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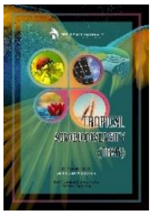

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RESEARCH ARTICLE

EFFECT OF ORGANIC AND INORGANIC NUTRIENTS ON GROWTH AND YIELD OF GREEN GRAM (*VIGNA RADIATA* L.) AT RUPANDEHI, NEPAL

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ABSTRACT

Green gram is an important commodity in Nepalese agriculture occupying an area of 3,35,143 hectare with a yield of 3,94,000 metric ton. In Nepal, farmers are unaware of the potential capacity of organic nutrients on growth and yield of green gram. To address this problem, a field experiment was conducted at Agronomy farm of Paklihawa Campus from March to June, 2022 to investigate the effect of organic and inorganic nutrients on growth and yield of green gram. The research was conducted in Randomized Complete Block Design with 7 treatments and 3 replications. Five sample plants were chosen randomly from each plot and data were collected at the interval of 15 days and data were analyzed using R-studio. The growth parameters studied under this research were plant height, leaf area index and number of trifoliate leaves while the yield and yield attributing characters studied were pod length, number of pods per plant, number of grains per plant, grain yield, stover yield, biological yield and harvest index. Significant difference was observed in leaf area index, pod per plant, grain yield, biological yield, stover yield and harvest index and vermicompost was found to be most effective treatment in terms of yield.

KEYWORDS

Goat Manure, Panchagavya, Vermicompost, Zinc.

1. INTRODUCTION

Green gram, scientifically known as Vigna radiata L. but commonly referred to as moongbean, is a swiftly maturing leguminous plant from the Leguminosae family. It is predominantly cultivated in Southeast Asia, often in rotation with rice crops. This legume boasts a chromosome number of 2n=22, allowing it to harness atmospheric nitrogen through symbiosis, enabling a nitrogen fixation capacity of approximately 42 kg N/ha (Razzaque et al., 2016). Characterized by a taproot system that delves deep into the soil, it forms symbiotic associations that enhance soil quality and reduce erosion. Additionally, it serves as a green manure. Moongbean exhibits remarkable drought tolerance, offering yields of up to 2961 kg/ha, contingent on factors like genotype and field conditions (Ullah et al., 2011). Notably, it is a valuable protein source for both human and animal consumption, containing protein content ranging from 14.6% to 33.0% per 100g, along with 1.3% fat, 60.4% carbohydrates, calcium, and phosphorus (118mg & 340mg /100g of grain) (Dahiya et al., 2015; Meena et al., 2016).

In Nepal, during the fiscal year 2077/78, legume production reached 394,000 metric tons over an expanse of 335,143 hectares, with a yield of 13,468.1 Kg/hectare. However, moongbean contributes just 3.8% to the overall pulse production in Nepal (MoALD, 2021). Given the limited domestic production, Nepal relies heavily on imports, with around 90% (equivalent to 5,000 tons) of green gram imported annually to meet demand (Ramesha, 2019). Currently, the yield for green gram stands at a mere 0.5 ton/ha, considerably below its potential yield of 1.04 t/ha (MoALD, 2021).

The inadequate production of moongbean in Nepal can be attributed to a variety of factors, with the quality and type of fertilizers being a predominant constraint. Many Nepalese farmers lack awareness regarding the benefits of organic fertilizers and have historically relied on chemical fertilizers for extended periods. Although this practice can lead to immediate yield increases, it ultimately degrades the natural soil fertility over time. Numerous international studies have demonstrated the potential of organic nutrients in enhancing the growth and yield of green gram (Razzaque et al., 2016). Multiple datasets reveal that organic fertilizers are increasingly proving to be a valuable alternative to chemical fertilizers, as they also enhance soil structure and microbial biomass (Naeem et al., 2006; Dauda et al., 2008; Dhull et al., 2004). The application of organic fertilizers such as vermicompost, panchagavya, and goat manure has shown significant improvements in crop growth and yield (Krenkel, 2002; Kumaravelu et al., 2009; Mohbe et al., 2015). In the case of Nepal, limited research has explored potential sources of organic nutrients and their comparative advantages or disadvantages in comparison to chemical fertilizers. As a result, this study was carried out using readily available organic nutrient sources and chemical fertilizers to assess their effects on the growth and yield of green gram.

