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Yield enhancement in greengram [*Vigna radiata* (L) Wilczek] through integrated nutrient management approaches

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Abstract
A field experiment was conducted at the Agricultural Experimental Farm of Calcutta University, Baruipur, 24 Parganas (South), West Bengal, during the summer of 2018 to assess the yield parameters of greengram [*Vigna radiata* (L) Wilczek] through integrated nutrient management strategies. The experiment was laid out in a randomized block design replicated thrice with 7 treatments. The results revealed that in T_6, the integrated application of 100% RDF + FYM @ 10t/ha + *Rhizobium* inoculation @ 25 g/kg of seed recorded significantly higher yield parameters over the other treatments. T_6 also recorded a higher seed yield of 1,096.93 Kg/ha as compared to other treatments. The number of pods per plant ranged from 20.19 to 29.04. Pod length showed considerable improvement from 7.38 cm in T_1(Control) to 9.13 cm in T_6, and test weight increased from 3.13 g under the control to 3.87 g in the highest performing treatment. Hence, the enhancement of crop growth and final grain production is closely linked to proper nutrient management, and INM achieves this through the synergistic use of fertilizers, organic manures, and biofertilizers.

Keywords: FYM, *Rhizobium*, INM, Greengram, Yield

Introduction
In India, pulses are a key component of nutrition, providing an affordable and rich source of protein, thereby ensuring nutritional security. The Ministry of Agriculture and Farmers Welfare, India, reported that the overall pulse production for 2024-25 is estimated at approximately 256.83 lakh tonnes, with Moong accounting for 42.44 lakh tonnes (Press Information Bureau, 2025) [1]. The cultivated area for pulse crops in India in 2024-25 was approximately 35.58 lakh hectares, accounting for almost 70% of global greengram output (Greengram Outlook-October,2024) [2]. Greengram serves as an excellent source of protein, dietary fibre, key minerals, as well as important vitamins. Its grains are utilized for preparing dal and soups, and also serve as a source of animal feed, whereas the crop residues are used as fodder or fuel. In addition to its nutritional benefits, green gram has the exceptional ability to fix atmospheric nitrogen in the soil through a symbiotic relationship with rhizobial bacteria, which converts atmospheric nitrogen into a plant-available form, enriching the soil with this essential nutrient (Senaratne *et al*., 1995) [3]. As a result of this inherent nitrogen-fixing ability, the inclusion of greengram as an intercrop or as a subsequent crop in rotation systems enhances soil fertility. Although the sole use of chemical fertilizers may increase the yield of crops, their continuous use has adverse impacts on soil physical, chemical, and biological properties, affecting sustainability. Consequently, greengram plays an important role in promoting sustainable agricultural practices by reducing dependence on synthetic nitrogen fertilizers and improving overall soil health. However, to achieve optimum and sustainable crop yields, the integrated use of organic amendments and chemical fertilizers is essential, as the exclusive use of organics may lead to nutrient imbalances and insufficient nutrient availability. INM integrates a combination of organic manures, biofertilizers, and inorganic fertilizers to provide balanced nutrients for the duration of crop growth. Integrated nutrient management (INM) has assumed considerable importance in recent years, due to the growing emphasis on sustainable agricultural practices. Organic manures like Farm Yard Manure (FYM) provide essential nutrients and organic matter,

enhancing the soil structure and microbial activity, supporting healthy root growth and long-term soil fertility (Tilahun *et al*., 2013) [4]. Application of biofertilizers like *Rhizobium* facilitates efficient nodulation and symbiotic nitrogen fixation, improving grain mass and total crop productivity (Mehandi *et al*., 2019) [5]. A field experiment was therefore formulated to study the effect of integration of inorganic fertilizer, organic manure (FYM), and *Rhizobium* on green gram.

