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Effect of Manures and Fertilizers on Varieties of Lentil at Tikapur, Kailali

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Abstract

Lentil, key exported pulse crop of Nepal has huge scope of improving its productivity in far western province, with slight modification in input use. To study the effect of different fertilizers on growth and yield of two commonly grown varieties of lentil, an experiment was conducted in Tikapur Kailali at Agronomy farm of Far Western University by using factorial RCBD. The factors considered were a. Varieties (Local masuro and Khajura masuro-2) and b. Organic fertilizers (farmyard manure, vermicompost, panchagavya and Control-no organic fertilizers). The results revealed no significant differences in most of the parameters except for shoot length, root length and days to flowering between the two commonly grown varieties compared in the study. Statistically, Khajura masuro-2 showed greater shoot length, smaller root length, and early flowering than local variety. Significant delay in maturity was observed with application of Panchagavya, followed by vermicompost which was statistically similar to farmyard manure. Statistically higher pod count per plant and grains per plant were observed with vermicompost over all the applications. The Control yielded significantly smaller length of shoot and correspondingly lesser grain yield indicating the importance of organic applications for improved growth and yield of lentil.

Keywords : Farmyard manure, Grains per pod, Panchagavya, Root length, Vermicompost

Introduction

Lentil (*Lens culinaris*), commonly known as *Masoor*, *Masuro* or *Musuro*, occupies special place in the cropping system as well as in the diets of Nepalese people. Also called a cousin of the bean (Neupane et al., 2020), this highly nutritious grain legume crop is grown for its protein (26%) rich seeds, which also contains 60% carbohydrate, 1.3% fat, 2.1% minerals, 3.2% fibers along with essential nutrients like potash, calcium, phosphorous, iron, zinc and vitamin B complex (Ali et al., 2012; Samaranayaka & Khazaei, 2024) and essential linoleic and oleic acids (Zia-Ul-Haq et al., 2011). Being the cheap source of proteins in the diets of many, this grain legumes is also called poor people's meat (Venkidasamy et al., 2019). This winter season legume is mostly cultivated as relay crop with paddy or as a sole crop after the harvest of paddy in Nepal, and contributes greatly to the economy.

Nepal ranks sixth among the top 10 countries producing lentil in the world, which are Canada, India, Australia, Turkey, Russian Federation, United States of America, Bangladesh, China & Kazakhstan (FAOSTAT, 2024). In the year 2022, this crop was grown in 198454 ha land, which produced 252283 mt. contributing 1.88% to agriculture gross domestic product of Nepal (MoALD, 2023). This crop is highly commercialized grain legumes of Nepal which shares 58.39% of the total area and 59.01% of total pulses' production, and is preferred by the consumers of Nepal (AITC, 2024). In the year 2023, Nepal imported 65,693,717 kilograms of lentils (both split and unsplit) worth 6,794,741,000 rupees, and exported 3,383,446 kg at 498,122,000 Nepalese rupees. Nepal imported approximately 19.41 times more lentils compared to its imports (DoC, 2024).

Apart from its nutritional benefits and contribution to economy, this crop acts as a barrier to disease cycle, can tolerate drought to some extent Gupta et al. (2019) and fixes 23.0–86.8 kg/ha atmospheric nitrogen in soil (Kebede et al., 2021). Hence, this crop could be a part and parcel for healthy farming system in both the plain areas of mid and far western provinces of Nepal. Despite these, this crop is grown in marginal and rainfed soil with low inputs and poor management practices, and faces several biotic and abiotic stresses with sudden outbreak of pests and diseases. Besides the situation is aggravated by low seed replacement rates, use of poor-quality seeds, unnecessary use of chemical fertilizers in preceding crop, and lesser use or no use of organic materials in lentil field. Recent data shows decrease in area, production and productivity of the crop by 12.82%, 20.41% & 8.70% as compared to last year i.e. 2078/79 (AITC, 2024). One of the major causes of lesser productivity of lentil could be attributed to poor or no use of organic manures and fertilizers leading to degradation in quality of soil needed for proper nitrogen fixation.

There are organic manures and fertilizers like farmyard manures, goat manures, vermicompost, bio-fertilizers and bio-tonics, which are cheaper and can be applied in

grain legumes for improving soil fertility and ultimately increasing their productivity in Nepal. But due to lack of availability of these organic manures for minor crop like lentil, farmers seldom use these in grain legumes. The use of biofertilizers, botanicals, and bio-tonic like Panchagavya has been reported to improve the yield of field crops (Patel et al., 2021). Panchagavya, an organic blend of cow milk, ghee, curd, dung, and urine, has been reported to increase soil minerals, stimulate plant growth, and improve disease resistance in plants through its nutrients, vitamins, growth-promoting substances and beneficial microorganisms (Behera et al., 2024). But in Nepal, this cheaper and easier alternative to organic manures and fertilizers, has received limited attention in research and extension. Hence, to compare the efficacy of panchagavya with farmyard manure and vermicompost, this experiment was conducted in two common varieties of lentil in Kailali district.

