Effect of Different Combinations of Manures and Fertilizers on Growth and Yield of Potato (*Solanum tuberosum* L.) Variety Khumal Seto in Bajhang, Nepal [1]

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Abstract

A field experiment was conducted considering different fertilizers and their combination at Bitthadchir Rural Municipality- 2 Syandi, Bajhang district of Nepal during Feb-June, 2024, to find their effect on potato var. Khumal Seto. The field was laid out in randomized complete block design with the treatments: Farmers' practice (T_1), Farmyard manure (T_2), Goat manure (T_3), Poultry manure (T_4), Compost manure (T_5), Panchagavya (T_6), & Farmyard manure + 50% RDF (T_7), which were replicated thrice. Chemical fertilizers were applied as recommended by the government in all the treatments except farmers' practices. The statistical analysis revealed significant variations among the treatments in days to sprouting, number of branches, and plant heights at 90 DAP at 5% level of significance. Plant height was found to be the highest in poultry manure followed by farmyard manure, and compost manure, with the lowest in farmers' practice. Plant height obtained from panchagavya was statistically similar to that obtained from goat manure. There was no significant difference in the yields among different treatments, except the marketable tuber weight, which was significantly highest in poultry manure. An increase in yield by 33.35, 26.06, and 22.09 percentage were observed in poultry manure, compost manure, and goat manure respectively, when compared to farmers' practice. Considering both the quality and quantity of potato, poultry manure could be suggested for profitable potato production in the study site.

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Introduction

Potato (*Solanum tuberosum* L.), a non-grain tuber crop belonging to the Solanaceae family, cultivated in 125 countries, is consumed daily by over a billion people worldwide. In terms of human consumption, it is the world's fourth most significant food crop after rice, wheat, and maize (Islam et al., 2021). Freshly harvested potatoes contain water 75 to 80%, carbohydrates 16 to 20% crude protein 2.5 to 3.2%, true protein 1.2 to 2.2%, mineral matter 0.8 to 1.2%, crude fats 0.1 to 0.2%, crude fiber 0.6% and different vitamins also contain a fair amount of essential amino acids such as isoleucine, leucine, and tryptophan (Reddy et al., 2018).

Nepal's total area, production, and productivity are 198,256 ha 3,410,829 mt, and 17.20 mt/ha. Potato production exhibits significant potential and a wide range of opportunities in the Sudur Paschim Province, with a production area and productivity of 16,554 hectares 262,655 metric tons, and 15.87 respectively (Ministry of Agriculture and Livestock Development [MoALD], 2023). Potato contributed 5.52 percent to AGDP and daily per capita consumption increased from 16.44 kg in 1961 to 86 kg in the fiscal year 2021/22 (Khadka et al., 2023). Bajhang, one of the districts of Sudur Paschim Province, had 1,545 hectares under potato crop which produced 22,866 metric tons with a productivity of 14.80 metric tons per hectare in the fiscal year 2021/22(MoALD, 2023).

The low production of potatoes in Nepal can be attributed to a variety of factors, lack of irrigation, proper storage facilities improved technology for combating biotic and abiotic stresses coupled with poor nutrient management have limited the production and productivity of potatoes in the mid and high hills of Nepal. FYM has been the only source of organic fertilizer used by many farmers despite having other sources of organic manures. Also, the availability of chemical fertilizer is limited in the mid-hills and high hills of Nepal, and even if available, it is unaffordable by smallholder farmers for application in potatoes (Upadhyay & Timilsina, 2020). As potato crops have a less developed shallow root structure, they require a lot of nutrients as compared to other crops in the upper zone of the soil. Since huge amounts of soil nutrients are depleted, the loss of nutrients in the soil is alarming (Bhujel et al., 2021). The haphazard amount and application of chemical fertilizers negatively impact the texture and structure of the soil, reducing the amount of organic matter in the soil, and inhibiting microbial activity due to soil toxicity (Ferdoushi et al.,2010). The various types of organic manure like poultry manure, cow dung, cattle manure, compost, farmyard manure, etc. are not only readily available to the farmers but are also environment friendly. The addition of such manure in the soil can increase the activity of microorganisms, improve soil fertility, and boost crop productivity. Therefore, the application of organic manure is widely increasing these days to sustain agricultural production (Islam et al., 2021). Therefore, it has been suggested that using well rotten animal dung may contribute to improved vegetative growth and higher tuber output (Mama et al., 2016). The organic matter essential for any agricultural soil is 4%. However, almost 60% of cultivable land contains organic matter of less than 1%, which can reduce the crop yield significantly (Sikder et al., 2017). Hence, to test the effect of different organic manures and compare each of them with farmers' practice on potato growth and yield, the study was conducted.