2. MATERIALS AND METHODS

2.1 Description of the field experiments

A Research entitled effects of organic and inorganic nutrients on growth and yield of green gram at IAAS Paklihawa condition, Rupandehi, Nepal was conducted at the agronomy farm of Paklihawa campus from 24th March to 27th June to evaluate the effect of organic and inorganic nutrients on growth and yield of SML- 668 for this Agro-ecological zone. This section includes all the details of research, experiments. Information of geographical situation, climatic condition, cultivation practices, intercultural operations, biometric observation, phenological observation are categorically presented on following subheadings.

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2.2 Experimental site

The research was conducted at horticulture farm of IAAS (Institute of agriculture and animal science) Paklihawa Campus. Geographically, the experimental site is situated at coordinates of 27º 28'48.24"North latitude and 83º 26'50.18"East longitude. The site is about 3 kilometers far from Bhairahawa, headquarter of Rupandehi district and about 108 meter above mean sea level.

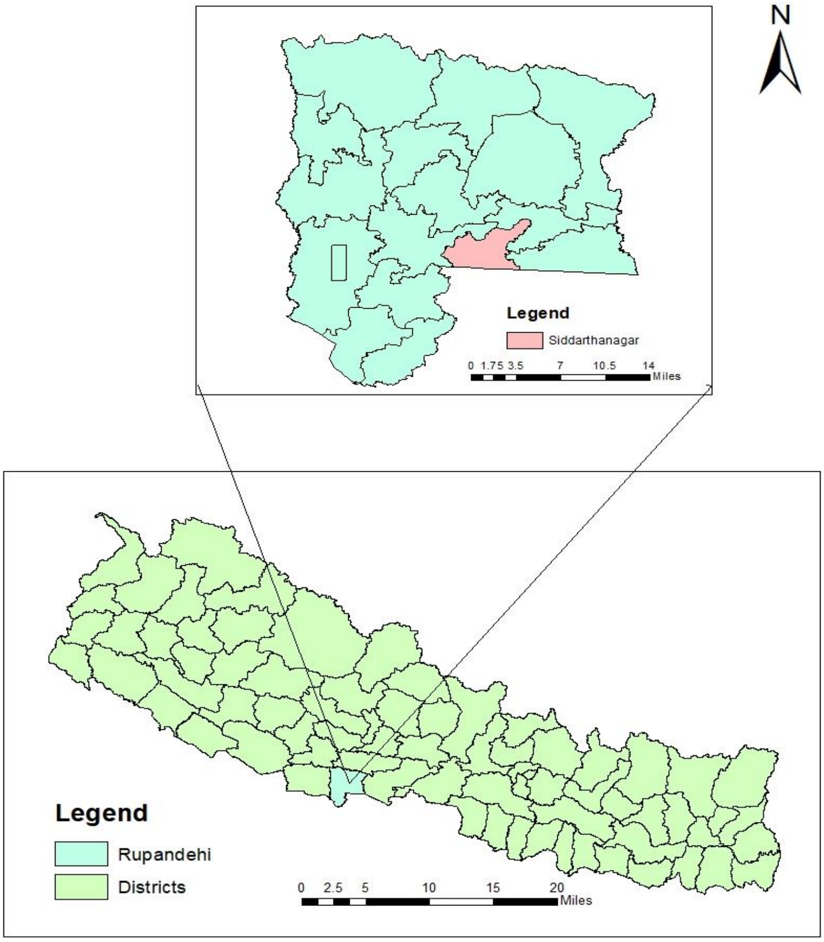

Figure 1: Map of Nepal and Rupandehi district showing research site

2.3 Agrometeorological condition of experiment site

The climatic condition of IAAS, Paklihawa Campus is subtropical humid climate where very low occurrence of rainfall can be observed in winter than summer. According to the agrometeorological data gathered from National Wheat Research Program (NWRP), Bhairahawa Rupandehi, the average maximum temperature is around 35°C and minimum temperature is around 23°C during the experiment period. It has faced low rainfall situations along with lack of availability of artificial irrigation resulting moisture stress during germination and vegetative stage. There is occurrence of high rainfall during reproductive stage resulting flooding situation.

