EFFECT OF LOCALLY AVAILABLE ORGANIC MANURES ON THE GROWTH AND YIELD OF POTATO IN BAJHANG DISTRICT

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ABSTRACT

Potato (Solanum tuberosum L.) is one of the significant food crops of the high hill and mountain region of Nepal. The field experiment was conducted during the month of Feb-June, 2023 at Talkot Rural Municipality-1, Bajhang district of Nepal. In the hilly region, farmers commonly use farmyard manure (FYM) in their potato crop as compared to other organic manures like goat manure, poultry manure, compost, etc. Thus, this study was carried out to investigate the effect of locally available organic fertilizers on the growth and yield of potato var. Desiree. The experiment was laid out in randomized complete block design with five treatments viz. T_1: control (without organic manure), T_2: poultry manure, T_3: farmyard manure, T_4: goat manure, and T_5: compost, and each treatment was replicated four times. The recommended dose of chemical fertilizers as recommended by government of Nepal was applied in all the treatments. There were no significant differences among the treatments on plant height and leaf number in potatoes except for the plant height at 60 days of planting. Plant height was found to be the highest in the plots treated with poultry manure followed by compost manure & goat manure. Statistically, the different treatments did not show significant variation in yield. However, the highest tuber yield was obtained from compost manure followed by poultry manure, goat manure, farmyard manure, and control. Application of compost manure yielded 37.6 t/ha potato tuber which is 19.69% greater than the control which yielded 30 t/ha only. Similarly, the result concluded that the application of goat manure obtained the highest net benefit among all other organic manures in the study area.

***Keywords**: canopy diameter, local manure, marketable tuber, nutrient availability, sustainable*

INTRODUCTION

Potato (*Solanum tuberosum* L.) is an annual herbaceous plant belonging to the nightshade family Solanaceae having chromosome number (2n=4X=48) originated from Peru (Mishra, 2018) which is one of the most important tuber crops in the world (Zewide et al., 2018). Potato is the most important crop in the world ranking fourth position after rice, wheat, and maize in terms of human consumption contributing to global food requirements (FAOSTAT, 2016). It is one of the widely cultivated staple food crops of Nepal that ranks in 2nd position after rice in terms of consumption and 4th position after rice, wheat, and maize in terms of production, and 1st in terms of productivity (MoALD, 2022). However, it is grown in all 77 districts of Nepal. Jhapa, Kavre, Illam, Morang, Makwanpur, Nuwakot, Solukhumbu, Bardiya, Bara, and Saptari are the top potato-producing districts of Nepal. It is the major tuber crop grown in all agroecological zones allowing year-round cultivation in Nepal.

Potato is one of the most nutritious and most diversified crops. Therefore, potato can be a good option to improve the health and nutrition factor of the rural population and are considered more productive than major cereals and have a higher economic value than cereals (Bajracharya & Sapkota, 2017). It is one of the necessary cash crops grown in 198,788ha of land with the production of almost 3,325,2311 tons/ha (MoALD, 2022) aiding both the food and nutritional security of Nepalese people. It is a cool season crop that requires low temperature, low humidity, and bright sunny days for proper growth and development.

Potato is a subsistence crop and is very popular among farmers, playing a larger role in National GDP. It contributes about 6.57% and 2.17% in AGDP and GDP, respectively. Potatoes Contribute to National Food Security by Providing Grain-Based Supplements and the diet and its production possibilities and productivity are higher as compared to other grains (Baral et al., 2021). The main obstacles in potato production are lack of irrigation facilities, insufficient information on chemical fertilizer use, insufficient amount of fertilizer, lack of availability of quality seed tubers, lack of available fertilizers at the right time and affordable price, shortage of labor, poor market, lack of technical knowledge on pest management and topographical barriers are major ones (Phulara et al., 2021). The trend of increasing population around the world results in increasing pressure on food production and food security. Potato is one of such crops that produces far more calories per hectare than any other cereal crops and no other crop can produce as much food per unit of land as the potato, making it the most efficient crop in terms of both energy and food production. Therefore, potatoes could be the most crucial crop in the upcoming years for ensuring food security (Sood et al., 2017).