Materials and Methods

Experiment site

This field study was carried out during November 2023 to March 2024 to study the effect of organic manures and panchagavya on lentil varieties at Agronomy Farm, Far Western University, Tikapur. The rice-wheat cropping system prevails in the area, and this year, lentil was grown after the harvest of paddy instead of wheat. Geographically, it is situated at 28^0 32'26" N latitude and $81^0$07'23" E longitudes at an elevation of 158 masl. The experimental site had warm tropical climate and sandy loam soil having neutral pH of 6.7 with low available organic matter (1.04 %), available nitrogen (0.06 %) and phosphorous (15.71 kg/ha), with medium amount of available potassium (118.28 kg/ha). The average maximum and minimum temperatures during the experiment period were 24.40^0C and 10.78^0C respectively. The temperature at experimental site reached up to 32.5^0C on 25 March and 1.5^0C on 25 January. The site received 43.81mm precipitation, with the highest on 4 March (13.2 mm) (DHM, 2024).

Experiment set up

The design used in the study was factorial RCBD and the factors considered in the study were Variety (V_1: Tikapur Local Masuro, V_2: Khajura Masuro-2) and Organic fertilizers (F_1: Control; F_2: Farm yard manure; F_3: Vermicompost and F_4: Panchagavya). Altogether there were 8 treatments, each replicated thrice. The plot receiving individual treatment was 2.0 m × 3.0 m ($6m^2$) size. The distance between treatments were maintained at 0.5m, whereas that between replication was maintained at 1 m. The land was prepared using power tiller, harrowing was done twice and application of nitrogen, phosphorous and potash were applied as basal dose through Urea, DAP and MoP, as practiced by farmers (20:20:20 kg NPK/ha). Application of organic manures and fertilizers were done as per the treatments (Table 1). On November 30th, seeds were sown continuously in 8 lines made 25cm apart in each plot. Thinning was done 10 days after

germination to maintain the spacing of 25cm x 5cm. Irrigation was done three times at 60, 75 and 100 days after sowing, immediately after taking data.

Table 1

Treatment details

Treatments	Details
Factor A (Varieties)	
Local Masuro	Common among farmers requiring 115-125days to reach maturity
Khajura Masuro-2	Recommended for terai of mid and far western region (Dang to Kanchanpur,100-700masl) having 2.1t/ha productivity, and 134 days maturity
Factor B (Organic Fertilizers)	
Control	Farmers' practice/ no organic manures or fertilizers
Farmyard manure	@6t/ha one week before sowing
Vermicompost	@4t/ha at the time of sowing
Panchagavya	@3% solution foliar spray 45, 70 and 80 DAS (Rawal et al 2024)

Panchagavya was acidic in nature with 4.13 pH, which had nearly Ca (1.25%), Mg (1.53%), Zn (6.56 mg/ml), Fe (41.6 mg/liter) and Cu (0.86 mg/ml). Panchagavya contained 0.18%, 0.04% and 0.43% nitrogen, phosphorous and potassium respectively whereas the farmyard manure contained 16.51 %, 0.61% and 2.93% nitrogen, phosphorous and potassium respectively with 16.51% organic carbon and 16.6:1 C:N ratio. But vermicompost contained 17.89% organic carbon and 21.8:1 carbon nitrogen ratio along with 0.82% nitrogen, 1.0% phosphorus and 2.40% potash.

Observations

Data were recorded from randomly selected 10 plants for shoot length, root length, branch number, days to flowering and maturity at 60, 75 and 100 days after sowing. The days to 50% flowering (when at least 50% of plants have at least 1 fully open flower) and physiological maturity (when 90% of the plants in a plot have turned golden brown with fully filled pods) was recorded form the entire plot. During the harvest, the yield attributing traits like pod counts per plant, grains per plant^{-1}, grains/pod, 1000 grain weight were recorded from randomly selected 10 plants whereas the grain and biological yields were recorded from 1m^2 area, with which harvest index was calculated.

Statistical analysis

For studying the treatment effects on different parameters, ANOVA table was

prepared for each parameter and DMRT was done to compare treatments means at 5% level of significance. For this, R studio version 4.3.0., package "doe bioresearch" was used.

Results and Discussion

Shoot Length

The height of the plant recorded from base to the tip of the plant were statistically at par for both the varieties at 60, 75 days after sowing and at harvest ($p \leq 0.05$). However, Khajura masuro-2 was statistically superior over local variety of lentil in shoot length expression at 100 days after sowing. The result is in line with the findings by Pokhrel et al. (2022), who showed increased plant height in Khajura masuro over other masuro genotypes. Similarly, the results revealed significant difference among the shoot lengths with the application of different organic fertilizers, over the control at all stages of lentil growth. The tallest plant was observed where panchagavya was applied followed by vermicompost and farmyard manures at 60 and 75 DAS, revealing the positive effect of panchagavya during early growth stage of the crop. This might be due to the growth promoting hormones like Auxins, Gibberellins and beneficial microorganisms contained in Panchagavya (Sarma and Talukdar, 2024), resulting in increasing shoot lengths of the lentil. Ramesh et al. (2021) also reported increased height of lentil crop with the application of panchagavya. Kumar et al. (2011) reported growth promoting effect of panchagavya in black gram crop over recommended dose of chemical fertilizer. At 60 DAS, application of panchagavya showed 4.54 % and 9.15 % increase in plant heights, which was statistically superior over vermicompost and farmyard manure respectively. However, plant heights were statistically at par for all the organic fertilizers, when used thereafter. The result showed statistically smallest shoot length from the control, which highlighted the importance of using organic fertilizer for increased plant heights. Addition of organic manures has been reported to improve the soil physical, chemical and biological properties, which improves the nutrient uptake by the plants (Aziz et al., 2010). This result corroborates with the findings of Rakesh et al. (2017) who reported increase in plant height with the application of 3% panchagavya over control in okra (*Abelmoschus esculentus*). Ali et al. (2011) also reported increased plant height of chilli, green gram and mustard with application of panchagavya over control. There was no notable interactions between variety and fertilizers on shoot length.