Materials and Methods

A field experiment was carried out during the summer season of 2018 at the Agricultural Experimental Farm of the University of Calcutta, Baruipur, South 24 Parganas, located in the Gangetic alluvial plains of West Bengal. The soil of the experimental field was clay loam soil with a slightly acidic reaction. The experiment was laid out in a Randomized Block Design (RBD) comprising seven treatments and three replications. The treatments consisted of different combinations of organic and inorganic sources of nutrients, designated as: T_1- Control, T_2- FYM @10t/ ha+ *Rhizobium*, T_3- 100% RDF (Recommended dose of Fertilizer) + *Rhizobium*, T_4- 50% RDF + *Rhizobium*, T_5- 50%RDF + FYM@10 t/ha + *Rhizobium*, T_6- 100% RDF + FYM@10 t/ha + *Rhizobium*, T_7- 50% RDF +FYM@10t/ha. FYM was applied 20 days before sowing. The *Rhizobium* inoculated seeds were dried in the shade prior to sowing. Crop management practices were followed as per standard recommendations. Urea, single superphosphate (SSP), and muriate of potash (MOP) served as the sources of nitrogen, phosphorus, and potassium, respectively. The recommended dose of fertilizers (RDF) for greengram was 20:40:20 kg/ha of N: P_2O_5: K_2O, along with 10 t/ha of FYM. Rhizobium inoculation was applied @ 25 g per kg of seed. The variety Samrat was used and sown at a spacing of 30 cm × 10 cm. The yield parameters, such as number of pods per plant, number of seeds per pod, pod length, test weight, and seed yield, were recorded after harvesting the crop. All observations recorded during the investigation were subjected to statistical evaluation.

Table 1: Treatment details and denotations

Treatment details	Denotations
Control	T_1
FYM @10t/ ha+ *Rhizobium*	T_2
100% RDF + *Rhizobium*	T_3
50% RDF + *Rhizobium*	T_4
50%RDF + FYM@10 t/ha + *Rhizobium*	T_5
100% RDF + FYM@10 t/ha + *Rhizobium*	T_6
50% RDF +FYM@10t/ha	T_7

Results and Discussion

Number of pods/ plant

The effect of various treatments on the number of pods per plant is presented in Table 2. The results revealed a favourable response to the combined application of chemical fertilizers, FYM, and biofertilizer. The number of pods per plant varied notably across the different treatments, ranging from 20.19 to 29.04. The minimum number of pods per plant was recorded in control (T_1: 20.19), indicating low yield under nutrient-deficient conditions. Among the treatments, T_6 recorded the highest number of pods per plant (29.04), followed by T_5 (28.63) and T_3 (28.07), suggesting that the combined application of chemical fertilizers along with FYM and biofertilizers had a synergistic effect in enhancing pod formation. Treatments T_2 (23.03) and T_7 (24.17) showed moderate performance, while T_4 (27.43) exhibited a considerable increase compared to control. Overall, the results clearly indicate that integrated nutrient management practices substantially improved pod formation in greengram, with T_6 emerging as the most effective treatment for enhancing reproductive growth. Similar results were also reported by Naushad *et al*. (2023) [6] and Kankarwal *et al*. (2025) [7].

Number of seeds/pod

The number of seeds per pod varied across the treatments and ranged from 7.02 to 9.79 (Table 2). The lowest value was observed in control (T_1: 7.02), under nutrient-deficient conditions. Among the treatments, T_6 recorded the highest number of seeds per pod (9.79). T_5 and T_3 were found to be statistically at par with each other, with values of 8.96 and 8.39, respectively, demonstrating the positive effect of integrated nutrient application involving RDF, FYM, and *Rhizobium* inoculation. Treatments T_2 (7.90) and T_4 (7.90) exhibited a moderate response, while T_7 (7.63) showed only a slight improvement over the control. These results were consistent with the findings of Tyagi and Upadhyay (2015) [8].

