suggested integrated nutrient management as a viable option to maintain soil fertility and productivity in SRI. Similar results were observed bySravan and Singh (2019), where 75% recommended dose of fertilizer combined with 25% recommended dose of nitrogen as farmyard manure along with Blue-green algae and *Azospirillum* gave higher yields as compared to 100% inorganic fertilizer. Site-specific nutrient management(SSNM) meets the nutrient deficit between the nutrient needs of a high-yielding crop and that supplied by soil indigenous nutrient supply, using indigenous nutrient sources, like crop residue and manure, and optimal amount of fertilizer used at proper time (Marahatta, 2017). It can also be used for managing plant nutrients at any scale. SSNM was reported to increase the yield, nitrogen uptake and N use efficiency (Dobermann et al., 2002).

CONCLUSION

Extensive research conducted on SRI has proven the system to be actually effective in increasing the yield, rather than just being unconfirmed field observations(UFOs). However, the replenishment of those nutrients removed from the deeper soil layer is a big question. High uptake of nutrients in SRI needs to be accompanied with an equal amount of nutrient addition in the soil.

The nutrients supplied by farmers in existing farming systems is not sufficient for sustaining crop intensification practices. The principle of SRI in using only organic manure for rice production may not be practical. Efforts must be directed towards increasing nutrient supply to the soil before adoption of high yielding practices like SRI. Adoption of integrated nutrient management approach in SRI can be done to increase the nutrient availability, combined with SSNM ensures a sustainable high yield while maintaining the soil fertility.

A delicate balance between the nutrient removed by the crop and the nutrient supply system should be maintained.

There is a need to realize the research gap in terms of nutrient sustainability of SRI. Long term experiments (LTEs) focusing on the nutrient sustainability is a mustto ensure long-term food security in Nepal.

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IMPROVED MANURE MANAGEMENT PRACTICES: OPTIONS TO REDUCE NITROGEN LOSSES IN THE FARMING SYSTEM OF MID-HILLS OF NEPAL

S. Aryal[1]

ABSTRACT

This research was conducted in the mid-hills district, Dadeldhura located in the SudurPashchim province of Nepal. The purpose of this study was to explore which method of manure handling will retain more nitrogen and which method is most liked by the farmers of the study area. Comparisons were made between the traditional method of manure handling prevalent in study area i.e. 1) stockpiling in open air over the improved methods of manure handling namely 2) single plastic covered on top and 3) double plastic covered on top and bottom. Results showed that farmers liked the single covered method of manure handling the most over other two methods. There was significant difference between the nutrient content in the manure stored in open air over the two other improved manure management options. However, there was no significant difference in the nutrient content between single and double covered method of manure handling.

Keywords: Farm yard manure, mid-hills, nutrient loss, participatory

INTRODUCTION

Farming in the mid-hills of Nepal is characterized by labour intense, subsistence based, complex and rain fed with low return (Dhungana et al., 2013). Livestock husbandry, arable cropping and forestry are closely integrated in the agricultural system of the mid-hills. Livestock in the hills are used for ploughing, and are an integral source of nutrients as they provide milk, meat, eggs along with farm yard manure for farming. Most of the farming in the upper mid hill region is organic by default because farmers are subsistence based and composted farm yard manure is the only source of nutrient to the plant (Pilbeam *et al.*, 2005). However, Over the last few years, farmers have been diversifying their cropping pattern and started to grow different cash crops, off-season vegetables and commercial livestock farming (Pokharel, 2019).

As according to Shah (2013), about 55-95% of the nitrogen content of the ingested food is excreted in the manure of the livestock. Appropriate manure management is therefore important to reduce nutrient losses. It is common to scrap off the manure from the floor of animal shed and put it in a pit which is

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usually left open in the mid hills of Nepal. Such practice of poor manure husbandry results in the losses of most of the nutrients from the manure through leaching and evaporation. According to Thorne and Tanner (2002) and Bettinelli (2014), significant losses of nitrogen occur during manure management chain like housing, storage and field application in Nepal.

This study tries to explore options to reduce nutrient losses in the farming systems through the participatory evaluation of different farm yard manure management options in the Dadeldhura district in the SudurPashchim province of Nepal. This study will specifically identify current manure handling management practices and reasons behind the use of current practice. It aims to assess the nutrient content of the manure types included in the experiments and identify farmers preferences concerning the different manure management techniques before and after the experimental results and explore reasons behind their preferences. The result from this study could actually be an option to reduce nutrient losses in the mid-hills of Nepal. Furthermore, it might provide guidelines to the policy makers and developmental workers before developing and launching developmental programs related to reducing nutrient losses in small holder farming system in the mid-hills of Nepal through improved manure management. The research questions of the study are:

1. What are the current practices of manure storage and what are the reasons for these practices?
2. What are the final nutrient contents of the manure experiments?
3. Which manure handling methods are most appealing for farmers and for what reasons?