Materials and methods

A field experiment was conducted from the 2nd week of February to the 2nd week of June 2024 at Syandi-02, Bitthadchir Rural Municipality, Bajhang district, Sudur Paschim Province, Nepal, on potato. The study site is located at the latitude: 29°32'11"N, longitude 80°47'42"E at an elevation of 2,027.68 masl. The experimental field had clay loam soil having 6.6 pH, 4.71% organic matter, 0.24% N, 19.03% phosphorous and 437.83% potassium and the design used in the study was Randomized Control Block Design (RCBD). Seven treatments consisting of combination of different organic manures and fertilizers along with farmers' practice were considered in the study. Each treatment was replicated three times, hence requiring 21 plots. The size of each plot was 2m x 2.4m with the space between each plot of 0.5 m and the space between each replication was 1m.There were 32 plants in a plot from which ten representatives' plants from each plot were selected randomly and tagged for regular observations. The total area of the field experiment was 158.4 m^2. The Khumal Seto-1 variety of potato was used in the study.

All the organic manures used in the experimental field like FYM, Poultry manure, and Goat manure @ 20 mt/ ha, and fertilizers at recommended dose @100:100:60 kg NPK per ha. Half a dose of Nitrogen, a full dose of Phosphorus and Potassium was applied during planting and the remaining half of Nitrogen was applied at the time of earthing up. Farmers' practice did not use any chemical fertilizers, which only used farmyard manure. Panchagavya was prepared by mixing 1 kg of cow dung and 100 gram of cow ghee in the plastic container thoroughly in the morning and evening and allowed incubation for 3 days under shade. One litre of cow urine and water was added in it and left for 15 days with regular mixing both in morning and the evening hours. After 15 days cow milk of 1 litre, cow curd of 500 gm and jaggery of 500 gm were added. The content was stirred twice a day both in the morning and evening. The Panchagavya stock solution was ready after 30 days and was applied @30ml/liter water. The physicochemical properties of all organic manures, shown in table 1, was analysed in Sundarpur soil and fertilizer testing lab, Kanchanpur. Panchagavya was analyzed using wet dilution method, which showed 0.81% Ca, 1.15% Mg, 5.45mg/ml Zn, 0.64mg/ml Cu and 46.22% Fe. Panchagavya had slightly acidic pH (5.24). Earthing up was done at 50 and 80 DAP. By using the furrow method of irrigation, the field was irrigated at 40, 55, 75 and 90 DAP. Data on growth parameters were recorded on the field at 45, 60, 75, and 90 DAP. The recorded data were tabulated in MS Excel, analyzed using R-Studio and discussed relating to different researches.

Table 1

Physico chemical properties of different organic manures used in the study

Treatment	Farmyard manure	Goat Manure	Poultry Manure	Compost	Panchagavya
Moisture(%)	76.54	62.36	21.94	28.00	-
pH	8.32	7.48	6.64	6.50	5.24
Organic carbon (%)	21.70	16.83	12.92	10	56.84
N (%)	2.88	2.35	1.13	1.50	0.18
P (%)	0.70	0.63	0.67	1.02	0.04
K (%)	1.87	2.93	1.34	1.50	0.20
C: N ratio	-	7.1:1	11.4:1	20:1	-