Pod length (cm)

The shortest pod length was recorded under the control (T_1: 7.38 cm). Progressive improvement was observed with the incorporation of fertilizers, FYM, and biofertilizer. Among all treatments, T_6 recorded the maximum pod length (9.13 cm), followed by T_5 (8.61 cm) and T_3 (7.99 cm), highlighting the beneficial effect of applying RDF in combination with FYM and *Rhizobium*. Treatments T_2 (7.65 cm), T_4 (7.63 cm), and T_7 (7.55 cm) demonstrated slight improvement over the control but remained lower compared to integrated nutrient treatments. The trend observed in pod length variation among treatments in the present study agrees with the findings of Patel *et al*. (2016) [9], where pod length increased with the application of organic and biofertilizer-based treatments.

Test weight (100g)

Treatment with 100% RDF, FYM, and Rhizobium recorded the highest test weight of 3.87g, followed by T_5 and T_3. Treatments T_2 (3.17 g), T_4 (3.46 g), and T_7 (3.37 g) showed moderate increases compared to the control, though their performance was comparatively lower than the fully integrated nutrient combinations. The test weight recorded in the present study aligns with the findings of Soni *et al.* (2024) [10], who also observed higher seed weight under the combined application of organic and inorganic nutrient sources.

Seed yield (Kg/ha)

Application of 100% RDF + FYM@10 t/ha + *Rhizobium* inoculation of seed in T_6 recorded significantly highest seed yield of 1,096.93 kg ha^{-1}, which was 37.48% higher than control, followed by T_5 (50%RDF + FYM@10 t/ha + *Rhizobium*) with a yield of 1,082.60 kg ha^{-1}. The enhancement in seed yield under T_6 maybe due to improved nutrient availability, better pod development, and higher seed set per pod. T_2 (875.50 kg ha^{-1}), T_4 (935.47 kg ha^{-1}), and T_7 (914.77 kg ha^{-1}) recorded intermediate yields, showing improvement over the control but lower than the fully integrated treatments. A similar increasing trend in seed yield under INM practices has also been reported by Sasmal *et al*. (2024) [11].

Table 2: Effect of INM on yield and yield attributing characters of greeengram

Treatments	No. of pods/plant	No. of seeds/pod	Pod length(cm)	Test weight (g)	Seed yield (Kg/ha)
T_1	20.19	7.02	7.38	3.13	797.87
T_2	23.03	7.90	7.65	3.17	875.50
T_3	28.07	8.39	7.99	3.56	1,070.63
T_4	27.43	7.90	7.63	3.46	935.47
T_5	28.63	8.96	8.61	3.71	1,082.60
T_6	29.04	9.79	9.13	3.87	1,096.93
T_7	24.17	7.63	7.55	3.37	914.77
C.D. at 5%	0.96	0.88	0.40	0.13	28.18
S.E.(m)±	0.31	0.28	0.13	0.04	9.05