Table 2

Effect of varieties and fertilizers on shoot length of lentil at Tikapur, Kailali.

Treatments	Shoot length (cm)			
	60 DAS	75 DAS	100 DAS	At harvest
Factor A (Varieties)				

Local	9.33	14.91	33.32[b]	37.73
Khajura Masuro 2	9.61	15.36	34.32[a]	38.75
SEm(±)	0.11	0.20	0.31	0.35
F test	Ns	Ns	*	Ns
Factor B (Fertilizers)				
Control	8.78[c]	14.30[b]	32.41[b]	35.88[b]
FYM	9.28[b]	15.21[a]	34.21[a]	39.02[a]
Vermicompost	9.69[ab]	15.27[a]	34.36[a]	39.16[a]
Panchagavya	10.13[a]	15.75[a]	34.29[a]	38.88[a]
SEm(±)	0.16	0.28	0.45	0.50
F test	***	*	*	**
A:B (Interaction effect)				
SEm(±)	0.23	0.40	0.63	0.71
F test	Ns	Ns	Ns	Ns
P value	0.21	0.97	0.94	0.89
CV (%)	4.20	4.68	3.25	3.24
Grand mean	9.47	15.13	33.82	38.24

Note. *, **and *** level of significance at 5%, 1% and 0.01% respectively and Ns means Nonsignificant. SEm(±): Standard error of the mean; CV: coefficient of variation; DAS: Days after sowing.

Root Length

The results (Table 3) showed no differences in root lengths between local masuro and khajura masuro-2 during early growth stage i.e. 60 days of sowing at $p \leq 0.05$. But root lengths were longer in local variety across all the observations, indicating the diversion of nutrients in the root growth over shoot, as is observed (Table 2 and Table 3). However, significantly longer roots were observed in local variety over Khajura masuro-2 at later growth stages of the crop, revealing its potential for growing in dry land areas, which also justifies the wider use of local masuro under rainfed condition in far western terai region. Likewise, the results revealed no significant difference in root lengths among different organic fertilizers and control at early growth stage i.e., 60 DAS. The difference in root length was not prominent using organic fertilizers might be due to lower concentrations of readily available nutrients in these fertilizers, resulting in a less noticeable change in root length. But significantly longer roots were observed at 75 and 100 DAS at $p \leq 0.05$ when organic fertilizers were applied in lentil. Application of vermicompost loosened the soil due to increased microbial activities, which might have favored the root growth (Khalid et al., 2023) and the nutrients like N, P, K, Ca, Mg, Zn, Bo in the soil promotes root growth

(Li et al., 2016), and most of these nutrients are present in vermicompost (Acharya et al., 2024). Panchagavya and vermicompost were statistically at par in increasing the root lengths, and were also superior over farmyard manure, when measured at 100 DAS.

The increased root length of lentil plant could be due to the presence of essential nutrients such as nitrogen, phosphorus, potassium, calcium and magnesium, as well as micronutrients such as iron, zinc, copper and manganese with humic and fulvic acids and other organic acids as well as beneficial microorganisms contained in vermicompost (Hosseinzadeh et al., 2016). Similar increase in growth of root parameters of common beans were observed with the use of vermicompost over compost only and over the control (Altawarah et al., 2024). Similarly, panchagavya contained Ca, Zn, Cu, Fe, Mn along with macro nutrients; which has been reported to contain growth promoting hormones like, indole-3-acetic acid, gibberellic acid (Rawal et al., 2024), was applied at 60 and 75 DAS in our study, which might have contributed to longest roots of lentil at 100 DAS. But due to slow-release of nutrients by farmyard manure in addition to its pH might have discouraged the formation of roots. No notable interaction effect between the factors was detected.

Table 3

Effect of varieties and fertilizers on root lengths of lentil at Tikapur, Kailali.

Treatments	**Root length (cm)**			
	60 DAS	**75 DAS**	**100 DAS**	**At harvest**
Factor A (Varieties)				
Local	9.06	9.66[a]	10.85[a]	11.27[a]
Khajura Masuro 2	9.05	9.30b	10.27[b]	10.72[b]
SEm(±)	0.14	0.09	0.15	0.15
F test	Ns	*	*	*
Factor B (Fertilizers)				
Control	8.61	9.03[b]	9.85[b]	10.58
FYM	9.03	9.43[a]	10.43[ab]	11.08
Vermicompost	9.50	9.70[a]	10.93[a]	11.13
Panchagavya	9.11	9.76[a]	11.03[a]	11.19
SEm(±)	0.20	0.13	0.22	0.22
F test	Ns	**	**	Ns
A:B (Interaction effect)				
SEm(±)	0.29	0.18	0.31	0.31
F test	Ns	Ns	Ns	Ns
P value	0.20	0.63	0.57	0.62
CV (%)	5.61	3.37	5.12	4.98

Grand mean	9.06	9.48	10.56	11.00

Note. *, **and *** level of significance at 5%, 1% and 0.01% respectively and Ns means Nonsignificant. SEm(±): Standard error of the mean; CV: coefficient of variation; DAS: Days after sowing.