THEORETICAL FRAMEWORK

This research is divided in three phases, namely 1) research design phase 2) Data collection phase and 3) Data analysis and conclusion phase (Figure 1). The research design phase included the literature review, and questionnaire preparation. The data collection phase included the biophysical data collection and social data collection. The biophysical data were collected by means of different manure trials. Social data were collected using questionnaires, focus group discussion (initial/final) and through board impact tool. Samples of the experiments were taken and explored in the laboratory. Results were output computed using Excel and GenStat- for ANOVA and indexing method- for computing index of importance. Data analysis was followed by drawing conclusion.

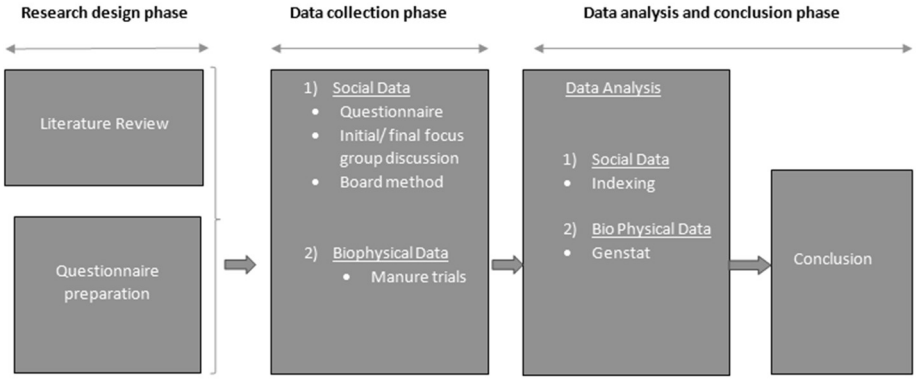

Figure 1 : Research Frame work

METHODOLOGY

STUDY AREA

The research was carried out in the village, littery of Amargadhi municipality in Dadeldhura district located in the SudurPashchim province of Nepal. Different experiments of manure handling were conducted in close participation with farmers in the study area in the month of September, where the average temperature fluctuated from 15.5°C to 23.3°C and the aggregated precipitation was 196 mm.

DATA COLLECTION

Social Data

a) Questionnaire

The exploration of the manure management practices was done through questionnaire that were prepared to seek farmers' perception just after the participatory trials and after showing the result of the experiments. Table 1 below summarises the main topics and main questions of the questionnaire that were explored in this study.

Table3 : Main topics and questions of the questionnaire

S.N.	Main topics	Main questions
1	Exploration of current management of manure handling	-how is manure handled
2	Perception on manure handling methods that were explored (just after the experiment)	-Which method of manure handling took more time, labour, money and in which method it is easier to gather necessary material and which method

		they prefer and would like to continue and why?
3	Perception on manure handling that were explored in the research (after showing the result)	-Which method of manure handling did they like, which method took more labour, extra care and they would like to continue in the following year and why?

b) Focus group discussion workshop (FGD- Workshop)

Initial/final focus group discussions and demonstrations were performed in the research. The initial FGD aimed to view the ideas of the farmers about the manure handling processes and prepare for the participatory experiments. It allowed to gather information (both positive and negative) on farmers' perception regarding our research. A final group discussion was conducted to assess their perception on the final result of the experiment and thank the farmers for their participation.

c) Board impact tool

It is a visual research tool to quantify the farmers perception on innovations using tokens that symbolizes different indicators like money, time, labour etc. on a desired scale (Zabala et al., 2011). In our research, the preference of farmers on three different methods of silage making and manure handling was quantified in a scale of 1, 2, 3 with 3 being the highest, 2 medium and 1 with least score. Farmers were given three tokens for each indicator: time, money, labour, initial preference and willingness to do in the future and were given freedom to put the number of tokens as per their preferences on the methods of manure handling. The perception was assessed twice with the farmers, once after the preparation of the experiments and another after showing the result of the experiments.

Out of the six indicators explored during the first perception assessment, four indicators for which farmers perception is most likely to be changed due to participatory experiments, namely preference, labour, time and like to continue in the coming year were used for the ex- post assessment.

d) Sampling

In total, thirty farmers participated in the workshop: 7 from the dalit community and 23 from chhetri community. 83% percentage of the farmers who attended the initial group discussion and demonstration were women. Almost all the households that were present during the experiment had livestock.

These thirty farmers who participated during the initial experiment session were listed and selected to quantify their perception about the methods of manure handling using board impact tool (ex-ante and ex-post). The questionnaire regarding the current management practices of manure storage were also asked to these thirty farmers.