The availability of chemical fertilizer is limited in this area and the cost of the chemical fertilizer is high increasing the cost of production for the farmer and making the smallholder farmer unaffordable to buy the fertilizer. So, there is a vital need to investigate sustainable alternatives, and organic farming, particularly the use of local manure has drawn interest as a potential solution. Farmers use only farmyard manure in their potato fields despite the availability of other organic manures viz. goat manure, poultry manure, compost, etc. So, this research is needed to evaluate the locally available organic manures viz. goat manure, poultry manure, compost, etc. on the growth and yield of potatoes. The result may convince farmers to use different organic fertilizers in potato crops, hence reducing the demand for farmyard manure. This study will assess the level of farmer's adoption of effective nutrient management practices influencing their production trend through locally available organic fertilizers. It may help the farmers to adopt environment-friendly and economically viable production/farming practices for small-scale farmers utilizing the existing knowledge of organic fertilizers ensuring high agricultural productivity and sustainable agricultural practices.

MATERIALS & METHODS

Experimental site

The field experiment was carried out at the farmer's field during the Spring season at Talkot Rural Municipality-1, Bajhang district of Sudurpaschim Province. Geographically, the study area is located at the latitude: 29.6174 North and longitude: 81.3218 East with an elevation of 2927.44 m asl. The soil is sandy loam type, and the climate is subarctic, with dry winter and cool summer receiving annual precipitation of 268.3 mm (DHM, 2023). The yearly average temperature is 23.35˚C with an average relative humidity of 80%.

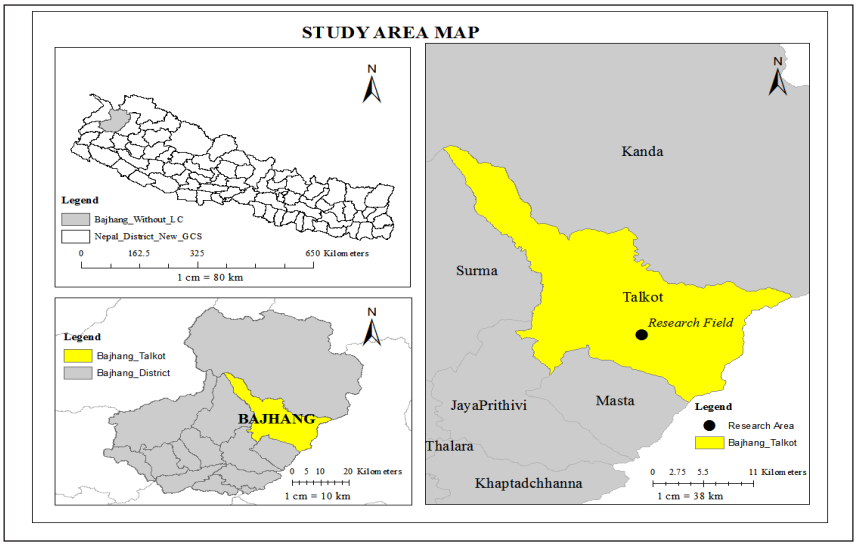

Figure 1. Map of the experimental site

Experimental design

The experiment was started in February 2023. The experiment was conducted in Factorial Randomized Complete Block Design (RCBD) with five treatments and four replications. The total area for the field experiment required was 99.6m^2. The treatments were allocated based on the amount of goat manure, poultry manure and farmyard manures commonly used by farmers, whereas compost manure was applied as recommended by government of Nepal. Basal application of recommended dose of chemical fertilizers were applied @100:100:60 kg NPK/ha in all the treatments through Urea, Di ammonium phosphate and Muriate of Potash respectively.

Table 1. Details of treatments used in the experiment during 2023

Treatment	Treatment combination	Fertilizer	Dose per plot
T_1	Without use of any organic manure	Control	No organic manure
T_2	Locally available broiler manure from poultry farm @ 10 ton/ha	Poultry Manure	3 kg/plot
T_3	Locally available manure from cowshed of farmer @ 20 ton/ha	Farmyard Manure	6 kg/plot
T_4	Locally available manure from goat shed of farmer @ 6 ton/ha	Goat Manure	2 kg/plot
T_5	Manure from PMAMP office @ 20 ton/ha	Compost	6 kg/plot

Observations taken

Soil and manure sample test

The composited soil samples and organic manure samples were sent to the Soil and Fertilizer Testing Laboratory, Sundarpur, Kanchanpur for analysis. Some physical and chemical properties of soil collected from a depth of 15-20cm soil depth before the application of fertilizer were analysed. The nutrient content of all organic manure was analysed in the soil laboratory.