Branch Count

There was no significant difference in branch number between the varieties compared in the study at 5% level of significance. However, the observation revealed slightly greater number of branches in in local masuro during early growth stage revealing the potential of local masuro for drought resistance, due to early growth habit. In line with this, no significant variations in branch number were observed for the various types of fertilizers, across all the observation period. Organic manures and fertilizers contained lesser amount of macro-nutrients to drastically increase branches in lentil. The total N, P and K content in vermicompost, farmyard manure and Panchagavya used in the research were 0.82%, 1.0% & 2.40%, 0.99%, 0.61% & 2.93% and 0.18%, 0.04% and 0.43% respectively. Though non-significant, the highest number of branches were observed in farmyard manure applied plots indicating the ability of this fertilizer to release nitrogen and potash at higher amount as compared to vermicompost and Panchagavya. Baqa et al. (2015) also reported significant increase in number of tillers in farmyard manure applied plot as compared to control. No significant interaction effects were observed for branch count.

Table 4

Effect of varieties and fertilizers on branch number of lentil at Tikapur, Kailali.

Treatments	**Branch count**		
	60 DAS	**75 DAS**	**At harvest**
Factor A (Varieties)			
Local	3.34	5.03	6.58
Khajura Masuro 2	3.11	4.70	6.86
SEm(±)	0.09	0.16	0.13
F test	Ns	Ns	Ns
Factor B (Fertilizers)			
RDF (Control)	3.02	4.50	6.38
RDF+FYM	3.31	5.30	6.94
RDF+Vermicompost	3.25	4.93	6.91
RDF+Panchagavya	3.33	4.73	6.63
SEm(±)	0.12	0.23	0.18
F test	Ns	Ns	Ns

A:B (Interaction effect)			
SEm(±)	0.17	0.33	0.26
F test	Ns	Ns	Ns
P value	0.55	0.71	0.95
CV (%)	9.60	11.94	6.84
Grand mean	3.23	4.86	6.72

Note. *, **and *** level of significance at 5%, 1% and 0.01% respectively and Ns means Nonsignificant. SEm(±): Standard error of the mean; CV: coefficient of variation; DAS: Days after sowing.

Days to 80% Flowering and Maturity

Significant differences were observed between the varieties on days to flowering, with the local variety taking longer time to produce 80% of flower than Khajura masuro-2. Longer shoot length and significantly shorter root lengths in Khajura masuro-2 throughout the growing period might be associated with water stress in this variety, which might have induced early flowering. Devasirvatham and Tan (2018) and Yashavantha et al. (2021) have reported water stress to be the cause of early flowering in chick pea and wheat crop respectively. A study by Dietz et al. (2021) and Comas et al. (2013) revealed longer root zone improved nutrient uptake and water availability which reduced the stress signals, (that otherwise triggered the flowering) leading to delay in flowering in the plants.

Both the varieties took nearly the same time to reach maturity, as shown by the values in (Table 5). The study showed forced maturity in local variety, which required longer period to reach flowering but very short period to reach maturity as compared to Khajura masuro-2, despite having longer roots to absorb moisture. The temperature was only 27 ^{0}C during flowering, which reached up to 36.5 ^{0}C during maturity, which might be the reason for forced maturity. Temperature stress induced maturity has also been reported in a study (Kumari et al., 2021).

Table 5

Effect of varieties and fertilizers on days to flowering and maturity of lentil at Tikapur, Kailali.

Treatment	Days to 80% flowering	Days to maturity
Factor A (Varieties)		
Local	83.08^a	121.66
Khajura Masuro 2	81.83^b	122.25
SEm(±)	0.26	0.23
F test	**	Ns

Factor B (Fertilizers)		
RDF (Control)	81.83	121.16[b]
RDF+FYM	82.50	121.83[ab]
RDF+Vermicompost	82.33	122.16[ab]
RDF+Panchagavya	83.16	122.66[a]
SEm(±)	0.36	0.32
F test	Ns	*
A:B (Interaction effect)		
SEm(±)	0.52	0.46
F test	Ns	Ns
P value	0.07	0.86
CV (%)	1.09	0.65
Grand mean	82.45	121.95

Note. *, **and *** level of significance at 5%, 1% and 0.01% respectively and Ns means Nonsignificant. SEm(±): Standard error of the mean; CV: coefficient of variation; DAS: Days after sowing.

When compared among the fertilizers, days to flowering of lentil were almost the same at $p \leq 0.05$. But days to maturity varied significantly across the fertilizer treatments, with delay in maturity shown by Panchagavya application. Maturity was significantly earlier in control plots followed by vermicompost, which was statistically at par with farmyard manure application. Application of panchagavya showed delayed flowering and maturity, indicating its significant positive effect on vegetative growth of the lentil crop, as compared to farmyard manure and vermicompost. This again justifies the foliar spray of panchagavya for increased vegetative growth of the crops, which aligns with the findings by (Sutar et al., 2019; Panda et al., 2020). Research further supported the increased vegetative growth of okra crop, when applied 4 and 5 times with panchagavya (Hathi et al., 2022). In contrary to the findings, application of 3% panchagavya took minimum days to 50% flowering in okra while maximum in control plot (Mandodi et al., 2022; Raviteja et al., 2022). Interaction effect of variety and fertilizers were non-significant for phenological observation.

