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**Himalayan College of Agricultural Sciences & Technology (HICAST)**

Post Box 25535, Kathmandu, Nepal

Email: info@hicast.edu.np; binayakprajbhandari@gmail.com

URL://www.hicast.edu.np/

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## **RESEARCH ARTICLES**

# **Production performance and chemical constituents of fodder maize varieties at different dates of sowing in the inner Terai region of Nepal**

**Sujaya Upreti<sup>1\*</sup>, Naba Raj Devkota<sup>2</sup>, Santosh Maraththa<sup>3</sup>, and Megh Raj Tiwari<sup>4</sup>**

<sup>1</sup>National Pasture and Fodder Research Program, NARC, Khumaltar, Lalitpur

<sup>2</sup>Gandaki University, Kaski, Pokhara

<sup>3</sup>Agriculture and Forestry University, Rampur, Chitwan

<sup>4</sup>Nepal Agricultural Research Council, Kathmandu

\*Corresponding Author: sujayaupreti824@hotmail.com

### **ABSTRACT**

*An experiment was done to compare the fodder biomass yield and major chemical constituents of different varieties of fodder maize (*Zea mays*) sown in different dates at National Cattle Research Programme (NCRP), Rampur, Chitwan (inner terai) during spring season (February to June), 2021. The experiment was laid-out in a Randomized Complete Block Design with four treatments; consisting three varieties of fodder maize (African Tall, J1006, and PMC-6) and one local maize variety Arun 2 (as a check), with four replications for each treatment. Periodic biomass was estimated along with measurement of growth performances parameters. Findings revealed that the dry matter (DM) yield of fodder maize varieties was statistically similar ( $p > 0.05$ ) among the treatments if harvested at 75 and 90 days after sowing (DAS). The plant height, leaf length and leaf breadth harvested at 75 DAS varied significantly ( $p < 0.05$ ) among the treatments while they were statistically similar ( $p > 0.05$ ) if harvested at 90 DAS. There was a significant difference ( $p < 0.05$ ) in plant height and dry matter yield if maize varieties were sown in different dates. African Tall sown on 1<sup>st</sup> March and harvested at 90 DAS recorded the highest dry matter (7.99 t/ha) yield and similarly African Tall sown in 1<sup>st</sup> February and harvested at 90 DAS results highest protein percentage (9.57%). Thus, the African Tall fodder maize varieties were found best in terms of DM and CP content in reflecting its suitability over other fodder maize varieties to be grown under the inner terai context of Nepal.*

**Keywords:** Biomass, dry matter, nutrient composition, fodder maize, different date

### **INTRODUCTION**

Commercial dairy farming is increasing in Nepal, especially in Terai, which required more fodder to replace the higher amount of concentrate feed. A recent prediction by the MoALD showed that the national Total Digestible Nutrient (TDN) demand is 15,597,950 t (2021/22) and that will be increased by 1.54 times more compared to the demand of 2016/17 (MoALD, 2019; Singh and Singh, 2019) to meet the need of an increased number of dairy animals. In spite of these challenges and scenario, feeding management of the ruminants including

productive dairy animals are not done well as most of the feeding materials are crop residues and crop stovers that are poor in digestibility and low in nutrient content, especially in terms of crude protein (Singh, 2019). Thus, it is necessary to work towards developing technologies that would address the need of more green fodder (with high nutrition and digestibility), especially for winter and spring seasons (Garg and Upreti, 2019). It is also because there have been significant changes in land use pattern in Nepal since 1990 (ICIMOD, 2010). The grassland area has reduced by 26.8 % and forest area by 7 percent, indicating the need to increase green fodder production to meet the TDN need. On the other hand, existing livestock feed is highly imbalanced, as straws constitute over 65% of total TDN supply, and makes up the major diet (>80%) during the winter, spring, and the dry summer. While considering paddy and maize, their TDN contribution from straw reaches about 80% of total TDN supply, but these feedstuffs are low in nutrient with poor digestibility due to the high content of silica in the fiber (Upreti and Shrestha, 2006, Banerjee 1998 and Mc Donald 2010).

In spite of the importance of fodder maize in dairy feeding, research work has not been done considering the productivity and the palatability issues. Increasing dairy population of the country is demanding more feed, especially during the winter. Therefore, it has become critically important to explore the production potential considering the possible feeding use of whole plants part such as green tops, husk, and stover of fodder maize to support in ruminant feeding.

In the recent years, fodder maize has been started to cultivate in diary pockets of Nepal (Garg & Upreti, 2019) but much of the information are not known regarding suitable fodder maize varieties that could be grown with higher level of herbage mass productivity. So far, GoN/NARC has released and well adopted 89 varieties of grain maize but none of them were intended for fodder production (NARC, 2018). Maize among the different fodder crops is regarded as one of the important fodders that can be available in all seasons. Maize is one of the most important non-legume green fodders. It is a tall, leafy plant with a potential herbage mass yield of 400–500 q/ha. It is a highly nutritious, palatable fodder, free from any unwanted anti-quality components. Maize has the potential to supply large amounts of energy-rich forage for daily animal diets and its fodder can safely be fed at all stages of growth without any danger of oxalic acid, or prussic acid as in the case of sorghum (Dahmardeh *et al.*, 2009) whereas the economics of milk production is largely dependent upon the quality of nutritious fodder fed to milch animals.

Fodder maize technology can be widely adopted across the agro-ecological zone of the country with more cutting in the terai region of Nepal. As the crop is dependent on the temperature and rainfall, the change in the weather pattern is critical to address in terms of identifying suitable dates/months to grow the maize to get more fodder during the scarce period, especially during winter, spring, and dry summer. Since the suitable sowing dates to get more foliage harvested have not been adequately researched in the country, this is high time to work in this line. Therefore, the research was done with the main objective to determine the suitable sowing dates with respect to the commonly available fodder maize varieties focusing on the productivity concern and nutrient composition of fodder maize in the Terai regions of Nepal.

## MATERIALS AND METHODS

### Experimental location

The field experiment was done at the National Cattle Research Programme (NCRP), Rampur, Chitwan during the spring season (February to June), 2021. The area is located at 27°39'15.93" N latitude and 84°21'05.22" E longitude with an elevation of 184.0992 masl (LRMP,1986) .

### Climatic information

It has a humid and subtropical climate with cool winter (2-3°C) and hot summer (43°C). The annual rainfall is over 1500 mm with a distinct monsoon period (>75% of annual rainfall) from mid-June to mid-September. During the cropping period, the maximum temperature was recorded in April (Monthly average = 26.02). The highest minimum temperature was recorded in February (Monthly average = 18.01) (Table 1). Total rainfall received during the research period (February to June 2021) was 937.1 mm.

Table 1. Weather records during a research period at Rampur, Chitwan, 2021

Weather records	Different dates of the research period				
	February	March	April	May	June
Maximum temperature	26.95	31.59	35.42	31.76	33.29
Minimum Temperature	9.08	14.12	16.62	21.67	24.60
Average Temperature	18.01	22.85	26.02	26.72	28.94

Source: National Maize Research Programme, Rampur, Chitwan

### Soil Characteristics

The soil properties of the experimental site reported by the Agriculture Technical Centre (ATC) are presented in Table (2). The soil condition was slightly acidic (6.12pH) in nature and the soil texture was sandy loam.

Table 2 Nutrient content of soil at research site

pH	N (%)	P <sub>2</sub> O <sub>5</sub> (kg/ha)	K <sub>2</sub> O (kg/ha)	OM (%)	Sand (%)	Silt (%)	Clay (%)	Soil Texture
6.12	0.19	38.37	160.8	3.38	72.32	21.18	6.50	Sandy Loam

Source: Agricultural Technology Centre Pvt Ltd, Lalitpur

### Experimental design and treatments details

The experiment was done by using Randomized Complete Block Design with four replications for each treatment. The treatment consisted of a combination of fodder maize varieties- African tall, J-1006, Pratap Makka Chari-6 (PMC-6), and local variety-Arun 2 and three different sowing dates- 1<sup>st</sup> February, 15<sup>th</sup> February, and 2<sup>nd</sup> March. The treatments details used in the experiments are as follows:

<u>Symbol</u>	<u>Treatments</u>
D1V1	Local maize-Arun 2 sown at 1 <sup>st</sup> February
D1V2	African Tall sown at 1 <sup>st</sup> February
D1V3	J1006 sown at 1 <sup>st</sup> February
D1V4	Pratap Makka Chari 6 sown at 1 <sup>st</sup> February
D2V1	Local maize-Arun 2 sown at 15 <sup>th</sup> February
D2V2	African Tall sown at 15 <sup>th</sup> February
D2V3	J1006 sown at 15 <sup>th</sup> February
D2V4	Pratap Makka Chari 6 sown at 15 <sup>th</sup> February
D3V1	Local maize-Arun 2 sown at 2 <sup>nd</sup> March
D3V2	African Tall sown at 2 <sup>nd</sup> March
D3V3	J1006 sown at 2 <sup>nd</sup> March
D3V4	Pratap Makka Chari-6 sown at 2 <sup>nd</sup> March

Note: D1=date one (1<sup>st</sup> February);D2= date two (15<sup>th</sup> February); and D3=date three (2<sup>nd</sup> March)

V1=Variety one (Local maize – Arun 2); V2=variety two (African Tall); V3=variety three (J1006); V4=variety four (Pratap Makka Chari 6)

### **Cultivation practices**

The recommended agronomic management practices were followed. The experimental plot was plowed 2-3 times with a disc harrow which made the soil friable. FYM was added before 5 days of sowing. The line-to-line distance was maintained at 30 cm and the plant-to-plant distance, at 15 cm in a net plot size of 4.05 × 2.4m. A population of 2,22,222.22 plants /ha. Seeds were sown at the rate of two seeds per hill which was thinned to one plant per hill on one week after emergence. Nitrogen, Phosphorous, and Potash were applied at 100:50:50 kg/ha, respectively. Phosphorous and Potash were applied during land preparation while nitrogen fertilizer was applied in two split doses, half at the time of land preparation and the remaining half after 30 days of sowing. Farmyard manure was applied at the rate of 10 t/ha during the time of land preparation. The plot was irrigated after sowing and then once in 10 days depending on the soil moisture. Weeding and hoeing were done on a when basis. Destructive harvesting was done at 75 and 90 days after sowing.

### **Data observation**

The treatment-wise green biomass yield was taken from each net plot and averaged to get green biomass yield per plot whereas for dry matter, harvested the weight of green matter was used to calculate dry biomass yield. The morphological characteristics (plant height, leaf length, leaf breadth, and leaf numbers) were determined on the basis of randomly selected 5 plants from each plot.

### **Laboratory analysis**

Fodder maize cultivars used as treatment were subjected to proximate analysis (DM, CP, NDF, ADF, Ca and P) and polyphenolics (ADL)), by following the procedure suggested by Association of Analytical Chemists (AOAC, 1980) at Animal Nutrition Division, NARC, Khumaltar.

### **Statistical analysis**

All the collected data were processed and ANOVA was done to test the significance of the treatments. A mean comparison of the treatments was done using LSD ( $p < 0.05$ ). Statistical software GenStat discovery 18<sup>th</sup> Edition (VSNi 2015) was used to analyze the data.

## **RESULTS AND DISCUSSION**

### **Fodder maize dry matter yield and biomass attributing characters**

The dry matter (DM) of fodder maize for all treatments were statistically similar ( $p > 0.05$ ) when harvested at 75 and 90 DAS whereas higher DM was obtained from Arun 2 (7.21 t/ha) followed by African Tall (6.66 t/ha) harvested at 90 DAS (Table 3). Lowest DM yield was recorded for PMC-6 (5.33 t/ha) harvested at 75 DAS. The plant height, leaf length and leaf breadth harvested at 75 DAS varied significantly ( $p < 0.05$ ) different but were similar ( $p > 0.05$ ) if harvested at 90 DAS. The fodder maize J1006 (77.37cm) harvested at 90 DAS had the highest plant height than Check variety- Arun 2 (193.7 cm) (Table 3). In the case of number of leaf per plant, J1006 (12.08 leaf/plant) had highest number of leaf per plant followed PMC-6 (11.08 leaf/plant) (Table 3).

There was a significant difference ( $p < 0.05$ ) in dry matter and plant height if date of sowing were considered (1<sup>st</sup> February, 15<sup>th</sup> February and 1<sup>st</sup> March). Fodder maize sown in 1<sup>st</sup> March and harvested at 90 DAS resulted highest dry matter yield (7.27 t/ha) and was lowest (4.16t/ha) if sown in 1<sup>st</sup> February and harvested at 75 DAS. Accordingly, highest plant height (227cm) was measured in fodder maize sown in 1<sup>st</sup> March and harvested at 90 DAS whereas lowest (163.2) plant height was measured for the fodder maize sown in 1<sup>st</sup> February and harvested at 75 DAS (Table 3).

At 75 DAS, plant height was statistically different ( $p < 0.05$ ) among the treatments with the highest plant height for African Tall if sown in 1<sup>st</sup> of March which was, however, statistically similar ( $p > 0.05$ ) to the plant height of PMC-6, sown in 1<sup>st</sup> March. Likewise, plant height of J1006 sown in 1<sup>st</sup> February, same variety sown in 15<sup>th</sup> February and PMC-6 sown in 1<sup>st</sup> February had similar plant height ( $p > 0.05$ ) (Table 4). The lowest plant height was measured for Arun-2, sown in 1<sup>st</sup> February and Africa Tall also sown in the same date. The leaf length, leaf breadth were significantly different ( $p < 0.5$ ) when date of sowing were considered (1<sup>st</sup> February, 15<sup>th</sup> February and 1<sup>st</sup> March) and harvested at 75 DAS while statistically similar ( $p > 0.05$ ) when leaf length, leaf breadth of different date of sowing harvested at 90 DAS (Table 4). Leaf length and leaf breadth were highest of African Tall (91.70cm) and 9.85 cm respectively sown in 15<sup>th</sup> February and harvested at 90 DAS.

### **Nutrient composition and polyphenolic of fodder maize varieties**

The crude protein (CP) and fiber fractions of the fodder maize and check variety are presented in Figure (5). While considering tested varieties sown on different dates and harvested on different days of sowing, the average crude protein percentage was highest for African Tall sown in 1<sup>st</sup> February (9.57%) and harvested at 90 DAS (Figure 5) followed by PMC-6 sown in 15<sup>th</sup> February (8.82%)

and harvested at 75 DAS whereas this value was lowest for J1006 (3.50%) sown in 1st March and harvested at 75 DAS.

Table 3 Fodder maize biomass attributing characters and dry matter yield of different varieties used and sown at different dates at Rampur, Chitwan during spring, 2021

Fodder maize varieties	75 DAS					90 DAS				
	Plant height (cm)	Leaf length (cm)	Leaf breadth (cm)	Leaf nos.	DM (t/ha)	Plant height (cm)	Leaf length (cm)	Leaf breadth (cm)	Leaf nos.	DM (t/ha)
Check-Arun2	183.10 <sup>c</sup>	64.8 <sup>b</sup>	6.22 <sup>a</sup>	8.93	6.19	193.7	57.10	6.59	7.83	7.21
African Tall	194.70 <sup>a</sup>	72.56 <sup>a</sup>	6.33 <sup>a</sup>	9.27	5.41	211.5	72.00	7.07	9.04	6.66
J1006	179.1 <sup>d</sup>	75.08 <sup>a</sup>	6.50 <sup>a</sup>	8.37	5.63	222.20	62.00	5.84	12.08	6.38
PMC-6	187.2 <sup>ab</sup>	72.34 <sup>a</sup>	5.61 <sup>b</sup>	9.87	5.33	205.2	67.50	5.82	11.08	5.62
SEM	4.83	2.74	0.25	1.12	0.56	10.39	6.92	1.06	2.74	0.60
F-test	0.019	0.005	0.010	NS	NS	NS	NS	NS	NS	NS
LSD (0.05 level)	9.82	5.55	0.52	2.28	1.14	21.13	14.09	2.16	5.59	1.22
CV	4	3.3	2.8	12.4	7.7	6.1	6.1	8.9	15.4	3.6
Date of sowing										
1 <sup>st</sup> February	163.2 <sup>c</sup>	71.48	6.48	8.40	41.6 <sup>c</sup>	194.3 <sup>b</sup>	65.1	6.29	9.26	6.31 <sup>a</sup> <sub>b</sub>
15 <sup>th</sup> February	191.4 <sup>b</sup>	71.02	5.92	1047	5.70 <sup>b</sup>	202.3 <sup>b</sup>	69.5	6.82	10.19	5.83 <sup>c</sup>
1 <sup>st</sup> March	203.5 <sup>a</sup>	71.16	6.10	8.45	7.07 <sup>a</sup>	227.9 <sup>a</sup>	59.4	5.87	1057	7.24 <sup>a</sup>
SEM	4.18	2.37	0.22	0.97	0.48	8.99	6.00	0.92	2.38	0.51
F-test	<0.001	NS	NS	NS	<0.001	0.002	NS	NS	NS	0.02
LSD (0.05 level)	8.50	4.83	0.45	1.98	0.99	18.30	12.20	1.87	4.84	1.05
CV	4	3.4	5.2	16.7	7.7	6.1	13.7	15.4	26.8	3.6

SEM= Standard Error of Mean, LSD= Least Significant Difference, CV= Coefficient of Variation

Likewise, the Nutrient Detergent Fiber (NDF) ranged from 62.66 to 88.28 percent. Similarly, Acid Detergent Fibre (ADF) varies from 38.39 to 75.54 percent. The results revealed that the polyphenolics (especially ADL) content was highest for J1006 (55.76%) sown in 1<sup>st</sup> March harvested at 75 DAS and was the lowest for African Tall (11.3%) sown in 1<sup>st</sup> March and harvested at 75DAS (Figure 5).

Table 4. Effects of treatment combination/interactions of sowing dates and varieties on biomass attributing character and dry matter yield of fodder maize at Rampur, Chitwan during spring, 2021

Treatment combinations ( varieties × Sowing dates)	75 DAS					90 DAS				
	Plant height (cm)	Leaf length (cm)	Leaf breadth (cm)	Leaf nos.	DM (t/ha)	Plant height (cm)	Leaf length (cm)	Leaf breadth (cm)	Leaf nos.	DM (t/ha)

Arun 2 sown at 1 <sup>st</sup> February	157.10 <sup>j</sup>	68.98 <sup>cde</sup>	7.17 <sup>a</sup>	8.70	5.76	175.3	56.2	6.89	8.40	8.28
Arun 2 sown at 15 <sup>th</sup> February	200.10 <sup>cdf</sup>	63.08 <sup>c</sup>	5.82 <sup>cd</sup>	10.00	6.65	198.00	60.30	7.06	9.30	6.47
Arun 2 sown at 1 <sup>st</sup> March	192.1 <sup>ef</sup>	62.62 <sup>e</sup>	5.68 <sup>cd</sup>	8.10	6.17	207.8	54.80	5.83	5.80	6.90
Africa Tall sown at 1 <sup>st</sup> February	160.70 <sup>j</sup>	70.27 <sup>cde</sup>	6.26 <sup>ab</sup>	8.05	4.09	184.80	62.70	5.74	8.30	6.54
African Tall sown at 15 <sup>th</sup> February	202 <sup>cd</sup>	72.19 <sup>ab</sup>	6.29 <sup>ab</sup>	10.05	4.63	223.0	91.70	9.85	11.11	5.46
African Tall sown at 1 <sup>st</sup> March	221.50 <sup>a</sup>	75.21 <sup>ab</sup>	6.45 <sup>ab</sup>	9.70	7.51	226.50	61.60	5.61	7.70	7.99
J1006 sown at 1 <sup>st</sup> February	165.70 <sup>gh</sup>	69.94 <sup>cde</sup>	6.51 <sup>ab</sup>	8.35	3.71	202.10	63.50	5.92	10.20	5.58
J1006 sown at 15 <sup>th</sup> February	182.20 <sup>g</sup>	73.54 <sup>ab</sup>	5.85 <sup>cd</sup>	8.60	5.46	20070	62.50	5.41	10.30	5.94
J1006 sown at 1 <sup>st</sup> March	189.5 <sup>ef</sup>	81.77 <sup>a</sup>	7.14 <sup>a</sup>	8.15	7.71	263.70	60.10	6.19	15.75	7.64
PMC-6 sown at 1 <sup>st</sup> February	169.20 <sup>gh</sup>	76.74 <sup>ab</sup>	5.99 <sup>cd</sup>	8.50	3.07	215.00	78.10	6.62	10.15	4.84
PMC-6 sown at 15 <sup>th</sup> February	181.4 <sup>fg</sup>	75.25 <sup>ab</sup>	5.74 <sup>cd</sup>	13.25	6.05	187.3	63.40	4.96	10.05	5.46
PMC-6 sown at 1 <sup>st</sup> March	211.10 <sup>ab</sup>	65.04 <sup>de</sup>	5.10 <sup>e</sup>	7.85	6.08	213.40	61.20	5.87	13.05	6.55
SEM	8.36	4.74	0.44	1.94	0.97	17.99	11.99	1.84	4.76	1.03
F-test	0.007	0.02	0.012	NS	NS	NS	NS	NS	NS	NS
LSD (0.05 level)	17.01	9.66	0.91	3.96	1.98	36.60	24.40	3.74	9.68	2.11
CV	6.4	9.9	10.2	29.5	4.9	11.8	25.9	43.1	69.9	20.8

SEM= Standard Error of Mean, LSD= Least Significant Difference,  
 CV= Coefficient of Variation

## DISCUSSION

Environmental factors, especially temperature are the key agents which influence plant growth and development (Dahmardeh, 2012). In our study, three fodder maize varieties were evaluated for agro-morphological traits along with one grain maize as a check. The average plant height, leaf length, and leaf breadth of fodder maize varied significantly ( $p < 0.05$ ) among the treatments considering varieties when harvested at 75 DAS. The variation could lead to differences in other biomass attributing characters and fodder yield. The plant height of three fodder maize varieties (African Tall, J1006, and PMC-6) varied significantly ( $p < 0.05$ ) in three different dates of sowing (1<sup>st</sup> February, 15<sup>th</sup> February, and 1<sup>st</sup> March). The maximum plant height (227.9cm) was observed in fodder maize sown in 1<sup>st</sup> March

and harvested at 90 DAS. This could be due to the variation in monthly average temperature, as it was in an increasing trend (22.85°C to 28.94°C) during the research period from the month of March to June which helps in mineralization of the available nutrients and thereby higher uptake by the plant (Davidson & Janssens, 2006). As both developmental rate of individual parts such as leaves and the progress of entire plant through various stages were quantitatively depend on temperatures (Sinclair, 1994). Besides, this may be also due to the potential for variation in different crop varieties and spatial effects found in the experiments. Since the temperature is varied with the sowing interval the increase temperature could have potential impact on the productivity of the fodder maize. The identified suitable date of sowing can have positive impact on the production potential of different fodder maize varieties.

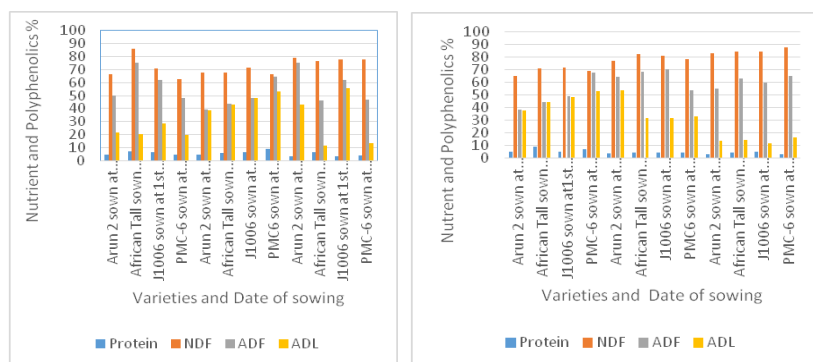


Figure 5 Nutrient composition and polyphenolic content of fodder maize harvested at 75 and 90 DAS

In deed planting/sowing date and variety selection, including soil fertility, temperature regimes and irrigation are the major factors affecting maize production (Ramankutty, 2002). The fodder maize dry matter (DM) were statistically similar ( $p>0.05$ ) among the treatments in terms of varietal differences as revealed in our findings when harvested at 75 and 90 DAS. The DM was highest for Check- Arun 2 (7.21 t/ha) followed by African Tall (6.66 t/ha) harvested at 90 DAS. It can be argued that introduced fodder maize can do well alike native cereal maize in our condition. The dry matter production of African Tall and J1006 is lower than the report of Chaudhary *et al* 2012 as the authors had reported dry matter yield of 6.89 t/ha and 11.33 t/ha, respectively. The dry matter of three fodder maize varieties varied significantly ( $p<0.05$ ) in three different dates of sowing. The highest dry matter (7.27 t/ha) yield was observed in fodder maize sown late in 1<sup>st</sup> March and harvested at 90 DAS. Total yield of dry matter increases as the crop grows and matures (Wattiaux, 1994). A suitable harvesting stage is required to get higher DM that has been indicated by this study.

Protein is an essential nutrient which is synthesized by plants and store in plant cells (Kearl, 1982). The concentration in protein increases with the maturity of the plant (Wattiaux, 1994). The results of this study was similar with the findings that the fodder maize varieties sown in 15<sup>th</sup> February (7.04% CP) and 1<sup>st</sup> March (4.54% CP) and harvested at 75 DAS had highest protein content than harvested

at 90 DAS which was 4.58 % and 4.31% respectively. Whereas, different results were recorded in fodder maize varieties sown at 1<sup>st</sup> February than the fodder maize harvested at 90 DAS (7.23%) recorded highest protein content than 75 DAS (6.05%). Lignification of the plant cell wall has been considered to be the primary impediment to forage digestibility (Jung, 1993). Abundant data are available that show negative correlations between lignin concentration and both DM and NDF digestibility using a variety of methods to determine lignin content (Smith, 1972). ADL content of more than 20% has been classified as high in ADL content, and sometimes reduces the fodder quality (Upreti and Shrestha 2006) and results of the study revealed that high ADL content in the fodder maize harvested at 75 DAS (32.59%) and 90 DAS (31.88%).

## **CONCLUSION**

On the basis of tested varieties, African Tall sown in 1<sup>st</sup> March and harvested at 90 DAS recorded highest dry matter (7.99 t/ha) yield and similarly African Tall sown in 1<sup>st</sup> February and harvested at 90 DAS results highest protein percentage (9.57%). Thus, the African Tall fodder maize varieties were found best in terms of DM and CP content than other fodder maize varieties and 1<sup>st</sup> March is suitable date for sowing considering DM. The fodder maize varieties tested in Nepal for biomass production, nutrient content, and palatability were at par with the native cereal maize and comparable to the performance in other countries. Therefore, it can be concluded that these varieties have the potential to produce more fodder yield with the suitable date of sowing in our context. The adoption of those varieties of fodder maize as an alternate green fodder could make substantial contributions to the quality fodder production systems in the Terai ecology of Nepal Whereas among other varieties tested, better performance of Africal Tall indicates its further suitability to grow for fodder purpose.

## **ACKNOWLEDGEMENTS**

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# Water quality assessment of Phewa Lake, Pokhara Nepal

Prabin Lama<sup>1</sup> and Sajani Shrestha<sup>2</sup>

<sup>1</sup>Goldengate International College, Tribhuvan University, Kathmandu, Nepal

<sup>2</sup>Research Center for Applied Science and Technology (RECAST), TU,  
Kirtipur, Nepal

## ABSTRACT

*This article is based on the Phewa Lake of Pokhara where different anthropogenic activities along with natural factors are deteriorating the water quality of the Lake water. It can cause different ecological problems along with social and economic problems. The different water physiochemical parameters of Phewa Lake were evaluated to shed light on the lake's water quality. The major parameters analyzed were pH, dissolved oxygen (DO), chloride, free CO<sub>2</sub>, iron, alkalinity, total hardness, and electrical conductivity (EC) The water samples were collected during the summer and winter seasons from 9 different sites containing inlet, outlet, and middle point. Among these physiochemical parameters pH, temperature, EC, alkalinity, iron, free CO<sub>2</sub>, and total hardness were found within satisfactory levels at all sites as per the Nepal Drinking Water Quality Standards (NDWQS 2062) for Nepal Standard Aquaculture.*

**Keywords:** Water quality, parameter, Chemical analysis

## INTRODUCTION

Phewa Lake is a wetland, the major water source in a lakeside area of Pokhara Metropolitan City, Kaski district. It is the Ramsar site with national and international importance. It is the second biggest lake in Nepal; and has religious and environmental importance. The lake water is commonly used for recreational, domestic, irrigation, and commercial purposes (Gurung et al. 2005). Phewa Lake is one of the major water sources in the Pokhara Metropolitan City, Nepal, where more than 0.5 million inhabitants are using water resources from the lake basin (CBS, 2011).

There is a huge amount of sewage continuously discharging into the lake from the surrounding settlements, hotels, urban areas, and farmlands. Harpan Khola and Andheri Khola are the main tributaries of Phewa Lake along with other seasonal streams. The water level in Lake is balanced by the dam throughout the year. Recent, the flow of national as well as international tourists is responsible for the pollution of the Lake. According to Bishwakarma et al. 2019, no special controlling devices have been set up at the inlets and other locations of the lake to keep Phewa Lake controlling the pollution. Different research conducted in Phewa Lake by (Gurung et al., 2005; Pant & Adhikari, 2015; Sharma et al., 2015)

has confirmed the presence of mercury contamination due to moderate chemical weathering of surrounding rocks and rapid urbanization in the surrounding areas of the lake.

In recent years, the lake area has declined sedimentation from Harpan Khola. The lake will lose 80% of its storage capacity in the next 110–347 years based on the rate of areal decline and sediment influx which will directly affect recreational use, agricultural irrigation, fishing, and a hydroelectric power facility (Watson et al. 2019).

## MATERIALS AND METHODS

The water samples were collected from 9 different locations in two seasons, i.e., winter (January 2017) and summer (July 2017). The sampling locations are selected in such a way that they represent the major parts of the lake. Collected samples are from pollutants areas, inlet, center, and outlet. A total of 18 water samples were collected in two seasons in polyethylene 1-liter sampling bottles. The samples from each site were collected at 20-30 cm below the surface and stored before laboratory analyses. GPS was used to determine the locations of the sampling sites. PH/ORP, DO CD/TDS meter i.e. multi-parameter water quality monitoring instrument was used to calculate the pH, DO, TDS, and conductivity directly in-situ. Chloride, iron, alkalinity, and free carbon dioxide (CO<sub>2</sub>) were analyzed at the Laboratory of Goldengate International College (GGIC) Battishputali, Kathmandu.

## RESULTS AND DISCUSSION

The water quality indicators of the different sites of Phewa Lake are its physicochemical parameters such as pH, temperature, DO, BOD, alkalinity, chloride, and free CO<sub>2</sub>. The average values of major physicochemical parameters of different sites were given in Table 1.

Table 1. Average value of physicochemical parameters of different sites

S.N.	Parameters	Summer Average	Winter Average	NEWS, 2062	Nepal's standard for aquaculture
1)	Temperature (°C)	27.35	17.93	-	4-30
2)	pH	6.05	8.17	6.5-8.5	6.5-9
3)	DO (mg/l)	6	5.65	6.5-8*	5-9
4)	Conductivity (µs/cm)	203.4	305.5	1500 µs/cm	-
5)	Total hardness(mg/l) as CaCO <sub>3</sub>	15.55	18.44	500 mg/l	-
6)	Alkalinity (mg/l) as CaCO <sub>3</sub>	78.88	334.4	20-200 mg/l*	20-100 mg/l
7)	Iron (mg/l)	0.047	0.135	0.3(3) mg/l	0.1 mg/l
8)	Chloride (mg/l)	13.55	12.41	250 mg/l	<600

9)	Free CO <sub>2</sub> (mg/l)	4.4	2.2	-	<12mg/l, up to 75 mg/l for warm water fish
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\*These values are not present in NDWQS, 2062 (Nepal Drinking Water Quality Standards). These are standard values accepted worldwide.

### 1. Temperature

The temperature was observed in the range of 17-18°C during the winter season whereas 26-29 °C during the summer. The average temperature during winter was 17.93 and 27.35 in the summer season.