Results and discussion

Phenological and yield parameters

Days to sprouting

Days to sprouting varied significantly among the treatments when observed at 5 % level of significance. Early sprouting was found in the farmers' practice while late sprouting was found in poultry manure i.e. at 36.33 days. The farmer's practice observed faster sprouting than other treatments use of raw farmyard manure has been shown to facilitate quicker sprouting due to its ability to enhance soil fertility and moisture retention. This results in a more favorable environment for seed germination and early plant growth (Lin et al., 2018). Goat manure was statistically at par with Panchagavya which exposed sprouts earlier than poultry manure. Potato tuber sprouted at 35.67 days from goat manure applied plots followed by Panchagavya (34.67 days).Compost manure and Panchagavya application were statistically at par with farmyard manure with RDF. A report stated that compost manure enhances soil organic matter, which improves soil structure, water-holding capacity, and nutrient availability, while Panchagavya, a fermented organic fertilizer, contains growth-promoting substances and beneficial microorganism that stimulate plant growth and nutrient uptake (Lin et al., 2018). Farmer's practice aided the sprouting of tubers to reach 80% plant population within the plot, i.e., 32.67 days, as compared to other organic manures and inorganic fertilizers among the treatments, as it showed the lowest mean days (34.81 days).

Table 2

Days to sprouting of potato tuber as influenced by combination of different manures and fertilizers

Treatment	Days to Sprouting	
	Days to1st Sprouting	Days to 80% Sprouting
Compost manure + RDF	24.67^{abc}	34.67^{b}
Farmers practice	22.67^{c}	32.67^{c}
Farmyard manure + RDF	24^{bc}	35.00^{ab}
Farmyard manure +50% RDF	23.33^{bc}	34.33^{bc}
Goat manure + RDF	25^{ab}	35.67^{ab}
Panchagavya+ RDF	25.33^{ab}	34.67^{b}
Poultry manure + RDF	26.67^{a}	36.67^{a}
SEm (±)	0	0.57
CV%	4.68	2.86
F test	*	*
$LSD_{0.05}$	2.04	1.77
Grand mean	24.52	34.81

Note: DAP: Days after Planting, SEm: Standard error of the mean, LSD: Least significant difference, CV: Coefficient of variation, NS: non-significant, *: Significant at 5% level of significance.

Plant height

According to the analysis of variance in Table 3, there was no significant difference ($p<0.05$) in the plant height affected by different manures and fertilizers. The increased height of the plants observed in compost manure applied plots during the initial growth stage (45 DAP) can be attributed to the slow and steady release of nutrients from the compost and the supply of essential elements for plant growth as the improved soil structure and water holding capacity provided by the compost create an optimal environment for plant growth, leading to increased plant height in the early stage (Bernal et al., 1998).The Panchagavya treatment showed the lowest plant height at 45 days because there was no spray of Panchagavya before the 45 days, so no available plant nutrients.At 90 DAP, Poultry manure treatment resulted in significantly higher plant height (75.76 cm) than other treatments, showing that poultry manure was more effective on the growth of plants in locations with high nitrogen, low phosphorus, and high potassium content in the soil. Lowest plant height (58.08 cm) was observed in the farmers practice plot as there was no use of any other additional fertilizers. The combined treatment of farmyard manure with 50% RDF resulted in smaller plant height than poultry manure but higher than farmers' practice and Panchagavya treatments. The smallest plant height in farmers' practice might be due to low phosphorous content in the soil, leading to poor growth of the plant, whereas the highest plant height in poultry manure might be due to the appropriate pH achieved due to the application of poultry manure having a pH value of 6.64. This might be also due to poultry manure contained significant amount of organic materials due to the manure and bedding material, litter can also affect soil pH and liming due to the different levels of calcium carbonate in poultry feed (Amanullah et al., 2007).The application of five and ten tons per hectare of poultry manure to the soil medium constantly increased plant height, stem girth, internode length, number of leaves, and branches (Ndubuaku et al., 2015).

Table 3

Plant height of potatoes as influenced by combination of different manures and fertilizers

Treatment	Plant height (cm)			
	45 DAP	60 DAP	75 DAP	90 DAP

Compost manure + RDF	33.57	49.94	62.40	67.40abc
Farmers' practice	32.77	45.75	53.57	58.08c
Farmyard manure + RDF	31.02	52.00	65.37	70.51ab
Farmyard manure +50% RDF	28.42	45.81	56.52	62.20bc
Goat manure + RDF	32.00	47.40	58.68	65.16bc
Panchagavya + RDF	27.37	44.87	58.21	64.86bc
Poultry manure + RDF	30.45	49.66	67.88	75.76a
SEm (±)	1.72	2.74	3.15	3.10
CV%	9.71	9.93	9.04	8.11
F test	NS	NS	NS	*
LSD0.05	5.32	8.47	9.72	9.56
Grand mean	30.80	47.92	60.37	66.28

Note: DAP: Days after Planting, SEm: Standard error of the mean, LSD: Least significant difference, CV: Coefficient of variation, NS: non-significant, *: Significant at 0.05 level of significance.