Biophysical Data

Participatory research acknowledges the importance of local participation and facilitates the use of local interest, knowledge, resources and decision in the research (Cornwall and Jewkes, 1995). Participatory experiments of manure handling were executed. The experiments were conducted in close participation with local people in the farmers field close to their house. Methods of manure handling that are generally recommended for small scale farmers were selected for the experiments (Shah, 2013).The manure trials were opened after 50 days of storage. The quality of the manure was visually evaluated (considering the physical appearance, aroma, quality etc.) together with farmers and assessed with them in a final group discussion workshop.

a) Manure trials

Three methods of manure handling were explored in the experiments. In the first method, manure was deposited in a pit and stored as heap in open air. In the second method, the manure heap was kept in pit and then covered by plastic from top. Finally, in the third method, manure was placed inside the pit, that was already lined with plastic and was again covered by plastic from top (Shah, 2013).The amount of manure used for each treatment was 5 kg.

There were total 24 samples with eight replications of these three methods of manure handling. The materials that were used for this trial were farm yard manure and the black colored plastic sheets, including bigger plastics sheets required for the double cover method.

b) Sampling

Samples of the manure experiments were collected for the laboratory analysis. The representative manure samples were taken with hand. The final sample was reduced to around 300 gram of manure as per the laboratory requirement by quartering method (FAA, 2015).

DATA ANALYSIS

Social data

The data base of the current management practices, questionnaire, focus group survey and board method was initially created using Microsoft access. The social data was analyzed using indexing method.

a) Indexing

In this research, the scoring of the perception, regarding three different methods of manure handling (obtained from board method, in a scale of 1, 2 and 3) was computed using the formula of index of importance as mentioned below (Ghose, 1981 and Kerlinger, 1983 cited in Timsina and Regmi, 2009) :

$$I_{imp} = \Sigma(Si\ Fi/N)$$

Where,

I_{imp} =Index of importance

Σ= Summation

Si= Numeric scale value

Fi= Frequency of importance given by the respondents

N= Total number of respondents

Biophysical data

The samples of manure experiments were analyzed in the laboratory of Animal nutrition division of Nepal Agricultural Research Council (NARC) in Khumaltar, Lalitpur, Nepal. The nitrogen content of manure samples was chemically analyzed using Kjeldahl digestion method (Barbano *et al*., 1990). The laboratory result of manure was analyzed using one-way ANOVA by GenStat (Bevans, 2020)

RESULTS

SOCIAL RESULT

a) Current management practices of manure handling

According to the survey result, the only method of manure handling in the research area is stockpiling manure in a heap. Farmers keep livestock in the ground floor of the house and scrap the manure from the floor manually by using a hoe. The manure is then placed in a bucket and complied in a heap in the backyard to make farm yard manure (FYM). Irrespective of the number of livestock farmers scrap the manure from the shed at 3-4 days interval.

According to the farmers, the FYM is generally used for crops (cereals and vegetables) and this is the only source of fertilizer for the crops from the soil. Farmers have been stockpiling manure since generations as it is easy and inexpensive. Livestock, especially bullocks and goats

are usually taken for communal grazing for about 6-7 hours daily and remains in shed for the rest of the day.

b) Ex- ante perception of manure handling methods

Out of the three different manure handling methods that were explored in the experiments, farmers gave the highest index for the indicator, preference (2.83) to the double covered method of manure handling. They also scored this method with highest index for labour (3.00), for cost (2.90) and for time (3.00). For all these indicators, the double covered method was followed by single covered method and openair method. Farmers gave the least score for labour requirement (1.00), cost requirement (1.13) and time requirement (1.00) for the open air method. However, the highest index was given for the indicators, easy to gather necessary materials (2.93) and like to continue in the coming year (2.67) for the open air method of manure handling (Table 2).

Table4: Index of importance on three different methods of manure handling

S. N.	Methods/Indicators	Index value		
		open air method	Single covered method	Double covered method
1	Preference	1.30	2.17	2.83
2	Labour	1.00	2.07	3.00
3	Money	1.13	1.93	2.90
4	Time	1.00	2.00	3.00
5	Easiest to gather necessary material	2.93	1.87	1.30
6	Liked to continue in following year	2.67	2.57	1.37

c) Ex- post perception of manure handling methods

Farmers gave the highest value of 2.97 to the single covered method for the indicator, preference. The highest value for labour (3.00) and time (2.90) was given to double covered method that was followed by single covered and open air method of manure handling. However, the least value of importance for the indicators, preference (1.00), labour (1.00) and time (1.13) was given for the open method. The result showed the similar index value (2.60) for the interest to follow in the coming year for open air and single covered methods of manure handling (Table 3).