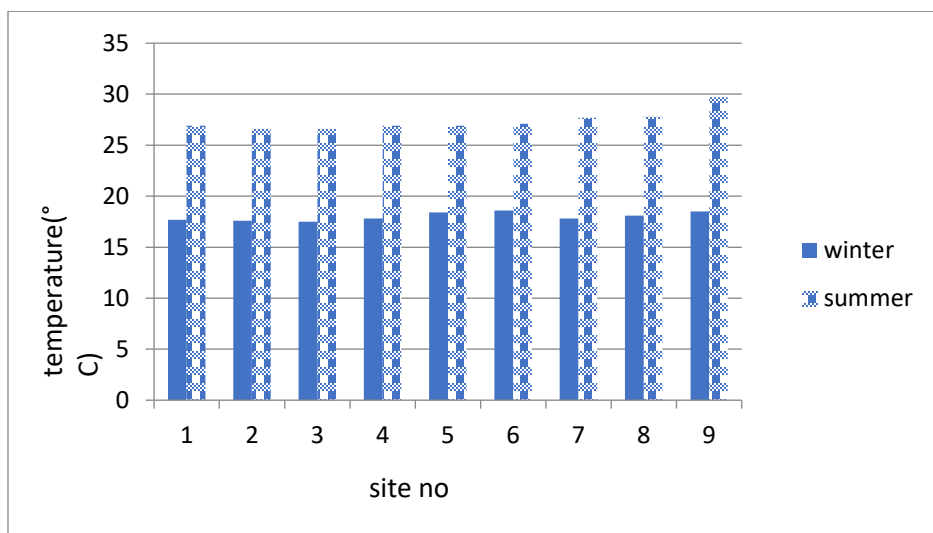


Figure 1. Variations in temperature

### 2. pH

The average pH found in Phewa lake was 6<sup>0</sup>C and 8.1<sup>0</sup>C during summer and winter respectively. The higher value of pH may be due to the industrial effluents and discharge from the households and hotels near the lake. The minimum value of pH may be due to agricultural runoff. Variations in pH may be due to different anthropogenic activities such as fishing, grazing, and other activities. Measurement of pH is one of the most important and frequently used tests in water chemistry. Natural water usually has a pH value ranging from 4 to 9. The pH value of Phewa lake water was found to be within the National Drinking Water Quality Standard and WHO guidelines, i.e. 7- 7.8 and 6.5-8.5, respectively.

### 3. Alkalinity

A significant difference in alkalinity was observed between the summer and winter seasons. The average alkalinity for summer and winter was 78.88 mg/l and 334.4 mg/l. The value of alkalinity is higher in winter than in summer. It can be because of different environmental factors such as rain, acid, and sanitizers. The

value of alkalinity in the winter season was 334.4 mg/l which shows the higher levels of calcium carbonate. It can show negative effects on fish populations and aquatic life. From the parameters examined we found that the water of Phewa Lake can be used for aquaculture depending upon the species of fish.

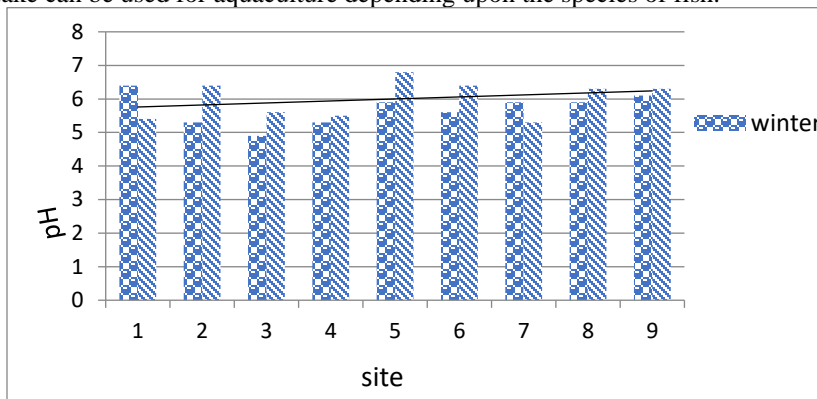


Figure 2: variations in pH

#### 4. Dissolved Oxygen (DO)

The dissolved oxygen (DO) in Phewa Lake ranged from 4-6 mg/l. The average DO was observed at 5.65 mg/l and 6 mg/l during winter and summer respectively. A significant difference was not observed in summer and winter. However, dissolved oxygen (DO) was lower compared to the WHO guideline (9mg/L).

The values of DO differ at different sampling locations. It means the degree of organic pollution and the presence of micro-organisms are also different in these locations. The dissolved oxygen in Phewa Lake ranged from 4-6. But the value of DO was different between boating, hotel sites (humans' active area), and forest areas (humans' less activity). The value of DO was observed to be higher in the area nearby forest than in samples of hotels, and settlement areas. It means microbial activity is less in forest areas and there is less organic pollution. The area nearby the hotels may be polluted due to wastewater and sewage.

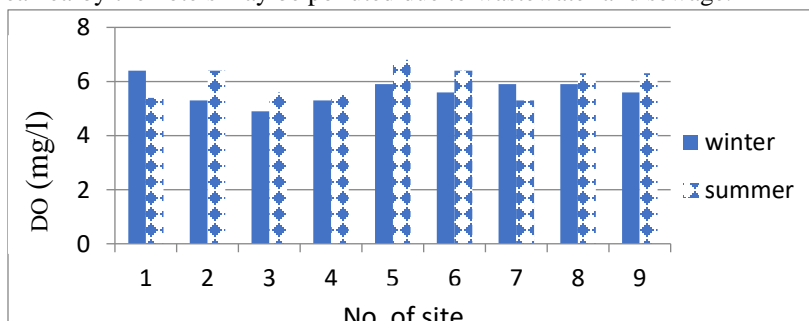


Figure 3. Variations in DO

#### 5. Electrical Conductivity (EC)

The EC in Phewa Lake showed seasonal variance. The average EC during summer and winter was  $203.4\mu\text{/cm}$  and  $305.5\mu\text{/cm}$ . However, EC was lower as compared to National Drinking Water Quality Standard ( $1500\mu\text{/cm}$ ). The values of EC are in a good range.

### 6. Total hardness

A significant difference in total hardness was not observed between the summer and winter seasons. The average total hardness observed during summer was  $15.55\text{ mg/l}$  and  $18.44\text{ mg/l}$  in the winter season.

### 7. Chloride

The chloride content in Phewa Lake during summer and winter was  $13.55\text{ mg/l}$  and  $12.41\text{ mg/l}$ . These high values of chloride contents may be due to the high agricultural runoff. The increase in agricultural activities may be the result of high agricultural runoff.

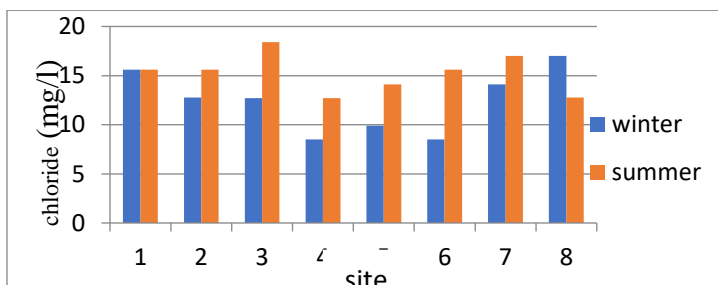


Figure 4. Variations in chloride content

### 8. Free Co<sub>2</sub>

The free Co<sub>2</sub> content in Phewa Lake during summer and winter was found to be  $4.4\text{ mg/l}$  and  $2.2\text{ mg/l}$ . It suggests that there is less microbial activity with the release of CO<sub>2</sub> by the respiration process. It may be due to the less presence of water hyacinth and other aquatic plants. The deduction number of hyacinths is due to the public effort in removing water hyacinths through weekly or monthly campaigns.

### 9. Iron

The average iron present in Phewa Lake during summer and winter was  $0.047\text{ mg/l}$  and  $0.135\text{ mg/l}$ .

## CONCLUSION

From this study, the water quality of Phewa Lake in summer and winter showed that all the physiochemical parameters varied in different locations. The major parameters analyzed were pH, conductivity, temperature, DO, chloride, iron, free CO<sub>2</sub>, total hardness, and alkalinity. Among these physiochemical parameters pH, temperature, conductivity, total hardness, iron, and free CO<sub>2</sub> were found within

the satisfactory level. Overall, the water of Phewa Lake can be used for aquaculture and drinking purposes as per the parameters examined. Thus, the water of Phewa Lake is recommended for aquaculture and drinking purposes.

### **ACKNOWLEDGEMENTS**

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## Effect of organic nutrient management on growth and yield of cauliflower (*Brassica oleraceae* L. var. *botrytis*)

Udaya Prakash Chongbang<sup>1</sup>, Karun Adhikari<sup>2\*</sup>, Ashis Rai<sup>2</sup>  
and Kailash Shrestha<sup>2</sup>

<sup>1</sup>Nepal Polytechnic Institute, Chitwan, Nepal

<sup>2</sup>Himalayan College of Agricultural Sciences and Technology, Kirtipur, Nepal

\*Corresponding Author: karunadhikary45@gmail.com

### ABSTRACT

An experiment was carried out in Dawan, Bhojpur to evaluate the efficacy of different organic sources of nutrients on growth and yield of cauliflower (*Brassica oleraceae* L. var. *botrytis*) from February 2020 to May 2020. The experiment was laid out in Randomized Complete Block Design (RCBD) and four different organic and conventional sourcenutrientsrient viz. Farm Yard Manure, Poultry manure, Mustard oil cake, Vermicompost, and control were taken as treatments and replicated 4 times. Results indicated that there was a significant difference in growth regarding plant height, number of leaves per plant, leaf length, canopy area, curd weight, and biomass weight between the different organic sources of the nutrient. Maximum plant height (41.35cm), maximum number of leaves per plant (17.57), maximum leaf length (35.05cm), highest canopy area (28.69), maximum curd weight (728.4g) was observed in treatment with Farm Yard Manure. On the other hand, Maximum biomass weight was observed in Vermicompost (1285gm). Minimum growth and yield were observed in control i.e. plant height (30.06cm), number of leaves (13.20), leaf length (25.67cm), canopy area (20.35), curd weight (328.7g) and biomass weight (686g). Although highest growth on most parameters was observed in FYM, all the other 3 treatments showed significant difference in growth and yield with regards to control. This finding indicated the effectivity of conventional and organic nutrient management, particularly FYM over control suggesting use of these nutrient sources as alternative to chemical fertilizers.

**Keywords:** Organic, Nutrients, Cauliflower, Fertilizers, Canopy area

### INTRODUCTION

Cauliflower (*Brassica oleracea* L. var *botrytis*), a crucifer, is one of the several vegetables in the genus *Brassica*, which shares its family, Brassicaceae with others cole crop like broccoli, Brussels sprouts, cabbage, collard greens and kale.

This vegetable constitutes about 13% of the total area under vegetable cultivation in Nepal which translates roughly to 32,98,816 ha. Furthermore, among vegetables, Cauliflower contributes highest in terms of production i.e. 5,50,004.8 tons annually (MoAD, 2016). Regardless, among green vegetables, Nepal imports large amount of cauliflower (Dhakal, 2021).

Productivity of a crop, beside other factors, depends largely on the soil property. Chemical fertilizer are popular because of their quick access and higher nutrient use efficiency, and has no doubt been an influential factor in ramping up production to meet global demands. But this comes at a cost, prolonged use of synthetic fertilizers result in reduction of organic carbon and organic matter, nutrient imbalance, deficiency of secondary macronutrients and micronutrients (Hossain *et al.*, 2022). The increase in unbalanced and rampant use of chemical fertilizers, has severe impact on the soil property, environment health and finances and can thereby result in negative effects such as aggravated acidification and alkalization, leaching, pollution of water resources, destruction of microorganisms in soil and useful insects, crop susceptibility to disease attack, reduction in soil fertility, nutrient imbalance, compaction of soil thus causing irreparable damage to the overall system (Hossain *et al.*, 2021). In Nepal, more than 90% of the commercial farmers use pesticides and commercial fertilizers (Joshi and Piya, 2021) and rampant overuse of chemical fertilizers and pesticides degrades soil and water (Dahal and Manandhar, 2021).

Organic manure on the other hand has been conventionally used for centuries in our part of the world. Organic manure although considered having low nutrient content, on a prolonged use are cheap relatively, environment friendly and has proved to have positive benefits (Shaheen *et al.*, 2017). Organic manure improves soil physical and chemical property, soil structure, water holding capacity, increases organic matter and hence microbial count of soil (Dada and Ewulo, 2011). The presence of high population of microorganism, bacteria and fungi in organic manure, increases microbiological activities and results in higher mineralization of plant nutrients and hence increases nutrients availability in plant (Shrestha, 2008).

Studies by Dada (2011) indicate rapid multiplication of soil microbe in application of lime with poultry manure. Similarly, the application of organic manure improves vegetative growth by enhancing role of organic N in cell division and expansion (Singh and Agarwal, 2001). Some organic manures like vermicompost release nutrients in plant-available form in and thus enhance productivity (Sharma and Garg, 2018). Organic manures also ramp up root growth, help in water and nutrient absorption due to the hormonal substances in the vermicompost with better nutrient retention (Canellas *et al.*, 2002; Theunissen *et al.*, 2010; Sinha *et al.*, 2010). Farmacyard manure has been recorded in enhancing growth productivity

and nitrogen and potassium content (Citak and Sonmez, 2009). One such example includes use of poultry manure as fertilizer which increased cauliflower head weight by 17% (Moyin-Jesu, 2015). This indicates increased yield from organic manure.

Organic manure even when applied, are not applied sufficiently or are not applied at a clear recommended dose due to the vagueness regarding the subject. This study was done to identify and evaluate effects of different organic sources of nutrient used conventionally at different doses on growth and yield of cauliflower. Identification of the organic fertilizers that fulfill the nutrient requirement of the crop could help serve as an alternative and eventually substitute the indiscriminate use of chemical fertilizers. This would also help eradicate the problem of timely unavailability, quality and shortage of chemical fertilizers advocating the use of locally available organic fertilizers.

## **MATERIALS AND METHODS**

### **Experimental site and design**

The experiment was carried out at Sushila Agriculture farm, Bhojpur-4, Dawan, Bhojpur from 22<sup>nd</sup> February, 2020 to 4<sup>th</sup> May, 2020. The experiment was conducted using randomized complete block design (RCBD) with 4 different organic nutrient sources as treatments and a control was placed where each treatment was replicated 4 times. The geographical location of the experimental site was situated at elevation of 1256 masl. Seedlings of Cauliflower variety 'white top' were transplanted in the field with 45\*45 cm spacing. And the experimental plot was maintained at size 2\*1.5m<sup>2</sup>. Each plot had 4 row and 5 plants were maintained in each row. Total number of plants per plot was maintained at 20. Total experimental area was 15\* 10 m = 150 m<sup>2</sup>.

### **Treatment structure**

The seed material of "White top", and other inputs were procured from the local market, and the farm itself. Nursery was prepared with 1m width and 1.5m length. Field was ploughed using local plough twice followed by planking after which the clods were broken and weeds and other unwanted plant stubbles, stone, weed, roots, and other particles were removed. Twenty plots were prepared according to the experimental design adopted. Fifteen centimeter raised plots were made for proper root development and drainage facilities. All the observations regarding several growth parameters viz plant height, no of leaves per plant, leaf length, canopy area, curd weight & biomass weight were recorded from five randomly selected sample plants from each plot for observation and data recording.

Table 1. Treatments used in the experiment

S.N	Treatments	Notation	Organic Manures applied	
			(kg/plot)	(Mt/ha)
1	Farm Yard Manure	T1	6	20
2	Poultry manure	T2	4	13.3
3	Vermicompost	T3	4	13.3
4	Mustard oil cake	T4	1.3	4.3
5	Control	T5	-	-

### Details of layout

Name of crop:	<i>Brassica oleracea</i> L. var. <i>botrytis</i> .
Cultivar/ variety:	“White top”
No. of Replications:	4
No. of Treatment:	5
Total number of plots:	20
Plots size:	2m x 1.5 m (3.0 m <sup>2</sup> )
Total plot area:	15 m × 10 m (150 m <sup>2</sup> )
Row to row distance:	45 cm
Plant to plant distance	45 cm

### Growth parameters

#### Plant height (cm)

Plant height (cm) was measured on randomly selected 5 plants from 2 standards rows of each plot and their mean was calculated. It was measured at its major growth stages i.e. from 30 days after transplanting and at 15 days of interval. Its average was calculated and computed in cm.

#### Number of leaves per plant

Number of green leaves per plant were counted from the same plants selected for observations of plant height. The number of leaves per plant was counted from 30 days of transplanting.

#### Canopy area (cm<sup>2</sup>)

Area covered by the plant was measured in cm<sup>2</sup>.

#### Curd weight (g)

The weight of curd from each plant was obtained by using the weighing balance machine.

#### Biomass weight (g)

The total weight of plant was taken after uprooting whole plant and weighed in weighing balance.

### **Statistical analysis**

The growth and yield parameters mentioned above were measured and recorded which was then transferred to Ms Excel Sheet for tabulation and analysis of the results of the experiment. The data were analyzed using GenStat for analysis of variance (ANOVA) and critical difference (LSD).

## **RESULTS AND DISCUSSION**

### **Growth parameters**

#### **Plant height**

Table no.2 represents effect of different nutrient sources on plant height. The highest plant height (41.35cm) was observed on treatment with 20mt/ha FYM on 60 DAT. Least growth was observed with control at 30.60 cm. Plant height with FYM was the only treatment significantly different to the growth with regards to control. Besides that, plant height on 60 DAT with poultry manure was at 36.35cm followed by mustard oil cake at 36.33cm and vermicompost (34.75cm). Similarly, there was no significant difference on plant height with poultry manure, vermicompost and mustard oil cake, on 30 DAT and 45 DAT. In contrast to this, plant height with FYM varied significantly in 30 DAT and 45 DAT. Particularly, the reason for improved growth with FYM might be due to increased soil physical properties i.e. soil porosity, water holding capacity and supply of other plant growth promoting substances.

Table 2. Effect of different organic manure on plant height during different period of cauliflower growth at Bhojpur, 2020

Treatment	Plant height (cm)		
	30DAT	45DAT	60DAT
FYM	23.70 <sup>a</sup>	35.48 <sup>a</sup>	41.35 <sup>a</sup>
Poultry manure	15.10 <sup>b</sup>	26.95 <sup>b</sup>	36.35 <sup>b</sup>
Vermicompost	16.20 <sup>b</sup>	27.65 <sup>b</sup>	34.75 <sup>bc</sup>
Mustard oil cake	15.05 <sup>b</sup>	26.32 <sup>b</sup>	36.33 <sup>b</sup>
Control	12.85 <sup>b</sup>	21.95 <sup>b</sup>	30.60 <sup>c</sup>
Grand mean	16.58	27.67	35.88
SEM( $\pm$ )	1.279	1.275	0.955
LSD	3.940	3.927	2.941
CV (%)	15.4	9.2	5.3

Mean separated by DMRT and columns represented with the same letter (s) are non-significant at 5 % level of significance. Note: CV represent coefficient of variation, and LSD means least significance differences, NS (Non-significant), DAT (Days After Transplanting), FYM (Farm Yard Manure).

### Number of leaves per plant

In case of number of leaves per plant, highest number per plant (17.57) was observed on FYM which was significantly different to that of control (13.20) on 60 DAT. The number of leaves per plant on vermicompost and poultry manure were similar at 15.75 for the former and 15.35 on the latter and both of them were varied significantly to the growth with control. The effects of organic manures on number of leaves/plants were significantly superior to control.

Table 3. Effect of different organic manure on number of leaves during different period of cauliflower growth at Bhojpur, 2020.

Treatment	Number of leaves		
	30DAT	45DAT	60DAT
FYM	7.750 <sup>a</sup>	11.425 <sup>a</sup>	17.57 <sup>a</sup>
Poultry manure	7.200 <sup>ab</sup>	9.650 <sup>b</sup>	15.35 <sup>ab</sup>
Vermicompost	7.375 <sup>ab</sup>	10.200 <sup>b</sup>	15.75 <sup>ab</sup>
Mustard oil cake	6.375 <sup>b</sup>	9.275 <sup>b</sup>	16.35 <sup>b</sup>
Control	6.125 <sup>b</sup>	8.125 <sup>c</sup>	13.20 <sup>b</sup>
<b>Grand mean</b>	<b>6.96</b>	<b>9.735</b>	<b>15.64</b>
<b>SEM(±)</b>	<b>0.273</b>	<b>0.2035</b>	<b>0.637</b>
<b>LSD</b>	<b>0.842</b>	<b>0.6269</b>	<b>1.963</b>
<b>CV (%)</b>	<b>7.8</b>	<b>4.2</b>	<b>8.1</b>

Mean separated by DMRT and columns represented with the same letter (s) are non-significant at 5 % level of significance. Note: CV represent coefficient of variation, and LSD means least significance differences, NS (Non-significant), DAT (Days After Transplanting), FYM (Farm Yard Manure)

### Leaf length

Most significant growth in leaf length was recorded in FYM at 35.05cm on 60 DAT followed by poultry manure (31.25cm), mustard oil cake (31.19cm) and vermicompost(29.83). the least leaf length measurement was observed with control (25.67cm). The leaf length with treatments varied significantly to that with control on 45 DAT and 60 DAT. Leaf elongation rate (LER) depends on Nitrogen supply which explains the growth and increase in leaf length from manure application. Yoshida et al. (1969) reported leaf length increased remarkably with additional supply of nitrogen. These result are in line with the findings of Ahmed Baloch *et al.* (2014)who found significant increase in number of leaves of radish with the sole application of NPK.

Table 4. Effect of different organic manure on leaf length during different period of cauliflower growth at Bhojpur, 2020.

Treatment	Leaf length (cm)		
	30DAT	45DAT	60DAT
FYM	20.52 <sup>a</sup>	27.78 <sup>a</sup>	35.05 <sup>a</sup>
Poultry manure	16.97 <sup>ab</sup>	21.68 <sup>ab</sup>	31.25 <sup>b</sup>
Vermicompost	16.10 <sup>ab</sup>	20.75 <sup>b</sup>	29.93 <sup>b</sup>
Mustard oil cake	16.52 <sup>ab</sup>	21.25 <sup>b</sup>	31.19 <sup>b</sup>
Control	12.30 <sup>b</sup>	13.95 <sup>c</sup>	25.67 <sup>c</sup>
<b>Grand mean</b>	<b>16.48</b>	<b>21.08</b>	<b>30.62</b>
<b>SEM(±)</b>	<b>1.332</b>	<b>1.322</b>	<b>0.777</b>
<b>LSD</b>	<b>4.104</b>	<b>4.075</b>	<b>2.393</b>
<b>CV (%)</b>	<b>16.2</b>	<b>12.5</b>	<b>5.1</b>

Mean separated by DMRT and columns represented with the same letter (s) are non-significant at 5 % level of significance. Note: CV represent coefficient of variation, and LSD means least significance differences, NS (Non-significant), DAT (Days After Transplanting), FYM (Farm Yard Manure)

### Canopy area

FYM significantly influenced canopy area and maximum canopy area (28.69cm) was recorded on 60 DAT. On 60 DAT, all treatments showcased significant difference in canopy area where spread of 24.50 cm in poultry manure, 22.33 cm in vermicompost and 22.15cm in mustard oil cake was observed.

Table 5. Effect of different organic manure on canopy area during different period of cauliflower growth at Bhojpur, 2020

Treatment	Canopy area (cm)		
	30DAT	45DAT	60DAT
FYM	12.500 <sup>a</sup>	22.75 <sup>a</sup>	28.69 <sup>a</sup>
Poultry manure	9.425 <sup>ab</sup>	20.05 <sup>ab</sup>	24.50 <sup>b</sup>
Vermicompost	9.050 <sup>ab</sup>	18.32 <sup>b</sup>	22.33 <sup>bc</sup>
Mustard oil cake	9.525 <sup>ab</sup>	18.63 <sup>ab</sup>	22.15 <sup>bc</sup>
Control	8.900 <sup>b</sup>	16.47 <sup>b</sup>	20.35 <sup>c</sup>
<b>Grand mean</b>	<b>9.88</b>	<b>19.25</b>	<b>23.60</b>
<b>SEM (±)</b>	<b>1.157</b>	<b>0.879</b>	<b>0.576</b>
<b>LSD</b>	<b>3.564</b>	<b>2.709</b>	<b>1.775</b>
<b>CV (%)</b>	<b>23.4</b>	<b>9.1</b>	<b>4.9</b>

Lowest canopy area was observed in control (20.35cm). Significant root growth after application of FYM might be due to proper root development, with increased availability of macro nutrients and micronutrients and hence flourishing canopy area. Similar study by Mojeremane, Chilume and Mathowa (2017) indicated growth in tomato canopy area with increased organic fertilizer application.

Mean separated by DMRT and columns represented with the same letter (s) are non-significant at 5 % level of significance. Note: CV represent coefficient of variation, and LSD means least significance differences, NS (Non-significant), DAT (Days After Transplanting), FYM (Farm Yard Manure)

### **Curd weight**

Concurring with other growth parameters, curd with maximum weight was produced on FYM plot. Highest curd yield (728.4gm) was observed in FYM and lowest curd yield (328.7gm) was observed in control. The curd yield recorded in all organic manure treatment was in general higher than control. Except for vermicompost (378.5gm), curd yield of all treatment; poultry manure (587.4gm), mustard oil cake (566gm) was significantly different to control. The promising results of FYM, vermicompost, poultry manure and mustard oil cake might be due to the higher content of readily available plant nutrients, organic matter, improved soil structure and easy root penetration and increased microbial biomass.

Table 6 Effect of different organic fertilizer sources on curd weight of cauliflower at Bhojpur, 2020

Treatment	Curd weight (g)
FYM	728.4 <sup>a</sup>
Poultry manure	587.4 <sup>b</sup>
Vermicompost	378.5 <sup>c</sup>
Mustard oil cake	566.0 <sup>b</sup>
Control	328.7 <sup>c</sup>
<b>Grand mean</b>	<b>518</b>
<b>SEM (±)</b>	<b>27.7</b>
<b>LSD</b>	<b>85.3</b>
<b>CV (%)</b>	<b>10.7</b>

Mean separated by DMRT and columns represented with the same letter (s) are non-significant at 5 % level of significance. Note: CV represent coefficient of variation, and LSD means least significance differences, NS (Non-significant), DAT (Days After Transplanting), FYM (Farm Yard Manure).

## **Biomass weight**

In case of biomass weight, all of the plants in treated plots varied significantly higher in weight to that of control. Highest biomass weight (1052g) was recorded in FYM, followed by vermicompost (1285g), poultry manure (1151g) and mustard oil cake (1018g) in that particular order. The lowest biomass weight (686g) was recorded in control. Higher biomass weight in all treated plots indicate improved overall growth in plots with organic manure due to increased, microbial activity, mineralization, soil organic matter and readily available plant nutrient.

Table 7. Effect of different organic nitrogen sources on Biomass weight of cauliflower at Bhojpur, 2020

Treatment	Biomass weight(gm)
FYM	1052 <sup>a</sup>
Poultry manure	1151 <sup>a</sup>
Vermicompost	1285 <sup>a</sup>
Mustard oil cake	1018 <sup>a</sup>
Control	686 <sup>b</sup>
<b>Grand mean</b>	<b>1038</b>
<b>SEM(±)</b>	<b>61.7</b>
<b>LSD</b>	<b>190.2</b>
<b>CV (%)</b>	<b>11.9</b>

Mean separated by DMRT and columns represented with the same letter (s) are non-significant at 5 % level of significance. Note: CV represent coefficient of variation, and LSD means least significance differences, NS (Non-significant), DAT (Days After Transplanting), FYM (Farm Yard Manure).

## **CONCLUSION**

The study projected that application of organic manures resulted in significant improvement in all of the growth parameters and yield attributing factors of cauliflower. Out of all, FYM performed best in most growth parameters viz. plant height, number of leaves, leaf length canopy area and resulted in maximum yield while maximum biomass weight was observed on vermicompost. This study concludes that the performance of the cauliflower (white top) was better in FYM in comparison with other organic manures from both growth and yield parameters. Therefore this study considers FYM as the best alternative, along with other organic manures for increasing growth and productivity of the cauliflower keeping soil health in consideration.

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## Success factors for micro and small agribusiness enterprises in Chitwan District, Nepal

Sushmita Bhatta and Binayak Prakash Mishra\*

Agriculture and Forestry University, Chitwan, Nepal

\*Corresponding author: binayakprakash.mishra@gmail.com

### ABSTRACT

*The success of micro and small agribusiness enterprise promotes the sustainable development of the agriculture sector. The research was carried out purposively in Chitwan district during 2022 to identify the success factors for micro and small agribusiness enterprises. One hundred and fifteen (115) entrepreneurs were selected randomly from the study area. Primary data was collected using pretested semi-structured interview schedule, FGD and KII. Descriptive statistics and probit model was used to interpret the findings. Findings from the research revealed that 71% of the sampled entrepreneurs' reported success in agribusiness. Age and education of the entrepreneurs, access to output market, training related to agribusiness management, subsidy to entrepreneurs' and adoption of improved technology was statistically significant in the success of agribusiness enterprise. Hence, it is recommended that programs and policies from government and private sectors should address these factors for success of the micro and small agribusiness enterprise.*

**Keywords:** Micro, small, agribusiness enterprise, success factor

### INTRODUCTION

Micro and small agribusiness enterprise are the potential means to create jobs, wealth and food security in the developing countries (Ferreira, 2007). Growth of micro and small agribusiness enterprises supports national economy (Mbugua et al., 2013). Micro and small agribusiness enterprises facilitate poverty alleviation in developing countries (Ndege and Park, 2015). These enterprises require less operating cost, but are capable to provide innovative technological changes and variety of new products, thus increasing the choices among the consumers (Pavitt, Robson & Townsend, 1987; Acs & Audretsch, 1990; Coad & Tamvada, 2012). In the recent time importance of micro and small agribusiness enterprise have been felt; government and private institutions are focusing on the growth and development of these enterprises through different programs. However, the failure of these enterprises is recorded and is a major concern to our resource poor community (Mead & Liedholm, 1998; Rogerson, 2000). Hence, this paper attempts to identify the success factors for micro and small agribusiness enterprise.

## **MATERIALS AND METHODS**

### **Study area**

The study was done during 2022 in Chitwan district of central Nepal. The survey was carried out in Bharatpur metropolitan, Ratnagar municipality and Khairani municipality.

### **Sampling technique**

The district was selected purposively to represent one of the major agribusiness focused district. One metropolitan and two municipalities were purposively selected considering large number of micro and small agribusiness enterprise within the district and availability of both successful and unsuccessful enterprises. Hundred and fifteen (115) enterprises were selected by purposive random sampling. The household survey was carried out with entrepreneur using a pretested semi-structured interview schedule. One (1) Focus Group Discussion (FGD) and 1 Key Informant Interview (KII) was carried out in each metropolitan and municipality to complement the information gathered through survey.

### **Empirical model**

Descriptive analysis and *t*-test was done using IBM SPSS Statistics 25. Probit model was employed using Stata/SE 12.1 in order to determine the success factors for micro and small agribusiness enterprise. Further, to assess the effect of each independent variable on the success factors, marginal effect on those variables was estimated in the probit model.

### **Model specification**

The probit model specified in this study to analyze success factors for micro and small agribusiness enterprise was expressed as follows.

$$\text{Pr}(Y = 1) = f(b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + b_7 X_7 + b_8 X_8 + b_9 X_9 + b_{10} X_{10} + b_{11} X_{11} + b_{12} X_{12} + b_{13} X_{13} + b_{14} X_{14})$$

Where,

Pr (Y = 1) = Probability of success of agribusiness enterprise

X<sub>1</sub> = Age (continuous)

X<sub>2</sub> = Gender (dummy)

X<sub>3</sub> = Education (continuous)

X<sub>4</sub> = Off income (dummy)

X<sub>5</sub> = Member in organization (dummy)

X<sub>6</sub> = Contact with extension worker (dummy)

X<sub>7</sub> = Income (continuous)

X<sub>8</sub> = Experience (continuous)

X<sub>9</sub> = Access to inputs (dummy)

X<sub>10</sub> = Access to output (dummy)

X<sub>11</sub> = Training (dummy)

X<sub>12</sub> = Subsidy (dummy)

$X_{13}$  = Access to credit (dummy)

$X_{14}$  = Improved technology (dummy)

$b_0$  = Regression coefficient

$b_1, b_2, \dots, b_{14}$  = Probit coefficient

The description of the variables used is presented in Table 1.

## RESULTS AND DISCUSSION

### Descriptive statistics

The descriptive statistics of variables is presented in Table 1. As observed, 71% of the sampled enterprises reported success in agribusiness operation, and 61% of the enterprise were headed by male. The average age of the respondent was 44.79 years. Respondents, on average, had 11.14 years of formal schooling. Respondents on average had household income of NPR 398521.74 and business experience of 18.61 years. On average, 56% of the respondents' household received income from outer sources, 74% of the respondents had participation in organizations and 39% of the respondents had regular contact with extension workers. Similarly, 81% of the respondents had access to input market and prices, 77% of the respondents had access to output market and prices, 70% of the respondents had training, 74% of the respondents had received subsidy, 80% of the respondents had access to credit and 68% of the respondents had adopted improved technology.