Number of leaves

The highest number of leaves (16.39) was recorded from compost manure and farmer practices whereas the lowest number of leaves was recorded in Panchagavya (12.93) at 45 days after planting. Panchagavya showed the lowest number of leaves because Panchagavya was applied after that. The maximum number of leaves was recorded under poultry manure (60.03) and the minimum numbers of leaves (44.20) in the farmers practice plot.

Table 4

The number of leaves of potatoes as influenced by combination of different manures and fertilizers

Treatment	Number of leaves			
	45 DAP	60 DAP	75 DAP	90 DAP
Compost manure + RDF	16.39	31.15	49.57	54.90
Farmers' practice	15.37	26.97	39.87	44.20
Farmyard manure + RDF	13.77	30.22	49.03	56.60
Farmyard manure +50%RDF	13.03	27.44	42.8	48.33
Goat manure+ RDF	14.3	32.21	47.3	54.03
Panchagavya+ RDF	12.93	27.34	41.63	47.90

Poultry manure+ RDF	13.3	25.98	50.77	60.03
SEm (±)	0.82	1.86	2.58	3.82
CV	10.13	11.13	9.78	12.68
F test	NS	NS	NS	NS
$LSD_{0.05}$	2.55	5.75	7.98	11.79
Grand mean	14.15	29.05	45.88	52.28

Note: DAP: Days after Planting, SEm: Standard error of the mean, LSD: Least significant difference, CV: Coefficient of variation, NS: non-significant

Though statistically non-significant the highest number of leaves observed in the farmer practice, after compost manure at 45 DAP, might be due to the immediate availability of nutrients from raw farmyard manure, which promoted rapid vegetative growth in the initial stage. However, farmers' practice could not generate a greater number of leaves at later growth stages as compared to other treatments (Rasool et al., 2023). The nutrient contents in compost manure were 1.5% N, 1.02% p, and 1.50% K which resulted in maximum number of leaves. Poultry manure did not provide adequate nutrients during the early phases of growth, resulting in the fewest leaves at an early stage. Excessive application of poultry manure has been reported to cause imbalances of nutrient and correspondingly reduction in germination leading to stunted growth especially during the early stages of plant establishment (Lin et al., 2018).

Number of stems per plant

The number of stems per plant showed non-significant differences among all the treatments. At 45 DAP highest number of stems per plant (4.2) was observed in farmyard manure and the lowest number of stems per plant was found in the farmers practice (3.26).The application of nutrients does not increase the number of stems. This may be because the stem number depends upon storage conditions, the physiological age of seed tuber of a particular variety, and tuber size, all of which are not greatly impacted by mineral nutrition (Lynch et al., 1995). The number of stems per plant is directly related to the number of sprouts in the seed tuber and is independent of the treatment given. The number of eyes on the tubers determines the numbers of sprouts and thus stems density (Koroto, 2019).

Table 51

The number of stems per plant of potato as influenced by combination of different manures and fertilizers

Treatment	Number of stems per plant			
	45 DAP	60 DAP	75 DAP	90 DAP
Compost manure + RDF	3.63	4.20	4.20	4.20
Farmers' practice	3.27	3.50	3.50	3.50
Farmyard manure + RDF	4.20	4.33	4.33	4.33
Farmyard manure +50% RDF	3.90	4.23	4.23	4.23
Goat manure + RDF	3.80	3.80	3.80	3.80
Panchagavya+ RDF	3.53	3.60	3.60	3.60
Poultry manure + RDF	3.73	3.87	3.87	3.87
SEm (±)	0.25	0.28	0.28	0.28
CV%	11.78	12.44	12.44	12.44
F test	NS	NS	NS	NS
LSD0.05	0.78	0.86	0.86	0.86
Grand mean	3.72	3.91	3.91	3.91

Note: The treatment means followed by common letters in same column does not significantly differ from each other based on DMRT at 5% level of significance.

