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Integrated Organic and Inorganic Nutrient Management for Enhancing the Yield of Green Gram (*Vigna radiata* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Abstract

Green gram (*Vigna radiata* L.) is an important pulse crop, but its productivity is often constrained by poor soil fertility and inadequate nutrient management. The integrated application of organic manures and inorganic fertilisers offers a potential approach to improving nutrient availability, crop growth and yield. A field experiment was conducted during the Kharif season of 2025 at the Agricultural Research Farm, Faculty of Agriculture, Tantia University, Sri Ganganagar, Rajasthan, to evaluate the effect of organic and inorganic nutrient management on green gram (*Vigna radiata* L.). The experiment was conducted in a randomised block design (RBD) with ten treatments and three replications. The treatments included different levels of the recommended dose of fertilisers (RDF), applied alone or in combination with farmyard manure (FYM) @ 5 t/ha or vermicompost @ 2 t/ha. Among the treatments, 100% RDF combined with vermicompost @ 2 t/ha (T9) recorded the highest number of pods per plant (19.53), number of grains per

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pod (9.60), test weight (31.90 g), grain yield (1178.67 kg/ha), straw yield (2559.44 kg/ha) and biological yield (4253.95 kg/ha). The performance of T9 was followed by 100% RDF + FYM @ 5 t/ha (T8) and 75% RDF + vermicompost @ 2 t/ha (T6), which were statistically at par for the reported yield attributes and yield parameters. The lowest values for number of pods per plant (13.60), grains per pod (6.60), test weight (30.10 g), grain yield (620.00 kg/ha), straw yield (1945.55 kg/ha) and biological yield (2701.73 kg/ha) were recorded in the control (T1). The results indicate that the combined application of the full recommended fertiliser dose and vermicompost improved green gram productivity under the conditions of the present study.

Keywords: Green gram; recommended dose of fertilisers; farmyard manure; vermicompost; integrated nutrient management.

1. Introduction

Pulses, commonly referred to as food legumes, are an important component of the Indian food system. They provide dietary protein, energy, minerals and vitamins and are particularly important in the diets of predominantly vegetarian populations. Pulses contribute substantially to food and nutritional security and account for nearly 20% of the area under food grains and 7–10% of total food-grain production in India (Mohanty & Satyasai, 2015). In addition to their nutritional value, pulse crops improve soil fertility through biological nitrogen fixation and the addition of nitrogen-rich crop residues. Some pulse crops can contribute approximately 30–50 kg N/ha to the soil, supporting their role in sustainable cropping systems (Makwana *et al.*, 2020).

Green gram (*Vigna radiata* L.), a member of the family Fabaceae, is an important short-duration pulse crop cultivated for grain, forage and green manure. It is a warm-season crop adapted to tropical and subtropical environments and is grown during the Kharif, spring and summer seasons in India. Its short duration, relatively low water requirement and adaptability to diverse climatic conditions make it suitable for inclusion in multiple-cropping systems and as a catch crop (Arya *et al.*, 2025). Green gram seeds contain approximately 20.97–31.32% protein, together with carbohydrates, minerals and essential amino acids such as lysine and tryptophan. The crop also supplies calcium, iron and vitamins, while its vigorous vegetative growth makes it useful as forage and for protecting soil against erosion (Anwar *et al.*, 2007). India is a major producer of green gram, which is cultivated in several states. During 2021–22, the crop occupied approximately 40.38 lakh hectares and produced 31.5 lakh tonnes, with an average productivity of 783 kg/ha, contributing nearly 11% of total pulse production (Kharol *et al.*, 2024). Rajasthan is the leading green gram-producing state, accounting for approximately 46% of the national area and 45% of production. Important producing districts include Nagaur, Jodhpur, Bikaner, Churu, Sikar, Jhunjhunu, Pali, Ajmer, Sri Ganganagar and Hanumangarh (Indian Council of Agricultural Research [ICAR], 2023).

Despite its importance, green gram productivity is often constrained by cultivation on marginal and sub-marginal soils, low soil fertility, inadequate adoption of improved agronomic practices, moisture stress, pest and disease incidence, limited availability of quality seed and inappropriate post-harvest management. Imbalanced and excessive application of inorganic fertilisers may also adversely affect soil health and biodiversity. Therefore, efficient nutrient management is essential for improving crop productivity while maintaining soil fertility (Chauhan *et al.*, 2024).

The indiscriminate and prolonged use of chemical fertilisers may contribute to environmental pollution and can adversely affect soil health and crop performance. These concerns have increased the need for integrated nutrient management approaches in sustainable agricultural production systems. The judicious combination of organic and inorganic nutrient sources can help maintain crop productivity while improving soil properties (Banotra *et al.*, 2022).