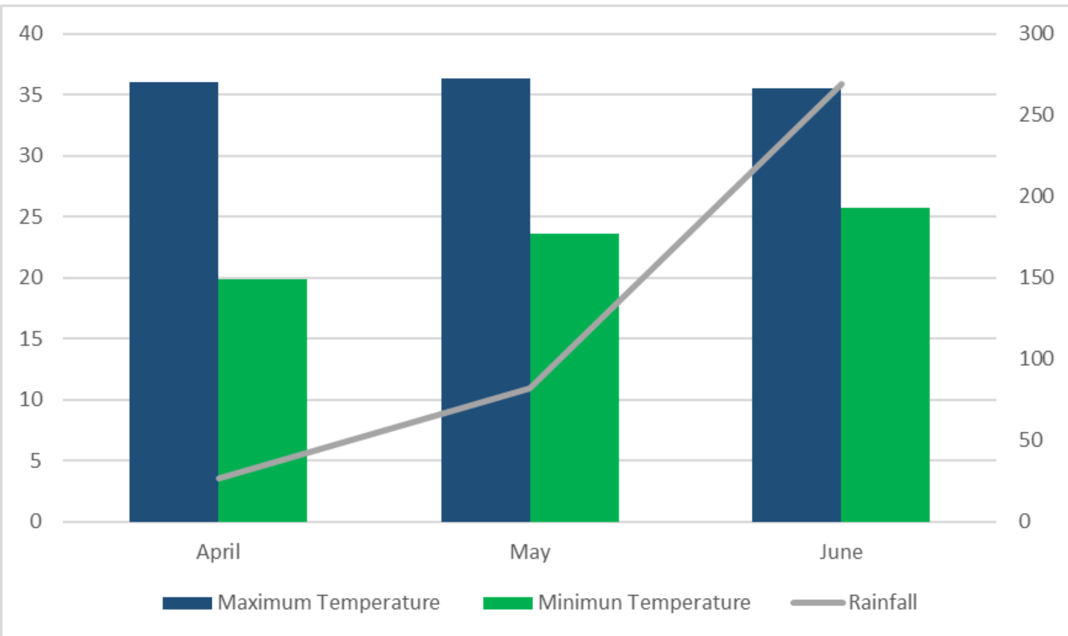

Figure 2: Agro-meteorological information at Paklihawa 2021 (Source: NARC)

2.4 Experimental Details

2.4.1 Layout of experimental field

Randomized Complete Block Design (RCBD) was used in the experiment. The size of the experimental unit was 12 m2 (4m * 3m) and the total size of the experimental area was 378 m2 (14m * 27m). The spacing between the blocks was 1m and between experimental units within a block was 1m. The total number of plots was 21 and, in each plot, there were 13 rows of crop with 30 *10 cm spacing. The layout of the experimental field is shown below:

2.4.2 Treatment details

The experiment was carried out in a simple randomized block design (RCBD) with 7 treatments and 3 replications. Organic nutrients used as treatments were Vermicompost, Goat manure and Panchagavya. Inorganic nutrients used as treatments were Recommended dose of fertilizer (RDF), NPK+MnSO4 and NPK+ZnSO4. All the treatments were broadcasted directly into soil at sowing time except Panchagavya which was sprayed into soil.