Table 6

The number of branches per plant potato as influenced by combination of different manures and fertilizers

Treatment	Number of branches per plant		
	60 DAP	75 DAP	90 DAP
Compost manure + RDF	4.97	8.53abc	8.90abc
Farmers' practice	2.90	5.833d	6.50c
Farmyard manure +RDF	3.30	9.40ab	9.06ab
Farmyard manure +50% RDF	3.20	6.06cd	6.53c
Goat manure + RDF	3.53	7.73bcd	7.96abc
Panchagavya+ RDF	2.73	6.40cd	6.70bc
Poultry manure + RDF	4.83	10.76a	10.16a
SEm (±)	0.74	0.83	0.81
CV	35.24	18.41	17.54
F test	NS	**	*
LSD0.05	2.28	2.56	2.49
Grand mean	3.63	7.81	7.97

Note: DAP: Days after Planting, SEm: Standard error of the mean, LSD: Least significant difference, CV: Coefficient of variation, NS: non-significant, **: Significant at 5% level of significance, *: Significant at 5% level of significance.

Number of branches

The highest number of branches (4.96) was recorded in compost manure with the lowest from Panchagavya i.e., 2.73 at 60 DAP. The plant height and leaf number were observed higher in compost manure which also resulted in a higher number of branches at 60 DAP. Enhanced nutrient availability and improved growth conditions might have increased branching, linking to increased plant height as increased by organic amendments like compost manure, which stimulated the branching in crops (Hughes et al., 2020). But at 75 and 90 DAP; highest number of branches (10.16) was recorded in poultry manure and minimum number (6.50) in farmers' practice. A result reported the highest number of branches in poultry manure and the lowest in control treatment which had the lowest number of branches in per plant(Ratna et al., 2016). The nutrients in the manure might have assisted the rapid development of healthy leaves and roots that went deeper into the soil thus, providing potatoes with an abundance of building blocks and water (Murugalatha et al., 2018). Panchagavya contains a variety of vitamins, macronutrients, micronutrients, amino acids, vitamins, growth regulators such as Auxins and Gibberellins, and beneficial microorganisms such as pseudomonas, acetobacter, phosphobacteria, etc (Alias, 2017) which resulted in the higher number of branches per plant compared to farmer's practice.

Yield and yield attributing parameters

Total tuber number per plant

There was no significant difference among the treatments regarding the total tuber number per plant. However, numerically the highest number of tubers per plant was observed from farmer's practice, i.e., 22.84and the lowest number of total tubers per plant was recorded from Panchagavya i.e., 17.03.The heavy foliage and vegetative growth promoted by the application of Panchagavya can lead to reduced combined division towards tuber formation, resulting in a lower number of tubers per plant (Rana & Deepanshu, 2023).Farmers' practices yielded higher total tuber production but resulted in a lower percentage of marketable tubers due to the presence of smaller, unmarketable tubers, which can be attributed to the selection of seed tubers and management practices employed(Luitel et al., 2021).The application of poultry manure and compost manure resulted in fewer but larger tubers compared to the control treatment, which might be due to the nutrient composition and release patterns of these organic amendments (Singh & Kushwaha, 2006).

Yield of potato (ton/ha)

Statistically, there was no significant difference among the treatments in yielding tubers at a 5% level of significance. However, the effect shown by each treatment was numerically different, which can impact the benefits. The highest yield was recorded from poultry manure followed by compost manure, goat manure, farmyard manure, and Panchagavya respectively. The lowest yield of potatoes was recorded from farmers' practice with a 20.74 t/ha difference between the poultry manure and the farmer's practice. 33.34% and 26.06% increases in yield were observed in poultry manure and compost manure respectively as compared to the control. Farmers' practices yielded higher total tuber production but resulted in a lower percentage of marketable tubers due to the presence of smaller, unmarketable tubers, these results are in accordance with (Luitel et al., 2021). The higher yield in poultry manure might be due to increased plant height, leaf number, and branch count per plant, as is observed from the correlation with the yield. The higher yield observed with poultry manure compared to other manures can be attributed to its soil and manure test report was optimal pH of 6.64, high nutrient content (1.13% N, 0.67% P, 1.34% K), and its ability to improve soil structure, which enhanced nutrient availability and root penetration (Nguyen, 2010). Similarly, neutral pH of 6.6, high nutrient content 0.24 % Nitrogen, 437.83 kg/ha Potassium and low Phosphorus 19.03 kg/ha was reported in the soil of experimental field (Soil and fertilizer lab, Sundarpur, Kanchanpur) which might be the reasons for higher yield.