Table 1. Descriptive statistics of variables for success factors of micro and small agribusiness enterprises

Variable	Description	Mean	Standard Deviation
Dependent variables:			
Success of agribusiness enterprise	=1 if respondent report success of agribusiness enterprise, 0 otherwise	0.71	0.454
Independent variables:			
Age	Age of respondent (years)	44.79	8.788
Gender	Gender of the respondent (1-male, 0-female)	0.61	0.490
Education	Years of formal education of respondent	11.14	3.978
Off income	=1 if respondent's household receive income other from agribusiness enterprise, 0 otherwise	0.56	0.499

Member in organization	= 1 if respondent is member in agribusiness related organization	0.74	0.441
Contact with extension worker	=1 if respondent has regular contact with extension worker, 0 otherwise	0.39	0.490
Income	Annual income of respondent's household (NPR)	398521.74	116251.719
Experience	Respondent involvement in agribusiness(years)	18.61	6.752
Access to inputs	=1 if respondent have proper access to input market and prices, 0 otherwise	0.81	0.395
Access to output	=1 if respondent have proper access to output market and prices, 0 otherwise	0.77	0.420
Training	=1 if respondent has received training related to agribusiness management, 0 otherwise	0.70	0.458
Subsidy	=1 if respondent has received subsidy, 0 otherwise	0.74	0.441
Access to credit	= 1 if respondent have proper access to credit, 0 otherwise	0.80	0.402
Improved technology	=1 if respondent have adopted improved technology in agribusiness, 0 otherwise	0.68	0.469

*Source: Field survey, 2022*

### **Characteristics of successful and unsuccessful agribusiness entrepreneur**

Table 2 presents the results of differences between means of characteristics describing successful and unsuccessful agribusiness entrepreneur. There appeared to be a significant difference in age, contact with extension worker, income, access to inputs and outputs market, training and subsidy between successful and unsuccessful agribusiness entrepreneur.

Table 2. Characteristics of successful and unsuccessful agribusiness entrepreneur

Variable	Successful	Unsuccessful	Mean difference	t value
Age	46.00	41.79	4.212	2.372**
Gender	0.61	0.61	0.004	0.036
Education	10.76	12.09	-1.335	-1.640
Off income	0.52	0.64	-0.112	-1.089
Member in organization	0.76	0.70	0.059	0.649

Contact with extension worker	0.501	0.435	0.209	2.097**
Income	382073.17	439393.94	-57320.769	-2.443**
Experience	18.72	18.33	0.386	0.276
Access to inputs	0.85	0.70	0.157	1.947*
Access to output	0.88	0.52	0.363	4.535***
Training	0.82	0.42	0.393	4.494***
Subsidy	0.88	0.39	0.484	6.116***
Access to credit	0.83	0.73	0.102	1.234
Improved technology	0.68	0.67	0.016	0.167

*Source: Field survey, 2022*

*Note: \*, \*\*, \*\*\* indicate significant at 10%, 5%, 1% level of significance, respectively.*

### **Factors affecting success of micro and small agribusiness enterprises**

Factors affecting success of micro and small agribusiness enterprises is presented in Table 3. Result showed that age, education, access to output market and prices, training, subsidy and improved technology was statistically significant in the success of enterprise. Keeping other variables constant, probability of success of enterprises increases by 1.21 per cent if respondent age increases by one unit. This is possibly because older entrepreneur are less likely to go for risky options. Keeping other variables constant, probability of success of enterprises decreases by 2.55 per cent, if the respondents' education increases by one unit. This is possibly because, higher education increases entrepreneurs' possibility of engagement in other sector for income generation, thus reducing focus on enterprise. Keeping other variables constant, probability of success of enterprises increases by 36.53 per cent if respondent has proper access to output market and prices. This is possibly because with better understanding of market and prices, higher economic benefits can be obtained. Result is in line with Boakye et al. (2018); Mead & Liedholm (1998).

Keeping other variables constant, probability of success of enterprises increases by 35.82 per cent if respondent has received training on agribusiness management. This is possibly because entrepreneurs obtain knowledge in risk management strategies and other aspects of agribusiness, thus increasing their competence. Result is in line with Mead & Liedholm (1998). Keeping other variables constant, probability of success of enterprises increases by 56.81 per cent if respondent has received subsidy. This is possibly because subsidy reduces economic burden to entrepreneurs and help them to improve production and marketing. Result is in

line with Mead & Liedholm (1998). Keeping other variables constant, probability of success of enterprises decreases by 13.45 per cent if respondent has adopted improved technology. This is possibly because adoption of improved technology doesn't guarantee economic benefits, as there are many other factors associated and also adoption of improved technology may have increased production cost.

Table 3. Probit regression analysis and marginal effect for factors affecting success of micro and small agribusiness enterprises

Variable	Coefficient	p-value	SE	dy/dx	SE(dy/dx)
Age	0.0666***	0.005	0.0238	0.0121	0.0047
Gender	-0.3216	0.460	0.4354	-0.0561	0.0707
Education	-0.1402**	0.040	0.0681	-0.0255	0.0123
Off income	-0.2645	0.484	0.3775	-0.0473	0.6904
Member in organization	-0.5281	0.394	0.6191	-0.0822	0.0817
Contact with extension worker	0.7311	0.160	0.5205	0.1221	0.0752
Log(Income)	1.0416	0.552	1.7505	0.1896	0.3204
Experience	0.0066	0.821	0.0292	0.0012	0.0052
Access to inputs	-0.4290	0.485	0.6148	-0.0660	0.0804
Access to output	1.3720**	0.011	0.5406	0.3653	0.1605
Training	1.4368***	0.004	0.5016	0.3582	0.1400
Subsidy	2.0549***	0.000	0.4954	0.5681	0.1351
Access to credit	0.3814	0.516	0.5871	0.0797	0.1372
Improved technology	-0.8844*	0.095	0.5291	-0.1345	0.0698
Constant	-8.6070	0.381	9.8267		
Summary statistics					
Number of observation	115				
LR chi2(14)	67.96				
Prob>Chi2	0.0000				
Pseudo R2	0.4930				
Log likelihood	-34.9510				

*Source: Field survey, 2022*

*Note: \*, \*\*, \*\*\* indicate significant at 10%, 5%, 1% level of significance, respectively.*

## CONCLUSION

Findings from the research revealed that 71% of the entrepreneurs reported success in agribusiness. This shows that agribusiness enterprise can be seen as profitable sector. Age and education of the entrepreneurs, access to output market, training related to agribusiness management, subsidy to entrepreneurs' and adoption of improved technology affected the success of agribusiness enterprise. Hence, the existing programs and policies should primarily focus on these factors to make micro and small agribusiness enterprise profitable and sustainable.

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## Disease diversity and disorder in cauliflower and their management practices adopted by farmers in Dhunibeshi municipality, Dhading

Anish Bhattarai<sup>1\*</sup>, Karun Adhikari<sup>1</sup> and R.P. Mainali<sup>2</sup>

<sup>1</sup>Himalayan College of Agricultural Sciences and Technology (HICAST),  
Kathmandu

<sup>2</sup>Nepal Agricultural Research Council (NARC)

\*Corresponding author: banish113@gmail.com

### ABSTRACT

*A study was conducted in Dhunibesi Municipality, Dhading to analyze the disease diversity and disorder of cauliflower along with the management practices adopted by farmers. Purposive sampling technique was used to select 67 respondents and information was collected using a semi-structured questionnaire. The study identified Alternaria leaf spot and club root as major diseases while Powdery mildew and damping off were minor in number. Diseases were mainly controlled using chemical fungicides and the major ones used were Copper oxychloride, Mancozeb, Azadirachtin, and Flisulphamide, and similarly cultural practices like crop rotation and proper sanitation were practiced by some farmers. Apart from the diseases, disorders like hollow stem, browning, and buttoning were found prevailing in large number in the farmer's field. The average dose of fertilizers used in the farm were urea @ 22.05kg/ropani, DAP (Di-ammonium phosphate) at 11.35 kg/ropani and Potash at 3.05 kg/ropani. The study further identified that the Manures used in the farm were Farm Yard Manure at 903.73 kg and Poultry manure at 450 kg per ropani. a miniscule percentage (3%) of the farmers used Biofertilizers, vermicompost, and compost manure that too at very low percentage due to their unavailability. Other micronutrients, growth regulators and hormones used in the farm were identified as Borax, Atonik, Multiplex, Biozyme, Maxflower, Multinutrient, Vegimax, and Blue Tsunami. Only 6% farmers had completed their soil test. Inorganic fertilizers were found to be used in large amount whereas organic fertilizers less in number, so the use of organic inputs should be encouraged.*

**Keywords:** Cauliflower, Diseases disorders, Management

### INTRODUCTION

Of late, vegetable farming has been a vital enterprise for commercial growers in Nepal. In the year 2019/20, the area for vegetable cultivation in Nepal was 281,132 ha and the production was 3,962,383 metric tons with productivity at 14.09 mt/ha (MoALD, 2021). Among the vegetables cultivated in Nepal,

cauliflower is the most significant vegetable cultivated on a large scale of the area i.e 33,685 ha and the production is recorded to be 501,457 mt. (MoALD, 2021).

Cauliflower (*Brassica oleracea* var. *botrytis*), considered as the queen of winter vegetables, is an important winter season vegetable crop in the family Brassicaceae (Giri, et al., 2020). However, it is currently grown as both seasonal and off-seasonal vegetables. Cauliflower is an annual plant with large rounded leaves grows to about 0.5m height, and the edible part is the curd, which is immature inflorescence or clusters of flowers (Petruzzello, 2019). It can grow in a wide range of soil with a good amount of moisture and organic manures. It grows efficiently on soil with slight acidity or neutral soil with approximately a soil PH of 6 to 7.

Commercial farmers in Dhading district are mostly based on vegetable production that too in cauliflower because of the climate suitability and high and quick return. Cauliflower production in Dhading is practiced in about 512 ha with a productivity of 14 metric tons per ha (MoALD, 2021). Likewise, Dhunibesi municipality of Dhading is also inclined towards cauliflower production. The technological advancement in the farming system and proper farming technique and knowledge of farmers has certainly increased productivity of cauliflower but still, there are certain constraints in farming.

Cauliflower is susceptible to several diseases which cause yield loss of around 50-70% of the production (Sharma et al., 2006). Major constraints for the production are physiological disorders, pests and diseases. Diseases of cauliflower that are being noticed throughout the world are Alternaria Leaf Spot (*Alternaria brassicicola*), Bacterial Soft Rot (*Pectobacterium carotovorum*), Blackleg (*Leptosphaeria maculans*), Black Rot (*Xanthomonas campestris*), Cauliflower Mosaic Virus, Clubroot (*Plasmodiophora brassica*), Damping Off (*Rhizoctonia*, *Pythium*) Downy Mildew (*Hyaloperonospora parasitica*), Powdery Mildew (*Erysiphe cruciferarum*), Ring Spot (*Mycosphaerella brassicicola*), Sclerotinia Stem Rot (*Sclerotinia sclerotiorum*), White Rust (*Albugo candida*) (Schiller, 2020).

Similarly, nutrient deficiency and its management technique affect in cauliflower production. Some deficiencies that affect cauliflower and play a significant role in cauliflower yield loss are whip tail, browning, buttoning, riceyness, fuzziness and hollow stem. Besides the chemical control practiced in huge number, some physical measures like crop rotation, deep ploughing, weeding, proper irrigation, adding manures, mulching are some of the environment-friendly approach of preserving and managing nutrients in the field (Reddy, 2019).

Although, it is a challenging issue to control the pest in an ecofriendly way, it is necessary to assess the disease diversity and nutrient management to come up with an environment friendly and economical way to manage these problems in

cauliflower cultivation. This study reveals the diseases and nutrient management practices in cauliflower which will further help to increase the productivity of the crop in Dhunibesi Municipality of Dhading district.

## **MATERIALS AND METHODS**

### **Study area, sampling technique and sampling size**

This survey was conducted in ward no. 4, 5, 6, 7, 8, and 9 of Dhunibesi Municipality of Dhading district. The major focus of the study was the commercial production areas of cauliflower so, purposive sampling techniques were followed to select 67 respondents from the commercial cauliflower production area of Dhunibesi Municipality.

### **Source of information, data collection and data analysis**

The semi-structured questionnaire was prepared to gather all the relevant primary data required to meet the objectives. Face to face interview was done with the farmers using pre-tested semi-structured questionnaire and observation methods for field inspection was also used. Secondary information was collected from different journals, magazines, books, research papers, articles, websites, and annual publications of different institutes like IAAS, NARC. Also, the secondary information was gathered from cooperatives as well as various NGOs and INGOs working in disease and disorder identification and management in cauliflower. The collected information was checked, arranged, revised, and then analyzed. Microsoft Excel was used to analyze the data. Pie-charts and Bar-diagrams were used to express the percentage value. Descriptive statistic was used to summarize the data and for statistical analysis.

## **RESULTS AND DISCUSSION**

### **Socio-demographic characteristics of the respondents**

The study depicted that 46% of the total respondents fall under Brahmin community, while Chhetri, Dalit and Janajati represented 21%, 6%, and 27% of the total percentage respectively. Out of the 67 respondents, 52% were male and had family members of about 5-6 members on average which consisted of 2-3 male and female each. The majority of the respondents were from the age group of 25-50. About 37.31% were illiterate and 98% had agriculture as their primary occupation, while other worked in the public service sector and business. Even though most of the respondents were involved in agriculture, only 9% of the respondents had undergone training related to agriculture and 22% did not have an irrigation facility on the farm whereas 78% had the privilege of irrigation facility. On average, land holding capacity was 7.35 ropani where average cultivated area was 3.61 ropani. Only 2.99% had tunnel farming as well as open fields whereas others had only open fields. Snow Mystique was the most

cultivated variety followed by Resami, Paras, N22, Anna90, DayB2, and Annapurna with no difference in seedling rate per ropani of 1244 seedlings.

### Diseases in the Dhading

The cauliflower grown in the study area were most affected by Alternaria (79.10%) particularly in their vegetative and reproductive stages of the crop, followed by clubroot (68.66%) which were infected in their seedling stage. Powdery mildew was found in about 4.48% of the farms in the study area and 1.49% of the crop were infected by damping off in their seedling stages (Fig 1).

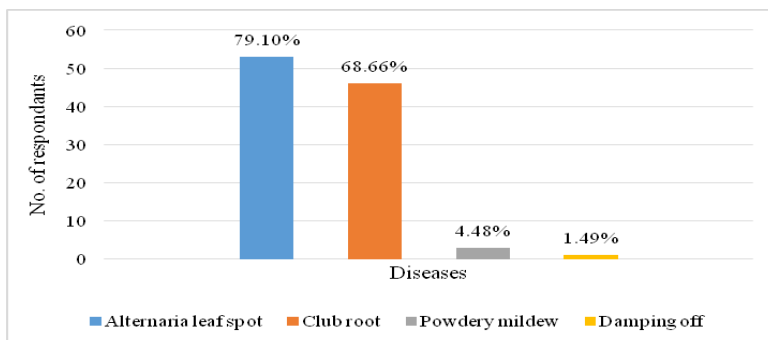


Figure 1. Diseases observed in the field

### Disease frequency and the extent of damage

The damage inflicted by club root was found high at 49% of the total diseases. The most cultivated variety Snow Mystique, was susceptible to club root, which is why club root infestation was particularly high. Alternaria leaf spot damaged 45%, while 5% was damaged by Powdery mildew and 1% by damping-off (Figure 2). According to the respondents, the disease frequency was said to be constant by the 58% percentage of the respondents, whereas other 36% reported that the disease infestation increased while 6% reported the infestation decreased (Figure 3).

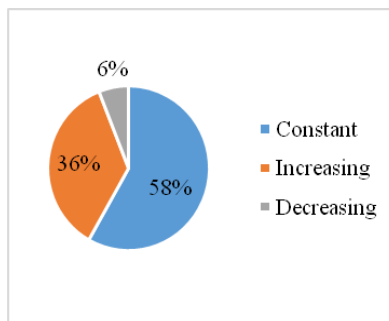
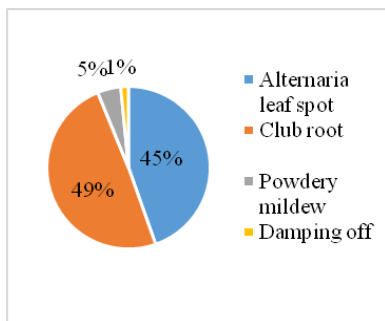


Figure 2. Status of damage level of diseases      Figure 3. Disease frequency

### Management methods

The respondents preferred using the easy, effective, and effortless control methods to manage disease incidence. So, 100% of the respondents used chemical methods to control all diseases. For this, chemical fungicides like copper oxychloride (blitox) for Damping off and Alternaria, Dithane-45 for Alternaria, Nebijin for club root and also non-hazardous biopesticide (Neem oil) for powdery mildew were used. Along with chemical management, the respondents also practiced cultural management to prevent the diseases. Cultural practices like crop rotation, proper sanitation, fertilization, and rouging of diseased plants were practiced but apart from this this other management method were not used.

### Disorders seen in the farm

Cauliflower disorders prevailing in farmer's field according to the respondents were browning and hollow stem. One-fourth (25%) of the respondents answered having browning in cauliflower while 22% accepted hollow stem as their main problem and to 2% Buttoning was a significant problem. 51% of the respondents were not able to identify cauliflower disorders and some were not aware of having any disorder in cauliflower (Figure 4).

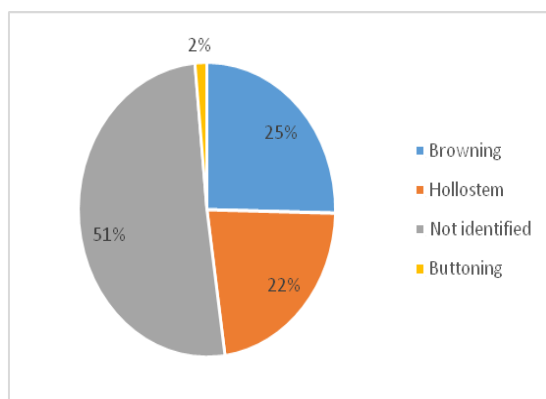


Figure 4. Disorders in cauliflower

The N22 variety was the only variety with buttoning disorder. The disorders prevailing in the study area in cauliflower happened due to boron deficiency and since boron are mostly absent in the acidic soil, this posed a great concern in that particular area

### Fertilizers, Manures and Nutrient used in the farm

Recommended dose for urea for cauliflower is 11 kg per ropani, 5 kg per ropani for DAP and for potash, it was 5 kg per ropani (Sawant, 2021). In the study area, it was found that only 23.39% of the respondents used approximately as recommended doses of urea while the other 77.61% used more than the recommended dose. The average dose of urea when calculated and it was found

out to be 22.05 kg which was double of the recommended dose. In the case of DAP, 52.24% used DAP as recommended dose while the other 47.76% used more than the recommended dose. The average dose of DAP was found out to be 11.35. In case of Potash, 26.87% used less than the recommended dose while the other majority (73.13%) used around the recommended dose (Figure 5). The average dose of potash was found out to be 3.05. These fertilizers were used in split doses. The first dose (half urea and full DAP and potash) was broadcasted just before transplanting and the second dose of urea was applied after 30-45 days by placement method. The dose of fertilizer used in the field was highly affected by the market price and availability in the market. Potash was used in low quantity because of the shortage in the market.

Among organic manures, respondents used FYM and poultry manures in the farm. Vermicompost and biofertilizers were not available in the study area and only 3% used compost manure @50kg per ropani. Due to the unavailability of these products, people compensated it with chemical fertilizers. While the recommended dose for FYM is 1000kg per ropani and poultry manure is 750 kg per ropani (Basnet, 2016), in the study area, 49.25% used doses less than the recommended dose, where as 44.78% of them used around the recommended dose and 5.97% more than the recommended dose. The average dose of FYM in the study area was calculated to be 903.73. In the case of poultry manure, 55.23% of the respondents used less than the recommended dose, where as 37.31% used around recommended dose and 7.46% more than the recommended dose (Figure 6). The average dose of poultry manure was calculated to be 450 kg/ropani. These manures were used before transplanting by broadcasting method and were mixed thoroughly. The use of FYM and poultry manure were less due to their shortage in the market.

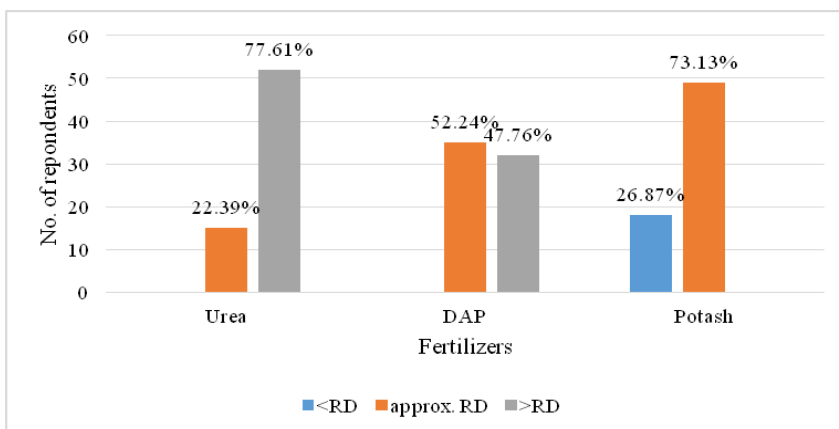


Figure 5. Doses of fertilizers used in the farm

Respondents who agreed to using micro and macronutrients used Borax @ 1 gm per liter, Atonik, Multiplex, Biozyme @ 50ml per 20liter of water, Maxflower @2-3ml in a liter of water at flowering stage, Multinutrient, vegimax @2-5ml per 20 liters of water, Blue tsunami as a source of zinc. These micronutrients were mostly sprayed in the field. Every nutrient was used according to the recommended dose as in the instruction label.

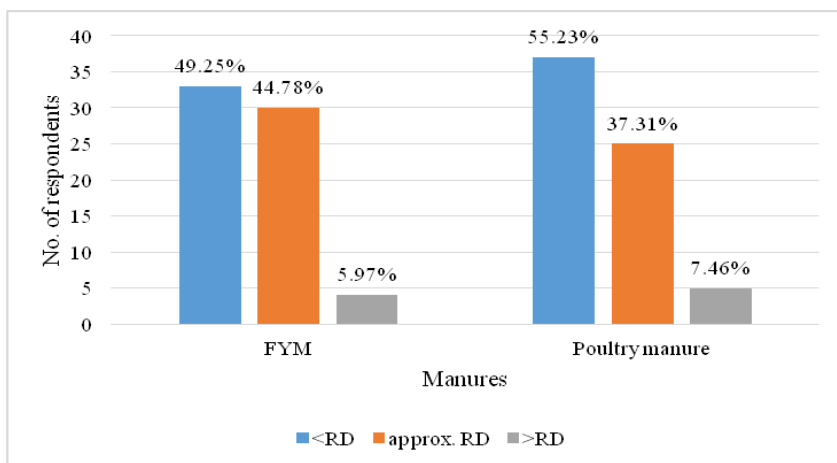


Figure 6. Doses of manures used in the farm

## CONCLUSION AND SUGGESTIONS

Based on the survey, the incidence of the disease in Dhunibesi Municipality, Dhading in cauliflower were Alternaria leaf spot, club root, Powdery mildew, and damping off. While the disorders observed in cauliflower in the study area were buttoning, browning, and hollow stem. The frequency of the diseases and disorder were increasing in cauliflower each year due to inappropriate and unrestrained management practices. Chemical pesticides and fertilizer were used because of their quick and effective means of control. The fertilizers like urea and DAP were used in high amounts while potash and other organic manures and fertilizers were used in less amount or not used at all. Only a small section of farmers used organic materials and appropriate doses of chemical inputs.

Although it is apt that farmers use botanical and biological management techniques, most of the farmers did not take any training, so training based on pest management and IPM can be very beneficial for them. Most of the farmers did not consider soil testing as a priority, so soil test should be done to recognize nutrient necessity. Shortage of organic manures and other inputs in the farm was observed, so stakeholders must shift their focus in ousting this market problem.

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# Vegetable farming and its impact on economic aspect of farmers' livelihood in Namobuddha Municipality, Kavrepalanchok

Arjana Basnet<sup>1\*</sup>, Karun Adhikari<sup>1</sup>, Anish Bhattarai<sup>1</sup> and Pratima Poudel<sup>1</sup>

<sup>1</sup>Himalayan College of Agricultural Sciences and Technology

\*Corresponding Author: basnetarjana2054@gmail.com

## ABSTRACT

*The study was conducted from October 2020 to March 2021 to analyze impact of vegetable farming in farmer's livelihood and subsequently their income generation. A total of 70 respondents were purposively selected and using an objectively designed survey, primary data was collected from direct personal interview with farmers. Majority (64.28%) of the farmers were male and three main vegetables viz. potato, cauliflower, tomato was grown as major crops. Majority (52.3%) of the farmers were marginal farmers with just above 0.5 ha land holding among which 42.9 % of the farmers utilized less than 0.2ha of land, 41.3% allotted 0.2-0.4 ha of land for vegetable farming. Almost 70% of the vegetable farmers' annual income ranged from 1 to 3 lakhs per annum while over 15% of them earning over 3 lakhs annually. The relative profitability calculation affirmed that all three majorly grown vegetable were profitable with B/C ratio higher than 1. Cauliflower was the most profitable among three with B/C ratio 2.2, followed by potato (1.7) and tomato (1.4). The average income of a farmer per ha of land from potato was Rs. 907000, and that of cauliflower was Rs.252000 while Rs.2450000 from tomato in one cropping season. District market was the primary market with 60 % of the crops being sold there using multiple marketing channels. Regarding problems, over 30% of the farmers faced irrigation problem, 28% faced financial and technical problems. 21.4% faced problems on marketing, and rest faced lack of agricultural inputs. Small land holding posed threat but with appropriate help from government regarding finances and technical support production of horticultural crops per unit of land could be enhanced and bring in economic stability in rural farmer households thereby also supplement national nutritional requirement and food security.*

**Keywords:** Vegetable, Livelihood, B/C ratio, food security, nutrition

## INTRODUCTION

Traditional agriculture which was primarily a subsistence-based farming system, has dominated the agriculture system in Nepal since long. Starting from the formulation of 5<sup>th</sup> 5-year plan (1975-1980) and before that, there have been efforts

to identify and prioritize agriculture to reduce poverty by ramping up crop productivity and by diversifying horticultural crop production. The national economy is by and large massively dependent on agriculture, the agriculture sector contributes around 26% of the total GDP (MOF, 2021). Agriculture system in Nepal is primarily dominated by cereal crops (MOALD 2019). Vegetable production alone contributes around 9.71% to the total Agriculture GDP (Ministry of Finance, 2015). Given the staple crop-based eating habit in Nepal, cereal crops are the major contributor on food and nutrition security with 65% of the total food energy and 60 % of the total food protein being supplied by these crops (Regmi, 2016). But on the other hand, small and scattered land holding poses problems on scaling up production. Over 52% of the farmers in Nepal are marginal land holder (less than 0.5 ha), 42.9% farmers with small land holding (0.5-2 ha) and only 4.4% large scale farmers (over 2 ha) (CBS, 2011). 84% of Nepalese live in rural areas and depend on subsistence agriculture for their livelihoods over to provide food for themselves. (Nepal Earthquake Case Studies). Small farmers cultivating staple crops earn less and often end up looking for non- agriculture related jobs (Rao, 2020). Relative profitability studies have shown that marginal and small land holding farmers observe higher net return growing horticultural crops, especially vegetables compared to cereal crops. A study by Garg and Prasad, 1974 concluded that the net income from tomato is 1.5 times higher than of wheat (Rao, 2020). Vegetable are considered high value cash crops as they provide almost 5 to 10 times higher economic value (Gurung et al., 2016). To uplift the living standard of farmers and to increase the economic status of the country, vegetable farming plays a vital role because it enhances regular flow of income by providing multiple products in a short period of time per unit piece of land. In addition to the economic aspect, vegetables farming is on the rise due to the awareness regarding its beneficial properties. Vegetables are rich in Vitamins, Minerals, Dietary fibers, Micronutrients, Phytochemicals, and help function properly (Kaparapu et. al, 2020). To meet this demand, there has been increase in vegetable production. Total fresh vegetable production climbed by 79 percent from 2,190,000 tonnes in 2005/06 to 3,929,034 tonnes in 2015/16. Similarly, the land used for vegetable cultivation has also increased by 48% and productivity by 21% during the same time frame (CASA, 2020). Newer farmers are shifting and focusing on vegetable farming particularly because it ensures cash revenue within a short period of time, even from small plots of land compared to that of other staple crops. Although there has been a growth in vegetable contribution, only 18% of total vegetable farmer are engaged in commercial farming. Vegetables crops are cultivated in only 7.3 percent of the total cultivable land in Nepal (CBS, 2009/10). This could be ramped up and increase vegetable production with multifold of effect on several aspects. Given its comparative benefit, vegetable farming will prove as an asset in making rural and small farmers economically independent and contribute in increasing total horticultural crop production and strengthen food security. Farming in Namobuddha municipality has been a long-practiced enterprise and

vegetable has been replacing staple crops due to their beneficiaries but little information is available about the actual impact of vegetable farming on rural household of farmers in Namobuddha Municipality. This study was undertaken to understand the socioeconomic status of vegetable farmers and further understand the impact of vegetable farming in their day to day life, on economic gain, on income generation and livelihood improvement. And also, problems faced by farmers undertaking vegetable farming. Although, Vegetable farming has emerged as a productive enterprise for income generation and self-employment, there is still a lot to be done to understand and analyze effects of farming on subsistent and commercial farmers.

## **MATERIALS AND METHODS**

### **Study Site and Sample size**

The study was conducted in Namobuddha Municipality, Kavrepalanchok from October 2020 to March 2021. A total of 70 respondents were selected using simple random sampling method from Namobuddha Municipality. These respondents were residents of two wards; ward no. 1 and ward no. 2.

### **Data collection and analysis**

Primary data was collected from direct personal interview with farmers involved in the vegetable production, key informants, and from direct household survey using semi structured questionnaire. An objectively designed survey questionnaire was developed to collect necessary primary data and information on socio-economic profile of vegetable growers, demographic information of family member, landholding of famers and cost of production. Meanwhile, Secondary data was collected from various published and unpublished documents, reports and research papers. The collected data was then tabulated and analyzed using MS excel. Analyzed data were presented in different forms viz. table, graph and pie-charts.

## **RESULTS AND DISCUSSION**

### **Socio-economic status of the respondents**

#### **Age and Gender of the respondents involved in vegetable production**

The involvement of male in vegetable production exceeded their female counterpart's involvement by a large margin. Although people from both genders were involved in vegetable farming, Majority (64.28%) of the farmers were male and female farmers (35.72%). Similarly, in the surveyed area, majority of the respondent farmers were from 35-45 age group (32.9%) and 45-55 age group (31.4%). Followed by a quarter of the respondents (25.7%) from the 25-35 age group. Older individuals i.e. farmers above 50 age group was 10% which was the least. This indicated the participation of young generation in vegetable farming in higher number.

**Literacy status of the respondents**

From the total surveyed individuals from the population, 75.7% of the respondents were literate i.e. they took at least some form of education and 24.3% of the respondents were found illiterate (no education). And among this, majority of the farmers (44.3%) had secondary level of education and farmers with bachelor's degree were at 5.7%. 14.3% of the farmers had undergone primary level studies. While 11.42% of them had completed high school (+2). This result indicated highest involvement of literate, that with secondary level of education farmers in vegetable farming.

**Family size of the respondents**

In the study area, out of 70 respondents it was found that 41.42 percent of the respondents had small family size upto 1-4 members. But higher (48.58%) number of farmers belonged to the average family size of 5-8 members. While 10 percent of the respondents were from a big family size of more than 8 members.

**Land holding under vegetable farming**

**Land ownership of the respondents**

On the study area, majority (52.9%) of respondents had more than 0.5 ha of land including khet, bari and kanlo and the lesser majority (47.1% ) owned less than 0.5 ha of land.

**Total Land under vegetable farming**

42.9 % of the farmers utilized less than 0.2ha of land for vegetable farming. Similar to this, 41.3% of the farmers utilized 0.2-0.4 ha for vegetable farming and 15.8 % of the farmers cultivated vegetables in >0.4ha of land. Farmers were expanding their total vegetable land which would help in commercializing it. The trend also showcased the expansion in the area of vegetable farming due to its better source of income and further could provide a double or triple increment compared to the cereal crops.

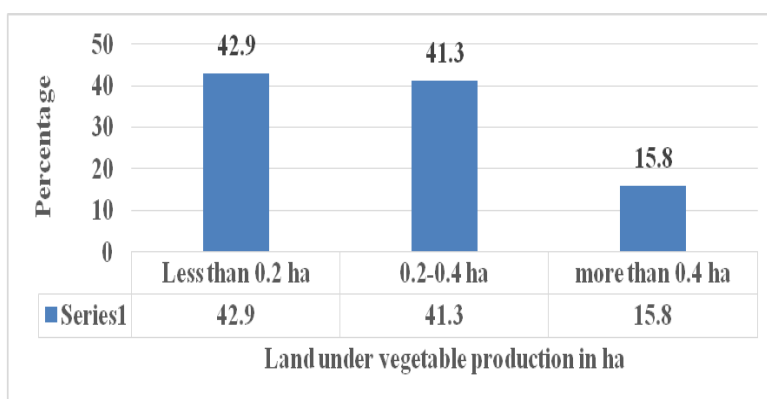


Figure 1. Land under vegetable farming

### Duration of farmers involvement in vegetable production

Farmers in Namobuddha Municipality have been involved in vegetable farming from varied point of its inception. 35.71% of the farmers had been at vegetable production for 4 -8 years and about 34.29% were involved in it since more than 8 years. 10% of the farmers were new (<4 years) farmers had gotten in were earning sufficiently. The new percentage of farmers indicated emerging involvement of new entrepreneurs in vegetable production.