Data collection of biometrical, yield attributes and yield parameters:

Data was taken at 35 DAP and 60 DAP from the sample plant and subsequent data was taken up to 90 days at 15 days intervals.

Leaf number:

Leaf numbers per plant was taken at 60 DAP, 75 DAP, and 90 DAP by counting the number of properly developed leaves of the plant.

Plant height (cm):

Plant height data was collected at 60 DAP, 75 DAP, and 90 DAP measuring from the base of the plants to the apex with the help of inch tape.

Yield and yield attributing traits:

Every tuber was counted to collect the number of tubers data and the potato tuber was weighed with digital weighing balance to measure tuber weight and total tuber yield and recorded at the time of harvest.

Economic analysis:

It helps to decide whether the use of locally available organic fertilizers is economically viable or not for potato production in the Bajhang district. The cost per kg for compost, farmyard manures, goat manure and poultry manure used in the analysis was Nrs. 20, 15, 16 and 16 respectively.

Benefit-cost analysis:

The benefit-cost analysis of different treatments was calculated by using the formula:

BC ratio = Gross Return / Cost of Cultivation (Total Variable Cost)

Statistical analysis:

The variance for all parameters was analyzed using Microsoft Excel and R-Studio statistical analysis system. All the analyzed data was subjected to Duncan's Multiple Range Test (DMRT) for mean comparison. A 5% level of significance was considered for ANOVA.

RESULTS AND DISCUSSION

Data on initial fertility status of soil

Table 2. Soil analysis results for physical and chemical properties of soil

Soil Properties	Soil depth (cm)	Soil texture	Organic Matter (%)	pH	N%	P(kg/ha)	K (kg/ha)
Value	15-20	Sandy-loam	4.64	7.1	0.23	23.84	244.8
Result	_	_	Medium	Neutral	High	Low	Medium

Report from Soil and Fertilizer Testing Laboratory, Sundarpur, Far Western Province, Nepal

Nutrient content of organic manures used in the experiment

The nitrogen content in the organic manures varied widely with the highest in farmyard manures, with was slightly greater than the compost fertilizer brought from the market, showing that the use of compost is farm better than using the compost, available in the nearby markets. Similarly, the potassium content in FYM is quite higher, which could be due to use of ash from the kitchen in the farmyard manure pit.

Table 3. Nutrient content of different organic manures used in the experiment in percentage

Nutrients / Characteristics	FYM	Poultry Manure	Goat Manure	Compost
Moisture (%)	74.62	27.82	39.22	71.52
pH	8.3	7.26	9.10	6.2
Organic Carbon (%)	45.55	34.39	32.58	36.66
N (%)	5.71	2.35	2.28	5.35
P (%)	0.2	0.07	0.08	0.17
K (%)	4.9	2.64	3.5	1.97
C: N ratio	7.97:1	14.63:1	14.28:1	6.85:1

Biometrical observations

Plant height (cm)

Plant height was affected by different organic fertilizers which is presented in Table 4. Statistical analysis of the data showed that the plant height was significantly affected by treatments at 60 days but at 75 days and 90 days, plant height is not significantly affected by different organic fertilizers. The data showed that the maximum plant height was recorded in poultry manure i.e., 29.47cm followed by goat manure i.e., 27.25 cm, and the minimum plant height was recorded in farmyard manure i.e., 22.39cm in 60 days. While in 75 and 90 days the maximum plant height was observed in the plot having compost manure i.e., 37.08 cm and 42.33 cm while minimum plant height was observed in farmyard manure. Since potato performs well at soil pH between 5 and 6.5. According to the soil and nutrient analysis result, the soil pH of the experimental site was neutral at 7.1 and the pH of the compost was 6.2. When compost was incorporated into the soil,

organic acids may have been released during the microbial decomposition process. These organic acids may have neutralized the soil alkalinity, resulting in a slight decrease in the pH of the soil that is suitable for potatoes (Adekiya et al., 2020). Hence, the compost-treated plots got the highest plant height. But application of farmyard manures, poultry manures and farmyard manures had higher pH value, which might have increased soil alkalinity, leading to smaller plant heights.