Pod per Plant

Results revealed no significant effect on pod number per plant between the varieties. But higher number of pods were observed for Khajura masuro over local variety. In line with our report, Prasai et al. (2019) also reported non-significant effect of 16 lentil genotypes on number of pods per plant. But, statistically significant variations in pod counts were observed among the fertilizer treatments with the highest obtained from vermicompost and lowest from control treatment. Ahmadpour & Hosseinzadeh (2017)

have shown significant effect on pod count of lentil crop with the use of vermicompost over control. In contrary, Patidar et al. (2024) and Sonkarlay et al. (2020) have reported increased number of pods per plant with the application of farmyard manure over control. However, the pod count obtained from farmyard manure and panchagavya application were statistically at par with control plot. This signifies that these fertilizers have no effect on the pod count in legumes like lentil, if applied in similar doses. Though the number of branches were high for farmyard manures, the roots and shoot lengths were shorter which might have reduced pod number per plant. Relatively smaller shoot length and less branch number might have contributed to lower number of pods per plant in panchagavya and control plots. Similar findings were also reported in research, which concluded luxurious growth of vegetative parts to contribute greatly to the formation of flowers in legumes (Krylova et al., 2020) leading to higher yields, which is missing in panchagavya and control plots.

Grains per Pod

There was no significant effect of both the factors i.e., organic manures and varieties on number of grains per pod at 5% level of significance. Slight increase in the value was observed for local variety, revealing the potential of local variety to generate higher number of grains per pod than Khajura masuro-2. Local variety were reported to perform better in yield attributes at Kailali, as per the conversation with farmers. Though non-significant slight increase in the grains per pod was observed with Panchagavya over other treatments, indicating the potential of panchagavya to be used as biotonic than other organic manures. The use of organic amendments had no significant impact on the number of grains per pod in mung bean (Rahman, 2013). In contrast to our results, Patidar et al. (2024) reported significant effect on grain count per pod with the use of inorganic fertilizers and organic manure in lentil.

Grains per Plant

Numerically higher grain counts per plant was observed for Khajura masuro-2 over local variety, which was statistically non-significant. But statistically significant variations were observed in number of grains per plant between the vermicompost and farmyard manures or panchagavya. Significantly highest number of grains was observed for Vermicompost, which was 15.53 %, 20.81% and 32.68 % increase when compared with farmyard manure, Panchagavya and control.

Table 6

Effect of varieties and fertilizers on yield attributes of lentil at Tikapur, Kailali.

Treatment	Pod per Plant	Grain per Plant	Grain per Pod	Thousand Grain Weight (g)

Factor A (Varieties)				
Local	100.59	171.36	1.70	14.41
Khajura Masuro 2	105.43	175.72	1.66	14.50
SEm(±)	2.81	5.42	0.02	0.16
F test	Ns	Ns	Ns	Ns
Factor B (Fertilizers)				
RDF (Control)	91.65[b]	151.77[b]	1.65	14.16
RDF+FYM	104.00[b]	174.30[b]	1.68	14.50
RDF+Vermicompost	119.61[a]	201.38[a]	1.68	14.66
RDF+Panchagavya	96.80[b]	166.69[b]	1.72	14.50
SEm(±)	3.98	7.67	0.03	0.22
F test	**	**	Ns	Ns
A:B (Interaction effect)				
SEm(±)	5.63	10.85	0.04	0.32
F test	Ns	Ns	Ns	Ns
P value	0.90	0.86	0.29	0.34
CV (%)	9.46	10.83	4.71	3.88
Grand mean	103.01	173.54	1.68	14.45

Note. *, **and *** level of significance at 5%, 1% and 0.01% respectively and Ns means Nonsignificant. SEm (±): Standard error of the mean; CV: coefficient of variation; DAS: Days after sowing.

Thousand grain weight

Statistically both the factors had non-significant effect on thousand grain weight, which ranged from 14.16 to 14.50 among the treatments compared in the study. Thousand grain weight was reported to be unaffected by variation in organic fertilizers for wheat crop Davari et al. (2012). Sonkarlay et al. (2020) also reported non-significant differences between control, farmyard manure and vermicompost treatment in yielding thousand grain weight of lentil. This might be due to meagre differences in the nutrient contents among these organic amendments. No significant interaction effects were detected in our study.

Grain Yield

Results revealed non-significant effect of varieties on grain yield, when compared at 5% level of significance. This might be due to non-significant effects on pod count per plant, grains per pod, and thousand grain weight between the varieties, as observed (Table 7). However, significantly highest grain yield was obtained from organic fertilizers when compared with control, which highlighted the significance of applying organic fertilizers

in lentil. Singh and Lakhan (2022) also reported increased grain yield of lentil when applied with farmyard manure and vermicompost fertilizer over the control. Organic fertilizers slowly released the mineral nutrients by the activity of microbes, which has the ability to improve soil fertility, aiding to increased crop production (Singh et al., 2020). Due to this significantly greater number of pods as well as numerically higher value of thousand grain weight, as observed in Table 6, the grain yield increased significantly in all the treatments except the Control. The significant influence of increased grain weight and number of pods per plant to the total grain yield has also been reported by Yesilbas & Togay (2021). Statistically all the organic fertilizers were at par in yielding total amount of grain per unit area, which might be due to similar lower amounts of key nutrient contents in each of these fertilizers, and similar influence in the growth of shoots, as observed (Table 2).The influence of macronutrient NPK on both the growth and grain yield is well established and studies have shown that balanced application of NPK levels leads to boosted yields by improving nutrient use efficiency and overall plant vigor (Ray et al., 2020; Hossain et al., 2021).