Integrated nutrient management (INM), which involves the balanced use of inorganic fertilisers and organic manures, offers a practical approach to improving green gram production. Organic nutrient sources, such as farmyard manure and vermicompost, add nutrients and organic matter to the soil and can improve microbial activity and soil water-holding capacity. Inorganic fertilisers, in turn, supply readily available nutrients required for crop growth. Their combined application may improve nutrient-use efficiency, soil properties, crop productivity and the sustainability of the production system compared with the use of either nutrient source alone. Thus, integrated nutrient management can contribute to improved growth and yield of green gram while supporting soil health and long-term productivity (Muwal & Dhaked, 2022). A field experiment in Rajasthan reported improvements in mung bean yield and nutrient uptake after the combined application of recommended mineral fertiliser, vermicompost and a biofertiliser (Patidar *et al.*, 2025).

Experimental evidence indicates that the response of mung bean to combined organic and mineral nutrient inputs depends on the amendment source, the proportion of mineral fertiliser and the growing environment. A two-season field study reported higher mung bean grain yield under vermicompost–mineral fertiliser combinations than compared with its fertiliser-only treatment, while a study of residual nutrient management demonstrated that preceding soil amendments can also influence the growth and nutrient uptake of a succeeding mung bean crop (Aslam *et al.*, 2024; Niranjan *et al.*, 2023). A recent investigation also observed differences in mung bean productivity among treatments containing vermicompost, compost and mineral nitrogen–phosphorus fertiliser, with the response varying across input combinations (Aslam *et al.*, 2025).

Beyond direct nutrient supply, organic amendments have been associated with changes in soil microbial communities and functions; a meta-analysis of 219 studies linked these responses with crop productivity, although the magnitude and direction varied with amendment type and soil conditions (Shu *et al.*, 2022). Field studies in different Indian production environments have likewise reported improved green gram performance with integrated nutrient inputs, but the combinations giving the strongest responses were not identical across studies (Paul *et al.*, 2025; Suddala *et al.*, 2024). These findings provide a comparative basis for examining FYM and vermicompost alongside graded fertiliser doses under the soil and seasonal conditions of Sri Ganganagar. Another field study documented variation in green gram seed nitrogen, phosphorus and potassium content among treatments involving farmyard

manure, vermicompost and mineral fertilisers (Kamal *et al.*, 2026). In separate two-season trials, comparisons of mineral nitrogen and microbial fertiliser treatments also showed that mung bean yield responses differed between genotypes (Yousefi *et al.*, 2025).

The studies discussed above do not directly establish how graded recommended fertiliser doses compare when combined separately with FYM or vermicompost under the sandy-loam field conditions of Sri Ganganagar. A location-specific comparison of these treatments is therefore warranted to assess their effects on green gram yield attributes and yield.

In this context, the present investigation was undertaken to evaluate the effects of different levels of inorganic fertilisers in combination with FYM and vermicompost on the yield attributes and yield of green gram.

2. Materials and Methods

A field experiment was conducted during the Kharif season of 2025 at the Agricultural Research Farm, Faculty of Agriculture, Tantia University, Sri Ganganagar, Rajasthan. The experimental soil was sandy loam, with a pH of 8.45 and an organic carbon content of 0.47%. The available nitrogen, phosphorus and potassium contents were 125.44, 16.93 and 120.01 kg/ha, respectively. Soil pH, organic carbon, available nitrogen, available phosphorus and available potassium were determined following the methods described by Piper (1966), Walkley and Black (1934), Subbiah and Asija (1956), Olsen (1954) and Jackson (1973), respectively. The experiment was laid out in a randomised block design (RBD) comprising ten treatments and three replications. The treatments were T1: control (no fertiliser); T2: 50% RDF + FYM @ 5 t/ha; T3: 50% RDF + vermicompost @ 2 t/ha; T4: 50% RDF; T5: 75% RDF + FYM @ 5 t/ha; T6: 75% RDF + vermicompost @ 2 t/ha; T7: 75% RDF; T8: 100% RDF + FYM @ 5 t/ha; T9: 100% RDF + vermicompost @ 2 t/ha; and T10: 100% RDF + Mo @ 1 kg/ha.

The recommended dose of fertilisers (RDF) consisted of 20 kg N and 40 kg P_2O_5/ha, supplied through urea (46% N) and single superphosphate (16% P, 12% S and 21% Ca). FYM and vermicompost were applied according to the respective treatment requirements. Each experimental plot measured 4 m × 3 m, with row-to-row and plant-to-plant spacings of 30 cm and 10 cm, respectively. Irrigation, weed management and other recommended agronomic practices were carried out uniformly in all plots throughout the crop growth period. Observations were recorded at harvest for yield attributes and yield parameters, including number of pods per plant, number of grains per pod, test weight, grain yield, straw yield and biological yield. The recorded data were subjected to statistical analysis to determine the significance of treatment effects, following the procedures described by Panse and Sukhatme (1967). The treatments were compared to identify the nutrient-management practice that most effectively improved green gram productivity.