Table 7

The yield of potato tuber as influenced by combination of different manures and fertilizers

Treatment	Tuber Yield of potato	
	Total tuber number per plant	Total tuber yield (t/ha)
Compost manure +RDF	18.23	56.06
Farmers' practice	22.84	41.45
Farmyard manure + RDF	20.37	51.99
Farmyard manure +50% RDF	17.38	46.84

Goat manure + RDF	18.07	53.20
Panchagavya +RDF	17.03	46.98
Poultry manure + RDF	18.27	62.19
CV	15.54	13.51
F test	NS	NS
LSD0.05	5.22	12.32
Grand mean	18.88	51.25

Note: LSD: Least of significance difference, CV: Coefficient of variation, NS: non-significant

Table 8.The quality of potato tuber as influenced by combination of different manures and fertilizers

Treatment	Tuber Quality			
	Marketable tuber number	Marketable tuber weight (g)	Unmarketable tuber number	Unmarketable tuber weight (g)
Compost manure + RDF	9.43	613.09ab	8.73	111.67
Farmers' practice	9.10	360.14c	15.47	178.09
Farmyard manure + RDF	9.17	620.74ab	10.87	128.65
Farmyard manure +50% RDF	8.01	549.48b	7.67	88.74
Goat manure + RDF	8.83	616.90ab	9.23	101.14
Panchagavya + RDF	7. 67	493.62b	9.37	132.22
Poultry manure + RDF	10.53	734.72a	7.73	89.32
SEm (±)	0.68	40.98	1.66	32.86
CV	13.14	12.46	29.13	48.02
F test	NS	**	NS	NS
LSD0.05	2.09	126.27	5.11	101.28
Grand mean	8.96	569.81	9.86	118.54

Note: DAP: Days after Planting, SEm: Standard error of the mean, LSD: Least significant difference, CV: Coefficient of variation, NS: non-significant, **: Significant at 5% level of significance, *: Significant at 5% level of significance.

Quality of potato tuber

Marketable tuber number

The highest marketable tuber number per plant was found in poultry manure i.e., 10.53, followed by compost manure, i.e., 9.43, and the lowest from Panchagavya, i.e., 7.67. Similarly, the highest unmarketable tuber number was found in farmer's practice, i.e., 15.47. The lowest number of unmarketable tuber numbers was found in farmyard manure + 50% RDF (7.67).The higher marketable tuber number in poultry manure applied plots can be attributed to the balanced nutrient supply and reduced pest infestation, which had promoted the development of well-sized, high-quality tubers (Amara & Mourad, 2013). The availability of essential nutrients in Panchagavya was 0.18 % N, 0.04 % P, and 0.2 % K which resulted in higher foliage than underground parts. The increased development of root and shoot compared to the underground parts has been reported by the use of Panchagavya (Somdutt et al., 2021), which resulted in the lowest number of marketable tuber number in Panchagavya. In farmers' practice, they use raw farmyard manure in the field, which does not provide appropriate nutrients to the plant. The number of marketable and unmarketable tubers is significantly influenced by soil conditions because raw farmyard manure may not provide adequate nutrients for optimal tuber development, leading to variations in yield quality and quantity (Lin et al., 2018).