Table 7

Effect of varieties and fertilizers on grain yield, biological yield and harvest index of lentil at Tikapur, Kailali.

Treatments	Grain yield (t/ha)	Biological yield (t/ha)	Harvest Index
Factor A (Varieties)			
Local	1.27	2.98	0.43
Khajura Masuro 2	1.33	3.16	0.42
SEm(±)	0.02	0.10	0.01
F test	Ns	Ns	Ns
Factor B (Fertilizers)			
RDF (Control)	1.21[b]	2.77	0.44
RDF+FYM	1.33[a]	3.14	0.42
RDF+Vermicompost	1.35[a]	3.23	0.42
RDF+Panchagavya	1.32[a]	3.15	0.42
SEm(±)	0.03	0.15	0.01
F test	*	Ns	Ns
A:B (Interaction effect)			
SEm(±)	0.04	0.21	0.02
F test	Ns	Ns	Ns
P value	0.56	0.91	0.65
CV (%)	5.65	12.23	10.82
Grand mean	1.30	3.07	0.42

Note. *, **and *** level of significance at 5%, 1% and 0.01% respectively and Ns means Nonsignificant. SEm(±): Standard error of the mean; CV: coefficient of variation; DAS: Days after sowing.

Biological yield

There was no variation in biological yield between the varieties at $p \leq 0.05$. Similarly, no variations were observed among the organic fertilizers compared in the study for this parameter. This might be due to uniform growth and development promoted by the capacity of soil with limited influence of organic fertilizers in shoot and root parameters.

Conclusion

Local variety and Khajura masuro-2 performed equally in growth and yield and hence both are best suited for growing in far western terai region, after paddy. Longer roots and higher number of branches in local variety can suppress weeds under the rice-lentil cropping system, and hence could be suggested for proper yield in the areas will less moisture. Three times spray of panchagavya is equally effective as vermicompost or farmyard manure which favors the vegetative growth, as is evidenced from increased root length, branch number and delayed flowering and maturity. Hence, 3% spray of panchagavya solution at least three times is suggested for improving vegetative growth. Also, use of any form of organic fertilizer is highly recommended to the farmers, under rice-based cropping system for increased yield of lentil.

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Conflicts of Interest

The authors confirm that no financial or non-financial interests might have influenced the research provided in this study.

References

Acharya, N., Vista, S. P., Pandit, N. R., Bhattarai, S., & Dahal, B. (2024). Effect of four different types of vermicomposts on okra productivity and farm income. *Heliyon, 10*(14), e34351. https://doi.org/10.1016/j.heliyon.2024.e34351

Ahmadpour, R., & Hosseinzadeh, S. R. (2017). Effect of vermicompost fertilizer on morphological traits of lentil under water stress. In Proceeding of the International Conference on agricultural engineering and natural resources (pp. 25–29). International Conference on Agricultural Engineering and Natural Resources

AITC (2024). *Agriculture and livestock diary 2081*. Ministry of Agriculture and Livestock Development. Agriculture information and training center (AITC). Hariharbhawan, Lalitpur, Nepal.

Ali, M.N., Ghatak, S., & Ragu, T. (2011). Biochemical analysis of Panchagavya and Sanjibani and their effect in crop yield and soil health. *Journal of Crop and Weed* ,*7*(2), 84-86.

Ali, M.O., Zuberi, M.I., & Sarker, A. (2012). Lentil relay cropping in the rice-based cropping system: An innovative technology for lentil production, sustainability and nutritional security in changing climate of Bangladesh. *Journal of Food Science and Engineering, 2*(9), 52.

Altawarah, B., Alasasf, M.A., & Mahadeen, A.Y. (2024). Efficacy of Compost and Vermicompost on Growth, Yield and Nutrient Content of Common Beans Crop (*Phaseolus vulgaris* L.). *Journal of Ecological Engineering, 25*(2), 215–226.

Aziz, T., Ullah, S., Sattar, A., Nasim, M., Farooq, M., & MM Khan, M.M. (2010). Nutrient availability and maize (*Zea mays*) growth in soil amended with organic manures. *International Journal of Agriculture and Biology, 12*(4), 621-624.

Baqa, S., Khan, A.Z., Inamullah, I., Khan, A.A., Anwar, S., Iqbal, B. ... and Usman, A.. (2015). Influence of farm yard manure and phosphorus application on yield and yield components of Wheat. *Pure and Applied Biology, 4*(4), 458-464.

Behera, S.R., Pandey, R., Golui, K., Sahoo, S., Jakhwal, R., & Pal, R. (2024). Application of Panchagavya, a Cow-based Liquid Formulation, as a Lever for Sustainable and Enhanced Vegetable Crop Production: *A Review. International Journal of Environment and Climate Change*, *14*(5), 214-232.

Comas, L. H., Becker, S. R., Cruz, V. M. V., Byrne, P. F., & Dierig, D. A. (2013). Root traits contributing to plant productivity under drought. *Frontiers in plant science, 4*, 1-16.