Table 6 : Index of importance for three different methods of manure handling (after experimental result)

S.N.	Methods/ Indicators	Index value		
		open air method	Single covered method	Double covered Method
1	Preference	1.00	2.97	2.03
2	Labour	1.00	2.00	3.00
3	Time	1.13	1.93	2.90
4	liked to continue in coming year	2.60	2.60	1.10

BIOPHYSICAL RESULTS

a) Nutrient content in manure

The data analysis showed a significant effect of different manure handling methods on the nitrogen content in the manure experiment. The nitrogen content in the compost from the open air method was significantly different over the single covered and double covered methods of manure handling.The highest nitrogen content was observed in double plastic cover method (1.49%) and was not significantly different with single plastic cover method (1.39%). The lowest nitrogen content was observed in open method (1.13%) (Table 4).

Table 7: The effect of manure treatment on nitrogen content

Treatment	N (%)
Open	1.13^{b}
Single plastic cover	1.39^{a}
Double plastic cover	1.49^{a}
F test	*
LSD	0.15
CV%	10.4
Grand mean	1.34

N= Nitrogen, CV= coefficient of variance. The values labelled with different subscripts were significantly different at 5% level of significant)

DISCUSSION

This study explored options to reduce nutrient losses through improved manure handling in mixed farming systems in the mid-hill district, Dadeldhura

located in the SudurPashchimprovinceof Nepal. Farmers perception of these alternative management options were also assessed.

Traditional methods used to store manure cause large nutrient losses in the nutrient cycle on farm in the study area. Manure is also left in the open air there by exposing it to rain and high temperatures. This results in a loss of nutrients through volatilization and leaching (Thorne and Tanner, 2002).

This study showed that farmers were aware of the loss of nutrient in their system especially because of the prevalent manure handling practices but were unaware of improved method of manure handling. The participatory experiment became a platform to expose farmers to different methods of improved method of manure handling.

Similarly, different method of manure storage had diverging effect on the nitrogen content. Both covering manure singly from the top or together from bottom and top resulted in strong reduction of nutrient losses. However, there was maximum loss of nitrogen in the open method of manure handling. This must be due the direct exposure of manure to air which accelerated emission of ammonia and moisture from the manure that represented a loss in nitrogen fertilizer content in the final product (Hartung and Phillips, 1994). The trend of nitrogen loss in this research is in line with the result of Shah (2013) where the rate of nitrogen loss was measured through ammonia emission with higher loss recorded in open method, single covered and double covered method of manure storage respectively. The higher percent of nitrogen in the covered method of storage could be due to the blockage of air circulation that inhibits organic matter decomposition and low internal heat production inside the manure configuration (Hansen et al., 2006).

Although open air method was prevalent in the research area, it is interesting to note that after observing the result, farmers preferred the single covered manure handling method the most. It could be because the compost that was prepared by single plastic covered method in the manure trials was darker and heavier resembling good quality (Thorne and Tanner, 2002) than that made by stock piling in open air, which implies that farmers might have changed their preferences after seeing the result of the manure trials. However, it is also interesting to see that although farmers preferred the single covered method of manure handling over other methods during ex-post evaluation, their index value of importance for the indicator like to continue in the following year is similar (2.60) to the open method. This could be due to the limitations of the farmers to the available materials like plastics, time, and money that are needed to use the improved method. During the focus group discussion farmers explain that if they would have enough materials specially plastics then they would cover manure. Furthermore, most of the farmers in the research area are female, who due to the increasing trend of

male migration, have increased their work load. Women in this area are overloaded with the responsibility of children, farming and livestock rearing at the same time (Maharjan et al., 2013). Therefore, they don't have enough time and money to go to the market to buy the materials to cover the manure. It may also be that although livestock are an integral part of their life, manure management may not fall in the first priority of the small holder farmers, especially women farmers in this region.

Farmers' interest seems to be very less towards double covered method. It may be because the visual quality of manure that was prepared in the single cover method was almost similar to the compost prepared by double covering method according to the farmers. Another reason could also be that they found lot of work, need of extra plastic and more time to open and cover the pit every time in this method.

It would have been much interesting to observe other nutrient contents in the manure trials except nitrogen, but we were not able to do so. The several hours of load-shedding, the Indian blockade and other technical problems in the NARC Laboratory at the time of manure testing stood as the major constraints in this attempt. Also, the manure trials could have been opened after sometimes (more than 50 days) but this was not possible due to the time constraints and long distance of the research area from the laboratory.

CONCLUSION

This research showed that current nutrient losses in the farming systems in the mid hills of Nepal could be substantially reduced through improved manure handling. Experimental results showed that improved manure handling could reduce nitrogenlosses in this system. Manure covered with a plastic sheet from one or both sides showed to contain more nitrogen than the manure stored unprotected in the open air. No significant differences were found between single and double covered manure storage making both methods potentially equally suitable for this region. Farmers were aware of the nutrient losses from their system especially in case of manure husbandry. However they were unaware of the improved methods of manure handling. Farmers showed interest to cover the manure with single plastics provided that there is availability of the necessary materials like plastics.

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