Table 1: Treatment details

Treatments	Details	Dose	Method of application
T1	Control	_	
T2	RDF	20:40:20kg/ha NPK	Broadcasting in soil
T3	Vermicompost	5ton/ha	Broadcasting in soil
T4	Goat Manure	5ton/ha	Broadcasting in soil
T5	Panchagavya 0.3%	60ltr/ha	Spray in soil
T6	NPK+ MnSO4	(20kg/ha)	Broadcasting in soil
T7	NPK+ZnSO4	(20 kg/ha)	Broadcasting in soil

2.5 Sampling techniques, observation and analysis

To facilitate sampling and observation, we randomly selected five plants from each plot and affixed tags to them. In an effort to mitigate any potential border effects, we excluded one outer row and 20 cm from both ends of each plot, resulting in a net plot measuring 4×2.6 meters. Before the harvest, we demarcated a 1 m2 area in each plot by using four pegs and a rope, which allowed us to collect data from this specific 1m2 area. We then determined the yield of green gram within this sample area and applied the unitary method to calculate the yield for the entire net area. Data entry was carried out using MS-Excel. Subsequently, data analysis was conducted using R-Studio, and the interpretation was based on ANOVA (Analysis of Variance) and DMRT (Duncan's Multiple Range Test) at a 5% significance level. Additionally, we performed simple regression analysis using IBM SPSS Statistics 22. The grain yield, stover yield, and Harvest Index were computed using the mathematical derivations outlined below.

Grain Yield (kg/ha) at 12% moisture $= \frac{(100-mc) \times Plot\ yield(kg) \times 10000(m2)}{(100-12) \times net\ plot\ area\ (m2)}$ (Paudel, 1995)

Stover Yield (kg/ha) = $\frac{Plot\ yield\ (kg) \times 10000\ (m2)}{Net\ plot\ area\ (m2)}$ (Dhakal et al., 2020)

HI (%) = $\frac{Economic\ yield\ (Grain\ yield)\ kg/ha)}{Biological\ yield(\ Economic\ yield+Straw\ yield)\ kg/ha} \times 100$ (Donald, 1962)

3. RESULTS AND DISCUSSIONS

3.1 Growth

Plant height and the number of trifoliate leaves exhibited no statistically significant changes, whereas the leaf area index was notably influenced by the application of organic and micronutrient treatments. The highest average plant height, measuring 49.13 cm, was observed in the Vermicompost treatment, closely followed by 48.60 cm in the NPK + ZnSO¬4 treatment, while the lowest height was recorded in the control group, with plants reaching 42.67 cm. This variation in plant height is likely due to the presence of plant growth regulators (PGRs) and the improved nutrient uptake facilitated by the application of vermicompost, which is supported by the findings of (Sarma et al., 2010). Previous studies have also reported that vermicompost can enhance plant height (Barua et al., 2014). The highest mean leaf area index, reaching 2.027, was recorded in the T3 treatment, closely followed by 2.026 in the NPK + ZnSO4 treatment, while the control group exhibited the lowest value.

The well-pronounced leaf area index in the crop can be attributed to the sufficient nitrogen supply from the NPK fertilizer, which promotes rapid cell division and cell elongation, thus increasing the leaf area index, a phenomenon consistent with the findings of (Gul et al., 2015). At 60 days after sowing (DAS), the highest mean number of trifoliate leaves was observed in the Vermicompost and NPK+ZnSO4 treatments, with the control group exhibiting the lowest value. These results align with the observations of who attributed this effect to the increased humic acid content in the soil (Durak et al., 2017). Zinc (Zn) plays a vital role as a cofactor for more than 300 enzymes and proteins, participating in diverse biological processes, including nucleic acid metabolism, cell division, protein synthesis, gene transcription regulation, and coordination of other biological mechanisms.

This may have contributed to the observed increase in the number of trifoliate leaves, as suggested (Haider et al., 2018). The enhanced microbial activity and elevated levels of macro and micronutrients in vermicompost-amended soil, reported in several studies, result in significantly higher soil nitrogen content, promoting superior plant growth in comparison to other nutrient sources (Singh et al., 2011). A group researchers proposed that the elevated soil nitrogen concentration can be attributed to the nitrogen content present in vermicompost, which stimulates nitrogen mineralization in the soil by facilitating the decomposition of earthworm tissues (Ananthakrishnasamy et al., 2009).