### Vegetable production

#### Major vegetable produced by the respondents

In the study area, 30% of the farmers cultivated both potato and cauliflower as their main crop. 27.1 percent of the farmers cultivated only potato and 25.7 percent of the respondents cultivated potato, tomato and cauliflower as their major crop. And the remaining 17.2 percent of the farmers cultivated tomato and cauliflower.

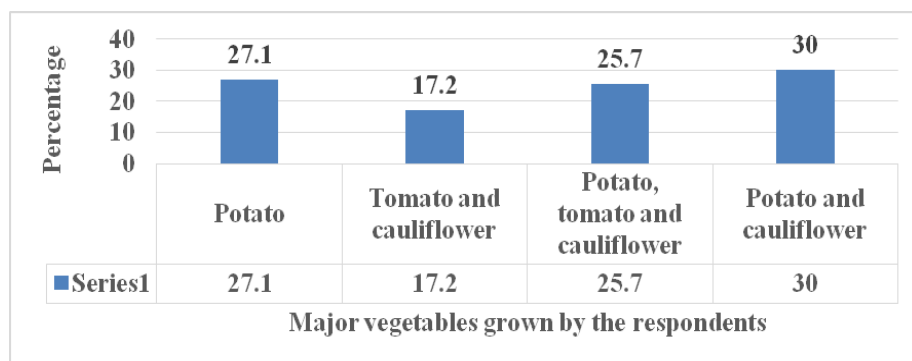


Figure 2. Major vegetable produced

#### Seed rate and seed types used

The farmers were planting local varieties in the past years but with the recent competitiveness, they have started using hybrid and improved varieties (55.7%) of vegetables particularly due to their high productivity, fast growth and supposed disease resistance. Improved varieties (27.1%) and hybrid 17.2%. Farmers have started focusing on seed types, seed rates, and this signifies their informed option picking because of the price rate, expensiveness of seeds and the unavailable of quality seeds in required time. Farmers used 196 grams of seeds per 1 hectare of land in case of tomato, 375 grams of seeds per 1 ha of land in case of cauliflower and 3500 kg of tubers per 1 ha of land in the case of potato.

#### Irrigation system used by the respondents

In case of water management, majority of the farmers (61.42%) used flooding system by pipe line for irrigation pipelines supplies water from rivulets and pond. 38.58% of the farmers irrigated by flooding the field using channels.

### Type of manure used by the respondents

Majority of the respondents (92.8%) percent used FYM + chemical fertilizer, and a meagre 7.2 percent of the respondents used FYM+ poultry manure in combination with chemical fertilizer.

Table 1. Cost of production of different cultivable vegetables in the study area per ha

Particular	Unit	Total Rs (For Potato)	Total Rs (For Cauliflower)	Total Rs (For Tomato)
<b>Variable cost (A)</b>				
Human labor	Man, per day	22620	30420	107,800
Tractor	Per hour	15680	15680	15680
Chemical Fertilizer Urea, DAP, Potash	Kg	22,500	19116.0	29000
Seed	kg	437500	19750	29400
Intercultural operation	Man, per day	8700	15440	16920
Plant protection+ Micronutrients		2500	8500	10000
<b>Fixed Cost (B)</b>				
Land tax		1207.4	1207.4	1207.4
Depreciation		1745.2	1745.2	1745.2
Maintenance		980	980	980
Plastic house Construction		-	-	1505000
<b>Total Cost (A+B)</b>		<b>513,432.6</b>	<b>112838.6</b>	<b>1716752.6</b>
Yield (kg/ha)		22675	9000	49000
Price (Rs/kg)		40	28	50
Gross income (Rs/ ha)		907,000	252000	2450000
Gross return (Rs/ha)		393,567.4	139161.4	733247.4
<b>BC ratio</b>		<b>1.7</b>	<b>2.2</b>	<b>1.4</b>

### Cost of Production, Gross return and Gross margin of different cultivated vegetables per ha

Table 1 presents the total cost of production, gross return, gross margin of 3 major vegetables grown in Namobuddha municipality. Potato, tomato and cauliflower were three major crops grown together and also as a single major crop. The profitability of each vegetable was assessed by calculating total Cost of production, Gross income, Gross return and B/C ratio.

Cost of cultivation per hectare was highest in tomato at Rs. 1716752 due to the plastic house construction while among the three cost of production was lowest (Rs. 112838.6) in cauliflower. While total cost of production in potato was Rs. 513,432.6. B/C ratio was calculated using formula

B/C Ratio = Gross Return / Total Cost

B/C ratio of all three vegetable crops viz potato, cauliflower and tomato were above 1 which meant that the vegetable farming business was profitable. Among three highest B/C ratio was of cauliflower (2.2) followed by potato (1.7) and tomato (1.4). The obtained B/C ratio are similar to the findings by DOA.

The average income per hectare of land from potato, cauliflower and tomato in one cropping season was found to be Rs. 9,07,000, Rs. 2,52,000 and Rs. 24,50,000, respectively.

### Impact of vegetable farming in income generation

In the study area it was found that, around 38.57 percent of the respondents had the annual income between 1-2 lakhs, 31.42 percent had an annual income between 2-3 lakhs. 15.72 percent respondents earned more than 3 lakhs. A majority (70%) of the vegetable farmers had an annual income ranging from 100000 to 300000. 14.28 percent of the respondents had an annual income less than 1 lakh. This result paints a positive picture of vegetable farming helping in improving income status of the farmers in Namobuddha Municipality.

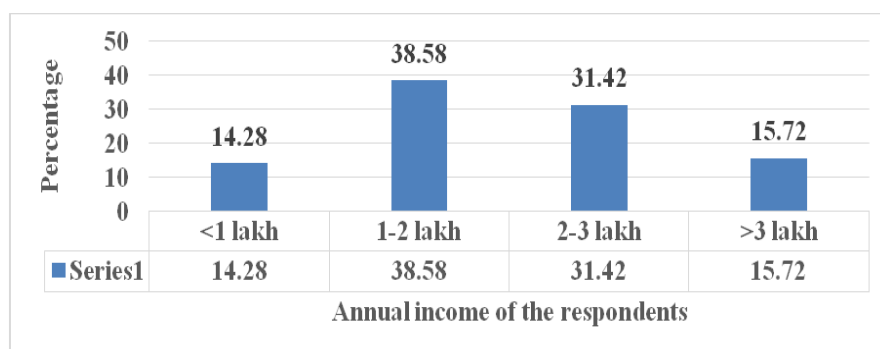


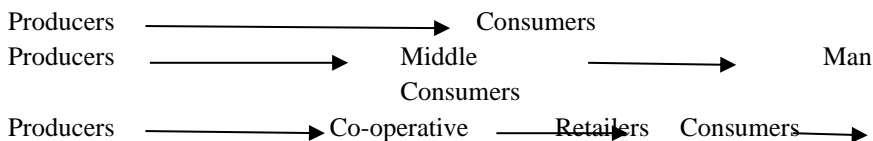
Figure 3. Annual income of the respondents

### Market, marketing channel, of vegetable crops

The main market of the study area was district market, Banepa with 60 percent of the commodity being sold there. 28.51% of the product was sold to local market through cooperatives i.e. Bhakunde Krishi Upaj Sankalan Kendra and 11.43 percent of the vegetable produced was sold to other places like Bardibas, Sindhuli and Kathmandu

### Marketing channel used by the respondents

Produced vegetable reached consumers through various channels; the first one was directly from producer to the consumer. Secondly, the farmer sold their vegetable to wholesalers from where vegetable was directly sold to consumer or through retailer. Thirdly, farmers also sold their products to the co-operative which after retailers reached consumers.



### Marketing of vegetable products

Majority of the farmers (47.14%) sold their vegetable product through middleman, 31.43 % of the farmers choose co-operatives and sold through them. And the remaining 21.43 percent of the farmers sold it themselves. This result also denotes the help and assurance co-operatives provide by shortening the marketing channel.

### Market Price Fixation of major vegetables

Generally, vegetable price is determined by market demand and the season. During early season and off-season, the vegetable price of respective vegetable rose while during the season it got low.

Table 2. Market price status of major vegetables

S. N	Vegetable	Selling price of farmer (NRs/Kg)	Selling price (NRs/Kg)	
			Retail	Wholesale
1	Tomato	Rs 45-50	Rs 80-90	Rs 60-65
2	Potato	Rs 35-40	Rs 60-65	Rs 45-55
3	Cauliflower	Rs 25-30	Rs 60-80	Rs 40-50

### Major problems faced by the respondents in the study area

Most (31.4%) farmers pinpointed irrigation as their major problem. Similarly, the other 21.4% felt a proper marketing channel was necessary to get prominent return. 18.6 % found that the unavailability of quality seeds and chemical fertilizer on time and in affordable price severed their chance of optimum production. About 15.7% of the respondents had financial problem and remaining 12.9 percent respondents had technical problems in the study area.

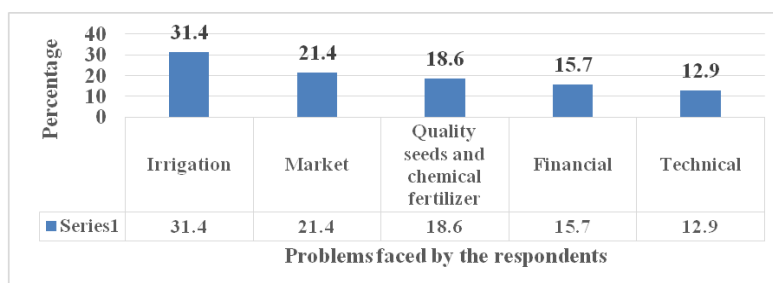


Figure 4 Problem faced by the respondents

## CONCLUSION

The earning from vegetable cultivation was substantive and relative income was higher. Vegetable farming was profitable with B/C ratios higher than 1 in the major vegetables grown. Average income per season was between Rs. 100000 – Rs. 300000 in majority. Both new and old farmers, besides a few factors regarding government help, were content with the choices they made. Although a lot has to be done on upscaling to better yield attributing factors and ultimately increase harvest, the comparative financial gain has motivated farmers. This motivation also indicates that the farmers received good income from vegetable farming. Although majority of the farmers were male there was substantial involvement of female in vegetable farming. Involvement of the youths in vegetable farming was higher. Kavrepalanchok district itself has a great opportunity to produce vegetables in commercial scales but the farming system is still traditional due to lack of multiple factors. The traditional farming system could be enhanced to commercial farming system and thus increasing production significantly resulting in higher return and livelihood improvement of the farmers. Still, farming has had positive impact on improving livelihood and improved income, providing positive economic benefits to the marginal farmers in Namobuddha Municipality.

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## Effect of harvesting time on tuber yield and quality characters of sweet potato genotypes in Lalitpur and Chitwan, Nepal

Prakash Bhattarai<sup>1</sup>, KM Tripathi<sup>2</sup>, AK Shrestha<sup>2</sup> and DM Gautam<sup>2</sup>

<sup>1</sup>National Potato Research Programme, Khumaltar (NPRP), Lalitpur, Nepal

<sup>2</sup> Agriculture and Forestry University, Rampur, Chitwan, Nepal

Corresponding author: prakash235@yahoo.com

### ABSTRACT

*The field experiments were carried out at Khumaltar, Lalitpur (1360 masl) and Rampur, Chitwan (228 masl), Nepal from July to December during 2018 and 2019 to determine the influence of harvesting time on tuber yield and quality of sweet potato genotypes. The trial was laid out in a factorial randomized complete block design (RCBD) with three replications and consisted of a total of twelve treatment combinations of three sweet potato genotypes (CIP 440015, CIP 440267, and Local White) at two locations (Khumaltar and Rampur) during two harvesting times [120 and 150 days after planting (DAP)]. Significant variations were found in marketable tuber number and weight plant<sup>-1</sup>, total tuberous root weight plant<sup>-1</sup> and tuberous root yield tha<sup>-1</sup> among genotypes and across the locations. CIP 440267 exhibited better in total and marketable yields than Local White, with a mean marketable tuber root weight of 0.468 kgplant<sup>-1</sup>. The genotype CIP 440267 produced the highest tuberous root weight (0.370kgplant<sup>-1</sup>) and tuberous root yield (20.57tha<sup>-1</sup>) in 2018 and (0.663kgplant<sup>-1</sup>) and (35.48 tha<sup>-1</sup>) in 2019. The time of harvest had no significant impact on yield characters. Yield characters were significantly influenced by the locations with greater yield in Khumaltar than Rampur. Moisture, dry matter, starch, and amylose content did not differ between genotypes, while reducing sugar was highest in the Local white. The starch content is affected by the harvest time, with delaying harvest (150DAP) resulted in a decrease in starch content (23.59%), compared to 30.61% at 120DAP in 2018. Late in the harvest, the reducing sugar was increased. The CIP genotypes had high (241.93mg/100g) levels of  $\beta$ - carotene, whereas Local white (2.2 mg/100g) had extremely low levels. The starch, reducing sugar and  $\beta$ - carotene content were higher in Rampur than Khumaltar. The results concluded that CIP orange fleshed sweet potato genotypes are suited for hilly areas of Nepal like Lalitpur, Khumaltar, but not for cultivation in Rampur or similar conditions. The crop harvested at dates 120 and 150DAP did not result in a significant increase in tuber yield, but some qualities were reduced at the late harvest time.*

**Key words:** Genotypes, harvest time, location, quality, tuberous root yield, sweet potato

## INTRODUCTION

Sweet potato [*Ipomoea batatas* (L.)] is the world's seventh most important crop (Low *et al.*, 2015; CIP, 2017). It is the third most important tuber crop in the world, after Iris potato and cassava (Ikeorgu, 2003) belongs to the Convolvulaceae family. It is grown globally in more than a hundred countries with an average yield of 12.09 t ha<sup>-1</sup> from 7.40 million ha of land (FAO, 2020). It is drought tolerant, has a high yield potential, wide adaptable, and requires low input (Nhanala and Yench, 2021; Musumbi *et al.*, 2015). It is regarded as a vital, versatile, and underutilized food security crop in the world, particularly in underdeveloped countries (Laurie *et al.*, 2015).

It is a very nutritious vegetable, providing significantly high edible energy per hectare per day compared to rice, wheat, maize and cassava. Per 100 g of edible component, it includes 12.7 g of starch, 4.2 g of sugar, 709 g of vitamin A, and 1.6 g of protein (USDA, 2013). The tuber of the sweet potato is a good source of carbohydrate and can be eaten raw. Among the Asian countries, China rank first in area and production and accounts more than 50 percent of worlds production with average yield of 21.86 t ha<sup>-1</sup> (FAO, 2020). In Nepal, sweet potato is one of the neglected and under exploited crops, but has religious and cultural values and usually tubers are harvested for *Thula Ekadasi* and *Makar sakranti* (festivals of Hindus). It is mostly grown in kitchen gardens in Nepal's mid hills and terai region (Gautam, 1991).

Sweet potato thrives in a variety of climates and environments (Ezumah *et al.*, 1987) and is a sensitive plant to environmental variation. Changes in environmental conditions may have a considerable impact on its yield and quality (Gurmu *et al.*, 2017). Cultivars, local climatic circumstances, and cultural techniques all influence yields (Antiaobong, 2007). The genotypes' yield potential may have been influenced by the environment. Tuber yield is reduced in cold and extremely hot conditions, whereas tuber yield is increased in a moderate or mild climate (Ngailo *et al.*, 2013).

Sweet potato is grown in Nepal as a rain-fed crop during the rainy season (June-August) and as a winter crop (October- December) with supplement irrigation. Because growth is hampered by cold weather and the crop requires a minimum frost-free growing period of 4-6 months in a tropical climate, the crop is cultivated both in the rainy and winter seasons, although in the hills, the major growing seasons are summer and rainy. Climate and temperature in different seasons and locations have an impact on growth and yield. Yields are 5 to 6 times greater at 25/20°C (day/night) than at 15/13°C (day/night), and higher at soil temperature of 30°C than 15°C (Sekioka, 1964). The lowest elevation has the highest average

yield (Rajendran and Shreekumar, 2012). Tuberization is completed 8 weeks after planting in tropical areas (Wilson, 1971).

Due to its excellent nutritional value and minimal input requirements for growth, the area of this crop in Nepal appears to be expanding. Since a long time, most farmers have solely grown native landraces. Poor agronomic practices such as production technology, poor variety selection according to location, and harvesting period are all factors that contribute to the crop's low sustainable yield in farmers' conditions. Farmers are primarily looking for excellent varieties that are specifically adapted to their environment and have a high level of long-term stability (Scott and Maldonado, 1998). Due to its high carotenoid content (a precursor to vitamin A) and good yields, as well as rich carbohydrates, vitamins, and minerals (Low *et al.*, 2015 and CIP, 2017), orange-fleshed sweet potatoes (OFSP) are considered resilient crops that can improve the nutrition of underprivileged farmers in many developing countries.

The tuber's growth, quality, and yield are predicted to be influenced by the maturity stage or harvesting time. Harvesting too early results in low yields and poor tuber quality, while harvesting too late contributes to disease and insect pest problems, which also affect tuber quality and yield (Alcoy *et al.*, 1993). Etela and Kalio (2011) found that varying harvesting dates within a particular environment affected sweet potato yields and quality. The process of maturation is slowed as altitude rises (Negeve *et al.*, 1992). In Australia, the sweet potato growing season typically varies from 16 to 25 weeks (Loader *et al.*, 2000). Harvesting sweet potatoes at the right time is critical for getting the best yields. The impact of location and harvesting time on the performance of sweet potato genotypes is investigated in this study. The objective of this research was to determine the influence of harvesting time on tuber yield and quality traits of sweet potato genotypes at Lalitpur and Chitwan condition of Nepal.

## **MATERIALS AND METHODS**

### **Experimental site and Climate**

The field experiments were carried out at Khumaltar, Lalitpur and Rampur, Chitwan, Nepal from July to December during 2018 and 2019. The sites Khumaltar and Rampur are located at 27°39'N, 85°19'E and 27°40'N, 84°19'E with an altitude of 1360 and 228 masl respectively. Soils of the experimental sites were collected with the help of screw augur from a depth of 0-30 cm prior to planting. The composite soil samples were evaluated in soil laboratory and the soils were sandy-loam type (Table 1). The Department of Hydrology and Meteorology (DHM), Babarmahal, Kathmandu, Nepal, provided monthly meteorological data (Table 2) for the corresponding year.

Table 1. The chemical properties of experimental soils

<b>Khumaltar</b>									
Year	pH	OM %	N %	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	Sand %	Silt %	Clay %	Soil texture
2018	6.93	0.83	0.06	40 mg/kg	179 mg/kg	-	-	-	-
2019	5.92	3.90	0.19	36.50 kg/ha	254.6 kg/ha	53.8	38.0	8.2	Sandy Loam
<b>Rampur</b>									
2018	7.18	2.86	0.12	164 mg/kg	185 mg/kg	-	-	-	-
2019	4.76	3.58	0.17	40.78 kg/ha	268.0 kg/ha	73.8	66.0	10.2	Sandy Loam

Table 2. Monthly weather during cropping season of 2018 and 2019 experimentation period at Khumaltar, Lalitpur and Rampur, Chitwan, Nepal

<b>Khumaltar</b>										
Months	Rainfall (mm)		Temp. (°C) 2018		Temp. (°C) 2019		Relative humidity (%)		Sunshine	
	2018	2019	Min	Max	Min	Max	2018	2019	2018	2019
July	294.5	445.4	20.8	28.2	20.6	27.9	82.0	78.8	2.6	4.1
August	322.0	172.8	20.5	27.7	20.9	29.2	77.3	78.7	2.8	5.6
September	53.2	264.3	19.2	28.4	19.3	27.0	76.2	82.4	6.4	2.9
October	0	3.0	11.8	25.9	14.4	25.7	72.1	76.1	7.8	6.8
November	0	0	6.7	22.8	10.4	24.0	69.4	69.4	6.2	6.7
December	0.9	29.2	3.7	18.5	3.7	18.2	70.8	62.8	6.5	6.8
<b>Mean</b>	<b>111.76</b>	<b>152.45</b>	<b>13.78</b>	<b>25.1</b>	<b>14.88</b>	<b>25.33</b>	<b>74.63</b>	<b>74.7</b>	<b>5.3</b>	<b>5.4</b>
<b>Rampur</b>										
July	199.8	529.7	26.0	33.7	25.1	33.4	93.8	92.3	5.2	5.7
August	354.6	176.8	25.4	33.3	24.3	35.5	94.9	80.7	5.9	2.5
September	220.8	299.0	24.3	33.4	24.5	33.1	97.7	83.7	5.4	4.5
October	24.6	12.4	17.8	31.3	20.0	31.5	81.4	81.8	5.9	2.5
November	0	0	11.7	27.4	15.7	28.6	83.6	86.2	5.9	3.5
December	0	24.4	7.5	23.5	9.4	22.0	83.5	86.7	4.3	2.5
<b>Mean</b>	<b>133.3</b>	<b>173.71</b>	<b>18.78</b>	<b>30.43</b>	<b>19.83</b>	<b>30.68</b>	<b>89.15</b>	<b>85.23</b>	<b>5.4</b>	<b>3.5</b>

Source: DHM, 2021

### Experimental treatments and design

The experiment was laid out in a factorial randomized complete block design (RCBD) with three replications and comprised of total twelve treatment combinations of three sweet potato genotypes (CIP 440015, CIP 440267 and Local White) at two locations (Khumaltar and Rampur) for two harvesting times [120 and 150 days after planting (DAP)]. The experimental area was ploughed,

harrowed, pulverized, and ridged before planting. The gross plot size was measured 3 m x 1.8 m (5.4 m<sup>2</sup>) consisting of 3 rows. Sweet potato vines (middle portions) of each genotype were cut with three nodes and planted on ridges with about two nodes buried in the soil uniformly for all treatments. The sweet potato vines (cuttings) were planted on July 29, 2018, and 2019 by hand in rows 60 cm apart and 30 cm between plants within rows. Blocks were separated by 1m whereas each plot were spaced between 75cm within the block. At planting time, each plot was fertilized with the recommended N: P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O fertilizers @ of 30:30:50 kg ha<sup>-1</sup>. Urea and DAP fertilizers were applied serving as the nitrogen and phosphorus source. Farm yard manure was applied as compost @ 20 t ha<sup>-1</sup>. All crop management procedures, such as cultivation, weeding, and so on, are carried out as desired during the crop growing period.

### **Data collection and statistical analysis**

Data on tuber yield, and quality attributes were recorded during the study period. Observations were made on five plants chosen randomly from per plot and averaged for the variable. Storage root characters were scored at 120 and 150 DAPS respectively. The experimental plots were harvested on 29<sup>th</sup> November and December of 2018 and 2019. Tuberous roots were also graded as marketable (>50 g) and unmarketable (<50 g) by weight basis and number and weight was taken accordingly. With the use of an electronic balance, the total tuberous root weight per harvested plot was recorded, and the expected yield per hectare was computed based on tuberous root weight/plot.

The AOAC method was used to determine the content of dry matter (DM), moisture, reducing sugar, beta carotene, and amylose (AOAC, 2005). Dry matter (%) content was determined by chopping and mixing of tubers into small pieces and drying of 100-gram sample in a hot air oven at 80°C for the first six hours and then at 65°C till constant weight was obtained (Kumar *et al.*, 2006). Reducing sugar (%) was determined by the di-nitrosalicylic colorimetric method (Miller, 1959). Light absorbance was recorded in a spectrophotometer (Agilent Technologies, Cary 60 UV-VIS, USA) at 510 nm. The solvent partition method, described in Rangana (2007), was used to evaluate the β-carotene concentration in sweet potato tuber samples. GenStat version 18 software for Windows was used to analyze the data (VSN International, 2016). Duncan's Multiple Range Test was used to distinguish the means.

## **RESULTS AND DISCUSSION**

### **Yield characters**

In 2018 (Table 3), the main effect of genotypes indicated a significant variation in marketable tuber number plant<sup>-1</sup>, with genotype CIP 440267 producing the maximum (4.68) tubers. The genotypic composition of the plants could explain

the variance in tuber number per plant. The findings are consistent with those of Rahman et al. (2013), who found that the number of tuberous roots per plant differed between cultivars. The genotypes did not differ significantly in the value of this character in the year 2019 and when pooled. The results showed that harvest timing had no effect on marketable tubers plant<sup>-1</sup> in each year, but there was a significant variation across the locations. The changes in environmental circumstances may have a considerable impact on its yield and quality (Gurmu *et al.*, 2017). The maximum number of tubers per plant was recorded at Khumaltar (4.13) than Rampur (3.35). Yields vary greatly according to cultivars, local climatic conditions and cultural techniques (Antiaobong, 2007). Significant interactions were noticed between genotype and harvest time and locations during 2018. There was a non- significant interaction of genotypes, harvest time and locations (data not shown).

The marketable tuber root weight per plant was significantly varied among genotypes in each year. The combined mean tuber weight was highest (0.468 kgplant<sup>-1</sup>) in the genotype CIP 440267 followed by Local White (0.355kgplant<sup>-1</sup>). According to Omiat *et al.*, (2005), the varietal effect had a significant impact on sweet potato marketable tuberous root as well as total tuberous root yield. The findings agree with those of Siddique (1985), who found that the weight of tuber per plant of different genotypes ranged from 260 to 1120g. The harvest time had no effect on marketable tuber weight per plant in both the year except a small increase in the weight of storage roots at late harvest. In all the genotypes, this parameter was significantly influenced by the locations except in 2018 with greater yield in Khumaltar as compared to Rampur. The pooled data showed the highest marketable tuber weight was recorded in Khumaltar (0.466kgplant<sup>-1</sup>) than Rampur (0.311kg plant<sup>-1</sup>).

Tuber size, number of tubers per plant, and stand count are all substantially associated to tuber yield (Nedunchezhiyan *et al.*, 2007) and are all highly affected by changes in environmental conditions. Between genotype and harvest time and locations interactions were found significant on marketable tuber weight plant<sup>-1</sup> in the year 2019 (Table3) and interactions were not significant among genotypes, harvest time and locations.

Table 3. Effect of locations and harvest time on marketable tuber number and marketable tuber weight plant<sup>-1</sup> of sweet potato genotypes during the years 2018 and 2019

Treatments	Marketable tuber number plant <sup>-1</sup> (no)			Marketable tuber weight plant <sup>-1</sup> (kg)		
	2018	2019	Mean	2018	2019	Mean
<b>A. Genotypes (G)</b>						
G1(CIP 440015)	3.61 <i>b</i>	3.82	3.71	0.303 <i>a</i>	0.384 <i>b</i>	0.344 <i>b</i>
G2 (CIP 440267)	4.68 <i>a</i>	4.18	4.43	0.339 <i>a</i>	0.596 <i>a</i>	0.468 <i>a</i>

G3 (Local White)	2.93 <i>b</i>	4.41	3.67	0.191 <i>b</i>	0.520 <i>a</i>	0.355 <i>b</i>
P- value	< .001	0.091	0.051	< .001	<.001	0.037
LSD (0.05)	0.730	0.539	0.682	0.061	0.076	0.1038
<b>B. Harvest time (H)</b>						
H1 (120 DAP)	3.61	4.03	3.95	0.272	0.507	0.390
H2 (150 DAP)	3.87	4.24	3.93	0.284	0.492	0.388
P-value	0.370	0.326	0.929	0.639	0.627	0.967
LSD (0.05)	0.596	0.440	0.557	0.049	0.062	0.847
<b>C. Location (L)</b>						
L1 (Khumaltar)	4.13 <i>a</i>	4.86	4.50	0.287	0.646	0.466
L2 (Rampur)	3.35 <i>b</i>	3.42	3.38	0.269	0.353	0.311
P value	0.013	<.001	<.001	0.479	<.001	<.001
LSD (0.05)	0.596	0.440	0.557	0.049	0.062	0.847
CV (%)	23.1	15.4	30.0	26.0	18.2	46.2
<b>G</b>	***	ns	ns	***	***	*
<b>H</b>	ns	ns	ns	ns	ns	ns
<b>L</b>	*	***	***	ns	***	***
<b>Interaction</b>						
<b>G×H</b>	**	ns	ns	ns	*	ns
<b>G×L</b>	***	ns	***	ns	**	ns
<b>H×L</b>	**	ns	ns	ns	ns	ns
<b>G×H×L</b>	ns	ns	ns	ns	ns	ns

ns =Not significant, \* Significant at P<0.05, \*\*Significant at P<0.01, \*\*\* Significant at P<0.001

Same small letters in column are not significantly different by DMRT at 0.05 level of Significance

The results (Table 4) indicated that the total tuberous root weight per plant and tuberous root yield ( $\text{tha}^{-1}$ ) were significantly influenced by the genotypes in both years. The genotype CIP 440267 produced the highest tuberous root weight ( $0.370\text{kgplant}^{-1}$ ) and tuberous root yield ( $20.57\text{tha}^{-1}$ ) in 2018 and ( $0.663\text{kgplant}^{-1}$ ) and ( $35.48 \text{tha}^{-1}$ ) in 2019. The combined mean value was statistically not significant ( $P=0.055$ ). The pooled value of total tuberous root yield ( $28.0 \text{tha}^{-1}$ ) was also in CIP 440267. Mekonnen *et al.* (2015) reported the marketable tuberous root production, and total tuberous root yield were all affected by the variety. In a similar experiment, Kathabwalika *et al.* (2013) observed substantial differences in total tuberous root yield among sweet potato varieties. In Bangladesh, Rahman *et al.* (2013) found that sweet potato tuber yields varied significantly among genotypes. CIP 194513.15 genotype produced the highest tuber yield ( $31.6 \text{tha}^{-1}$ ), followed by CIP 440267.2 genotype ( $30.97 \text{tha}^{-1}$ ).

The harvest time did not affect yield characters significantly. Delaying harvest does not result in significant increase in yield, but a small increasing trend was noticed on tuber yield harvested at 150 DAPS because the additional growing time was helpful for small roots to reach harvestable size. Our findings in sweet potato were contradicted by Etela and Kalio (2011). Wees *et al.* (2016) found that the exception of a modest increase in the weight of storage roots in 2011, delaying harvest had no influence on any of the yield parameters with the 'Beauregard' cultivar. Delaying harvest, on the other hand, had a far bigger influence on the cultivar 'Georgia Jet.'

Comparing the two locations for tuberous root weight plant<sup>-1</sup> and tuberous root yield, the Khumaltar supported higher (P<.001) yield than Rampur condition except the experimental year 2018. The two year mean data revealed that the highest tuberous root yield (28.6tha<sup>-1</sup>) was recorded in Khumaltar and lowest (18.6tha<sup>-1</sup>) was in Rampur. The reason for higher yield at Khumaltar may be due to plenty of sunshine and average temperature for storage root development. Karan and Sanli (2021) reported that sweet potato requires plenty of sunshine and light intensity and average temperature (25°C or above) good for root development and yield. The genotypes' yield potential may have been influenced by the environment. Tuber yield is reduced in cold and extremely hot conditions, whereas tuber yield is increased in a moderate or mild climate (Ngailo *et al.*, 2013).

Due to more favorable climate and fertile soil with optimum organic matter (%) and nitrogen (%), 2019 produced a better yield than 2018 (Table 1&2). Khumaltar had a much higher tuber yield than Rampur, which could be due to differences in soil fertility and rainfall, with Khumaltar being more fertile and providing optimum rainfall during the crop growing season, as well as a favorable soil pH. Sweet potato development and root yield are normally supported by sufficient soil quality and an adequate amount of moisture (Yahaya *et al.* 2015). Interaction between genotype and location for root weight plant<sup>-1</sup> and root yield tha<sup>-1</sup> was significant in 2019 (Table 5), while other interactions were not significant (data not shown).

Table 4. Effect of locations and harvest time on tuberous fresh root weight plant<sup>-1</sup> and total tuberous root yield (tha<sup>-1</sup>) of sweet potato genotypes during the years 2018 and 2019

Treatments	Tuberous fresh root weight plant <sup>-1</sup> (kg)			Total tuberous root yield (tha <sup>-1</sup> )		
	2018	2019	Mean	2018	2019	Mean
<b>A. Genotypes (G)</b>						
G1(CIP 440015)	0.324 a	0.454 b	0.389	18.01 a	24.16 b	21.1

G2 (CIP 440267)	0.370 <i>a</i>	0.663 <i>a</i>	0.517	20.57 <i>a</i>	35.48 <i>a</i>	28.0
G3 (Local White)	0.214 <i>b</i>	0.588 <i>a</i>	0.401	11.89 <i>b</i>	31.59 <i>a</i>	21.7
P- value	<.001	<.001	0.055	<.001	<.001	0.055
LSD (0.05)	0.064	0.0823	0.1143	3.565	4.485	6.21
<b>B. Harvest time (H)</b>						
H1 (120 DAP)	0.292	0.560	0.426	16.21	30.04	23.1
H2 (150 DAP)	0.314	0.577	0.445	17.43	30.78	24.1
P-value	0.396	0.605	0.678	0.396	0.680	0.701
LSD (0.05)	0.052	0.0672	0.0933	2.910	3.662	5.07
<b>C. Location (L)</b>						
L1 (Khumaltar)	0.316	0.714	0.515	17.55	39.64	28.6
L2 (Rampur)	0.290	0.424	0.357	16.09	21.18	18.6
P –value	0.310	<.001	0.001	0.310	<.001	<.001
LSD (0.05)	0.052	0.0672	0.0933	2.910	3.662	5.07
CV (%)	25.0	17.1	45.4	25.0	17.4	45.5
<b>G</b>	***	***	ns	***	***	ns
<b>H</b>	ns	ns	ns	ns	ns	ns
<b>L</b>	ns	***	**	ns	***	***
<b>Interaction</b>						
<b>G×H</b>	ns	ns	ns	ns	ns	ns
<b>G×L</b>	ns	**	ns	ns	**	ns
<b>H×L</b>	ns	ns	ns	ns	ns	ns
<b>G×H×L</b>	ns	ns	ns	ns	ns	ns

ns=Not significant, \* Significant at P<0.05, \*\*Significant at P<0.01, \*\*\* Significant at P<0.001

Same small letters in column are not significantly different by DMRT at 0.05 level of Significance.