Table 4. Effect of locally available organic manures on the plant height in Bajhang district

Treatment	Plant height 60 DAP (cm)	Plant height 75 DAP (cm)	Plant height 90 DAP (cm)
Control	27.58[a]	31.96	34.74
Poultry manure	29.47[a]	34.32	38.32
Farmyard manure	22.39[b]	27.06	30.29
Goat manure	27.25[a]	33.64	37.35
Compost	28.14[a]	37.08	42.33
Sem (±)	1.48	2.52	3.29
LSD value	4.572	7.768	10.138
F-test (0.05)	*	Ns	Ns
CV (%)	11	15.37	17.98
Grand mean	26.97	32.81	36.61

*Note: Sem (±): Standard Error of the mean, LSD: Least Significance Difference, CV: Co-efficient of Variance, ns: non-Significance, * significant difference at 0.05 level of significance.*

Number of leaves per plant

The number of leaves was found to be non-significant at 60DAP, 75 DAP, and 90 DAP among the treatments. Among the observations, the highest number of leaves was observed in poultry manure as compared to goat manure, compost, farmyard manure, and control. The number of leaves was found to be the highest i.e., 36.78 when poultry manure was applied followed by control at 60 DAP. Similarly, at 75 days and 90 days the highest number of leaves was found in plots treated with compost in comparison to other plots followed by goat manure during both periods. Though non-significant the lowest number of leaves was observed in farmyard manure during all growth stages, due to slow release of nutrients from farmyard manure as compared to all other manures and compost used in the experiment. Besides, farmyard manure had high pH and was applied in huge amount as compared to other organic manures, the increased pH of soil could have

hindered nitrogen uptake leading to lesser number of leaves, as compared to other organic manures. Moreover, it has been reported that high soil pH, the solubility and availability of micronutrient cations decreases due to adsorption-precipitation reactions (Alam et al., 1999). Research stated increase in the growth of plants especially the number of leaves in the added chicken manure and cow dung plots due to greater nutrient uptake than in the other plots (Ahmed et al., 2019), as the mineralization of N from poultry manure is higher and quicker as compared to farmyard manure (Amanullah et al., 2006), which support the results.

Table 5. Effect of locally available organic manures on the number of leaves per plant in Bajhang district

Treatment	Number of leaves 60 DAP	Number of leaves 75 DAP	Number of leaves 90 DAP
Control	34.72	42.75	47.06
Poultry manure	36.78	42.11	47.31
Farmyard manure	27.75	40.25	46.03
Goat manure	32.75	48.28	52.94
Compost	30.53	48.53	58.03
Sem (±)	2.24	4.05	5.09
LSD value	6.89	12.48	15.71
F-test (0.05)	Ns	Ns	Ns
CV (%)	13.76	18.25	20.29
Grand mean	32.51	44.38	50.27

Note: Sem (±): Standard Error of the mean, LSD: Least Significance Difference, CV: Coefficient of Variance, ns: non-Significance.

Tuber quality and yield

The yield of potatoes was not significantly affected due to use of different organic manures, at 5% level of significance. The highest yield was obtained in compost manure (37.6t/ha) whose weight of marketable tuber is 33.33t/ha and unmarketable tuber weight is 4.27t/ha. The total number of tubers obtained on the compost manure applied plot is 297 which is the highest number of tubers harvested per plot, followed by the goat manure with 33.03t/ha and 295 number of total tubers per plot. The lowest yield was obtained from control at 30.02 t/ha with 26.87t/ha of marketable tuber weight and 3.3t/ha of unmarketable tuber weight. The total number of tubers obtained from the control is 273. The least number is obtained from farmyard manure i.e., 262, owing to lesser growth in plant height and leaf number, as observed in the tables 4 and 5. Though the improved