3. Results and Discussion

3.1 Effect of Organic and Inorganic Nutrient Management on Yield Attributes

The application of different levels of the recommended dose of fertilisers (RDF), either alone or in combination with FYM and vermicompost, significantly influenced the yield attributes of green gram (Table 1). The highest number of pods per plant (19.53) was recorded under T9 (100% RDF + vermicompost @ 2 t/ha). The next highest values were observed under T8 (100% RDF + FYM @ 5 t/ha; 18.60) and T6 (75% RDF + vermicompost @ 2 t/ha; 17.47). The control (T1) recorded the lowest number of pods per plant (13.60). A similar trend was observed for the number of grains per pod. T9 recorded the maximum value (9.60), followed by T8 (9.27) and T6 (9.00), whereas the lowest value (6.60) was recorded in the control.

Test weight was also significantly influenced by nutrient management. The highest test weight (31.90 g) was recorded under T9, followed by T8 (31.70 g) and T6 (31.50 g); these treatments were statistically at par. The lowest test weight (30.10 g) was observed in the control. The improvement in yield attributes with the combined application of organic manures and chemical fertilisers may be associated with a more favourable soil physical, chemical and biological environment (Pandey *et al.*, 2019). Improved nutrient availability may promote root development, biological nitrogen fixation and plant growth, thereby increasing photosynthetic activity and the translocation of assimilates from source to sink. These processes may contribute to better pod formation and other yield attributes in green gram (Makwana *et al.*, 2020). The combined use of organic and inorganic nutrient sources may also improve nutrient-use efficiency, soil health and microbial activity in the rhizosphere. Such synergistic effects are particularly relevant to short-duration pulse crops, which require an adequate nutrient supply during their reproductive stages (Singh *et al.*, 2025).

Similar associations between integrated nutrient inputs and reproductive traits have been documented in field studies of mung bean. Kumari *et al.* (2023) reported increases in pod number, seeds per pod and test weight under a treatment combining recommended fertiliser, vermicompost and biological amendments; Suddala *et al.* (2024) also observed improved pod production with integrated nutrient management. In saline-region trials, Paul *et al.* (2025) found that yield components varied with both nutrient treatment and cultivar, indicating that the relative benefit of particular amendments may be context dependent.

In the present experiment, the numerical contrast between treatments was more evident for pods per plant and grains per pod than for 1,000-seed weight. This pattern is consistent with the possibility that improvements in reproductive sink formation contributed to the observed treatment response, although nutrient uptake, nodulation, photosynthetic activity and soil microbial processes were not measured directly. Consequently, mechanisms proposed in other investigations should be regarded as plausible explanations rather than demonstrated causal pathways for this trial (Aslam *et al.*, 2024; Shu *et al.*, 2022).

3.2 Effect of Organic and Inorganic Nutrient Management on Yield

Grain yield was significantly influenced by the nutrient-management treatments (Table 2). The highest grain yield was recorded under T9 (1178.67 kg/ha), followed by T8 (1129.80 kg/ha) and T6 (1089.67 kg/ha), which were statistically at par. The control recorded the lowest grain yield (620.00 kg/ha). Straw yield was also highest under T9 (2559.44 kg/ha), followed by T8 (2446.11 kg/ha) and T6 (2347.89 kg/ha); these treatments were statistically comparable. The lowest straw yield (1945.55 kg/ha) was recorded in the control. Similarly, the maximum biological yield was obtained under T9 (4253.95 kg/ha), followed by T8 (3994.69 kg/ha) and T6 (3750.89 kg/ha), whereas the control recorded the minimum value (2701.73 kg/ha). The higher grain, straw and biological yields under the combined application of organic and inorganic nutrient sources may be attributed to improved nutrient availability and more balanced plant nutrition, which support vegetative growth, dry-matter accumulation and assimilate production. Similar improvements in yield and yield attributes following balanced nutrient management have been reported by Mishra *et al.* (2016), Meena *et al.* (2015), Patil *et al.* (2025), Muchomba *et al.* (2023) and Patel *et al.* (2026).