Table 2: Effect of organic and micronutrients on plant height, leaf area index and number of trifoliate leaves of green gram

S.N.	Treatments	Plant height (cm) at harvest	Leaf Area Index	Number of trifoliate leaves
1.	Control	42.66667	1.550758	5.480000^{b}
2.	RDF (20:40:20 kg/ha NPK)	45.66667	2.027633	7.350000^{a}
3.	Vermicompost @ 5 ton/ha	49.13333	2.029847	7.560000^{a}
4.	Goat Manure @ 5 ton/ha	46.66667	1.967002	6.876667^{ab}
5.	Panchagavya @ 60 liter/ha	46.26667	1.356808	6.356667^{ab}
6.	NPK + MnSO4 @ 20kg/ha	48.13333	1.350290	6.563333^{ab}
7.	NPK + ZnSO4 @20kg/ha	48.6000	2.021567	7.560000^{a}
	LSD (0.05)	7.736064	1.028129	1.406980
	SEM (±)	2.510644	0.3336665	0.456618
	F-Value (0.05)	NS	**	NS
	CV (%)	9.314547	12.88776	11.67482
	Grand Mean	46.68571	1.757272	6.774286

Note: the common letter(s) within the column indicates a non-significant difference based on the Duncan multiple range test (DMRT) at a 0.05 level of significance. LSD (0.05) indicates the Least significant Difference test at 0.05 level of significance. CV% indicates the Coefficient of Variation.
NS = non-significant.
*** = Highly significant.
** = moderately significant.
* = Significant

3.2 Yield and Yield Attributes

The outcomes of the study revealed noteworthy differences among the various treatments when it came to the total number of pods per plant. The NPK + ZnSO4 treatment exhibited the highest number of pods per plant, closely followed by the Vermicompost treatment, whereas the control group had the fewest pods per plant (Table 3). This variation can be attributed to the influence of zinc on protein and carbohydrate metabolism, particularly its role in processes related to sugar conversion and photosynthesis. These effects play a crucial part in providing the necessary carbohydrates and proteins for both vegetative and reproductive plant growth (Alag et al., 2015). However, the analysis of variance for pod length and the number of grains per pod revealed no significant differences among the treatments. The average number of grains per pod ranged from 9.67 (T1) to 10.77 (T3), with an overall mean value of 10.19 (refer to Table 3).

These findings are in line with Al Isawi's study, which similarly reported an increase in the number of grains per pod due to the application of zinc (Al Isawi's, 2010). This increase is associated with zinc's contribution to elevated protein and carbohydrate levels, positively impacting certain growth processes within the plant and resulting in a higher number of seeds in the pods. The maximum average pod length was observed in the NPK + MnSO4 treatment, while the highest number of grains per pod was recorded in the NPK+ZnSO4 treatment, with the control group having the shortest average pod length and grain count per pod. These results align with research conducted (Dhinagaran et al., 2021). Furthermore, there were no significant distinctions among the various treatments in terms of 1000-grain weight. The mean value of 1000-seed weight was highest in the vermicompost treatment and lowest in the control group, with a grand mean value of 40.15 grams overall (see Table 3).

Table 1: Effect of organic and micronutrients on pod/plant, pod length, grain/pod and 1000 grain weight of green gram