Davari, M., Sharma, S.N., & Mirzakhani, M. (2012). The effect of combinations of organic materials and biofertilizers on productivity, grain quality, nutrient uptake and economics in organic farming of wheat. *Journal of organic systems*, *7*(2), 26-35.

Devasirvatham, V., & Tan, D.K. (2018). Impact of high temperature and drought stresses on chickpea production. *Agronomy*, *8*(8), 1-9.

Dietz, K.J., Zorb, C., & Geilfus, C.M. (2021). Drought and crop yield. *Plant Biology*, *23*(6), 881-893.

DoC. (2023). *Nepal foreign trade statistics fiscal year 2022/23 (2079/80).* Ministry of Finance. Department of Customs, Tripureshwor, Kathmandu.

FOASTAT. (2024). Food and Agriculture Organization Corporate Statistical Database. Retrieved in July 23, 2024, from https://www.fao.org/faostat/en/#data/QCL

Gupta, D., Dadu, H.R., Sambasivam, P., Bar, I., Singh, M., Beera, N., & Biju, S. (2019). Toward climate-resilient lentils: challenges and opportunities. In: Genomic Designing of Climate-Smart Pulse Crops (Kole, C. eds) *Springer*, Cham. pp.165-234.DOI: https://doi.org/10.1007/978-3-319-96932-9_4

Hathi, H.S., Patel, M.V., & Zankat, S.V. (2022). Effect of liquid organic substances, spray frequency and levels of fertilizer on yield, quality and economics of okra (*Abelmoschus esculentus* L. Moench). *The Pharma Innovation Journal*, *11*(7), 833-838.

Hossain, M.M., Yesmin, S., Islam, M.Z., Hossain, M.A., & Jahan, M.A. (2021). Physiological attributes of mungbean (*Vigna radiata* L.) influenced by different sources of nutrients (NPK) in Madhupur tract region of Bangladesh. *Journal of Science Technology and Environment Informatics, 11*(1), 736-748.

Hosseinzadeh, S.R., Amiri, H., & Ismaili, A. (2016). Effect of vermicompost fertilizer on photosynthetic characteristics of chickpea (*Cicer arietinum* L.) under drought stress. *Photosynthetica*, *54*, 87-92.

Kebede, E. (2021). Contribution, utilization, and improvement of legumes-driven biological nitrogen fixation in agricultural systems. *Frontiers in Sustainable Food Systems*, 5, 1-18. https://doi.org/10.3389/fsufs.2021.767998

Khalid, I., Haq, SIU., Lan, Y., Hussain, M., Anwar, A., & Shan, C. (2023). Effect of Vermicompost Types along with Rhizobium Inoculation Impact on Nodulation Potential, Growth and Yielding Attributes of Lentil. *Biosciences Biotechnology Research Asia, 20*(2), 735-744.

Krylova, E.A., Khlestkina, E.K., Burlyaeva, MO., & and Vishnyakova, M.A. (2020). Determinate growth habit of grain legumes: Role in domestication and selection, genetic control. *Ecological genetics*, *18*(1), 43-58.

Kumar, R.S., Ganesh, P., Tharmaraj, K., & Saranraj, P. (2011). Growth and development of black gram (*Vigna mungo*) under foliar application of Panchagavya as organic source of nutrient. *Current Botany*, *2*(3), 9-11

Kumari, V.V., Roy, A., Vijayan, R., Banerjee, P., Verma V.C., Nalia, A., ... & Hossain, A. (2021). Drought and heat stress in cool-season food legumes in sub-tropical regions: Consequences, adaptation, and mitigation strategies. *Plants, 10*(6), 1-21. https://doi.org/10.3390/plants10061038

Li, X., Zeng, R., & Liao, H. (2016). Improving crop nutrient efficiency through root architecture modifications. *Journal of integrative plant biology*, 58(3), 193-202.

Mandodi, D., & Bahadur, V. (2022). Effect of Panchagavya on Growth, Yield and Quality of Okra (*Abelmoschus esculentus* L.). *International Journal of Plant & Soil Science*, *34*(22), 525-531.

MoALD (2023). Statistical information on Nepalese Agriculture 2078/79(2021/22). Ministry of Agriculture and Livestock Development. Planning and Development Cooperation Coordination Division. Statistics and Analysis Section. Singhadurbar, Kathmandu, Nepal.https://moald.gov.np/wp-content/uploads/2023/08/Statistical-Information-on-Nepalese-Agriculture-2078-79-2021-22.pdf

Neupane, S., Subedi, S., & Darai, R. (2020). Field screening of lentil genotypes against aphid infestation in inner Tarai of Nepal. *Journal of Nepal Agricultural Research Council*, *6*(1), 78-84.

Panda, D., Padhiary, A.K., & Mondal, S. (2020). Effect of panchagavya and jeevamrit on growth and yield of tomato (*Solanum lycopersicum* L). *Annals of Plant and Soil Research*, *22*(1), 80-85.

Patel, S.P., Malve, S.H., Chavda, M.H., & Vala, Y.B. (2021). Effect of Panchagavya and Jeevamrut on growth, yield attributes and yield of summer pearl millet. *The Pharma Innovation Journal*, *10*(12), 105-109.

Patidar, A., Kumar, P., & Dhaked, G.S. (2024). Effect of Organic Manures and Inorganic Fertilizer on Growth and Yield Characters of Lentil. *Asian Journal of Soil Science and Plant Nutrition, 10*(1), 233-238.