variety of Desiree was used in the field. At the harvesting time, a mixed tuber was observed concluding that the seed used was of low quality affecting the yield of the potato. Diseases and poor seed quality can also affect potato yields (Kooman & Haverkort,1995). When soils are treated with other manure of a high C: N ratio immobilization of soil nutrients occurs which could be the cause of the reduced development and yield in plots treated with other manures compared to those treated with poultry manure (Adekiya et al., 2020). In contrast to previous findings, the potato could not perform well in other organic manure than compost due to the immobilization of soil nutrients. The lower yield of tuber in the plots treated with farmyard manure could be attributed to slow release of nutrients in the early growth stages of the crop leading to lesser canopy cover as shown by lesser number of leaves and plant height at all growth stages, as observed in table 4 & 5.

Table 6. Effect of locally available organic manures on the yield of tuber in Bajhang district

Treatment	Total number of tubers per plot	Total tuber yield (t/ha)	Weight of marketable tuber (t/ha)	Weight of unmarketable tuber (t/ha)
Control	273	30.02	26.87	3.3
Poultry manure	295	34.03	30.23	3.7
Farmyard manure	262	30.97	26.57	3.77
Goat manure	279	33.03	28.47	4.37
Compost	297	37.6	33.33	4.27
Sem (±)	21.92	0.77	0.75	0.12
LSD value	67.55	2.36	2.32	0.36
F-test (0.05)	Ns	ns	Ns	Ns
CV (%)	15.59	15.42	17.27	19.85
Grand mean	281.23	9.95	8.73	1.16

Note: Sem (±): Standard Error of the mean, LSD: Least Significance Difference, CV: Coefficient of Variance, ns: non-significance

Economical production of potato/ Benefit cost analysis of potato production

Local markets determine price premiums, although the premium for organic fresh market products typically costs around 55% more than conventional (The New Farm, 2007). The current study revealed that the study region is suitable for using commercial organic fertilizer in a potato production system. Economic analysis showed the highest gross benefit from compost followed by poultry manure and goat manure respectively. As

compost was the most expensive fertilizer among all, the net profit was lower than other treatments except farmyard manure. Among all, the highest B: C ratio was observed in goat manure, making it the most profitable form of input for short duration crop like potato. The least net benefit was observed in the farmyard manure treatment, as a result of lower yield making it a less profitable among all. Since, farmers mostly use their own farmyard manures in their field and that too at greater amount, due to its availability in most of the farming households, it could be sustainable practice contributing to succeeding crops. But, as per the economic analysis, the use of farmyard manure containing higher moisture content is not profitable, when considered for production of potato in one season, if it is to be purchased like other fertilizers in the study area. Since, farmyard manure contains more moisture and hence has to be applied at higher doses than goat manure or poultry manure, the input cost of this fertilizer is higher.

Table 7. Cost of cultivation, gross benefit, net benefit, and B: C ratio of different organic fertilizers

Treatment	Cost of Cultivation (NRs./ha)	Gross Benefit (NRs./ha)	Net Benefit (NRs./ha)	B: C Ratio
Control	933333.3	1509799	576465.6	1.62
Poultry manure	1100000	1701042	601041.7	1.55
Farmyard manure	1253333.3	1548446	295112.8	1.23
Goat manure	1006666.7	1651476	644809	1.64
Compost	1333333.3	1880104	546770.8	1.41

Correlation and regression analysis

Pearson's correlation coefficient was analyzed between different variables. Positive correlation was observed between potato yield, plant height, and number of leaves per plant respectively.