Table 5. Interaction effect of genotype and location on tuberous root weight plant<sup>-1</sup> and tuberous root yield ha<sup>-1</sup> of sweet potato during the 2019

Genotypes	Tuberous root weight plant <sup>-1</sup> (kg)		Tuberous root yield (tha <sup>-1</sup> )	
	Khumaltar	Rampur	Khumaltar	Rampur
CIP 440015	0.519	0.389	28.86	19.47
CIP 440267	0.832	0.494	46.23	24.72
Local White	0.789	0.387	43.83	19.35
P-value	0.006		0.005	
LSD (0.05)	0.1164		6.342	

CV (%)	17.1	17.4
G×L	**	**

\*\*Significant at P<0.01

### Quality characters

Moisture and dry matter (DM) content of storage roots were not significantly affected by different genotypes and harvest time during both years in both locations (Table 6). Even though the moisture and DM content were not significantly influenced, mean value of highest dry matter and lowest moisture was observed in CIP 440015. Harvest date had very little effect on dry matter (%) without significant value where the earliest harvest date (120DAP) had higher DM than at late harvest date (150DAP). Regarding locations, the mean value showed the highest dry matter content was found in Rampur condition than Khumaltar. In contrast, different results were reported by Karan and Sanli (2021) in sweet potato.

Table 6. Effect of locations and harvest time on moisture and dry matter content of sweet potato genotypes during the years 2018 and 2019

Treatments	Moisture (%)			Dry matter (%)		
	2018	2019	Mean	2018	2019	Mean
<b>A. Genotypes (G)</b>						
G1(CIP 440015)	73.74	73.62	73.68	26.26	26.38	26.32
G2 (CIP 440267)	74.61	73.50	74.06	25.39	26.50	25.94
G3 (Local White)	75.67	75.03	75.35	24.33	24.97	24.65
P value	0.301	0.434	0.168	0.301	0.434	0.168
LSD (0.05)	2.526	2.679	1.832	2.526	2.679	1.832
<b>B. Harvest time (H)</b>						
H1 (120 DAP)	73.75	73.97	73.86	26.25	26.03	26.14
H2 (150 DAP)	75.59	74.14	74.87	24.41	25.86	25.13
P value	0.078	0.870	0.183	0.078	0.870	0.183
LSD (0.05)	2.062	2.188	1.496	2.062	2.188	1.496
<b>C. Location (L)</b>						
L1 (Khumaltar)	74.50	75.03	74.77	25.50	24.97	25.23
L2 (Rampur)	74.84	73.08	73.96	25.16	26.92	26.04
P value	0.739	0.077	0.283	0.739	0.077	0.283
LSD (0.05)	2.062	2.188	1.496	2.062	2.188	1.496
CV (%)	4.0	4.3	4.3	11.8	12.2	12.4
G	ns	ns	ns	ns	ns	ns
H	ns	ns	ns	ns	ns	ns
L	ns	ns	ns	ns	ns	ns
Interaction						

G×H	ns	ns	ns	ns	ns	ns
G×L	ns	ns	ns	ns	ns	ns
H×L	ns	ns	ns	ns	ns	ns
G×H ×L	ns	ns	ns	ns	ns	ns

ns= Not significant

The starch content was not varied significantly among three genotypes; however, the reducing sugar was highest in local genotype (Table 7). The reducing sugar was significantly affected by genotypes during 2018 with the highest value (4.72%) in Local White and lowest (3.0%) in CIP 440015. The harvest date affects the starch content during 2018, but it was not varied significantly during 2019. Delaying harvest showed the decreasing trend of starch content (23.59%) at 150 DAPS, while it was 30.61% at 120DAP during 2018. The reducing sugar was not changed significantly by harvest time, but increased slightly with late harvest date (150DAP). The starch and reducing sugar were significantly influenced by locations also in 2018 and 2019 respectively. The highest starch (29.18%) and reducing sugar (5.03%) content was in Rampur as compared to Khumaltar (25.02) and (4.13%) in 2018 and 2019 respectively. The genetic and environmental factors may affect the starch and reducing sugar content of sweet potato root. Reynolds *et al.* (1994) reported the total sugar, sucrose and starch contents as well as percent dry weight were significantly affected by harvest date for both cultivars in their study in Canada. As harvest date was delayed in 1989 and 1990, starch concentration and percent dry weight declined but and sucrose and total sugar concentrations increased.

The decrease in starch and increase in sugars observed in the late harvest (150DAP) in 2018 and 2019 are thought to be due to low average daily temperatures or cool night temperatures which may cause a stoppage in growth and a conversion of some of the root's storage reserves in the form of starch into sugars. Albuquerque *et al.* (2018) found that delayed harvest enhanced sugars, starch, and vitamin C levels than previous harvest. In comparison to other harvests, the 150-day harvest had higher quantities of soluble sugars, carbohydrates, and vitamin C in their study.

Table 7. Effect of locations and harvest time on starch and reducing sugar content of sweet potato genotypes during the years 2018 and 2019

Treatments	Starch (%) dwb			Reducing sugar (%) fwb		
	2018	2019	Mean	2018	2019	Mean
A. Genotypes (G)						
G1(CIP 440015)	24.35	33.5	28.94	3.0 <i>b</i>	4.84	3.92
G2 (CIP 440267)	28.79	34.4	31.61	3.20 <i>b</i>	4.28	3.74
G3 (Local White)	28.17	35.4	31.79	4.72 <i>a</i>	4.61	4.67

P value	0.072	0.764	0.373	0.036	0.468	0.086
LSD (0.05)	4.084	5.30	4.509	1.408	0.924	0.874
B. Harvest time (H)						
H1 (120 DAP)	30.61 <i>a</i>	35.1	32.86	3.71	4.31	4.01
H2 (150 DAP)	23.59 <i>b</i>	33.8	28.69	3.56	4.85	4.21
P value	< .001	0.535	0.027	0.791	0.150	0.583
LSD (0.05)	3.334	4.33	3.689	1.150	0.754	0.713
C. Location (L)						
L1 (Khumaltar)	25.02 <i>b</i>	36.5	30.78	3.49	4.13	3.81
L2 (Rampur)	29.18 <i>a</i>	32.4	30.77	3.79	5.03	4.41
P value	0.017	0.058	0.995	0.599	0.022	0.099
LSD (0.05)	3.334	4.33	3.682	1.150	0.754	0.713
CV (%)	17.8	18.2	25.4	45.7	23.8	36.8
G	ns	ns	ns	*	ns	ns
H	***	ns	*	ns	ns	ns
L	*	ns	ns	ns	ns	ns
Interaction						
G×H	ns	ns	ns	ns	ns	ns
G×L	ns	*	ns	ns	ns	ns
H×L	**	ns	ns	ns	ns	ns

ns =Not significant, \* Significant at  $P < 0.05$ , \*\*Significant at  $P < 0.01$ , \*\*\* Significant at  $P < 0.001$

Same small letters in column are not significantly different by DMRT at 0.05 level of Significance

The  $\beta$  -carotene content was significantly ( $P < .001$ ) differed by sweet potato genotypes during both years of the study (Table 8). The highest  $\beta$ -carotene content of storage roots was recorded in CIP 440015 and lowest was in Local White during both years. The highest mean value was  $224.7 \text{ mg}100\text{g}^{-1}$  and lowest was  $4.0 \text{ mg}100\text{g}^{-1}$ . Kosambo *et al.* (1998) and Teow *et al.* (2007) reported significant variations in respect to  $\beta$  -carotene content among sweet potato genotypes, and orange flesh had higher b-carotene content than white flesh. The influence of harvest time on  $\beta$ -carotene concentration was not significant in both years, although it was shown to be reduced when crop harvesting was delayed (150DAP). During 2019, there was a significant effect of location on  $\beta$ -carotene content, as well as the mean value of both years. Rampur ( $171.6 \text{ mg}100\text{g}^{-1}$ ) had the highest mean value than Khumaltar ( $97.3 \text{ mg}100 \text{ g}^{-1}$ ).

According to Kosambo *et al.* (1998), the total carotenoid content of sweet potato cultivars varied greatly depending on growing region. Grumbach and Lichtenthaler (1982) reported that carotenoid biosynthesis was increased by light.

Apart from light or shade, effect of varying environmental factors on the Beta-carotene levels in the sweet potato (Andrade *et al.*, 2009). The amylose content was not significantly differed by different genotypes during both years, while significantly affected by both harvest date and locations. The content of amylose was increased with late harvesting (150DAP) with recorded value of 243.98mg100gm<sup>-1</sup> in 2018 and 380.0mg100g<sup>-1</sup> in 2019. In contrast, a late harvest date led to significant but slight decrease in amylose content in potato (Noda *et al.*, 2004). Regarding locations, Rampur had highest amylose content as compared to Khumaltar during both years of experiment. This might be due to sufficient rainfall, temperature and light for plant during crop growing period in Rampur. The highest pooled value of amylose was 395.0 mg/100gm in Rampur and lowest (183.0 mg100g<sup>-1</sup>) in Khumaltar condition.

Table 8. Effect of locations and harvest time on  $\beta$  -carotene and amylose content of sweet potato genotypes during the year 2018 and 2019

Treatments	$\beta$ -carotene (mg100g <sup>-1</sup> ) dwb			Amylose (mg100g <sup>-1</sup> ) fwb		
	2018	2019	Mean	2018	2019	Mean
<b>A. Genotypes (G)</b>						
G1(CIP 440015)	241.93 a	207.4 a	224.7 a	292.41	249.0	271.0
G2 (CIP 440267)	148.42 b	201.1 a	174.8 b	392.34	219.0	306.0
G3 (Local White)	5.80 c	2.2 b	4.0 c	299.61	280.0	290.0
P- value	<.001	<.001	<.001	0.137	0.233	0.829
LSD (0.05)	48.79	40.36	38.29	110.7	71.5	114.1
<b>B. Harvest time (H)</b>						
H1 (120 DAP)	136.18	150.3	143.3	412.26 a	118.0	265.0
H2 (150 DAP)	127.92	123.5	125.7	243.98 b	380.0	312.0
P-value	0.671	0.105	0.266	<.001	<.001	0.321
LSD (0.05)	39.84	32.95	31.27	90.4	58.4	93.1
<b>C. Location (L)</b>						
L1 (Khumaltar)	122.60	72.0	97.3	263.71 b	101	183.0
L2 (Rampur)	141.51	201.8	171.6	392.53 a	397	395.0
P -value	0.336	<.001	<.001	0.007	<.001	<.001
LSD (0.05)	39.84	32.95	31.27	90.4	58.4	93.1
CV (%)	43.6	34.8	49.3	39.9	33.9	68.4
<b>G</b>	***	***	***	ns	ns	ns
<b>H</b>	ns	ns	ns	***	***	ns
<b>L</b>	ns	***	***	**	***	***
<b>Interaction</b>						
<b>G×H</b>	ns	ns	ns	ns	ns	ns
<b>G×L</b>	ns	***	**	ns	ns	ns

<b>H×L</b>	ns	ns	ns	ns	***	**
<b>G×H ×L</b>	ns	ns	ns	ns	ns	ns

ns =Not significant, \* Significant at P<0.05, \*\*Significant at P<0.01, \*\*\* Significant at P<0.001, fbw =fresh weight basis, dwb=dry weight basis. Same small letters in column are not significantly different by DMRT at 0.05 level of Significance

Significant interactions were found between genotypes and location on starch content during 2019 and between harvest date and locations during 2018 (Table 7). For  $\beta$ -carotene, interaction between genotypes and locations were found significant in 2019 and when pooled (Table 9). It might be due to combined effect of growing locations and genotypic characters. The interaction effects of the factors (genotypes, harvest time and locations) on all recorded quality characters in this study were not significant (data not shown).

Table 9. Interaction effect of genotype and location on  $\beta$ -carotene content of sweet potato during 2019 and when pooled

Genotypes	$\beta$ -carotene content mg 100gm <sup>-1</sup>			
	2019		Pooled	
	Khumaltar	Rampur	Khumaltar	Rampur
CIP 440015	109.4	305.4	159.4	289.9
CIP 440267	105.1	297.0	127.6	221.9
Local White	1.5	2.9	5.0	3.0
P-value	<.001		0.003	
LSD (0.05)	57.08		54.15	
CV (%)	34.8		49.3	
G×L	***		**	

\*\*Significant at P<0.01, \*\*\*Significant at P<0.001

## CONCLUSION

The findings showed significant variation in marketable tuber number and weight plant<sup>-1</sup>, total tuberous root weight plant<sup>-1</sup> and total tuberous root yield tha<sup>-1</sup> among genotypes and between the locations. The highest tuberous root yield was recorded from the genotype CIP 440267 in 2018 (20.57tha<sup>-1</sup>) and 2019 (35.48 tha<sup>-1</sup>). The harvest time did not affect yield characters significantly, but a small increasing trend was noticed on tuber yield harvested at 150 DAPS. In all the genotypes, yield characters were significantly influenced by the locations with greater yield in Khumaltar as compared to Rampur.

Moisture, dry matter, starch, and amylose content did not differ between the three genotypes, while reducing sugar was highest in the local genotype. Delaying

harvest showed the decreasing trend of starch content, while reducing sugar was increased. The highest  $\beta$ -carotene content of storage roots was recorded in OFSP genotype CIP 440015 which may be potential source of Vitamin- A and lowest in Local White. The highest starch, reducing sugar and  $\beta$ -carotene content was in Rampur as compared to Khumaltar. The  $\beta$ -carotene content was found to be decreased with delaying harvesting of crop (150DAP). From the study, it is concluded that OFSP genotypes are suitable for hilly area of Nepal like Lalitpur, Khumaltar but not suited for cultivation at Rampur or similar condition. The crop harvested at dates 120 and 150 DAP did not result in a significant increase in tuberous yield, but some prime qualities were reduced at the late harvest time (150DAP), suggesting that sweet potato crop can be harvested at 120DAP with appropriate yield and quality attributes.

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## **A study on the conception rate of artificially inseminated cattle at Kirtipur municipality, Kathmandu**

**Sagun Baral<sup>1</sup>, Arjun Pandit<sup>1</sup>, Balaram Thapa<sup>2</sup>**

<sup>1</sup>Himalayan College of Agricultural Sciences and Technology, Kirtipur  
Kathmandu

<sup>2</sup> Mobile Veterinary Hospital, Jawalakhel, Lalitpur  
Corresponding author: baralsagun29@gmail.com

### **ABSTRACT**

*Artificial Insemination is the one of new and most common technology that is being used in almost all the organized farm and small-scale farming as well, which was introduced in Nepal back in 2025/26 BS. To find out the Conception Rate, questionnaire survey was conducted for the data collection from primary source, the questionnaire was prepared focusing on the different possible causes that can alter the Conception Rate. Survey was done for total 150 successfully conceived cattle during 26 April, 2021 to 1 May, 2021. The overall conception rate of cattle was 54.15%. This showed that the Conception Rate was lower while comparing with the national value (57.11%). For improving the conception rate a suitable training may be conducted about the factors affecting conception rate in cattle to the technical persons who are involved in this artificial insemination.*

**Keywords:** Artificial Insemination, Conception Rate, cattle, Kirtipur

### **INTRODUCTION**

Artificial Insemination is the process of collecting male gametes from superior males and inseminating them into the female through artificial method avoiding copulation. It is the most important tool for the genetic improvement of animal because few superior males can produce enough sperm to inseminate thousands of females (Sastri and Thomas, 2010). For the purpose of increasing milk production in a herd AI is one of the best ways. There is increase in milk production by 30% in herds using AI to proven sire as compared to other herd using natural service (Roberts, 1971).

Artificial insemination project was established at Tripureshwor in BS 2025/26. That project is renamed so many times and currently it is known as National Livestock Breeding Center which is located at Lampatan, Pokhara. Now 66 Districts with AI service in Nepal with 58 regular AI service districts and 8 districts with casual or seasonal AI service (NLBO, 2020). Total 577719 AI services were done in the year of 2076/77 with growth rate of -7.21% as compared

to the previous year which was 622619. In Bagmati and Karnali province there was growth percentage of -23.53% and 49.14% respectively. The total semen production in the year 2076/77 is 793884 with overall growth of 19.23% (NLBO, 2020). To achieve better performance of an individual cattle or a herd minimum calving interval is necessary. Lower conception rate may be associated with higher calving interval which leads to decrease the milk production of a herd or an individual. Specific objectives of this study is to find out the conception rate of artificially inseminated cattle. General objectives of this study is to find out the relation of breed, age with the conception rate in cattle and another general objective is to find out the relation of conception rate at particular area with the national values of conception rate.

## MATERIALS AND METHODS

### Study area

Study area was Kirtipur Municipality which is located in the south-west direction of Kathmandu District.

### Method

In this study a set of questionnaires were made focusing on the different cause that may alter the conception rate like number of AI done, age, breed etc. Total 150 successfully conceived cattle were analyzed. In this study aborted animals were also counted on the successful conception. For the questionnaire survey KoBo collect application was used.

$$\text{Conception Rate} = \frac{\text{Number of successful conception}}{\text{Total number of AI required}} * 100$$

### Analysis of Data

Simple statistical tools will be used where necessary and for the analysis Microsoft excel and IBM SPSS software are going to be used.

## RESULTS AND DISCUSSION

### Overall Conception Rate (CR)

Altogether 150 successful conceptions was obtained by 277 insemination which gives the conception result of 54.15% (Table 1).

Table 1. Overall Conception Rate

Number of Successful Conception	Number of AI Required	Conception Rate
150	277	54.15%

NLBO, 2020 had published the overall CR of 57.11% in all over the Nepal and service per conception was 1.84. Sinha et al. (2019) had found the conception rate of 52.16% in the interval in 4 years. Patil et al. (2020) reported that the overall conception rate was 40.75%. Sherchand (2000) had found the conception rate of

44% in case of cattle. The less CR may be due to breed and production performance variation.

### **Age wise Conception Rate**

Animals were divided into 5 different age groups with range of 2 years. They were categorized into <3 years, 3-5 years, 5-7 years, 7-9 years and >9 years. Here the highest conception rates were found on the age group between 3 to 5 years (58.57%) and lowest on the age group above 9 years (50%) (Table No. 2). As the animal reaches the age of 3-5 the reproductive organs gets completely matured which leads to the proper hormonal balance. The CR is lowest in case of age above 9 years while comparing with Khan et al. (31.3%), it may be due to the less number of animals taken for the study in this category. Khan et al. had found the conception rate in the interval of 3.5 to 5 years of age (77.8%) and lowest in case of above 9 years of age (31.3%).

**Table 2. Age-wise Conception Rate**

Age (In years)	Number of Successful Conception	Number of AI done	Conception Rate (%)
Below 3	19	33	57.58
3 to 5	41	70	58.57
5 to 7	47	89	52.81
7 to 9	34	67	50.74
Above 9	9	18	50

### **Breed-wise Conception Rate**

Animals were divided into 3 groups Jersey cross, Holstein Friesian Cross and Local Cross. Highest CR is found in Local Cross (58.33%) followed by Jersey cross and HF cross. (Table No. 3) Conception rate is highest in local breed it may be due to their adaptability to this environmental factor, their strong immunity power compared to exotic breed of cattle. Khan et al. had found that the conception rate of Holsetin cattle as 57.1%. And that of local cattle was 63.8%. Khatun et al. had found the conception rate of local cattle 52.9% and that of Holstein was 62.3%.

**Table 3. Breed wise Conception Rate**

Breed	Number of Successful Conception	Number of AI done	Conception Rate (%)
Jersey Cross	104	191	54.45
HF Cross	39	74	52.70
Local Cross	7	12	58.33

### **Stage-wise Conception rate of Cattle**

Cattles were classified based of their stage whether they are heifer (nulliparous)

or cattle. In case of heifer the conception rate is higher (57.58%) comparing normal cattle (53.69%). (Table No. 4) Even though the CR is highest in 3 to 5 years of age, the stage cow includes the aged cattle also and they have the low conception rate which directly decreases the CR of whole class. Khan et al. has found the conception rate of heifer was 57.1% and other cattle had conception rate of 59.64%.

Table 4. Conception Rate based on stage of the cattle

Stage	Number of Successful Conception	Number of AI done	Conception Rate (%)
Heifer	19	33	57.58
Cow	131	244	53.69

### **Body Score Condition wise conception rate**

Animals were classified based on their external appearance on different classes from 1 to 5. In all the category of BCS, conception rate is almost similar ranging between 52.55% to 56.43%. Conception rate is highest in BCS 2.75 and lowest in BCS 2.5 (Table No. 5). BCS mainly refers to the nutritional status and health status of cattle. In this study, no cattle was found with BCS 4& 5. Even though the nutrition supplement plays vital role in reproductive performance of cattle.

Table 5. Conception rate based on body score condition

BSC	Number of Successful Conception	Number of AI done	Conception Rate (%)
2.5	9	17	52.94
2.75	57	101	56.43
3	72	137	52.55
3.25	12	22	54.55
4	0	0	0

### **Conception Rate based on time difference between estrus and AI done**

We had categorized the time difference between estrus and AI done into 5 different groups with the range of 4 hours. And it was found that the CR was higher in 13 to 17 hours time interval (58.82%) and the lowest after 22 hours (Table 7). The best time for AI was after 12 to 18 hours of estrus in case of cattle (Banerjee, 2018). It could be the reason for being the highest CR in between 13 to 17 hours in this study.

Table 7. Conception Rate based of time difference between estrus and AI done

Time difference ( in hours)	Number of Successful Conception	Number of AI done	Conception Rate (%)
<b>Up to 8</b>	8	16	50
<b>8 to 12</b>	47	89	52.81
<b>13 to 17</b>	40	67	58.82

<b>18 to 22</b>	43	80	53.75
<b>After 22</b>	12	25	48

### Season wise Conception Rate

As there are mainly 4 season spring (March-May), summer (June-August), autumn (September-November) and winter (December-February). The conception rate is highest in summer season (57.35%) and the lowest in case of autumn season (Table 8). During summer season there is very high production of grasses compared to other season. During this season the animal gets proper quantity of grasses along with concentrates along with rainfall. But in case of other season like autumn there is scarcity of grasses due to which animal needs to depend completely on concentrates and hay only. Khatun et al. had found that CR was highest in spring (78.9%) followed by winter (72.1%), rainy (35.7%) and summer (29.8%), respectively.

Table 8. Season wise Conception Rate

Season	Number of Successful Conception	Number of AI done	Conception Rate (%)
Spring	41	76	53.95
Summer	39	68	57.35
Autumn	36	69	52.17
Winter	34	64	53.13

### Conception rate based on complications faced on last parturition

Among total 150 animals, 12 of them had faced problems like dystocia, ROP; and they had the conception rate of 46%. While having no problem during the last parturition the animals had the conception rate of 54.98% (Table 9). The CR was low due to pathological condition present in the reproductive organs like, metritis, pyometra, destruction of cotyledons during ROP. It was also found that 8.6% of the cattle faced some kind of problems during parturition.

Table 9. Conception Rate based on complications faced on last parturition (CFoLP)

Complications	Number of Successful Conception	Number of AI done	Conception Rate (%)
Faced	12	26	46.15
Not faced	138	251	54.98

## CONCLUSION

The study was focused for the investigation of Conception Rate of Artificially Inseminated cattle based on survey research. Altogether 150 successfully conceived cattles were taken for a questionnaire survey. Data were analyzed to

determine the Conception Rate of cattle among different parameters. The overall conception rate was found to be 54.15%.

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## **Analysis of the value chain of lentil sub-sector in Bardiya district of Nepal**

**Susan Subedi<sup>1\*</sup>, Anup Tiwari<sup>1</sup>, Susmita Neupane<sup>1</sup>, Kamana  
Adhikari<sup>1</sup>, Suresh Panta<sup>1</sup>**

<sup>1</sup> Institute of Agriculture and Animal Science, Campus of Live Sciences,  
Tribhuvan University, Nepal

\*correspondence: susansubedi56@gmail.com

### **ABSTRACT**

*Lentil is a leading pulse crop having considerable export potential. The study on value chain analysis of Lentil (*Lens esculenta*) was conducted in Bardiya district of Nepal during Jan- April 2019. The main aim was to investigate value chain analysis of lentil which explored the functional and economic linkage among the actors, interviewing 60 lentil producers with the help of cooperatives by means of pre-structured and pretested questionnaires. In addition to that, 10 traders from Nepalgunj, Butwal and the local market were also chosen for the research study. The finding indicated that farmers were attracted in lentil growing because of satisfactory return and high-level profit margin. Lentil business was found to be profitable business with a B/C ratio of 1.30 in the study area. Producer's share and marketing efficiency have been found higher when the producers were selling their products straight to wholesalers for the international markets. Various production and marketing problems were faced by the farmers in the study area. The main problems faced by the lentil growers for production in the study area was lack of subsidies followed by a problem of technical factor. Beside this, price fluctuation and open border were the main problem faced by the traders in the study area. To conclude, from the research it is strongly recommended to improve the production of the lentil through the relevant technology and maintain the strong vertical and horizontal integration across the value chain actors.*

**Key words:** Lentil, Production, Marketing, Value chain, Producer share

### **INTRODUCTION**

Nepal, being a geographical diversified country has been richly endowed with agricultural biodiversity. Most of the people (65.6%) are involved in agriculture providing food, income and employment thereby acting as the foundation of livelihood (GoN, 2018). 43 major agriculture commodities accounts for more than 60% of agriculture exports and among those agriculture commodities, Lentil accounts for around a third of Nepal's overall agricultural exports (Mishra, 2018).

Lentil is the important grain legume of Nepal with 208,766 ha under cultivation and yield of 1203 kg/ha (MOAD,2018/2019). Because of favorable climatic conditions and, more importantly, easy access to major highway routes, most of the lentil production is concentrated in Terai. In terms of area and production, it accounts for more than 60% of Nepal's total pulse production (Mishra, A. K 2018). Nepal was the world's 5<sup>th</sup> largest producer of lentils in 2014, and in 2016 ranked 6<sup>th</sup> position after Canada, India, Turkey, United states of America, Kazakhstan (FAO,2017). Lentil exports account for 2.3% of total national exports and 3.1% of global exports (ITC, 2010). Lentil is among the prioritized 19 commodities with export potential in Nepal (NTIS 2016). Several studies have claimed that lentil has a high export potential (Magar et al. 2014; USAID, 2011; Kumar et al., 2016).

On the other hand, export of lentils has dramatically decreased in these years due to lack of value addition, narrow export basketSS (FAOSTAT,2018). Though lentil production in Nepal carries a long history, commercialization has not occurred due to several production problems and marketing problems. According to Kumar et al. (2016), most lentil farmers are small and are forced to sell to local traders who have considerable market power.

Magar et al. (2014) reported that limited technical knowledge, lack of availability of quality seeds, disease incidence were the key constraints associated with the lentil production whereas poor marketing system & quality assurance system, inadequate market information and market guarantee were the major limitations related to the marketing. Large number of the farmers engaged in lentil production are small farmers characterized by traditional technologies and post-harvest practices. Due to various abiotic, biotic, and socio-economic factors, there is a huge difference between the attainable yield potential and the yield in farmers field (Shrestha,2011). USAID (2011) also reported that absence of collective marketing at community level, absence of trade and market information that is related at the producer and trader level, Bangladesh dependent trade, Low bargaining capacity and low purity percentage as a major marketing problem in Nepal. Most recent evidence has claimed that farmers in this region have no access for post- harvest handling and processing of the lentil instead of selling them at a low cost due to the limited storage facilities. The research finding of the study will contribute to concerned stakeholders to further develop strategy concerning the commercialization of lentil cultivation and processing and well-functioning of different value chains existing in the locality leading lentil sector as an efficient agribusiness enterprise.

Utilizing information collected from the actors of the lentil value chain (i.e., Input suppliers, producers, brokers, and other stakeholders), this research examines the value chain of lentil in Bardiya district of Nepal. Precisely, the study finds the

stakeholders and their function throughout the value chain and major production & marketing problems. It examines the price spread across the value chain and contribution of lentil in the household economy. In addition, it tries to analyze the factors affecting the production of lentil.

## **MATERIALS AND METHODS**

### **Research area and sampling**

Study was carried out in Bardiya district, which is situated in the Mid-western part of the country. The Bardiya district was deliberately selected for this research since it was one of the major lentils growing domains and had significant contributions in the overall production of lentils in the nation. The sites selected for the study were Simara and Piplapur locality of Badaiya rural municipality.

List of farmers growing lentil from each study site had been prepared separately which was made available by the local cooperatives. A total 60 respondents (Lentil producer) were interviewed using random sampling technique. Out of which 30 respondents each from Simara and Piplapur. Additionally, 5 traders from Nepalgunj, 2 traders from Butwal and 3 local traders have been interviewed for mapping of the value chain.

### **Overview of research design**

Primary data was collected through survey from the producers, key informants' interview, market visit and field visit. Scheduled interview was done with producers, traders, wholesalers, and retailers with the help of pre-tested questionnaire. Key informant interview (KIIs) was conducted with lentil producers, traders and other stakeholders concerned in the value chain to assess the supplementary information about production of lentil and its trade.

Research used both methods of sampling, i.e., random sampling for lentil producers and snowball sampling for marketing institutions. As the total population of lentil producer was known (from cooperatives), random sampling method was used whereas the total population of the marketing institution was unknown, snowball sampling method was used.

Primary data was collected primarily from the lentil producers in the study area whereas secondary data has been collected from the Journal articles and officially published department reports of the Ministry Of Agriculture and Livestock Development (MOALD), Food and Agriculture Organization (FAO), Grain legume research programme, District Agriculture Development Office (DADO) and Central Bureau of Statistics (CBS).

## **Data analysis**

Information collected from the research area and the secondary sources have been encoded and were entered on Statistical Package for Social Science (IBM SPSS version 20) and Microsoft Excel (Microsoft 365 apps for Enterprise). Analysis was performed using SPSS and MS-Excel. Multiple regression model and Chi-square tests have been used as a means of inferential statistics whereas frequencies and percentages were also calculated. As the production function was linear, multiple regression model was used for determining factors affecting lentil productivity.

Benefit cost analysis is defined as the return from the farm business in relation to its costs. This analysis generally indicates the relationship between costs and benefit of a business. It was estimated by using the formula below. Mathematically.

$$\text{B:C ratio} = \text{Total revenue} / \text{Total Variable Cost}$$

Variable costs were considered for the analysis of the gross margin. Gross margin is defined as difference between the gross return and total variable costs of a farm business. It was estimated using the formula below:

Mathematical,

$$\text{Gross margin} = \text{Gross return} - \text{Total Variable costs}$$

where,

$$\text{Gross return (NPR)} = \text{Price of lentil (NPR per kg)} * \text{Total amount produced (kg)}$$

$$\text{Total Variable cost (NPR)} = \text{Total cost of all the variable inputs used (NPR)}.$$

$$\text{Producer share (Ps)} = \{ \text{Farm gate price (pf)} / \text{Retail Price (Pr)} \} * 100$$

where,

$$\text{Ps} = \text{Producer's share (\%)}$$

$$\text{Pf} = \text{Farm gate price (NPR) and,}$$

$$\text{Pr} = \text{Retail price (NPR)}$$

$$\text{Total Marketing Cost (MC)} = \text{Total expense of (Weighing + Packaging+ Loading)} \\ + \text{Excise tax} + \text{other taxes}$$

$$\text{Total Marketing Margin (MM)} = \text{Selling price of the retailer} - \text{Net price received} \\ \text{by the producer- Marketing expenses}$$

$$\text{Acharya's Index of marketing Efficiency} = [ \text{Retailer's Price} / (\text{Marketing cost} + \\ \text{Marketing margin}) - 1 \text{ (Rane \& Deorukhkar, 2007).}$$

### **Productivity of Lentil production**

Multiple linear regression model has been used to analyze the factors affecting the quantity of lentil production. The amount of the lentil produced is the depended continuous variable. Gujrati (2004) stated the multiple regression model is as defined as:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_i X_i + \epsilon_i$$

Where,  $Y_i$  refers to the volume of lentil produced by the farmer (Dependent variable),  $X_1$  to  $X_i$  are the independent variables,  $\beta_0$  is the intercept,  $\beta_i$  are the parameters of the  $i^{th}$  independent variables and  $\epsilon_i$  is the error term.