The higher grain yield observed under the combined fertiliser–vermicompost treatment agrees in direction with results from a two-season mung bean trial in which integrated vermicompost and mineral fertilisation increased grain production (Aslam *et al.*, 2024). Comparable advantages of combined inputs have been described for mung bean in a field experiment using FYM with recommended fertiliser (Ayekpam *et al.*, 2026). Nevertheless, these studies employed different fertiliser formulations, organic-input rates and environments; their treatment-specific yield values should therefore not be interpreted as directly interchangeable with those of the present experiment.

The evidence also warrants qualification rather than an assumption of universal benefit. In post-mined soils, Muchomba *et al.* (2023) reported responses that differed between green gram varieties and seasons, with a grain-yield benefit from combined manure and fertiliser observed for one variety in the second season. Similarly, Paul *et al.* (2025) reported treatment-by-variety differences under saline conditions. These contrasts suggest that cultivar, soil constraints and growing season may modify the yield response to integrated nutrient management. Because the present study represents one location and one growing season and did not report post-harvest soil nutrient balance or economic returns, its relative treatment performance should be interpreted within the tested conditions rather than as proof of a universally optimal nutrient regime (Niranjan *et al.*, 2023).

Table 1. Effect of organic and inorganic nutrient management on yield attributes

S. No.	Treatment description	Number of pods/ plant	Number of grains/ pod	Test weight (1000 seeds/g)
T_1	Control	13.60	6.60	30.10
T_2	RDF (50%)+ FYM@5t/ha	14.47	7.33	30.50
T_3	RDF (50%)+ Vermicompost @2 t/ha	15.80	8.00	31.10
T_4	RDF (50%)	13.87	6.73	30.30
T_5	RDF (75%)+ FYM@5t/ha	15.93	7.87	30.90
T_6	RDF(75%)+ Vermicompost @2 t/ha	17.47	9.00	31.50
T_7	RDF (75%)	15.27	7.67	30.70
T_8	RDF (100%)+ FYM@5t/ha	18.60	9.27	31.70
T_9	RDF (100%)+ Vermicompost @2 t/ha	19.53	9.60	31.90
T_{10}	RDF (100%)	16.93	8.87	31.30
	S.Em.(±)	0.41	0.26	0.21
	CD (5%)	1.23	0.78	0.64

Table 2. Effect of organic and inorganic nutrient management on grain, straw and biological yields

S. No.	Treatment description	Yield (kg/ha)		
		Grain	Straw	Biological
T_1	Control	620.00	1945.55	2701.73
T_2	RDF (50%)+ FYM@5t/ha	940.67	1996.55	2902.20
T_3	RDF (50%)+ Vermicompost @2 t/ha	1019.27	2149.55	3261.00
T_4	RDF (50%)	925.47	1955.00	2749.40
T_5	RDF (75%)+ FYM@5t/ha	986.60	2062.66	3157.62
T_6	RDF(75%)+ Vermicompost @2 t/ha	1089.67	2347.89	3750.89
T_7	RDF (75%)	960.67	2023.00	3035.53
T_8	RDF (100%)+ FYM@5t/ha	1129.80	2446.11	3994.69
T_9	RDF (100%)+ Vermicompost @2 t/ha	1178.67	2559.44	4253.95
T_{10}	RDF (100%)	1045.60	2230.78	3559.84
	S.Em.(±)	4.84	4.81	13.24
	CD (5%)	14.65	14.56	40.05

4. Conclusion

The study demonstrated that the yield attributes and yield of green gram responded to the tested combinations of organic and inorganic nutrient sources. Among the treatments evaluated, 100% RDF combined with vermicompost at 2 t/ha (T9) produced the highest recorded values for pods per plant, grains per pod, test weight, grain yield, and straw yield. The combination of 100% RDF

with FYM at 5 t/ha also produced favourable results. These findings indicate that combining the recommended fertiliser dose with an organic nutrient source can support green gram productivity under the conditions of the present experiment. However, because the experiment was conducted during a single season at one location, broader recommendations should be based on additional validation across seasons, locations, and soil conditions.

5. Limitations

The experiment was conducted during a single kharif season at one location, limiting the generalisability of its findings to other soils, climates and growing seasons. The manuscript does not report direct measurements of nutrient uptake, nodulation, soil microbial activity, post-harvest soil fertility or economic returns. Consequently, the proposed mechanisms underlying improved yield cannot be confirmed, and long-term soil and financial implications cannot be assessed. Additional replicated studies across sites and seasons would be necessary to evaluate the stability of the observed treatment responses.

Declaration of AI Use

This manuscript was prepared through the intellectual contributions of the author(s) to the study design, data analysis, interpretation of results, and scholarly content. ChatGPT, Claude and Perplexity were used solely to assist with grammatical refinement and reference formatting during manuscript revision. The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Competing Interests

Authors have declared that no competing interests exist.

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