Table 8. Correlation between Plant heights, Number of leaves per plant, and Potato yield

	Plant Height at 90 DAP	Total Yield	Number of Leaves per Plant at 90 DAP
Plant Height at 90 DAP	1		
Total Yield	0.631979	1	
Number of Leaves per Plant at 90 DAP	0.56378	0.491237	1

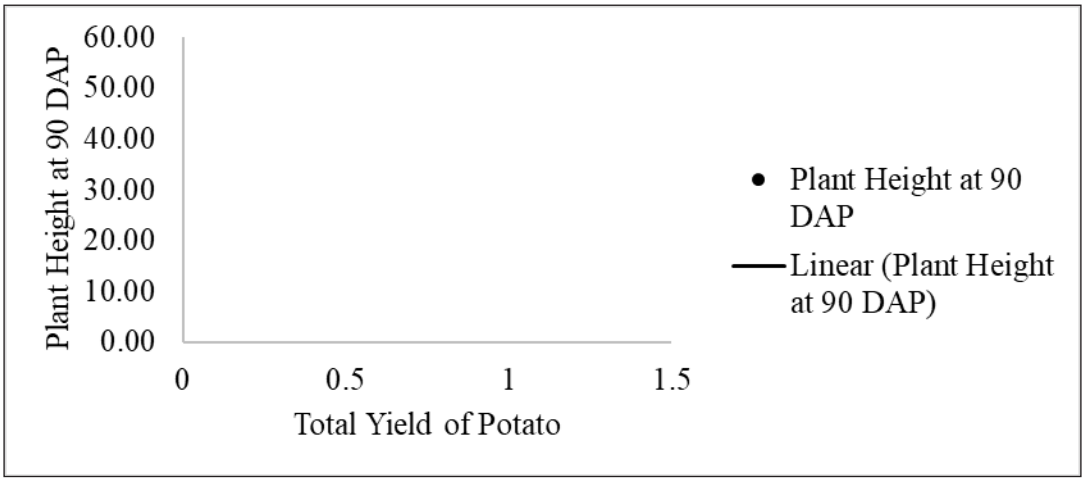

Figure 2. Estimated linear relationship between plant height at 90 DAP & total yield of potato

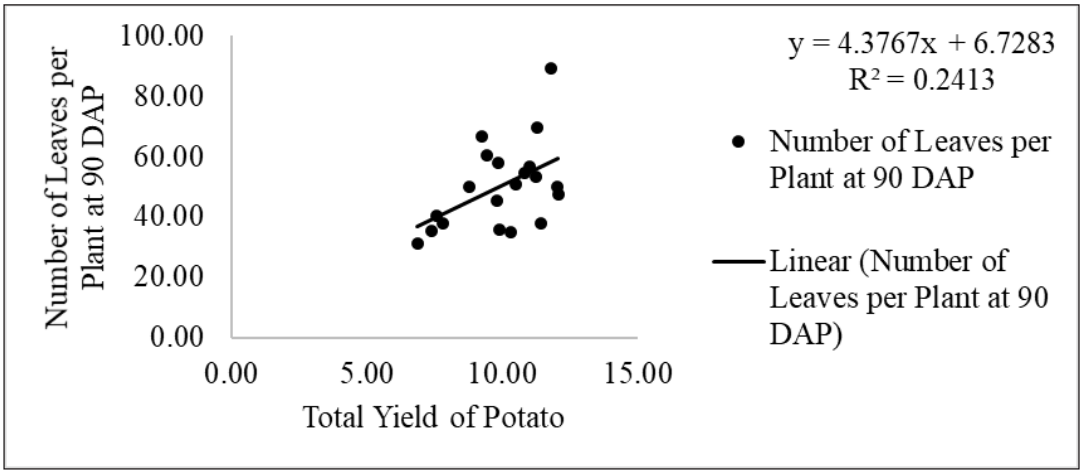

Figure 3. Estimated linear relationship between number of leaves per plant at 90 DAP & total yield of potato

CONCLUSION

Among different organic manures and fertilizers tested in the study, application of compost fertilizers yielded relatively higher number of tubers and marketable yield, but with higher cost of production, making it the most expensive one. But application of farmyard manure showed poor performance in growth and yield of potato and hence, could not generate much profit from potato production, due to the huge amount of associated cost for purchase, owing to its higher moisture content and slow nutrient release nature. However, farmers might get higher yields from the succeeding crop due to huge amount of farmyard manures applied in potato, making the potato based cropping system more

resilient in the mid hills of Nepal. But, considering a single growing season and the same environment, application of 6t/ha goat manure along with basal dose of recommended chemical fertilizer is profitable and hence is recommended to the mid hill farmers of Far Western Province.

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