### **Value Chain mapping**

Value chain analysis focuses on the simple idea that commodities and services are manufactured by a complicated and a sequential set of activities. Value chain map is a useful framework to bring specialists and stakeholders from different backgrounds and concerns (Mcleod et.al,2009). Mapping of value chain is generally done with the objective to obtain an essential overview of value chain to guide full value chain. (M4P,2008).

### **Indexing**

Various problems were categorized using indexes. Scaling techniques, which provide the guidance and extremity mindset of the interviewee towards any proposition (Miah, 1993) was used to create indexes. Intensity level of production and marketing of lentil related problems encountered by the lentil farmers respectively have been identified using three-point scaling technique comparing severe, moderate, and slight using scores of 3, 2 and 1 respectively.

Following equation has been used to discover the index for intensity of various problems.

$$I_{Pro} = \sum S_i f_i / N$$

Where,  $I_{Pro}$  = index values for intensity of problem;  $\sum$  = Summation,  $S_i$  = Scale value of  $i^{th}$  intensity;  $f_i$  = Frequency of  $i^{th}$  response;  $N$  = Overall number of observations.

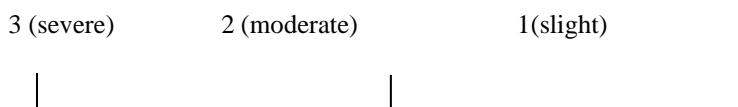


Figure 1. Scale value for indexing of problems

## RESULTS AND DISCUSSION

### Socio-demographic characteristics of Lentil producers

Research area have been dominated by ethnic groups Brahmin (40%) and Tharu (40%) community equally followed by Chhetri's (11.67%) and Dalits (8.33%). Majority of those producers surveyed (80%) were involved in agriculture while 20% of the people had government job, business as a primary occupation. Majority proportions of respondents were found literate in both Piplapur area and Simara.

The proportion of male respondents was very high as compared to female in both the locations (Piplapur & Simara). Brahmins were highest followed by Chhetri's in Simara area whereas Tharu were highest followed by Dalit in Piplapur area, respectively. Respondents were found more literate in Piplapur as compared to Simara. Table 1 presents all the additional detailed information on socio demographic characteristics of respondents.

Table 1. Socio demographic characteristics of respondents (2019) (n=100)

Item	Aspect	Piplapur n=30	Simara n=30	Full sample N= 60	Chi-square
Gender	Male	27(45.0)	25(41.6)	52(86.7)	0.5
	Female	3(5.0)	5(8.3)	8(13.3)	
Ethnicity	Brahmin	1(1.6)	23(38.3)	24(40)	43.1***
	Chhetri	2(3.3)	5(8.3)	7(11.6)	
	Tharu	22(36.6)	2(3.3)	24(40)	
	Dalits	5(8.3)	0(0)	5(8.3)	
Education	Illiterate	10(16.6)	8(13.3)	18(30)	1.33
	Literate	13(21.6)	11(18.3)	24(40)	
	Secondary (SLC)	4(6.6)	6(10)	10(16.6)	
	Bachelor	2(3.3)	3(5)	5(8.3)	
	Above Bachelor	1(1.6)	2(3.3)	3(5)	

Note: \*\*\* reveals significant differences at 1% level of significance and numbers in parenthesis indicate percentage

Source: Field survey, 2019

Based on Chi-square test, it was found that there was a considerable association between ethnicity of the respondents and the location of the study area at 1% level of significance.

### **Economically Active population**

Population age range between 15 - 59 years is regarded as an economically active population. Economically active population was found to be more in Piplapur (82) than Simara (57). The proportion of non- economically active population and economically active population was found to have significant differences in the study area.

Table 2. Population distribution of economically and non-economically active population

Population	Piplapur n=181	Simara n=153	Total N=334
Non - economically active	99	96	195
Economically active population	82	57	139

Source: Field survey, 2019

### **Factors affecting Lentil Productivity**

The result of multiple regressions (Table 3) indicated three of the 9 hypothesized independent variables have been found to have significantly affected the amount of lentil produced by the farmer. The significant variables were average selling price of the lentil (Rs/qt), total revenue generated from the lentil and the number of labors used.

Table 3. Factors affecting lentil production (qt) (2019)

Variables	Estimated Coefficients	P- Value
Constant		0.088
Total lentil cultivated land(kattha)	0.120	0.396
Total number of households	-0.003	0.980
Average selling price of lentil (Rs/qt)	-0.310**	0.011
Total revenue generated from lentil (Rs)	0.411***	0.001
Seed treated	-0.207	0.072
Rhizobium powder unit	-0.085	0.469
Number of labors used	0.281**	0.021
Amount of MOP used (Kg/kattha)	0.109	0.393
Where you sell the lentil product	0.042	0.723

Dependent variable: Quantity of lentil produced (Qt)

\*\*\*Significant at 1 percent level of significance, \*\*Significant at 5 percent level of significance(R=38.1%).

Adjusted R<sup>2</sup> value was found to be 0.381. This result suggests that about 38.1% of a variation in the amount of lentil produced was attributed to the hypothesized value.

The average selling price of lentil, in 2018, was negatively and significantly related to the quantity of lentil produced. In economic principle, the amount produced increases as the selling price rises which is not supported in this result. Though, this could be related to the less price obtained by the lentil producer in the past years. The total revenue generated from the lentil was found positive and significantly related to the amount of the lentil produced. As the revenue generated from lentil increases, it convinces farmers to produce more amount of lentil.

The total number of labors used is significantly and positively associated with the amount of lentil produced by the farmers. The positive relations imply that an additional 1 labor increases the quantity of lentil produced by 1.281 quintals. A research conducted by Paudel et al. (2020) also found that the number of labors was positively and significantly associated with the output.

### **3.4 Household income**

Income generated from the farm was higher than the income generated from non-farm activities.

Table 4. Contribution of Lentil to annual household income (2019)

SN	Source of revenue generated	Total average income (NPR)	Share on total Family income (%)
1	Lentil	45,000	38.49
2	Major cereal crop	5000	4.28
3	Vegetables	2000	1.71
4	Milk and milk Product	3500	2.99
5	Livestock	20000	17.11
6	Fruits	1400	1.20
7	Remittance	40,000	34.22

	<b>Total income</b>	<b>116,900</b>	<b>100</b>
	<b>Total off farm income</b>	<b>40,000</b>	<b>34.22</b>
	<b>Total farm income</b>	<b>76,900</b>	<b>65.78</b>

Source: Field Survey, 2019

Similarly, the contribution of lentil in the total family income was the highest (38.49%) among all types of farm and off-farm income as indicated in the table no 4. Magar et al. (2014) also reported that selling of lentil as pulse as well as seed as a major contributor of household income to the producers in their research area.

### **Production and Productivity of Lentil**

Average production of lentil was 4.69 quintal in the research area whereas the productivity(kg/Katha) was discovered to be 45 kg per Katha. Production and Productivity was found to be almost similar in both study areas whereas average areas per household was more in Piplapur. Productivity of lentil in the study district has been found to be 45.98 kg/katha((MOAD,2018/19) which is like that of the productivity of the study area.

Table 5. Average area per family, production, and productivity by study area

Study area	Area (Katha)	Production (quintal)	Productivity (kg/kattha)
Piplapur	12.01	4.91	44.91
Simara	9.03	4.47	45.21
Average	10.52	4.69	45.06

Source: Field survey,2019; 1 hectare = 30 kattha

### **Benefit- Cost analysis**

Lentil production seemed to be a lucrative business in the research area as indicated by the B/C ratio of 1.30. Higher B/C ratio was found in the Simara area as the farmers were selling lentil for the seed purpose. Similar B/C ratio was calculated by Kumar et al. (2012), Paudel et al. (2020) and Hajong et al. (2020) of 1.27, 1.33 and 1.75 respectively indicating the likely benefit of cultivating lentil for individual farmers.

Table 6. Benefit/cost analysis of lentil production by study areas (2019).

Study area	Average Revenue (Rs/kg)	Average Cost (Rs/kg)	Variable B/C ratio
Piplapur	53.03	51.10	1.03
Simara	88.06	56.05	1.57
Total	70.54	53.57	1.30

Source: Field survey, 2019

### Analysis of gross margin

Higher gross margin was discovered in the Simara area(32/kg) as the farmers in that area were selling lentil for seed purpose. Lower gross margin (1.92/kg) in the Piplapur area was found as they were selling lentil as a pulse. Beside this, it may be due to poor pricing structure as Tharu community were lacking pricing strategy. USAID, (2011) also reported that farmers can earn a profit margin of NPRs of 3-4/ kg of lentil.

Table 7: Gross margin analysis of lentil production by research area (2019)

Research area	Gross margin (NPR/Kattha)	Gross margin (NPR/kg)
Piplapur	584.80	1.92
Simara	2719.70	32.00
Total	1652.25	17.86

Source: Field survey, 2019

### Production and Marketing problem

#### Production Problem of Lentil Producer

Production issue ranking of various kinds of problems encountered by the respondents indicated that lack of subsidies followed by technical factors, unavailability of quality seed in time and many other problems as shown in Table no 8. Subsidies should only be provided by identifying the actual farmers. USAID (2011) also reported that yield of lentil has been low in developing countries due to a combination of policy level and technical constraints.

Table 8. Major problems in lentil production among respondents

Problems	Scale value			Total	Index	Rank
	3	2	1			
Lack of subsidies	24	4	2	82	2.73	I
Technical factors	23	3	4	79	2.63	II
Unavailability of quality seed in time	21	6	3	78	2.60	III
Unavailability of commercial rhizobium at first seed treatment	19	6	5	74	2.47	IV
Chilling/frost injury	18	7	5	73	2.43	V
Weeds	17	7	6	71	2.37	VI

### Problems in marketing of Lentil

Ranking of the various problems associated with the marketing of lentils indicated that, low farm gate price per unit was the main problem followed by price variation, lack of storage facilities, no primary importance being exported potential, lack of market potential and open border as shown in Table no 9. USAID (2011) also reported that exporter and large-scale traders have been dominating the lentil market resulting in price fluctuation in the market.

Table 9. Problems encountered by producers in the marketing of Lentil

Problems	Scale value			Total	Index	Rank
	3	2	1			
Low farm gate price per unit	25	3	2	83	2.77	I
Price variation	22	6	2	80	2.67	II
Lack of storage facilities or processing facilities	10	5	15	55	1.83	III
No primary importance being export potential commodity	5	10	15	50	1.67	IV
Lack of market assurance	6	5	19	47	1.57	V
Open border	6	2	22	44	1.47	VI

### Value addition activities

A Large Proportion of the respondents have been practicing cleaning (86.67%), drying (75%) and grading of the lentil (58.33%) while very few farmers were processing (6.67%) the lentil before selling to the market as shown in figure no 2. Cleaning and drying of lentil are done in a traditional way before selling to the local collectors or the vendors. Hajong et al. (2020) also reported that most of the farmers practice cleaning before selling into the market although a few have been processing the lentil before selling. However, processing of the lentil is done by few farmers who are willing to sell to the local market to get the good price of the lentil.

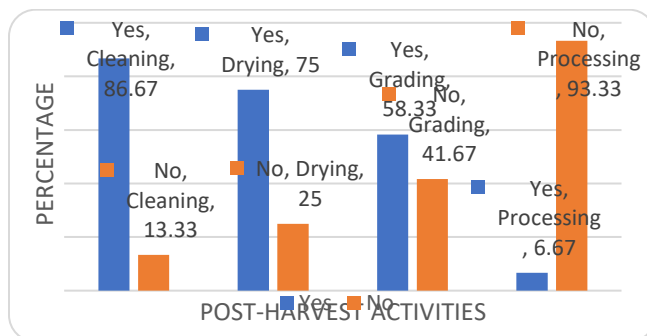


Figure 2. Various post-harvest activities which increases the value of lentil

Source: Field survey, 2019

### **Lentil marketing channel**

#### Marketing channel /Actors

The movement of lentil was not confined in a single channel. Various marketing channels have been observed the investigation area. Mostly the producers are selling their product to vendors or local collectors. Following market channels have been found in the research area:

1. Farmers... Collectors (cooperatives / vendors) ..... Wholesaler....Local market
2. Farmers..... Collectors..... Wholesalers cum millers.....Domestic market. (Nepalgunj/ Dhangadi/ Butwal/ Kathmandu)
3. Farmers.....Wholesalers.....International Market (Bangladesh and other countries)
4. Farmers---Collectors----. Wholesalers cum millers----- International market (India)

Different prices are received by the different stakeholders across the marketing channels as shown in Table no 10. Producers are receiving less price as the number of stakeholders involved in the marketing channel increases.

Table 10. Price received by different stakeholders on different marketing channels in the study area

Marketing Channels	Producers	Collectors (small scale /cooperatives)	Wholesalers cum millers	Wholesalers	Large mill	Local market	Domestic market	International market
1*	50.25/kg	75/kg		100/kg		125/kg		
2*	48.75/kg	60/kg	100/kg				125kg	
3*	60/kg			125/kg				135/kg
4*	54.00	65/kg	100/kg					125/kg

Source: Field survey, 2019

\*indicates the four different kinds of marketing channel identified within the research area

### **Producer Share's**

Producers' shares can be defined as a key indicator to predict the price paid by the producers in comparison with the paid off by consumers while purchasing it. Higher producer share's (44.42%) and index of marketing efficiency (0.8) had

been found when the farmers directly provided their lentil to wholesalers for the international market. USAID (2011) also reported 56% producer's share in his study in Nepal. Marketing efficiency was found very low due to lack of systematic marketing arrangement and higher marketing cost. Analysis of lentil value chain demonstrated that marketing efficiency and producer's share on consumer rupees has been declining with increasing numbers of intermediaries as shown in Table 10.

Table 11. Evaluation of producer shares and index of marketing efficiency in various marketing channel

Details	Marketing channel			
	1*	2*	3*	4*
Net price obtained by producer (FP)	50.25	48.75	60.00	54.00
Total marketing cost (MC)	20	21	22	23
Total marketing margin (MM)	54.75	55.25	53	53
Retailer's sales Price (RP)	125**	125**	135**	125**
Producer's Share (PS) %	40.20	39.00	44.44	43.20
Index of marketing efficiency (MME)	0.67	0.63	0.80	0.76

Source: Field survey, 2019

\*indicates the four different types of marketing channel identified in study area

\*\*indicates the price that was regarded as the final price to reach end consumer.

## Lentil value chain

### Stakeholders and their Responsibilities

Map of lentil value chain in the Bardiya district has been traced as illustrated in figure 3. More than 60% of the production of lentil reported amongst all the surveyed households has been contributed by the small land holding producers. Local agrovets, seed producing cooperatives, fertilizer dealers were the main input suppliers in the lentil value chain. There was no strong correlation amongst the lentil producers as they can gather the large amount at one place for negotiating for a higher price with the collectors. Both small scale and large-scale collectors were found active in collection of the lentil. Over 10-25 collectors (small scale) from all the VDC have been participating in the collection where 95% of the collection (lentil) was sold to the district trader (large collector) and 5% were sold to the local large mills/ exporters. Wholesalers were found to sell the whole lentil or the processed lentil to retailers, restaurants, hotels, and other wholesalers in Nepal as well as in India due to easy access to India from Nepalgunj border (Rupadia). The wholesalers were mainly involved in processing of the lentil. In the study area, very few farmers were selling the processed lentil.

### Enablers and Supporting Organization

Ministry of Agriculture and Livestock Development (MOAD) and National Grain Legume Research Programme (NARC) were the government institutions that were found actively involved. Mostly these institutions were focused on production site with few programs focusing on research only. While non-governmental organizations working in the Lentil were LIBIRD (Local Initiatives for Biodiversity Research and development), GATE (Global Agri-tech Nepal), FORWARD. These organizations are facilitating technology for supporting the stakeholders in the value chain in several factors like the input supply, policy making, technology dissemination and infrastructure development. Beside these many financial institutions(co-operatives) are providing services like loan providing, technical support to the small-scale farmers. But currently they are focusing more and more on large traders and processors for providing loans.

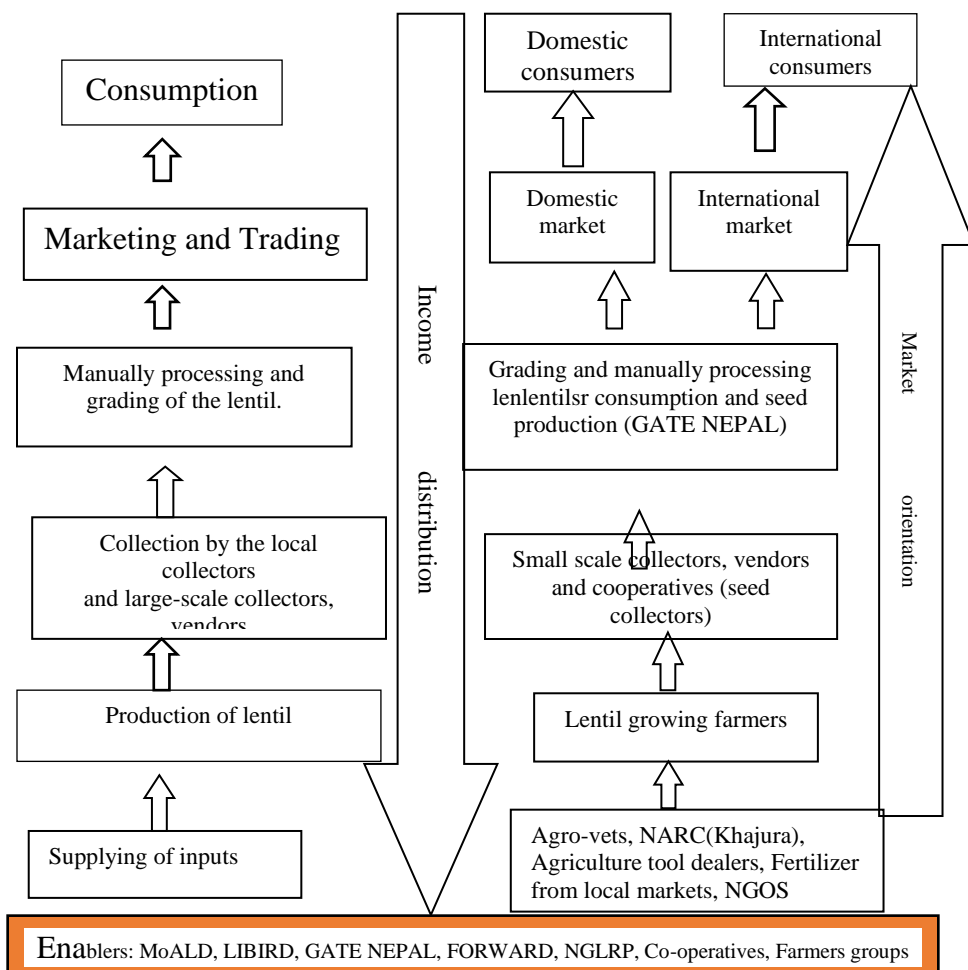


Figure 3. Value chain map of lentil production in Bardiya district

## **CONCLUSION**

This study concluded that there have been several stakeholders and enablers throughout the lentil value chain in Bardiya district. Key actors were the input suppliers, producers, traders (Local collectors, Wholesalers, Retailers). Many governmental institutions and non-governmental institutions (GATE, FORWARD) were found to be the enablers and facilitators in the lentil sub sector in the research area. Additionally, there is a necessity to increase the production and productivity of lentil in the research area. This might be via using the appropriate technology such as use of quality seeds, training to the farmers, treatment of seed with commercial rhizobium and enhanced post-harvest management practices. These techniques will ultimately improve the quality as well as the productivity. Ranking of different production and marketing related problems suggested that lack of subsidies and technical factors were the major cause of less production whereas low farm gate price and price variation were the major cause of reduced producer's share and marketing efficiency. Regarding the producer's share and index of marketing efficiency, higher producer share (44.42%) and index of marketing efficiency (0.8) had been discovered during which the farmers were directly providing the lentil to the wholesalers for the international market. Beside this, findings also showed that lentil production is profitable and contributes a major part in the total annual household income. Moreover, the estimated linear regression model showed that number of labors used, total revenue generated, and average selling price of lentil significantly affects the amount of lentil produced.

There is a great need to upgrade the coordination among the concerned stakeholders in order to make the value chain more efficient. The study also showed that Nepalese lentil is India and Bangladesh centered which is causing price fluctuation in Nepalese market. To sum up, there seems to be strong need for the involvement into both the production and marketing side by the government to render the production process more efficient, the automation and marketing system fairer and a lot more genuine.

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## The trend of breed-wise piglet mortality in Lalitpur District, Nepal

**Maheshwar Dahal\*, M.P. Acharya, and N. Baskota**

Swine and Avian Research Program, Nepal Agricultural Research Council,  
Lalitpur Nepal

\*Corresponding author: dr.maheshwardahal@gmail.com

### **ABSTRACT**

*Pre-weaning piglet mortality is one of the major economic issues in pig farming. Piglet mortality is a multifactorial complex influenced by different factors such as litter size, the health of sow, farrowing, and management system. A retrospective study was done to study the cause of mortality on 5 different farms in Lalitpur. A total of 92 piglets died due to different causes. Results of the study revealed that diarrhea, stillbirth, crushing, runt, pneumonia, fever, and starvation led to death. Breed-wise, Duroc piglets died mostly being stillbirth (53%), Landrace piglets mostly due to stillbirth (46%), Badel cross piglets mostly by diarrhea (43%), and Nagpuri piglets mostly by runting and diarrhea (33%). The seasonal mortality pattern revealed that the major causes of piglet mortality during summer were stillbirth (51%) followed by diarrhea (25%) and runting (13%). Similarly, during winter, most piglets died of diarrhea and runt (29%) followed by crushing (26%). Lastly, sex-wise mortality patterns revealed that the majority of male and female piglets died of diarrhea, stillbirth, crushing, and runt. It was observed that the number of piglet mortality during summer was high. Mortality of piglets was highest during 8-14 days of age. Out of dead piglets, 60% and 40% were males and females respectively.*

**Keywords:** Breed, crushing, mortality, pig, pre-weaning, stillbirth

### **INTRODUCTION**

Pigs are predominantly reared by ethnic groups such as Rai, Limbu, Magar, Tamang, Sherpa, Tharu, and Biswakarma in certain restricted areas of the country. Both ethnicity and religious beliefs have imposed restrictions on pig farming which does not receive much attention from policymakers when compared to other livestock species (Gurung, 1990). In 2019/20, Nepal has 15,19,593 heads of domesticated pigs and pork production was 29,493 MT. Pig farming is seen as one of the potential tools to alleviate poverty, particularly amongst underprivileged communities (Joshi, 2006). It is included in several rural development ventures including some projects for the empowerment of women. Pig farmer cooperatives have proven successful in many areas (HT 2009). Piglet mortality is a multifactorial complex; and can be explained by various factors,

such as the sow and maternal characteristics (Andersen, *et al*; 2005). The first group of exotic pig breeds to enter Nepal in 1957 comprised Yorkshire, Landrace, Hampshire, and Duroc (Joshi, 2006). Over the years, government institutions and non-governmental agencies have imported other exotic breeds like Tamworth, Saddleback, and Fauyen (Joshi, 2006). The Yorkshire and Landrace strains are the most popular. Duroc was imported from Malaysia in 1994 (Wilson, 1997). Starvation or dehydration can occur either because the sow fails to produce enough colostrum or because individual piglets fail to consume enough. Since the causes of the early piglet mortality were mainly non-infectious, such as crushing by the sow and/or starvation (Westin *et al*; 2015a) the effect of confining the sow around farrowing or during the whole suckling period has been investigated in several earlier studies.

In Nepal, nowadays the popularity of Yorkshire, Landrace, and Duroc is increasing rapidly. Piglet mortality is a major economic issue in pig farming. It is a multifactorial complex influenced by different factors regarding litter size, the health of sow, farrowing system, and management. There are so many factors affecting piglet mortality. In Nepal, piglet mortality is higher on governmental and farmers' farms. It occurs on all the farms and is caused by congenital factors resulting in weak piglets, environmental factors, disease in the sow or piglet, and other managemental factors. The death of these piglets is usually due to suffocation from being overlain by the sow. The other main problems are chilling, failure of colostrum intake, diarrhea, and birth defects. This is a common problem affecting modern lines of pig breeds on many farms.

Piglet mortality is one of the major problems in the piggery of Nepal. Many commercial as well as small farmers facing big economic losses due to higher piglet mortality. Gatenby *et al*; (1990) reported 27.4% piglet mortality in the Koshi hills of Nepal which is very high in the farmer's management system. Higher still-birth (4.86%) and pre-weaning mortality (10.4%) of Pakhibash Black Pigs were found in the Pakhribash Agricultural center (Ghimire and Aryal 1999). Maximum piglet death cases occurred in the first week of age of piglets in every season. Weak birth and overlying by sows are the major causes in Yorkshire and landrace in different seasons. The objective of the study was to study the trend of piglet mortality on five different farms pig of the Lalitpur district.

## **MATERIALS AND METHODS**

This study was conducted on different farms in Lalitpur district including the data of swine and Avian Research Program Khumaltar. Pigs of different breeds on the farms were recorded. The commercial farms fed commercial pig ration and household wastes were as SARP Khumaltar pig farm fed 2-3 kg/head/day commercial feed from KISHAN Feed Lagankhel and clean drinking water was provided 24 hrs a day. The routine vaccines for swine fever and FMD were given on all farms regularly. No, creep ration was provided to piglets. Weaning was

done 45 days after farrowing. All the piglet's teeth were cut after a day and inject iron injection. In this breeds piglet mortality, season-wise piglet mortality, sex-wise piglet mortality, and causes of male and females piglet mortality data were collected and studied. Data were analyzed by Microsoft excel package Version - 07.

## RESULTS AND DISCUSSION

The causes of pre-weaning piglet mortality of all the piggeries of death of different breeds were observed. Stillbirth, diarrhea, rushing, weak birth, and runting were the major causes of piglet mortality. The total mortality was 92 piglets from farrowing to weaning.

### Breed wise Piglet Mortality

Major causes of pre-weaning death in Landrace were stillbirth, diarrhea, crushing, and runting. Due to stillbirth(1%), diarrhea (24%), and crushing (12%). runting (9%), Poor health of piglet (6%) and Anorexia (3%) were also not the negligible cause of pre-weaning of the Landrace breed. Similarly, stillbirth, runting, diarrhea, pneumonia, and being unable to suck piglets were the major causes of death in Duroc which lost most of the Piglets. HA high number of piglets were dead due to stillbirth (53%) and other causes were runting (16%), diarrhea (11%), pneumonia (10 %) and unable to suck (10%) respectively. Major causes in Yorkshire piglets were death by crushing. This was similar to Pradhan *et al.*,1998 reported crushing by the dam mostly within 3 days of life which was one of the major causes of piglet mortality. In Badel cross most important cause was diarrhea (43%). The major cause of piglet mortality in the Nagpuri breed was diarrhea (33%), runting (33%), stillbirth (19%), crushing (10%), and followed by fever (5%). Change piglets mostly died of diarrhea followed by runting. Some piglets died due to mothers' defect. A few piglets died by other causes (external injury, anal defect, paralysis and unknown causes). Mortality gradually decreased with growth of piglets.

Table 1. Breed- wise piglet mortality

Breed	Causes of piglet mortality
Landrace	Anorexia (1), Crushing (4), Diarrhea (8), Poor health of sow (2), Runting (3) and Still birth (15)
Duroc	Diarrhea (2), Pneumonia (2), Runting (3), Still birth (10) and Unable to suck milk (2)
Yorkshire	Crushing (3)
Badelcross	Crushing (1), Diarrhea (6), Poor health (2), Runting (3) and Still birth (2)
Chanwche	Diarrhea (1) and Runting (1)
Nagpuri	Crushing (2), Diarrhea (7), Fever (1), Runting (7) and Still birth (4)

Numbers in parenthesis indicates number of piglet deaths

Most of the farms there were crushing and weak at birth. Starvation was also the main factor of pig mortality. There was a clear sign of diarrhea and also weak piglet was due to crushing, starvation and other predisposing factors. Most of the improved and cross breeds deliver many sows and have low milk production, so, piglets died due to low milk production from sow.

### Season-wise piglet mortality

Highest mortality of piglets during summer by diarrhea followed by stillbirth and crushing. In summer season seem to be a good season for farrowing. In the winter season piglets died mainly by runting was higher followed by crushing and diarrhea. The seasonal mortality pattern revealed that major causes of piglets mortality during summer were still birth (51%), diarrhea (25%), followed by runt (13%), poor health of piglet (6%), crushing (3%) and anorexia (2%). Similar result was found Ghimire; *et al*; 2002) that higher still birth rates were seen in summer season and low in winter season. Similarly, during winter majority of piglets died of diarrhea (29%) and runting (29%) followed by crushing (26%), pneumonia (7%), unable to suck (6%) and fever (3%). Same result was found in exotic breeds and crossbreed of swine in different seasons weak birth and crushing (overlying) by sows were the major causes of piglet mortality. To save the small and weak piglet at a different season, we must provide plenty of bedding materials and also provide a piglet brooding box for up to 2 weeks.

Table 2. Season-wise piglet mortality

Season	Causes
Summer	Anorexia (1), Crushing (2), Diarrhea (15), Poor health (4), Runt (8) and still birth (31)
Winter	Diarrhea (9), Crushing (8), fever (1), Pneumonia (2), Runt (9) and unable to suck milk (2)

Numbers in parenthesis indicates number of piglet deaths

### Sex-wise piglet mortality

Sex-wise mortality pattern explores that majority of male and female piglets died by Stillbirth, diarrhea, runting, crushing, poor health of piglet, pneumonia and runt. Death of piglets were highest during 8-14 days of age. Out of dead piglets 60 % and 40 % were males and females respectively. Mortality in male piglets was found higher in both cross and exotic breeds. Similar causes were seen in male and female mortality. In male piglet mortality still birth (27%), diarrhea (25 %) followed by runt (24%), crushing (13%), poor health of piglet (5%), fever, unable to suck milk and pneumonia (2%). Whereas female piglets were died by still birth (43%) followed by diarrhea (27%), runt (11%), crushing (8%), pneumonia, unable to suck, poor health (3%), and anorexia (2%) respectively.

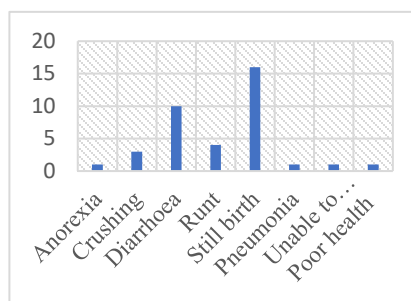
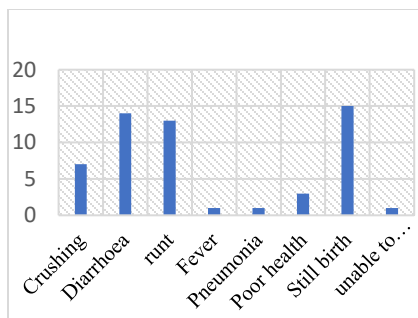


Fig 1. Causes of male piglet mortality Fig. 2. Causes of female piglet mortality

Table 3. Causes of male and female piglet mortality

Sex	Causes
Male	Stillbirth (27%), diarrhea (25%), runting (24%), crushing (13%), poor health of piglet (5%), fever, unable to suck milk, and pneumonia (2%).
Female	Stillbirth (43%), diarrhea (27%), runt (11%), crushing (8%), pneumonia, unable to suck, poor health (3%), and anorexia (2%)

## DISCUSSION

Pig mortality data of a number of farms revealed that there were most of the causes were diarrhea, crushing and runt. Similar results were obtained by Fraser *et al*; (1990) that a prominent characteristic of high piglet mortality litters is poor piglet live weight gain in the immediate post-farrowing period. Similarly, stillbirths generally account for 30-40% of the total mortality. Diarrhea was the major cause of piglet mortality during this study. Diarrhea may be the primary cause leading to secondary causes like crushing, runting and stillbirth, starvation and other diseases. Farrowing in late winter had lower mortality rate, diarrhea, weak birth and overlay were major causes of piglet mortality, the first two weak of age are risk for piglet deaths. High number of piglets were deaths due to stillbirth (53%) and other runting (16%), diarrhea (11%), pneumonia (10%) and unable to suck (10%), respectively.

Major causes in Yorkshire piglets were death by crushing. This was similar to Pradhan *et al.*, (1998). It was observed that the numbers of piglet death during summer was high. Despite high standards of hygiene this farm also facing continuing problem. Crushing is the major problem in piglet during study similar result in (Easicare,1993) is the main cause. According to (Ghimire and Aryal,1999) higher still birth (4.86%) and pre-weaning mortality (10.4%) at Pakhribash Agriculture center. Weak birth and crushing by sows are the major cause in Yorkshire and landrace in different seasons at swine and Avian Research

program, Khumaltar (Ghimire and Dhaubhadel,2002). Many commercial as well as small farmers big economics losses due to higher mortality. Gatenby *et.al.*, (1990) reported 27.4% piglet mortality in Koshi hills of Nepal which is very high in farmers management system. Piglet mortality is the outcomes of a set of complex interactions between the sows, the piglet and environments. Although crushing by sows is the main ultimate cause of piglet death.