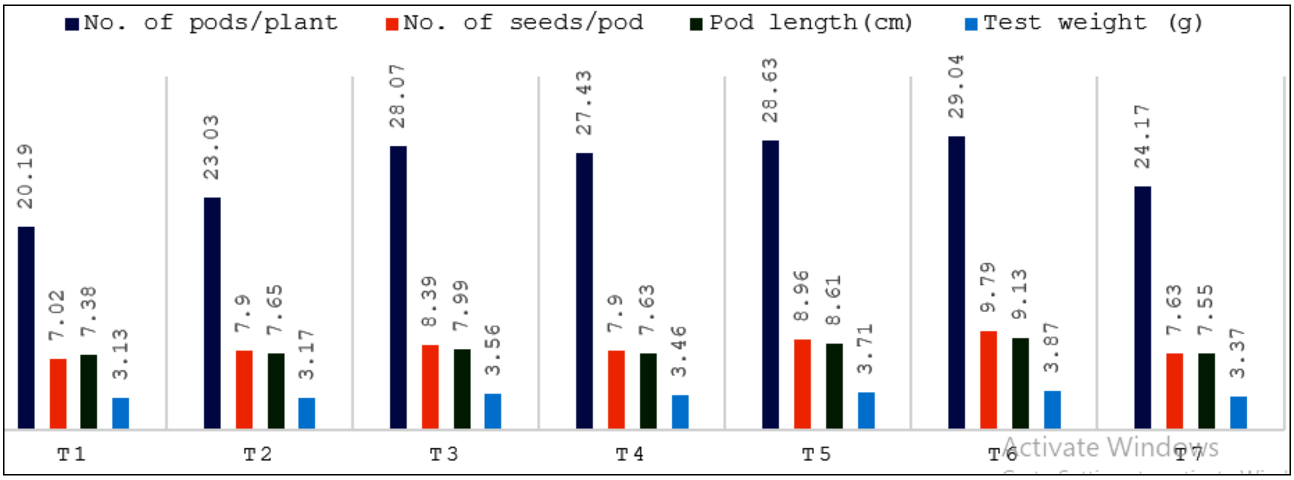

Fig 1: Effect of INM on yield parameters

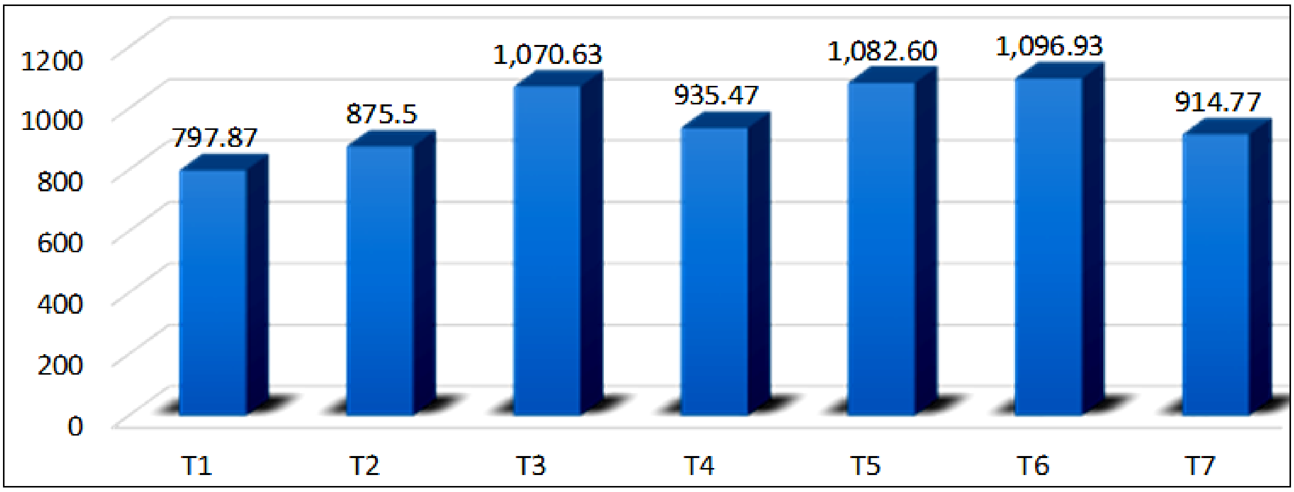

Fig 2: Effect of INM on seed yield (Kg/ha)

Summary and Conclusion

The results of the study indicate that the varying levels and sources of NPK, FYM, and Rhizobium inoculation exerted differential impacts on crop growth and yield. The treatment T_6-100% RDF + FYM@10 t/ha + *Rhizobium* showed superior performance for all yield and yield-attributing traits, suggesting that nutrient integration plays a crucial role in enhancing overall plant vigour. In contrast, treatments receiving only chemical fertilizers or without biological inoculants showed comparatively lower yield, indicating that sole reliance on inorganic fertilizers may not fully optimize crop response. This further highlights the significance of balanced nutrient management over single-source fertilization.

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