Pokhrel, A., Karki, T.B., & Dang, S. (2022). Increasing the productivity of lentil through agronomic interventions in Nepal. *Agronomy Journal of Nepal*, *6*(1), 75-86. https:// doi .org/10.3126/ajn.v6i1.47941

Prasai, H.K., Sharma, S., Kushwaha, U.K., Joshi, B.P., & Shrestha, J. (2019). Performance evaluation of lentil and chickpea genotypes in Doti district of Nepal. *International Journal of Applied Biology*, *3*(2), 46-56.

Rahman, M.W. (2013). Effect of potassium and vermicompost on the growth, yield and nutrient contents of mungbean (Bari mung 5). Master Thesis. Faculty of Agriculture, Sher-e-Bangla Agricultural university, Dhaka.

Rakesh, S., Poonguzhali, S., Saranya, B., Suguna, S., & Jothibasu, K. (2017). Effect of Panchagavya on growth and yield of *Abelmoschus esculentus* cv. Arka Anamika. *International Journal of Current Microbiology and Applied Sciences*, *6*(9), 3090-3097. https://doi.org/10.20546/ijcmas.2017.609.380

Ramesh, A.S., Rai, P.K., & Nagar, S. (2021). Influence of Chemicals, Botanicals and Growth Regulator Treatments on Plant Growth and Yield Attributing Traits of Lentil (*Lens culinaris* L.) Variety: K-75. *International Journal of Plant & Soil Science, 33*(19), 124–129. https://doi.org/10.9734/ijpss/2021/v33i1930608

Raviteja, P.V., Bara, B.M., & Sravani, P. (2022). Pre-sowing Seed Treatment with

Botanicals and Organics on Plant Growth, Yield and Yield Attributing Traits of Okra (*Abelmoschus esculentus* L.) cv. VROH-12 Kashi Shristi. *International Journal of Environment and Climate Change*, *12*(11), 960-968.

Rawal, J.S., Joshi, G.G., Gurung, L., & RC, P. (2024). Application of panchagavya in agriculture: practices and benefits. *i TECH MAG,* 6, 44-49.

Ray, K., Banerjee, H., Dutta, S., Sarkar, S., Murrell, T.S., Singh, V.K., & Majumdar, K. (2020). Macronutrient management effects on nutrient accumulation, partitioning, remobilization, and yield of hybrid maize cultivars. Frontiers in Plant Science 11:1307. https://doi.org/ 10.3389/fpls.2020.01307

Samaranayaka, A., & Khazaei, H. (2024). Lentil: revival of poor man's meat. In: Sustainable protein sources2nd ed (S Nadathur, JPD Wanasundara and L Scanlin, ed.) Academic Press; pp 201-217. https://doi.org/10.1016/B978-0-323-91652-3.00031-9.

Sarma, H.H., & Talukdar, N. (2024). Dasagavya and Panchagavya: Elixirs of Organic Farming. *Indian Farmer*, *11*(6), 198-202.

Singh, S., & Lakhan, R. (2022). Productivity, nutrient uptake and quality of lentil (Lens culinaris) and soil fertility as influenced by organic manures and fertilizers. *Annals of Plant and Soil Research, 24*(1), 16-22.

Singh, T.B., Ali, A., Prasad, M., Yadav, A., Shrivastav, P., Goyal, D., & Dantu, D.K. (2020). Role of organic fertilizers in improving soil fertility. In: Contaminants in agriculture (M Naeem, AA Ansari and SS Gill, eds.) pp.61-77. https://doi.org/10.1007/978-3-030-41552-5_3

Sonkarlay, E., Luikham, E., & Athokpam, H.S. (2020). Effect of Chemical Fertilizer, Organic Manure and Biofertilizer on Nodulation, Yield and Economics of Lentil (*Lens culinaris* L. Medik.). *Int. J. Curr. Microbiol. App. Sci*, *9*(8), 2653-2662.

Sutar, R., Sujith, G.M., & Devakumar, N. (2019). Growth and yield of Cowpea [*Vigna unguiculata* (L.) Walp] as influenced by jeevamrutha and panchagavya application. *Legume Research*, *42*(6), 824-828.

Venkidasamy, B., Selvaraj, D., Nile, A.S., Ramalingam, S., Kai, G., & Nile, S.H. (2019). Indian pulses: A review on nutritional, functional and biochemical properties with future perspectives. *In: Trends in Food Science & Technology*, *88*, 228-242. https://doi.org/10.1016/j.tifs.2019.03.012.

Yashavantha, K.J., Baviskar, V.S., Navathe, S., Patil, R.M., Bagwan, J.H., Bankar, D.N., ... and Singh, G.P. (2021). Impact of heat and drought stress on phenological development and yield in bread wheat. *Plant Physiology Reports*, *26*(2), 357-367.

Yesilbas, C., & Togay, Y. (2021). The Effect of Organic and Inorganic Fertilization on The Yield and Some Yield Components of Lentil (*Lens culinaris* Medik.) In Van Conditions. *ISPEC Journal of Agricultural Sciences, 5*(4, 786-794.

Zia-Ul-Haq, M., Ahmad, S., Shad, M.A., Iqbal, S., Qayum, M., Ahmad, A., ... & Amarowicz, R. (2011). Compositional studies of lentil (*Lens culinaris* Medik.) cultivars commonly grown in Pakistan. *Pak. J. Bot*, *43*(3), 1563-1567.