## CONCLUSION

This study showed that pre-weaning piglet mortality was a major problem among the pig farmers in the study area. As we know that all the factors associated with mortality cannot be controlled, but understanding them and taking proper health care, feeding and management will assist the farmers and producers in minimizing piglet death loss. Results showed that the higher stillbirth rates were seen in summer season and low in winter season in all breeds. But in winter piglet diarrhea was the major cause. In winter season some piglets died from pneumonia and poor health. Mortality in male piglet was found higher in cross and exotic breeds of swine. Therefore, proper healthcare programs and management practices must be undertaken in advance to avoid these huge economic losses under field conditions. Besides the above-mentioned factors recently in some of the farms it is noticed that a viral disease Porcine Reproductive and Respiratory Syndrome (PRRS) is a major cause of still birth, abortion and piglet mortality. PRRS has been confirmed by PCR. Therefore, it is very important to identify the strain of PRRS in field and arranged vaccine accordingly to protect PRRS in pig production.

## ACKNOWLEDGEMENTS

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## Water hyacinth used vermicompost nutrient analysis: a case study of Phewa Lake, Pokhara

Deepa Lama,<sup>1</sup> Sajani Shrestha<sup>2</sup> and Indu Bania<sup>2</sup>

<sup>1</sup>Goldengate International College, Tribhuvan University, Kathmandu, Nepal

<sup>2</sup>Research Center for Applied Science and Technology (RECAST), Kirtipur,  
Nepal

### ABSTRACT

Water hyacinth (*Pontederia crassipes*) is a perennial macrophyte locally known as 'Jalkumbhi'. In Nepal, Phewa Lake is highly affected by water hyacinth. This lake has favorable condition for the growth of water hyacinth which is mainly caused due to heavy pressure from both natural and human factors. Water hyacinth contains nutrients such as nitrogen (N), Phosphorus (P) and Potassium (K) that makes it useful as organic inputs to soil. The objective of this study was to analyze the NPK of water hyacinth byproduct substrate vermicompost. This study was based on experimental design. NPK analysis was carried out using Kjeldahl method, Morgan method and extraction method respectively. The highest average N level was found in vermicompost of 1:2 sample ratio i.e. 1.870%, P level in rice straw i.e. 0.279% and K level in water hyacinth only i.e. 0.055%. This experimental research supports the fact that it can be used in producing vermicompost. Thus, produced vermicompost can further be utilized in agriculture sectors where farmers are already struggling due to high price of chemical fertilizers and lacking of compost.

**Key words:** Nitrogen, nutrients, vermicompost, water hyacinth,

### INTRODUCTION

Water hyacinth (*Pontederia crassipes*) is a perennial macrophyte locally known as 'Jalkumbhi'. Water Hyacinth was first reported in Nepal in 1966 (Dahal, 2007). In Nepal, lakes of Pokhara especially Phewa, Begnas and Rupa are highly affected by water hyacinth invasion. These lakes have favorable condition for the growth of water hyacinth which is mainly caused due to heavy pressure from both natural and human factors.

Water hyacinth contains nutrients such as nitrogen (N), Phosphorus (P) and Potassium (K) that makes it useful as organic inputs to soil (Amoding et al., 1999). Vermicompost made of it enhances the chemical and biological properties of soil improving the soil fertility. Further it helps in decreasing the use of chemical fertilizer. Water hyacinth, which is considered as menace to other plants and aquatic bodies can actually be an opportunity. Apart from handicrafts, briquettes,

biogas, this threatening plant has also been used as substrate for mushroom farming and byproduct of mushroom farming for vermicompost. Many successful attempts in Thailand and Zimbabwe have been made to use it for the same purpose (Prophant, 2005).

## MATERIALS AND METHODS

Phewa Lake is stream fed dam regulated and semi natural located in Kaski District, Gandaki Province of Nepal at the Southwestern edge of Pokhara valley ( $28^{\circ} 1' N$ ,  $82^{\circ} 5' E$ , altitude 742 m). The total surface area covered by the Lake was estimated of 4.43 km<sup>2</sup> whereas the area of the catchment is 123 km<sup>2</sup> (Gautam & Kafle, 2007). The lake level fluctuates seasonally depending on the withdrawal for power generation, irrigation purpose and inflow means. The lake has the biodiversity richness holding 7 types of vegetation type, 39 aquatic macrophytes including 23 hydrophytes and 16 helophytes (Shrestha and Janauer, 2001). Physical shape and size of the lake is degrading due to massive sedimentation and encroachment activities.

### Vermicompost Preparation

Vermicomposting, or worm composting is a technology that takes advantage to convert biodegradable waste into organic manure with the help of Red worm (*Eisenia foetida*) also known as “Red-Wigglers”. The water hyacinth and rice straw in different combination were used as a substrate for mushroom production. Byproducts of mushroom production were used for vermicomposting. Water hyacinth was used in different combination. Thus prepared substrate compositions were placed in 5 different bins. Red worm (*Eisenia foetida*) induced in all different samples for composting and kept for about 1-2 months. In between water was sprayed in the sample bucket 3-4 day's interval. All combination different substrate of water hyacinth and rice straw samples were packed in plastic bags with a level. These samples were done chemical analysis.

### Nutrient Analysis

For nutrient analysis, obtained vermicompost sample of different combination were air dried for 3-4 days to remove the moisture completely. Finally, obtained dried vermicompost samples were powdered using mortar and sieved using 2 mm sieve.

NPK determination was done in laboratory for the nutrient analysis. Nitrogen determination was carried out using Kjeldahl method where sample was digested using sulfuric acid converting N to NH<sub>3</sub>. Similarly, Phosphorus determination was done using Morgan's method (UV 2010 spectrophotometer) where Acetic acid was used as an extractant. On the other hand Potassium was determined by extracting from compost sample using Microprocessor Flame Photometer Model 1382. Thus,

extracted sample was mixed with ammonium acetate solution and Potassium present in the extract was determined using photometer.

## RESULTS AND DISCUSSION

### Nutrient Composition of Vermicompost

The experiment was done in three batches of samples. Phosphorus (P) content was little bit high in water hyacinths and rice straw combination product vermicompost sample. Phosphorus content was little bit high in water hyacinth vermicompost sample than water hyacinth and rice husk combination. Potassium (K) % content was high in water hyacinth sample than different substrate of vermicompost. However, Nitrogen % content was high in combination water hyacinth and rice straw. Table 1 showed the concentration of phosphorus, potassium and nitrogen respectively in different combination of substrate. The experiment was done in three batches of samples of all substrate combination of vermicompost. Figure 1, 2 and 3 showed the concentration of nitrogen, phosphorus and potassium in different combination of substrate.

Table 1. Average concentration of Phosphorus, Potassium and Nitrogen present in different combination of vermicompost

SN	Sample Ratio	Phosphorus (P) %	Potassium (K) %	Nitrogen %
1	Rice Straw	0.279	0.041	1.349
2	Water hyacinth	0.250	0.055	1.239
3	1:1	0.222	0.040	1.650
3	1:2	0.264	0.019	1.870
4	2:1	0.230	0.044	1.817

Note : Substrate combination: 1 Control Rs = rice straw; control WH=water hyacinth; 1:1 = Equal amount of rice straw and water hyacinth; 1:2 Water hyacinth 1 and Rice straw 2; 2:1 = Water hyacinth 2 and Rice straw

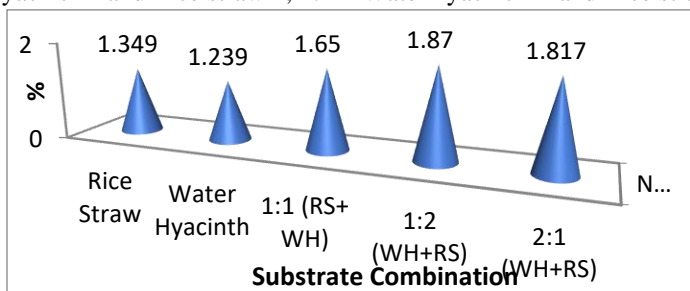


Figure 1. Nitrogen (N) % available in different substrate composition of vermicompost

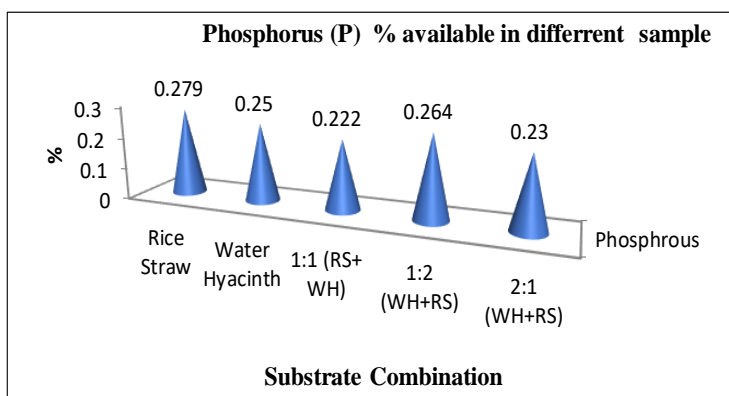


Figure 2. Phosphorus (P) % available in different substrate composition of vermicompost

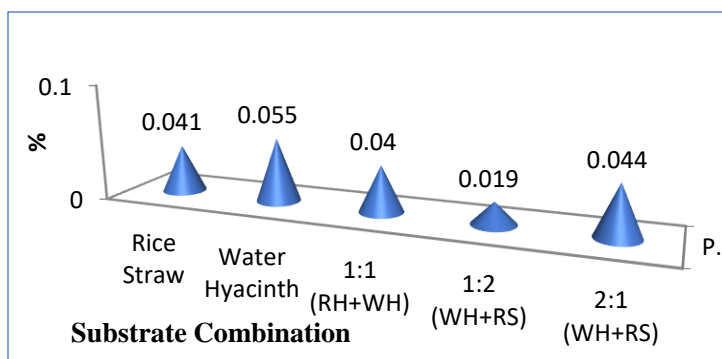


Figure 3. Potassium (K) % available in different substrate composition of vermicompost

Different study showed that the nutrient composition in vermicompost widely depends on the waste materials being used. Moreover, the common available composition of nutrients in vermicompost is Nitrogen (0.5– 1.5%), Phosphorus (0.1- 0.30%) and Potassium (0.15- 0.56%). Nutrient composition of all three batches of vermicompost remains within this range. Study conducted by Paul & Bhattacharya in 2012 suggests vermicompost made out of water hyacinth as greater nutrient source to Marigold in comparison to normal cow dung. In a similar manner such vermicompost can be used for agriculture production here in Nepal as well. This study further supports the fact in adopting water hyacinth vermicompost. On the other hand, several studies have found that water hyacinth vermicompost is beneficial for the growth of various crops and vegetables (Malik, 2007).

However, in this study water hyacinth alone was more beneficial when it combined with rice straw. Among five different ratio combinations, 1:1, 1:2 and 2:1 ratio combination was found quite beneficial in terms of nutrients level. It also enhances the decomposition of organic matter in soil and enrichment of NPK (Sakthika & Sornalakshmi, 2019).

## CONCLUSION

Water hyacinth being an abrupt invasive plant species has been laborious to manage in the context of Nepal. In such scenario, this experimental research supports the fact that it can be used in producing vermicompost. Thus, produced vermicompost can further be utilized in agriculture sectors where farmers are already struggling due to high price of chemical fertilizers and unavailability of compost fertilizer. Moreover, this experiment displays the viable option for the sustainable management of water hyacinth and its use as a resource.

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## Assessment of bacterial contamination of marketed pork meat from retail meat shops of Kathmandu valley

<sup>1</sup>\*Ayusha Shrestha, <sup>1</sup>Upendra Man Singh, and  
<sup>1</sup>Santosh Chaudhary

<sup>1</sup>HICAST, Kirtipur, Nepal

\*Corresponding Author: ayushashrestha4502@gmail.com

### ABSTRACT

*A qualitative and quantitative study of raw pork meat samples from different retail meat shops of Kathmandu valley was carried out in Microbiology Laboratory of Himalayan College of Agricultural Sciences and Technology (HICAST) Kirtipur, Kathmandu during February to April 2021 with an aim to assess the bacterial contamination of pork with special emphasis on isolation of Salmonella spp and Escherichia coli. Out of 48 pork meat samples, 47 (97.91%) were found positive for Total viable count (TVC), 40 (83.33%) for coliforms, 26 (54.16%) for E. coli and 6 (12.5%) for Salmonella spp. Out of 26 E. coli positive samples, 12 (46.15%), 9 (34.61%) and 5 (19.230%) samples were from Kathmandu, Lalitpur and Bhaktapur respectively. Out of 6 Salmonella positive samples, 2 (33.33%), 3 (50%) and 1 (16.66%) samples were from Kathmandu, Lalitpur and Bhaktapur respectively. The mean TVC and Total coliform count (TCC) were found to be  $7.73 \pm 0.179 \log_{10} \text{ cfu/g}$  and  $3.82 \pm 0.252 \log_{10} \text{ cfu/g}$  respectively which is more than the standard prescribed by the ISO. These also exceeded the standards of Bureau of Indian Standards i.e.,  $< 10^5 \text{ cfu/g}$  for TVC and  $5 \times 10^2 \text{ cfu/g}$  for TCC. Higher bacterial load and presence of intestinal commensals E. coli and Salmonella spp indicated that the meat might have been contaminated by the visceral contents and awareness to be created for hygienic meat production.*

**Key words:** Total Viable Count, Total Coliform Count, E. coli, Salmonella spp, ISO standard

### INTRODUCTION

Pig farming is one of the important sub-sector within animal husbandry in Nepal. Pig farming and pork production is at an early stage of development compared to other livestock systems. In past 10 years, the population of pig has increased by 43.10% and pork production by 68.88%. The total pork production in Nepal is 28,579 metric tons and the contribution made by it in total meat production is about 8% (MoALD, 2020).

Raw meat is an excellent medium for the proliferation of numerous microorganisms because of its high moisture content (70-80%) and abundant availability of proteins, peptides and amino acids as well as growth factors and minerals. It also contains fermentable glycogen and has  $p^H$  ideal for a wide range of microbes (Holck *et al.*, 2017). Many pathogenic microorganisms are capable of growing in meat which includes *Salmonella spp*, *Escherichia coli*, *Staphylococcus aureus*, *Campylobacter spp*, *Clostridium perfringens*, *Listeria monocytogenes*, *Yersinia enterocolitica* and *Aeromonas hydrophila* (Bhandare *et al.*, 2007). Among them, the presence of *Salmonella spp*, *Campylobacter spp*, *Listeria monocytogenes* and verocytotoxin producing *E. coli* O157:H7 indicate public health hazard and possible occurrence of food borne illness (Bantawa *et al.*, 2018).

The microbial quality of fresh meat is determined by factors such as animal husbandry, transportation, physiological status of animal at slaughter, contamination spread during slaughter, cutting and packaging as well as temperature and other conditions of storage and distribution (Nychas *et al.*, 2008). *Salmonella spp*, *Campylobacter jejuni* and *E. coli* O157:H7 are mainly enteric pathogens in animals and can contaminate carcass surfaces due to improper slaughtering procedures (Wang *et al.*, 2013). Contamination of raw meat also easily occurs from external sources. External contamination of meat is a constant possibility from the moment of bleeding unit consumption (Lawrie, 2006).

### Microbial standard of meat

To monitor microbiological quality of meat preparations and meat products, guidelines and recommendations of international and national level have been developed in addition to legal requirements. But most of the organizations like EU, WHO and ISO have established their own standards for qualitative assessment of the meat from microbial point of view. Generally, ISO standards for meat and meat products is followed in Nepal (Table 1).

Table 1. Recommended microbial standards for raw pork meat (EU, 2005)

S. N	Particulars	Permissible limits
1	Total viable count	$10^7$ CFU/g
2	Total coliform count	$10^2$ CFU/g
3	Salmonella	Absent in 25g

Microbiological aspect is the important factor to study the quality and safety of meat. In Nepal, quality management systems such as ISO and HACCP still do not exist, and researches have not been updated. Only few studies have been conducted on the microbial load in pork so far. Therefore, this study was conducted to investigate the bacteriological quality of raw pork meat with special emphasis on isolation of *Salmonella spp* and *E. coli* available in commercial areas

of Kathmandu valley as well as to compare microbial load in the samples with international standards.

## MATERIALS AND METHODS

### Sample collection

A total of 48 pork meat samples (200 gram each) were collected randomly from the different retail meat shops of Kathmandu valley. 20 samples were collected from Kathmandu, 16 from Lalitpur and 12 from Bhaktapur. The samples were collected and labelled accordingly from the different regions of the carcass, such as neck and thigh in a sterile, dry sealed Ziploc plastic bag kept in ice box. The samples were then transported to Microbiology Laboratory of HICAST for further processing.

### Bacteriological analysis

25 grams of each meat samples was taken and homogenized in 225 ml of 1 % buffered peptone water using a meat grinder under sterile conditions. Further tenfold dilutions of the homogenates up to  $10^{-6}$  in buffered peptone water were made using sterile pipette according to the recommendation of International Organization for Standardization. All the samples were subjected to bacteriological analysis to determine TVC and TCC as well as presence of *E. coli* and *Salmonella spp* using the agar plate culture method and later on, confirmation was done by biochemical tests.

### Enumeration of TVC and TCC

The total viable count (TVC) was determined by standard pour plate method. One ml of each tenfold dilution was inoculated in Nutrient agar plate just before the solidification of agar. The plates were then kept in an incubator at 37°C for 24 hrs. Following incubation, plates exhibiting 30-300 colonies were counted. A plate without inoculum was kept as control and colony counting was done by using microbial digital colony counter. The number of colonies in particular dilution was multiplied by the dilution factor to obtain the TVC.

For the determination of TCC, the same method used for TVC was employed. Violet Red Bile agar was used for culture and the procedures of sampling, dilution and pouring was similar to those followed in TVC of bacteria. The pink to red colonies that generally surrounded by a reddish zone of precipitated bile were counted using microbial digital colony counter.

### Isolation of *Salmonella*

5 ml of the homogenized sample with 25ml buffer peptone water was incubated at 37°C for 24 hours for pre-enrichment. 1 ml of pre-enriched sample was poured into 9 ml of Selenite F-broth and incubated at 37°C for 24 hours for enrichment. One loopful of the enriched sample from selenite F-broth was inoculated in selective media i.e. Xylose Lysine Deoxycholate agar and one petri dish was kept

as control. Then petri dishes were incubated at 37°C for 24 hours. After overnight incubation, the red colonies with black center were picked up from VRBA and re-culture was done on Nutrient agar for the isolation of pure culture and incubated at 37°C for 24 hours. For the identification of *Salmonella spp*, further biochemical tests were performed.

#### **Isolation of *E. coli***

One loopful of pre-enriched sample in buffered peptone water was inoculated in selective media i.e. Eosin Methylene Blue agar and one petri plate was kept as control. Then the petri plates were incubated at 37°C for 24 hours. The colonies with greenish metallic sheen and dark center were picked from EMB agar plate and re-culture was done on Nutrient agar for isolation of pure culture and incubated at 37°C for 24 hours. For the identification of *E. coli*, further biochemical tests were performed.

#### **Biochemical tests**

Gram's staining of pure isolates from Nutrient agar plate was done for the determination of the category of bacteria. Appropriate biochemical tests i.e., Methyl Red (MR), Voges-Proskauer (VP), Oxidase, Catalase, Indole, Citrate utilization, Triple Sugar Iron (TSI) test were carried out for the identification of bacteria.

#### **Data analysis**

The data collected were tabulated and analyzed graphically and statistically by using Microsoft Excel 2016.

## **RESULTS AND DISCUSSION**

Altogether 48 pork meat samples were collected from different retail meat shops of Kathmandu valley. In this study, four different parameters were studied so as to assess the bacterial contamination of pork meat found in Kathmandu valley. Out of 48 samples, 97.91% (47/48) were found to be positive for TVC, 83.33% (40/48) for coliforms, 54.16% (26/48) for *E. coli* and 12.5% (6/48) for *Salmonella spp* (Figure 1).

#### **Results of TVC and TCC**

The mean values of TVC and TCC of raw pork samples from different retail meat shops of Kathmandu valley was found to be  $12 \times 10^7$  cfu/g and  $4.5 \times 10^4$  cfu/g respectively (Table 2).

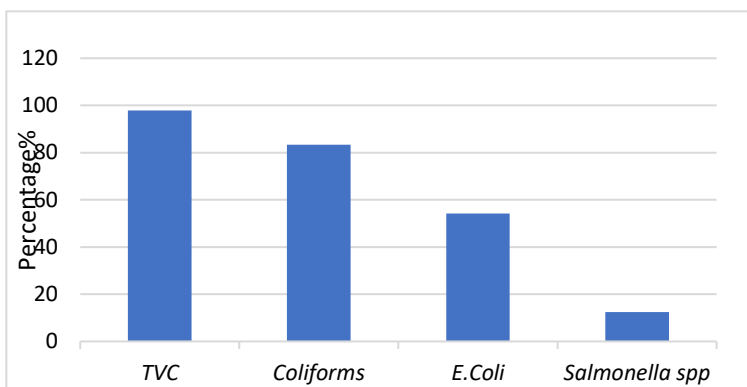


Figure 4. Findings of bacteriological examination of pork meat samples

Table 2. The observed mean values of TVC and TCC of pork in Kathmandu valley

Parameters	TVC	TCC
Observed mean (cfu/g)	$12 \times 10^7$	$4.5 \times 10^4$
Observed mean ( $\log_{10}$ cfu/g)	7.73	3.82
Standard mean (ICMSF)	7	2
Standard deviation	1.2424134	1.74625
Standard error	0.1793	0.2520
Z value	4.0764	7.2315
Z value @ 5% level of significance	1.96	1.96
Decision	Significant	Significant

Both mean TVC and TCC findings are higher than the ICMSF standard of 7  $\log_{10}$  cfu/g (Figure 2) and 2  $\log_{10}$  cfu/g (Figure 3), respectively.

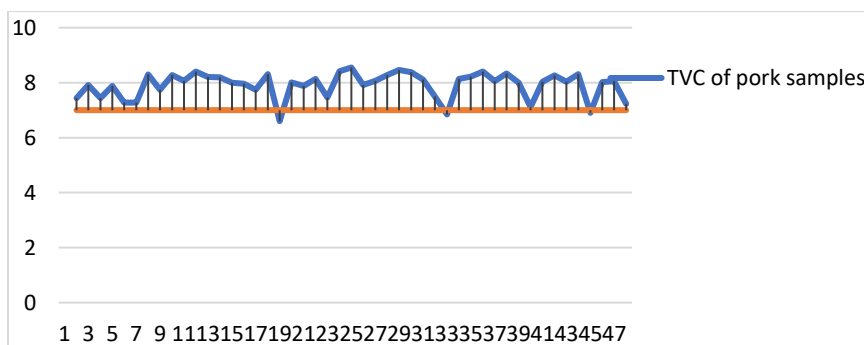


Figure 5. Comparison of TVC of positive samples with ICMSF standard

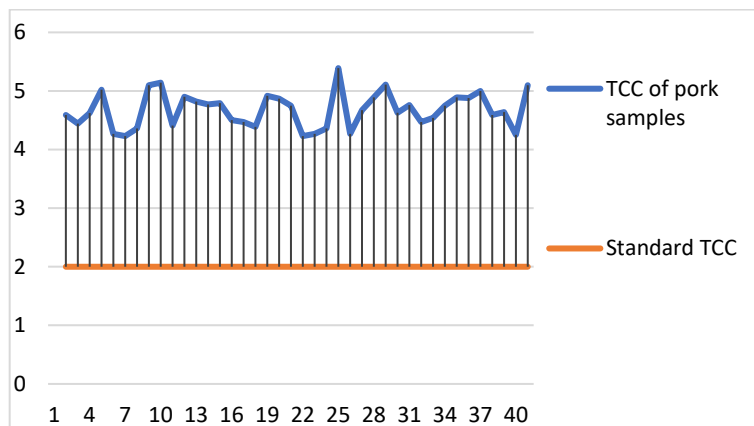


Figure 6. Comparison of TCC of positive samples with ICMSF standard

#### Overall findings of *Salmonella spp*

Out of 48 pork samples collected from different retail meat shops of Kathmandu valley, 6 samples were found to be positive for *salmonella spp*, which gives overall findings of 12.50% (figure 4).

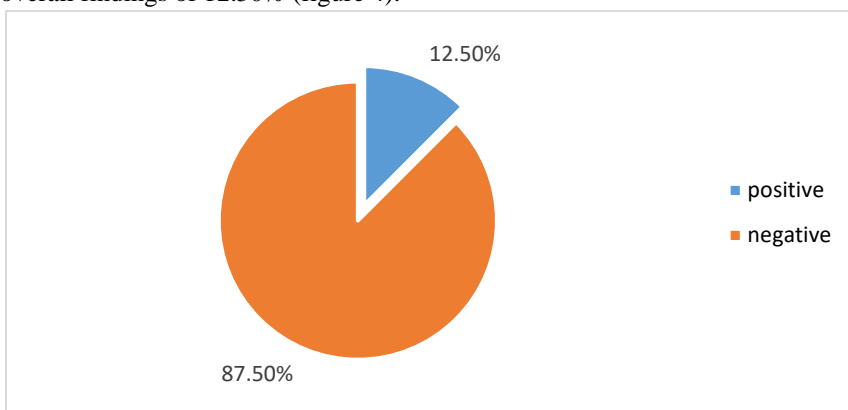


Figure 7. Overall findings of *Salmonella spp*

#### District wise findings of *Salmonella spp*

Among 6 positive samples, 2 (33.33%) samples from Kathmandu, 3 (50%) samples from Lalitpur and 1 (16.66%) samples from Bhaktapur were found to be positive for *Salmonella spp* (figure 5).

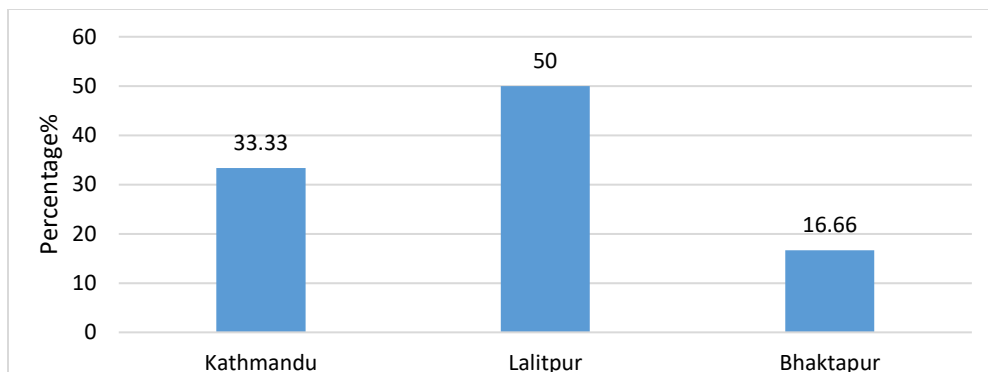


Figure 8. District-wise findings of Salmonella spp

### Overall findings of *E. coli*

Out of 48 pork samples collected from different retail meat shops of Kathmandu valley, 26 samples were positive for *E. coli*, which gives overall findings of 54.16% (figure 6).

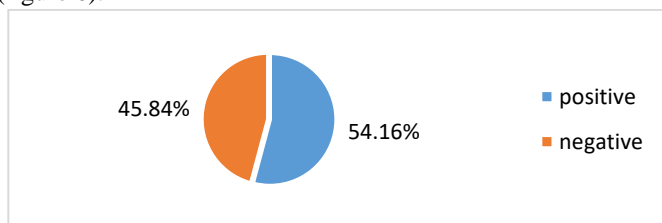


Figure 9. Overall findings of *E. coli*

### District wise findings of *E. coli*

Among 26 positive samples, 12 (46.15%) samples from Kathmandu, 9 (34.61%) samples from Lalitpur and 5 (19.230%) samples from Bhaktapur were found to be positive for *E. coli* (figure 7).

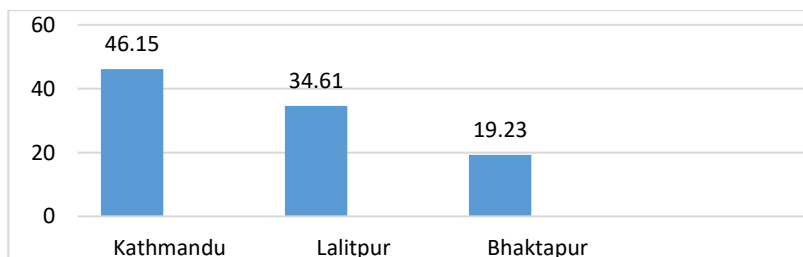


Figure 10. District-wise findings of *E. coli*

### Results of biochemical analysis

All the isolates were found to be gram-negative short rods. Bacteria determined by Gram's staining were further tested by biochemical tests to identify *E. coli* and *Salmonella spp* (Table 3).

Table 3. Biochemical characteristics of Strains *E. Coli* and *Salmonella spp* isolated form pork sample

Species	Oxidase	Catalase	TSI	Indole	Citrate	MR	VP	No of isolated strains
<i>E. Coli</i>	-	-	A/A, gas	+	-	+	-	26
<i>Salmonella</i>	-	+	K/A, $H_2S$	-	+	+	-	6

### Discussion

The observed mean value of TVC of raw pork samples from different retail meat shops of Kathmandu valley was found to be  $12 \times 10^7$  cfu/g ( $7.73 \pm 0.179 \log_{10}$  cfu/g) which was more than the standard prescribed by the ISO. This also exceeds the standard of Bureau of Indian Standards, i.e.  $10^5$  cfu/g and standard prescribed by ICMSF (1974), i.e.  $7 \times 10^6$  cfu/g. The findings of this study were also found to be higher than that of the result given by Das *et al.* (2018), i.e.  $5.9985 \pm 0.0254 \log_{10}$  cfu/g and Joshi *et al.* (2018), i.e.  $1.51 \times 10^6$  cfu/g. The reasons of higher TVC might be due to lack of appropriate slaughtering facilities, unsatisfactory slaughtering and storing facilities, lack of awareness in meat seller on hygienic practices etc.

The observed mean value of TCC of raw pork samples from different retail meat shops of Kathmandu valley was found to be  $4.5 \times 10^4$  cfu/g ( $3.82 \pm 0.25 \log_{10}$  cfu/g) which was more than the standard prescribed by the ISO as well as standard of Bureau of Indian Standards, i.e.  $5 \times 10^2$  cfu/g. This level of coliform contamination reveals unhygienic sanitary conditions and chances of fecal contamination either from animal itself or human sources. Contaminated water might be another risk. However, the findings of this study were found to be lower than the results given by Bantawa *et al.* (2018), i.e.  $6.16 \pm 0.92 \log_{10}$  cfu/g and Joshi *et al.* (2018), i.e.  $5.2727 \pm 0.0707 \log_{10}$  cfu/g.

Out of 48 pork meat samples, 26 samples were positive for *E. coli* giving overall prevalence of 54.16% which was found to be way higher than the prevalence rate given by Zhao *et al.* (2001), i.e. 16.3% and close to results given by Bantawa *et al.* (2018), i.e. 54%. Presence of *E. coli* indicates the carcass is contaminated by feces of either animal itself or human or the water which has been already contaminated with fecal materials.

Out of 48 pork samples, 6 were found to be positive for *Salmonella* giving overall prevalence of 12.5% which were found to be higher than the results given by Prendergast *et al.* (2009), i.e. 2.6% and Zhao *et al.* (2001), i.e. 3.3% whereas the findings of this study was found to be much lower than that of results given by Bantawa *et al.* (2018), i.e. 34%. These differences may be due to the sample sizes and hygienic practices in different slaughter slabs.

During the research and collection of samples, it was discovered that well and tap water are commonly utilized for carcass washing. It was also discovered that prior to cutting meat from various carcasses, no cleaning or washing of the knives and chopping boards was done. Another problem encountered was flies. Almost all shops had no means of controlling flies. Despite the fact that almost all of the businesses had refrigerated systems, the meat was still kept outside in the open, unprotected from the sun, dust, dirt flies, and other insects. The lack of adequate hygiene practice like using apron and masks were also remarkable characteristics of the shops visited. All these findings showed that there are no well-established conditions in retail meat shops of Kathmandu valley.

## CONCLUSION

Out of 48 pork meat samples, 97.91% were positive for TVC, 83.33% were positive for coliforms, 54.16% were positive for *E. coli* and 12.5% were positive for *Salmonella spp.* Based on the findings, it can be stated that the degree of contamination is at the rejection level in terms of food safety but still there is room for improvement in the practices and sanitation done in slaughtering and processing of pork in Kathmandu valley. There is also the chance of fecal contamination in meat and meat products as a result of unsanitary human practices. Contaminated water used for dressing and washing carcasses, animal feces, the environment, or the butcher's unsanitary procedure could all be sources of contamination.