S.N.	Treatments	Pod/plant	Pod length (cm)	Grain/ pod	1000 grain Weight (gram)
1.	Control	19.36667[c]	7.426667[b]	9.666667	38.67333
2.	RDF (20:40:20 kg/ha NPK)	22.53333[b]	7.906667[ab]	10.133333	40.14667
3.	Vermicompost @ 5 ton/ha	23.90000[a]	8.373333[a]	10.533333	40.74000
4.	Goat Manure @ 5 ton/ha	20.0667[bc]	8.000000[ab]	9.800000	40.96000
5.	Panchagavya @ 60 liter/ha	23.83333[a]	7.700000[ab]	10.066667	38.68667
6.	NPK + MnSO4 @ 20kg/ha	23.80000[a]	8.513333[a]	10.333333	41.34667
7.	NPK + ZnSO4 @20kg/ha	24.2667[a]	8.273333[ab]	10.766667	40.52667
	LSD (0.05)	2.886139	0.8070436	1.409340	4.039137
	SEM (±)	0.9366607	0.261916	0.4573839	1.310852
	F-Value (0.05)	*	NS	NS	NS
	CV (%)	7.19823	5.651138	7.777678	5.654347
	Grand Mean	22.5382	8.027619	10.18571	40.15429

Note: the common letter(s) within the column indicates a non-significant difference based on the Duncan multiple range test (DMRT) at a 0.05 level of significance. LSD (0.05) indicates the Least significant Difference test at 0.05 level of significance. CV% indicates the Coefficient of Variation.
NS = non-significant.
*** = Highly significant.
** = moderately significant.
*= Significant

Significant variations in grain yield were evident among the diverse treatments. The average grain yield per hectare ranged from 425.8 kg/ha (T1) to 977.89 kg/ha (T3), with an overall mean value of 742.00 kg/ha (see Table 4). Among the treatments, the highest grain yield for green gram was achieved with the application of vermicompost, closely followed by NPK+ZnSO4. These research findings corroborate the results obtained by numerous researchers across different crop varieties (Bhide et al., 2017; Britto and Girija, 2006). Likewise, the highest stover yield was associated with the vermicompost treatment, followed by NPK+MnSO¬4, while the control group exhibited the lowest yield, with an overall mean of 2317.71 kg/ha.

These outcomes align with the observations reported (Karmegam and Alagumalai, 1999). The mean values for stover yield across all treatments are presented in Table 4. The maximum biological yield was observed for T3 (3463.58 kg/ha), while the minimum was recorded for T1 (2496.37 kg/ha), with an overall mean of 3059.72 kg/ha. Similar results have been reported by (Tyagi et al., 2014). Vermicompost plays a pivotal role in influencing soil microbial activity, enhancing oxygen availability, maintaining optimal soil temperature, increasing soil porosity, improving water infiltration, enriching nutrient content, and ultimately promoting plant growth, yield, and quality (Arora et al., 2011). Furthermore, there was a significant difference in the case of the harvest index among the various treatments. The highest harvest index was noted for T3 (28.29%), while the lowest was observed in T1 (17.28%), with an overall mean value of 24.01% (refer to Table 4).

Table 4: Effect of organic and micronutrients on grain yield, stover yield, biological yield and harvest index of green gram

S.N.	Treatments	Grain Yield (kg/ha)	Stover Yield (kg/ha)	Biological Yield (kg/ha)	Harvest Index (%)
1.	Control	425.8667[e]	2070.507[b]	2496.373[c]	17.28101[c]
2.	RDF (20:40:20 kg/ha NPK)	737.7280[cd]	2345.131[ab]	3082.859[b]	23.84635[ab]
3.	Vermicompost @ 5 ton/ha	977.8913[a]	2485.697[a]	3463.589[a]	28.293836[a]
4.	Goat Manure @ 5 ton/ha	614.5033[d]	2341.033[ab]	2955.537[b]	20.89395[bc]
5.	Panchagavya @ 60 liter/ha	764.9480[c]	2233.971[ab]	2998.919[b]	25.66869[a]
6.	NPK + MnSO4 @ 20kg/ha	795.1607[b]	2375.959[ab]	3171.119[b]	25.10302[a]
7.	NPK + ZnSO4 @20kg/ha	877.9420[a]	2371.703[ab]	3249.645[ab]	27.04080[a]
	LSD (0.05)	130.2194	339.3450	354.0643	4.436796
	SEM (±)	42.26109	110.1302	114.9072	1.439907
	F-Value (0.05)	***	*	**	***
	CV (%)	9.864932	8.230141	6.504684	10.38375
	Grand Mean	742.0057	2317.714	3059.72	24.01824