Marketable and unmarketable tuber weight per plant

The highest marketable tuber weight per plant was recorded in poultry manure, with 734.72 gm followed by compost manure, farmyard manure, and goat manure respectively. The lowest marketable weight per plant was recorded in farmers' practice with only 360.14 gm. As Belay (2019) reported application of increasing poultry manure from 0 t/ha to 5 t/ha resulted in a higher marketable tuber yield. Similarly, the highest unmarketable tuber weight per plant was recorded in farmer's practice, farmyard manure, Panchagavya, and compost manure respectively and the lowest unmarketable weight per plant was recorded by poultry manure. The small size and larger number of tubers per plant in farmers' practice due to the lower tuber growth rate, led to the highest unmarketable tuber weight per plant, which was also reported in a study (Ahmed et al., 2019). Using poultry manure and compost manures significantly increased the yields of marketable tubers as a result of higher leaves, plant height, and branches. In poultry manure content is 11.4:1 C:N ratio, 6.64 pH, and 12.92% organic carbon. The significant increase in the yields of marketable tubers from the use of poultry manure and compost manures can be attributed to improved soil nutrient availability and better plant growth conditions, as these amendments enhance leaf development, plant height, and branching due to their favorable C: N ratios and moisture retention capabilities lead to healthier plants that produce large sizes and a greater number of tubers. Studies have reported significant increases in marketable tuber yield in poultry manure applied fields (Rees et al., 2014).

Correlation analysis of the growth and yield components

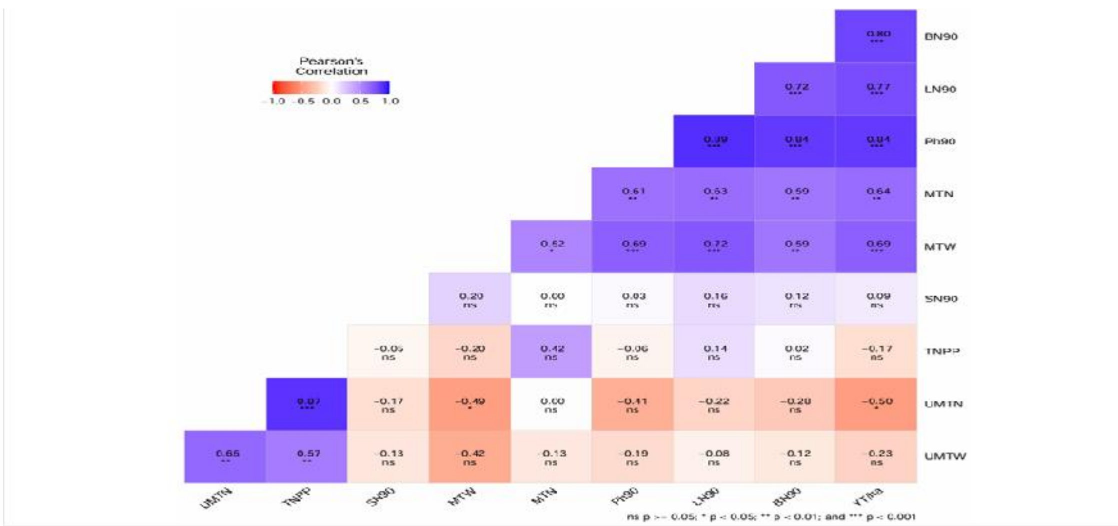

Figure 1. Correlation analysis of growth and yield components

In the current study, it was noted that total there is a strong and positive correlation between total tuber yield and the following factors: marketable tuber number (r=0.64**), plant height (r=0.84***), leaf number (r=0.77***), branch number(r=0.80***), marketable tuber weight (r=0.69***). The relationship between these parameters can be explained by the fact that an increase in plant height leads to higher photosynthesis, resulting in a higher total tuber yield. This result is consistent with that of Tekalign and Hammes (2005) they observed that a rise in stem numbers significantly increased tuber numbers and total tuber production per unit area of land, as well as plant height and total tuber yield, showing that both parameters have a positive relationship.

Conclusion

Among different nutrient management practices tested in the study, farmers' practice could not generate good yield due to poor growth of potatoes. The use of panchagavya showed growth promoting effect, which was statistically similar to that of goat manure. Among all the organic manures and fertilizers tested in the study, application of poultry manure along with recommended dose of chemical fertilizer improved the growth, quality and yield of potatoes, making this combination highly profitable. Hence application of poultry manure is suggested over all organic manures in clay loam soil of Bajhang district, for increasing the quality and quantity of potato tubers. But, further study of this combination on potato quality and yield as well as soil-pest dynamics is suggested at different location for sustainable production in Bajhang district.

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