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## Gender Differentials in Technical Efficiency of Rice Farmers in Jhapa district of Nepal

**Rakesh Acharya and Sushmita Bhatta\***

Agriculture and Forestry University, Nepal  
Corresponding author: agrisushmita55@gmail.com

### **ABSTRACT**

*Rice is the major staple crop in Nepal having higher production potential, but the average yield of rice is very low. The prevailing yield gap may be due to the inefficient use of available resources. This paper consider the gender difference in the technical efficiency of rice production and assess the major factors influencing on technical efficiency. A sample of 44 farmers having male household head and 44 farmers with female household head were selected using simple random technique in 2022. Stochastic production frontier model and Tobit model were used to compute the results. The average technical efficiency of rice production was 76.8 percent ranging from 47.7 to 92.5 percent which revealed the scope of increasing technical efficiency. The farmers with male household head were more technically efficient than with female household head. The majority of the farmers (61.36)having male household head were at higher technical efficiency level of greater than 80 percent while majority of farmers (47.73) having female household head were technically efficient at 60-80 percent. Years of schooling, source of income and membership to cooperatives were found significantly related to technical efficiency score of rice farmers having male and female household head. Rationale use of available resources in efficient manner was seen necessary to optimize the production of rice in the study area rather than developing new technologies. The study recommended that the government and concerned organizations should focus on commercial farming, access to better quality seeds and labor employment to increase the production level improving technical efficiency.*

**Keywords:** Gender, stochastic frontier, technical efficiency, rice, Tobit

### **INTRODUCTION**

Rice is main staple crop and its sufficient production is vital in achieving food security in Nepal (CBS, 2011). In 2018, 5.6 million tons of rice were produced annually in Nepal on 1.49 million ha, with an average productivity of 3.5 t/ha (MoALD, 2018). In Nepal, there is a yearly demand for milled rice of 4.08 million tons (6.56 million tons of paddy), projected against 3.25 million tons of milled rice (5.2 million tons) were produced in 2017. And, 0.75 million tons of milled rice were imported by Nepal in 2019 (TEPC, 2020). For the optimum production and productivity, efficient utilization of input resources is needed which in turn increases the commercialization and competitiveness of agriculture sector

(Mutoko, Hein & Shisanya, 2014; Bhatta, Baral & Datta, 2020). Due to male migration, in most of the places in the country, rice production is dominantly managed by female. Studies have showed 20% to 30% less productivity in female managed farms around the world (Ojo, Baiyegunhi, Abbeam & Ogundeji, 2020). There is no much information available on the difference between male and female managed farms in the country. Hence, this study attempts to find the gender differentials in technical efficiency of rice farms.

## **MATERIALS AND METHODS**

### **Selection of study area**

For the study, Jhapa district was purposely selected. Rice production is highest in the Jhapa district of terai plains. Government implemented project PMAMP is currently in action which declared the first superzone of rice in Jhapa. Arjundhara municipality and Kanchankawal rural municipality were the study sites consulting the agricultural officials and agriculture knowledge center and the local government.

### **Sampling procedure and data collection**

In collaboration with the rice super zone office in Jhapa, a sampling frame of the farmers who grow rice in the study area was obtained. The sample was then chosen from the sampling frame using a simple random sampling approach. The pre-tested interview schedule was used to acquire the primary data, and Key Informant Surveys were also conducted. Additionally, related literature reviews were done to collect the secondary data. 88 samples in total were collected from the research locations for the study which had 44 farmers with male household head and 44 female household head.

### **Data analysis**

MS EXCEL was used to code and enter the obtained data, while SPSS and STATA was used for the data analysis.

### **Econometric model**

The methodology to assess technical efficiency was studied from the book by (Coelli, Rao, O'Donnell, & Battese, 2005). And (Aigner, Lovell, & Schmidt, 1977) considered a Cobb-Douglas production frontier to estimate the stochastic production frontier of the form:

$$Y_i = f(X_i, \beta) + \varepsilon_i$$

Where  $i = 1, 2 \dots n$  and  $\varepsilon_i = (V_i - U_i)$

$Y_i$  represents the  $i$ th farm output,  $f(X_i, \beta)$  is Cobb- Douglas production specification,  $X_i$  are the input vectors for the  $i$ th farm and  $\beta_i$  are unknown production function parameters,  $\varepsilon_i$  represents error term composed of random error ( $V_i$ ) which has zero mean and variance  $N(0; \sigma^2)$ .  $V_i$  is associated with measurement errors and factors which a farmer does not have control over control

(e.g., weather, natural disasters and luck).  $U_i$  is the other component of and it is a random non-negative ( $U_i \geq 0$ ) truncated half normal  $N(0; \sigma^2)$  variable that hinders a certain farm from achieving maximum output because it is associated with farm factors. It measures the shortfall in output from its maximum value given by the stochastic frontier. It is associated with TE and ranges between 0 and 1. The two components  $v$  and  $u$  are also assumed to be independent of each other. This method was used by Bravo-Ureta & Pinheiro (1993); Bi (2004) by estimating the maximum likelihood method. Technical efficiency levels were predicted from the stochastic frontier production function estimation. The technical efficiency score was obtained and categorized in an interval.

Technical efficiency is thus expressed as follows:

$$TE_i = \frac{Y_i}{Y_i^*}$$

where,  $Y_i^* = f(X_i, \beta)$ , the highest predicted output for the  $i$ th farm

The TE of the  $i$ th farm is expressed by the ratio of the observed output to the corresponding stochastic frontier output. The measure of technical efficiency takes a value between zero and one. It measures the output of the firm relative to output that could be produced by a fully efficient firm using the same input vector.

Similarly, we adopted a two-limit Tobit model (Maddala, 1985) to determine the effects of explanatory variables on rice farm efficiencies. Tobit model has been widely used to find the factor affecting technical efficiency (Mukami, 2018). The dependent variable, efficiency score, is censored distribution rather than normal distribution because their efficiency scores are bounded between zero and unity. Using such censored samples in ordinary least square (OLS) estimates gives inconsistent estimation; thus, we used Tobit regression model using the maximum likelihood approach (Tobin, 1958).

Various socio-economic and demographic variables were regressed to determine the factors affecting technical efficiency. The equation of the Tobit model used was;

$$Y_i^* = X_i\beta_i + \varepsilon_i$$

where,

$Y_i^*$  is latent variable for the  $i$ th rice producer farmers (male and female household head) and the values was censored at 0 and 1.  $X_i$  were the explanatory variables used in models,  $\beta_i$  were the estimated coefficient and  $\varepsilon_i$  was the distributed error term which was assumed to be normally distributed at zero mean and constant variance.

In this study, the Tobit model was used as.

$$Y = \beta_0 + \sum_{n=1}^9 \beta_n X_n + \varepsilon_i$$

Where ,

Y = Technical efficiency scores (0-1),  
 $\beta_n$  = Unknown parameters,  
X1 = Age of respondents (in years)  
X2 = Schooling of respondents (in years)  
X3 = Family size  
X4 = Distance to market (km)  
X5 = Experience of respondents (in years)  
X6 = Access of training (0= yes, otherwise 1)  
X7 = Use of credit facility (0= yes, otherwise 1)  
X8 = Source of income (0 = agriculture only, otherwise 1)  
X9 = Membership to cooperatives (0= yes, otherwise 1)  
b0 = Constant  
 $\epsilon_i$  = Error term  
Y = Technical efficiency scores (0-1)

## **RESULTS AND DISCUSSION**

### **Description of variables used in the study**

Description of variables is presented in Table 1. The results of the stochastic frontier production function that was estimated to determine the factors affecting the output of rice production in Jhapa are presented in Table 2.

The estimated model had a log likelihood value of -24.324 and a Wald chi<sup>2</sup> of 46.22, which was strongly significant at 1% level. This shows that the model was correctly specified and that the explanatory variables were collectively able to explain the variations in output level of rice in Jhapa. The value of lambda ( $\lambda$ ) was approximately 1.46 and according to Lema et al. (2016), a value greater than one indicates that the one-sided error term ( $\mu$ ) dominates the random error ( $v$ ). This means that most of the variations in rice yield emanated from farmers' practices as opposed to random variability. Labor, seed and area under vegetable cultivation were found significant to the output quantity of rice. This relation was positive, consistent with the expected sign. Here, with 1% increase in labor (person-days) and seed quantity, the yield quantity of rice was expected to increase by 0.084% and 0.13 % respectively at 10 % level of significance. Labor was employed in every stage of rice farming like planting, land preparation, fertilizer application, weeding, staking, harvesting etc. Better crop management can be possible with more labor force, resulting higher yield. Similarly, improved seed in recommended dose will always increases the production level. Moreover, with 1 % increase in land area under rice production was expected to increase the yield by 0.376%, highly significant at 1 % level of significance. Land is the major factor of production and with increase in this input increases the output. This can also

state the economy of scale. The sum of the elasticity found to be less than one (0.499) confirmed that there was decreasing returns to scale which is in line with (Sapkota, Yadav & Sapkota, 2021).

Table 1. Description of variables used in the study

Variables	Unit	Variable specification	Mean
Output quantity	Kilogram(kg) per hectare	Quantity of vegetable output	2992.33
Efficiency	Scores	Subtract efficiency score from one	0.768
Land	Hectare	Area of land covered by vegetables	1.85
Labor	Person-day/ hectare	Labor (family and hired) used in farms	78.06
Traction/ animal power	Hours/ hectare		14.04
Seed	Gram/hectare		52.69
Chemical Fertilizers	Kilogram/hectare		329.08
Socio-economic variables			
Age	Years	Age of farmer	43.89
Family size	Number	Number of family members	6.06
Years of schooling	Years	Academic years of schooling of farmer	7.99
Years of experience	Years	Total years of farmer working in vegetable farming	10.91
Training	Dummy	0 if farmer have received training, 1 otherwise	0.38
Use of credit facility	Dummy	0 if farmers availed credit, and 1 otherwise	0.53
Membership in Cooperatives	Dummy	0 if farmer involved in farmers' group or cooperative, 1 otherwise	0.57

Distance of market from farm	Kilometer	Distance of farms to markets estimated in kilometer	10.53
Source of income	Dummy	0 if farmer was engaged in only agriculture, 1 otherwise	0.68

Source: Field survey, 2022

Table 2. Stochastic cobb-Douglas production function analysis of rice output in the study area

Variables	Coefficients	Std error	P value
Rice output			
Land	0.376***	0.059	0.000
Seed	0.130*	0.069	0.063
Traction power	-0.028	0.069	0.684
Labor	0.084*	0.050	0.096
Chemical fertilizers	-0.063	0.068	0.358
Constant	7.659	0.590	0.000
/lnsig2v	-2.847	0.464	0.000
/lnsig2u	-2.089	0.656	0.001
Sigma _ v ( $\sigma_v$ )	0.241	0.055	
Sigma _ $\mu$ ( $\sigma_\mu$ )	0.352	0.115	
Sigma 2	0.182	0.060	
Lambda $\lambda$	1.460	0.165	

Source: Field Survey, 2022

Note: \*\*\*,\* indicate significant at 1%, 10% level of significance, respectively.

### Technical efficiency distribution of rice production among gender of household head

From Table 3, it was clear that majority of the rice farmers having male household head (61.36 %) had technical efficiency of greater than 80% and minimum had technical efficiency ranging 40-60 %. In rice production by female household head, the majority (47.53 %) had technical efficiency ranging 60- 80 % and minimum had technical efficiency below 60%.The technical efficiency of rice farmers was categorized on the basis of gender of household head. The mean technical efficiency of rice farmers having male household head was found 0.781 ranging from 0.518 to 0.913. Similarly, the mean technical efficiency of rice farmers having female household head was found 0.763 ranging from 0.477 to 0.925 which was slightly greater than those farmers having male member as head of the family. The overall technical efficiency was found 0.768 which is lesser than Subedi et al. (2020) and more than Boubacar, Hui-qiu, Rana, & Ghazanfar (2016)

Table 3. Technical efficiency distribution of rice production among gender of Household head in the study area

TE	Male HHH		Female HHH	
	Frequency	Percent	Frequency	Percent
0.4-0.6	5	11.36	4	9.09
0.6-0.8	12	27.27	21	47.73
>0.8	27	61.36	19	43.18

Source: Field survey, 2022

Table 4. Summary of technical efficiency of rice production among gender of household head

Particular	TE scores		
	Mean	Minimum	Maximum
Male HH	0.781	0.518	0.913
Female HH	0.763	0.477	0.925
Overall	0.768	0.477	0.925

Source: Field survey, 2022

### **Factors affecting technical efficiency scores in rice farmers among gender of household head**

In order to determine if there were any underlying socioeconomic causes for the efficiencies in rice farms, various explanatory variables were regressed on the efficiency scores of each rice farms having male and female household head differently. There are interesting empirical evidences on the relationship of explanatory variables and efficiencies in rice production. Results showed that in

both the categories of gender of household head, years of schooling, source of income and membership to cooperatives were found to affect the technical efficiency of rice production.

Here, with the increase in years of academic education in schools was positively significant to the technical efficiency scores of rice producers (both male and female household head), significant at 1 % level of significance. Educated farmers are more innovative likely to adopt new technologies more easily and also use the available inputs more rationally to increase the technical efficiency. Similarly, in rice production by farmers having head of the family as male, source of income was found negatively significant to the technical efficiency at 10 % level of significance. Those male household head having income source other than agriculture intended to reduce the technical efficiency in rice production. This may be due to the less time available for the management of crops which reduced the technical efficiency. But female household head having income from other off farm sources increased the technical efficiency. Likewise, in both the gender groups membership to cooperatives were found positively significant to the technical efficiency of rice farmers. Cooperatives help to provide the technical assistance, financial support, introduce new technology and promote innovation which increases the efficiency level of engaged farmers.

Table 5. Tobit regression estimates of factors influencing technical inefficiency scores in rice farmers among gender of household head

TE Variables	Male HHH			Female HHH		
	Coeff	SE	p value	Coeff	Std. Error	P value
Age	-0.001	0.002	0.721	-0.0001	0.001	0.982
Years of schooling	0.014***	0.002	0.000	0.013***	0.002	0.000
Family size	-0.012	0.011	0.313	0.003	0.007	0.658
Distance to market	0.017	0.015	0.258	-0.014	0.012	0.247
Years of experience	-0.001	0.002	0.898	0.001	0.001	0.825
Training	0.015	0.023	0.504	-0.016	0.015	0.318
Use of credit facility	-0.022	0.019	0.283	-0.007	0.014	0.603
Source of income	-0.044*	0.022	0.051	0.072***	0.020	0.001
Membership to cooperatives	0.085***	0.023	0.001	0.030*	0.016	0.074
Constant	0.708	0.086	0.000	0.615	0.067	0.000

Log likelihood	0.000			0.000		
Prob > chi2						

*Source; Field survey, 2022*

Note: \*\*\*, \* indicate significant at 1 % and 10% levels, of significance respectively

### **CONCLUSION**

The average technical efficiency of rice production among male household head farmers was found higher than female household head farmers. The overall technical efficiency reported from stochastic frontier model was about seventy seven percent. This showed that there is ample scope to maximize the production level with existing inputs. Similarly, the study showed that the technical efficiency could be improved by providing the academic education; engaging famers to off farm works without limiting the time for crop management. Also, the farmers should be encouraged to be the member of agriculture related cooperatives to increase the technical efficiency. To increase the income from rice production, better resource allocation and judicious use of existing technology should be given priority. Making better use of existing resources and technologies would be more cost-effective than developing entirely new ones. Government should prioritize increasing the efficiency of its existing resources. Better technical efficiency among farmers would allow them to use inputs more effectively and maximize production, implying profitable business and improves the livelihood of farmers.

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## An Analysis of Resource Use Efficiency of Vegetable Growers in Chitwan district of Nepal

Uma Kiran Rijal<sup>1</sup> and Sushmita Bhatta<sup>2\*</sup>

<sup>1</sup> Himalayan College of Agricultural Science and Technology (HICAST),  
Kathmandu, Nepal

<sup>2</sup> Agriculture and Forestry University, Chitwan, Nepal

Corresponding author: agrisushmita55@gmail.com

### ABSTRACT

*Vegetable farming provides self-employment opportunities that generate income for the upliftment in the rural household economy. This study was done in the Chitwan district of Nepal in 2022 to estimate the cost-benefit ratio and analyze resource use efficiency with the use of marginal value product-marginal factor cost (MVP-MFC) approach. For this, primary data was obtained from a total of 80 vegetable growers with the help of pretested semi-structured questionnaires. The benefit-cost ratio (BCR) of vegetables was found 1.43 indicating that vegetable farming is profitable with every unit spent on production yielding 43 units' profit. Cobb- Douglas production function analysis revealed the positive and significant relationship of land preparation, seed, labor, pesticides, marketing, and fixed costs were found with the gross returns from vegetable production. The return to scale was reported 1.497 indicating increasing return to scale. The resource use efficiency analysis showed that all of the significant variables i.e., land preparation, labor, seed, pesticides, marketing, and fixed cost were overutilized resources. Higher traction power cost, use of high seed rate and low-quality seeds, higher labor cost, frequent occurrence of pests, higher post-harvest losses during the marketing, and inappropriate technology use in offseason cultivation was the reason for over utilization. Thus, this study concludes with the prioritization of efficient utilization of input resources to maximize returns from vegetable farming.*

**Keywords:** Cobb-Douglas, efficient, profitable, overutilization

### INTRODUCTION

The contribution of agriculture sector in Nepalese economy is significant as it shares 25.8% of GDP in fiscal year 2020/21(MoF, 2020). Over the years, agriculture remains the key sector employing majority of the population to enhance the inclusive economic growth and structural transformation of country (NPC, 2019). Though the output share of food crops was found higher, productivity of vegetables was more in Nepal. The ever-increasing demand and limited supply of fresh vegetables had caused the dramatic trade deficit in recent years (CASA, 2020).

Vegetable farming is appealing to farmers due to higher returns from comparatively lesser production cost, gender friendly and easy production technology. It is also considered as the strategic component to improve the rural economy as it provides self-employment opportunities and generates income for livelihood (Shrestha, 2018). In Nepal, vegetable is growing in 284875-hectare land area with overall production of 4196208.8 MT (MoALD, 2020). For instance, vegetable production is increasing due to the dramatic increment in consumption demand. Many government and non-government projects and programs are currently in action for the promotion of this sector in country. In the meantime, ADS has prioritized vegetable value chain for profitable commercialization so as to substitute import scenario (ADB, 2013). Likewise, many production pocket zones are established under Prime Minister Agriculture Modernization Project (PMAMP) and several donor agencies like ADB, USAID, etc., are involved in upliftment of vegetable sector. The major vegetables grown are cauliflower, cabbage, beans, radish, tomatoes, etc., which can be grown in both the growing and off-seasons. Thus, Nepal could exploit the opportunity of comparative advantages of vegetable production and marketing to establish robust export markets. Despite of significant scope and increasing trend of production, there is still yield gap which is ascribed by inefficient input utilization, management practices, climatic conditions and poor adoption of any new and improved technologies. The major problem acquainted by vegetable farmers were ineffective extension services, pest and disease attack, unavailability of quality inputs and weaker market access which was also reported in Akobundu et al., (2004); Pokhrel (2010); Pandit & Basak (2013). These problems resulted in the inefficient vegetable production with higher cost for the produce in the market.

Efficient utilization of input resources is needed for the optimum production and productivity which increases the commercialization and competitiveness of agriculture sector (Mutoko, Hein & Shisanya, 2014; Bhatta, Baral & Datta, 2020). It is crucial to know the allocative efficiency of resources by farmers in order to achieve maximum productivity and profitability (Ohen, Ene & Umeze, 2014). Though there were several studies on resource use efficiency of other agricultural commodities like buckwheat, rice, maize etc., but few on vegetable sector in Nepal. Thus, the aim of this paper was to determine the profitability and resource use efficiency of vegetables production in Chitwan district and suggest policy recommendations.

## **MATERIALS AND METHODS**

Chitwan district of Nepal was purposively selected for the study as it was the potential district in terms of production and productivity of vegetables. Vegetable zone was established under prime minister agriculture modernization project (PMAMP) which also prioritized this district for commercial vegetable production. According to the statistical information on Nepalese agriculture in the year 2020, the total area of vegetable production in Chitwan was recorded 7265 hectares with average production of 95703 MT and productivity was 13.17 MT/ha.

All the vegetable farmers of the study area who sold majority of the vegetable output were study population. The total of 80 vegetable farmers was taken as the sample for the study using simple random sampling technique. The primary data was collected through household survey of vegetable farmers, key informant interview (KII) of related government and non-government officials. We used both structured and semi-structured questionnaires for the survey. Similarly, secondary information was obtained from several government and non-government organization's report, annual agricultural statistical book, newsletters, bulletins and different journals. Those data obtained through the questionnaire survey were coded and entered in MS Excel and analyzed using SPSS and STATA version 12.1.

### **Cost, Return and Profitability**

The variable inputs like traction power for land preparation, labor including family and hired labor, seeds, chemical fertilizers, FYM manure, pesticides, marketing and other cost involved in vegetable farming were all taken at existing market prices for cost of production calculation. We considered both purchased and owned inputs for cost estimation in the study. The major fixed cost accounted were land lease and depreciation on equipment and the plastic house tunnels.

The Total cost is the summation of total variable cost and total fixed cost. The calculation of Gross return was done by multiplying the total volume of individual vegetables sold by their average price.

Profitability of the vegetable was determined by benefit- cost analysis. For this, benefit- cost ratio was calculated using formulae given below.

$$\text{BC ratio} = \text{Gross return (NPR /Kattha)} / \text{Total cost (NPR /Kattha)}$$

### **Production Function Analysis**

To assess the input- output relationship, we used Cobb-Douglas production function. Different studies used this approach to determine the relationship in different commodities.

The Cobb-Douglas production function can be written as below in mathematical form.

$$Y = ax_1^{\beta_1} x_2^{\beta_2} x_3^{\beta_3} x_4^{\beta_4} x_5^{\beta_5} x_6^{\beta_6} x_7^{\beta_7} x_8^{\beta_8} x_9^{\beta_9} e^u$$

Where, Y= Returns from vegetable farming (in NPR per Kattha)

X1 = Land preparation cost per Kattha

X2 = Seed cost per Kattha

X3 = Labor cost per Kattha

X4 = Chemical fertilizer cost per Kattha

X5 = FYM cost per Kattha

X6 = Marketing cost per Kattha

X7 = Pesticide cost per Kattha

X8 = Fixed cost per Kattha

e = Base of natural logarithm

U = Stochastic random error term

Hence, after log transformation, the production function can be written as follows.

$$\ln Y = \ln a + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + \beta_8 \ln X_8$$

### Calculation of return to scale (RTS)

To calculate return to scale in vegetable farming, addition of all coefficients from log linearized Cobb- Douglas production function was added. This sum indicated the nature of return to scale.

$$RTS = \sum b_1, b_2, b_3, b_4, b_5, b_6, b_7 \text{ and } b_8$$

When,

RTS > 1: Increasing return to scale

RTS = 1: Constant return to scale

RTS < 1: Decreasing return to scale

### Resource use efficiency

The ratio of the Marginal Value Product (MVP) of a variable input to the Marginal Factor Cost (MFC) for the input was used to calculate the allocative efficiency.

The formulae for efficiency ratio were given as:

$$r = \frac{MVP}{MFC}$$

Where, MVP = Marginal Value Product

MFC = Marginal Factor Cost

The MVP was calculated with the formula as below:

$$MVP_i = \frac{b_i * Y}{X_i}$$

Where,  $b_i$  = Estimated regression coefficients

Y = Geometric mean of total income from vegetable production

$X_i$  = Geometric mean of  $i^{\text{th}}$  inputs

Decision Criteria  $r = 1$  indicate the efficient use of the resource

$r > 1$  = underuse of the input resource which means gross return could be increased by using more of the resource

$r < 1$  = over use of the input resource which means more use of resource should be decreased to minimize the loss.

## RESULTS AND DISCUSSION

### Socio- economic information of vegetable growers in the study area

The socio-economic information of vegetable growers in Chitwan district was presented in Table 1. The average age of the vegetable farmers was found to be 42.16 years with maximum of 57 years and minimum of 30 years. It showed that aged people were more inclined to the vegetable farming. Likewise, the average

years of experience in vegetable farming was reported to be 9.53. The average years of schooling was 8.1 ranging from 0 to 16 years. Similarly, the average family size was 5.65 ranging from 3 to 9 members in the family. The average number of male members (3.2) was more compared to the female members (2.45). Economically active population was the population which falls between the age group of 15 to 59 years. In the study area it was 4.49. The average land area which was occupied for vegetable production was 0.92 hectare. Lastly, the distance of vegetables market from the production site was 19.2 kilometers (km).

Table 1. Socio- economic information of respondents in the study area

Particulars	Mean	Minimum	Maximum
Age (years)	42.16	30	57
Experience (years)	9.53	1	20
Years of Schooling	8.1	0	16
Family size	5.65	3	9
Male members	3.2	1	5
Female members	2.45	0	4
Economically active	4.49	1	6
Farm size (hectare)	0.92	0.17	3.32
Distance to markets (km)	19.2	3	85

*Source: Field survey, 2022*

### **Cost, returns and Profitability**

The average variable cost of production for vegetable cultivation was found NPR. 20511 per Kattha per year and average fixed cost of production was NPR.4914 which gave average benefits of NPR 37392 per Kattha per year. The gross margin and net margin from vegetable farming were found NPR 16881 and NPR 11966 per Kattha per year. The overall BC ratio was reported to be 1.43. This showed that vegetable farming was profitable to farmers in the study area. This result is in line with the Gurung et al. (2012); Dhakal et al. (2015); Shende & Meshram (2015); Mariyono (2017); Verma, Agrawal, Tamrakar & Tiwari (2018); Subedi, Kalauni, Khadka & Kattel (2020); Gaire & Dahal (2021).

### **Production function analysis**

Table 2 displays the overall descriptive statistics of the variables that were incorporated into the model. To determine the impact of various factors on the gross return of vegetable production in the study, a Cobb-Douglas production model was used. The independent variables included in this model were cost of land preparation, seed, labor, chemical fertilizers, FYM, pesticides, marketing and fixed cost. The regression model obtained for vegetable production is presented in Table 3.

Table 2. Description of the variable used in the Cobb-Douglas model for production function analysis

Variables	Description of variables	Mean	Std. Dev	Min	Max
In vegetable returns	Total annual household income from vegetable farming (in NPR)	10.10	0.53	7.91	11.72
Independent Variables					
In land preparation cost	Cost of land preparation per Kattha	7.74	0.70	5.03	9.06
In seed cost	Cost of Seeds per Kattha	7.42	0.63	6.43	10.74
In labor cost	Cost of labor per Kattha	8.23	0.99	4.45	9.59
In chemical fertilizer cost	Cost of chemical fertilizers per Kattha	6.75	0.62	5.72	8.97
In FYM cost	Cost of FYM per Kattha	7.46	0.66	5.28	9.57
In marketing cost	Cost of marketing per Kattha	6.44	2.71	0	9.26
In Pesticide cost	Cost of pesticides per Kattha	7.04	0.72	5.81	9.57
In Fixed cost	Cost of fixed cost (land rent and depreciation) per Kattha	8.36	0.58	6.21	9.72

Source: Field survey, 2022

The Adjusted R<sup>2</sup> value of the estimated model for vegetable production was 0.6122. This means 61.22% of the variation is due to the explanatory variable used in the model. The model had an excellent fit since the F ratio was highly significant. Positive coefficients were present for all major explanatory factors.

Cost for land preparation, seed, labor, pesticides, marketing and fixed cost were found positively significant to the returns from vegetable production. In the similar study, these variables were also found positively related to output quantity of vegetables which ultimately had effect on returns (Shrestha, Huang & Ghimire, 2014; Shrestha, Huang & Pradhan, 2017; Shrestha, 2018; Asfaw, 2021). From the table, cost of land preparation, seed and labor was highly significant to the vegetable returns at 1% level of significance. In every 1% increase in cost of land preparation, seed and labor, there is increase in returns from vegetable farming in 0.269, 0.203 and 0.153 % respectively. Use of tractor and animal power while preparing land for vegetable cultivation was found necessary to increase the production. Similarly, with increase in seed cost using improved seed and in recommended doses increases the returns from vegetable farming. And, intensive crop management practices employing a greater number of labors were seen necessary for more returns.

Along with this, cost for pesticides, marketing cost and fixed cost were significant to vegetable returns in 5 % level of significance. With every 1% increase in pesticidal cost, marketing cost and fixed cost, returns to vegetable farming

increases by 0.16, 0.174 and 0.068 % respectively. Diseases and pest were the major problems reported in vegetables of Chitwan district. So, to increase the production and returns, we need to use pesticides to counter the disease and pest attack. Similarly, lesser the marketing channel and access to wider markets increases the returns. Fixed cost included land lease and purchase of farm equipment. Cultivation of vegetables in large scale in more rented land utilizing modern technologies also helps in increasing vegetable returns.

### Return to scale

All the coefficients of explanatory cost variables were added to calculate return to scale which was found to be 1.5 indicating increasing return to scale in vegetable production (Table 3). This showed that an increase in the input costs would increase the return from vegetables relatively in higher amount. In general, an additional proportion of output is slightly greater than the additional proportion of inputs employed. The result was in contrast of (Anim, Thaba & Tshikororo, 2015).

Table 3. Production function analysis of vegetable production in study area

ln_ vegetable returns	Coeff	Std. Error	T	P> t
ln_ land preparation cost	0.269	0.662	4.06***	0.000
ln_ seed cost	0.203	0.747	2.71***	0.008
ln_ labor cost	0.153	0.418	3.66***	0.000
ln_ Chemical fertilizer cost	-0.057	0.789	-0.72	0.472
ln_ FYM cost	0.562	0.659	0.85	0.397
ln_ Pesticide cost	0.160	0.658	2.44**	0.017
ln_ marketing cost	0.033	0.014	2.29**	0.025
ln_ fixed cost	0.174	0.068	2.58**	0.012
Constant	2.418	0.769	3.15***	0.002
<b>Sum of elasticities</b>	1.497			
<b>F value = 16.59</b>				
<b>Prob &gt;F = 0.0000</b>				
<b>R- squared = 0.6515</b>				
<b>Adjusted R Square = 0.6122</b>				

Source : Field survey, 2022

Note: \*\*\*, \*\* indicate significant at 1%,5% level of significance respectively.

### Resource use efficiency

Resources are employed effectively when the allocative efficiency (MVP/MFC) equals to 1 or the marginal value product (MVP) equals the marginal factor cost (MFC). Since all resources were expressed as an additional rupee spent on certain input resources, the marginal factor was taken to be one. The expected increase in

gross income from the addition of one unit of that resource while retaining the same quantity of other resources was used to compute MVP.

The resource use efficiency ratio was highest for marketing cost (0.54) followed by land preparation cost (0.35) and seed cost (0.28), as shown in Table 4. This showed that expenses on marketing, land preparation and seed would result in more returns in vegetable farming. More clearly, in every additional rupee spent on these variables would result in the returns of 0.54, 0.35 and 0.28 respectively. Moreover, all of the variables were found overutilized showing that the use of resources as not efficient.

Table 4. Allocative efficiency of vegetable production in the study area

Variables	Coeff.	GM	MVP	MFC	r	Remarks
ln _ land preparation cost	0.269	1.309	0.35	1	0.35	Overutilized
ln_ seed cost	0.203	1.364	0.28	1	0.28	Overutilized
ln _ labor cost	0.153	1.236	0.19	1	0.19	Overutilized
ln _ pesticide cost	0.160	1.440	0.23	1	0.23	Overutilized
ln _ marketing cost	0.033	16.442	0.54	1	0.54	Overutilized
ln _ fixed cost	0.174	1.209	0.21	1	0.21	Overutilized

*Source: Field survey, 2022*

## CONCLUSION

The objective of this study was to analyze the resource use efficiency of vegetable production in Chitwan district of Nepal. Benefit- cost analysis showed that vegetable farming is profitable in study area with ample scope of higher returns in future. The production function analysis revealed that cost for land preparation, seeds, labor, pesticides, marketing and fixed cost was positively significant to the returns from vegetable farming. Similarly, return to scale was reported higher than 1 i.e., 1.497 showing increasing return to scale. Then, the ratio of resource use efficiency showed that all of the significant variables were overutilized. This indicates that spending more on land preparation, seeds, labor, pesticides, marketing and fixed (rental and depreciations) would yield less returns. The study suggests for the farm- level policy which is directed to the availability of custom hiring service to farmers to reduce excessive traction cost for land preparation. Along with this, extension service to suggest recommended seed rate, pesticidal doses is seen important in study area. Concerned authorities like PMAMP- vegetable zone in Chitwan must focus on establishment of collection centers to reduce post-harvest losses and hence lowered marketing cost. The RUE of fixed cost which also includes depreciation on plastic tunnels and equipment was found below unity which showed problem in off season production technology and marketing strategies. Thus, policies to strengthen the offseason production and marketing from state level are important for robust vegetable faming business in Chitwan district.

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