Note: the common letter(s) within the column indicates a non-significant difference based on the Duncan multiple range test (DMRT) at a 0.05 level of significance. LSD (0.05) indicates the Least significant Difference test at 0.05 level of significance. CV% indicates the Coefficient of Variation.
NS = non-significant.
*** = Highly significant.
** = moderately significant.
*= Significant

3.3 Correlation studied

In order to assess the connections between various growth parameters, yield-related characteristics, and grain yield, we computed simple correlation coefficients. As displayed in Table 4, a significant positive correlation was evident between the number of trifoliate leaves (NTL) and grain yield (GY), a finding that is consistent with the results reported (Kumar et al., 2010). Conversely, we observed a noteworthy negative correlation between plant height (PH) and GY. Furthermore, we identified a significant positive association between GY and the number of pods per plant (PPP), as well as GY and pod length (PL), which aligns with the research findings (Manivelan et al., 2019). However, no significant positive correlation was identified between PH and GY, leaf area index (LAI) and GY, grains per pod (GPP) and GY, or 1000-grain weight (1000GW) and GY (refer to Table 4).

It is interesting to note that a significant positive correlation was established between PH and LAI, PH and PPP, and PH and GPP. Conversely, a negative correlation was observed between PH and 1000GW. These observations are consistent with the findings reported (Gul et al., 2008). Similarly, we discovered a significant positive correlation between LAI and GPP, NTL and PPP, while negative correlations were noted between LAI and PL, as well as PPP and 1000GW. Apart from these specific correlations, all other parameters displayed positive relationships in our research. This suggests that a higher number of pods per plant, increased pod length, and an elevated number of trifoliate leaves contribute to greater grain yield.

Table 5: Simple correlation coefficient (r) of grain yield and associated components among seven different treatments

	GY	PH	LAI	NTL	PPP	PL	GPP	1000GW
GY	1							
PH	0.340	1						
LAI	0.058	0.671**	1					
NTL	0.649**	0.397	0.249	1				
PPP	0.711**	0.563**	0.128	.456*	1			
PL	0.565**	0.001	-0.014	0.251	0.287	1		
GPP	0.375	0.694**	0.623**	0.271	0.413	0.079	1	
1000GW	0.294	-0.091	0.115	0.037	-0.096	0.343	0.378	1

* = Significance at 5% probability level, GY= Grain Yield, PH= Plant Height, LAI= Leaf Area Index, NTL= Number of Trifoliate Leaves, PPP= Pod Per Plant, PL= Pod Length, GPP= Grain Per Pod, 1000GW= 1000 Grain Weight

Coefficient of Variation.

* = Significant.

*** = Highly significant.

** = moderately significant.

4. Conclusion

Upon analyzing all the data and results obtained from this research, it can be concluded that organic nutrient vermicompost outperforms other nutrient sources in terms of yield. The second-best performer was the application of NPK with Zinc micronutrient. These findings underscore the advantages of using vermicompost as a nutrient source for green gram production in the area due to its cost-effectiveness and superior productivity compared to alternative nutrient sources. If the soil conditions and temperature in a given area align with the data from this research, vermicompost is recommended for achieving higher yields in the field. It is worth noting that while this treatment exhibited high yields at Paklihawa Agronomy Farm, further verification is needed at both research centers and on farmers' fields to fully validate the experiment's findings.

Moreover, this study highlights the research gaps and opportunities it presents, offering academics and policy-makers the chance to address issues affecting green gram production in Nepal. The use of organic nutrients such as vermicompost and panchagavya is encouraged to address the low yield potential of current fertilizers. Additionally, the study emphasizes the importance of expanding access to improved biological and straw yields for green gram. Addressing these issues and capitalizing on the opportunities presented by this research has the potential to increase maize output and enhance food security in Nepal.

Conflict of Interest

The authors declare that they have no known financial or interpersonal conflicts that would appear to have an impact on the research presented in this paper.

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