International Journal of Environment, Agriculture and Biotechnology
Vol-10, Issue-4; Jul-Aug, 2025
Peer-Reviewed International Journal
Journal Home Page Available: https://ijeab.com/
Journal DOI: 10.22161/ijeab

Effect of Integrated Nutrient Management on Growth, Yield Attributes, and Productivity of Green Gram (*Vigna radiata* L.)

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Received: 09 Jun 2025; Received in revised form: 03 Jul 2025; Accepted: 10 Jul 2025; Available online: 17 Jul 2025

***Abstract*— *A field experiment was conducted at the Instructional Farm, Rajasthan College of Agriculture, MPUAT, Udaipur, during the Kharif season of 2024 to study the effect of integrated nutrient management (INM) on green gram (Vigna radiata L.) growth, yield attributes and productivity. The trial was designed in a randomized block design, with twelve treatments replicated three times. The treatments involved different combinations of chemical fertilizers (RDF), farm yard manure (FYM), vermicompost and seed inoculation with Rhizobium and phosphate solubilizing bacteria (PSB). The experimental soil was clay loam in texture, low in available nitrogen, medium in phosphorus, and high in potassium with adequate levels of DTPA-extractable micronutrients (Zn, Fe, Mn and Cu). The combined application of 50% RDF with 1 t ha^{-1} each of vermicompost and FYM, along with Rhizobium + PSB (T_{12}), led to a significant enhancement in plant height at harvest (64.11 cm), number of branches plant^{-1} (6.06), number of effective root nodules plant^{-1} at 40 DAS (37.75), number of pods plant^{-1} (32.14), number of seeds pod (12.64), test weight (43.80 g), seed yield (1350.60 kg ha^{-1}) and biological yield (3390.90 kg ha^{-1}). These values significantly outperformed the absolute control treatment (T_1). The results emphasize the advantage of nutrient synergy in INM systems, highlighting their potential to enhance crop productivity through sustainable and balanced nutrient inputs.*

***Keywords*— Green gram, FYM, RDF, Vermicompost, Rhizobium, PSB.**

I. INTRODUCTION

Pulses are important food legumes cultivated for their dry, edible seeds, which serve as rich sources of protein, dietary fiber, and essential minerals. These crops play a crucial role in ensuring nutritional security, particularly in regions dependent on plant-based diets. Moreover, pulses contribute to sustainable agriculture by enhancing soil fertility through biological nitrogen fixation. Among these, green gram (*Vigna radiata* L.), commonly known as mung bean, is especially valued for its high nutritional content. It contains approximately 24–25% protein, 1.0–1.5% fat, 60–65% carbohydrates, 3–4% fiber, and essential nutrients such as calcium, phosphorus, iron, and vitamins A, B-complex, and C (Potter & Hotchkiss, 1997; Tyagi & Upadhyay, 2015). As a dietary staple, particularly among rural and economically disadvantaged populations, green gram is instrumental in combating protein malnutrition. Its short duration (65–70 days), nitrogen-fixing ability, and adaptability to various agro-climatic zones make it well-suited for improving food security and sustaining soil health in pulse-based cropping systems. However, declining soil organic matter and excessive reliance on synthetic fertilizers have led to reduced productivity and nutrient-use efficiency in many such systems.

Among the various approaches to enhance crop growth and yield, Integrated Nutrient Management (INM) has gained significant importance. INM involves the combined use of inorganic fertilizers, organic manures, and biofertilizers to supply balanced nutrients throughout the crop growth period. It improves vegetative growth, flowering, and pod development — all of which directly influence yield attributes and final productivity (Aulakh & Adhya, 2005; Meena *et al*., 2015). Farm Yard Manure (FYM) is a natural soil amendment made from decomposed livestock waste and farm residues. It provides essential nutrients and organic matter that enhance soil structure, moisture retention, and microbial activity. Its gradual nutrient release supports healthy root growth and long-term soil fertility, especially under rainfed conditions (Dhakal *et al*., 2016; Tilahun *et al*., 2013). Vermicompost is an organic amendment derived from the biological activity of earthworms that decompose organic residues into a fine, nutrient-rich compost. It supplies a balanced mix of essential plant nutrients, enzymes, and growth-promoting substances, along with enhancing microbial populations in the soil. Vermicompost also contributes to improved soil aeration, water retention, and overall soil structure, thereby supporting root growth and improving nutrient availability throughout the plant's life cycle (Ceritoglu *et al*., 2019; Giraddi *et al*., 2006).

Biofertilizers like *Rhizobium* contribute to better nodulation and nitrogen fixation, supporting shoot and root growth, while also increasing grain weight and overall yield (Mehandi *et al*., 2019). Phosphate Solubilizing Bacteria (PSB) are a group of beneficial microbes that enhance phosphorus availability in the soil by converting insoluble phosphate compounds into forms that plants can absorb. They do this by releasing organic acids and other compounds that break down bound phosphorus. When used alongside organic manures and other biofertilizers like *Rhizobium*, PSB contribute to better phosphorus uptake, improved root development, and increased crop yield, especially in phosphorus-deficient soils (Rao, 2007; Rekha *et al*., 2018). The present investigation was carried out to evaluate the effect of integrated nutrient management on the growth, yield attributes, and productivity of green gram under field conditions.

II. MATERIALS AND METHODS

2.1 Field location and materials:

The experiment was laid out during *Kharif* season of 2024 at the Instructional Farm, B1 Block (Agronomy), Rajasthan College of Agriculture, MPUAT, Udaipur. The site is situated at 24º34′52.93″ N latitude and 73º42′14.4″ E longitude with an average altitude of 581.13 m above mean sea level. The region falls under Agro-climatic zone IV-a (Sub-Humid Southern Plain and Aravalli Hill Zone) of Rajasthan. The soil of the experimental field was clay loam, slightly alkaline in reaction (pH 8.28) with low available nitrogen (220.47 kg ha^{-1}), medium phosphorus (19.10 kg ha^{-1}), and high potassium (325.78 kg ha^{-1}).

2.2 Experimental detail:

The experiment was conducted using a Randomized Block Design (RBD) with 12 treatments and three replications. The treatments included different combinations of inorganic fertilizers, organic manures (FYM and vermicompost), and biofertilizers (*Rhizobium* + PSB). The test crop was green gram (*Vigna radiata* L.), variety NVL-516, sown on 5th July 2024 at a spacing of 30×10 cm using a seed rate of 20 kg ha^{-1}. Twelve different integrated nutrient management treatments were evaluated in the experiment. The Absolute control plot (T_1) received no fertilizers or amendments. Treatments T_2, T_3, and T_4 consisted of 50%, 75%, and 100% of the recommended dose of fertilizers (RDF) respectively, where RDF was 20:40:20 kg NPK ha^{-1}. To assess the impact of organic inputs, T_5 and T_6 included 50% and 75% RDF combined with farm yard manure (FYM) at 2 t ha^{-1} and 1 t ha^{-1} respectively. Similarly, T_7 and T_8 received 50% and 75% RDF along with vermicompost at 1 t ha^{-1} and 0.5 t ha^{-1}, respectively. Treatments T_9 and T_{10} involved the integration of 50% and 75% RDF with biofertilizers (*Rhizobium* + phosphate solubilizing bacteria). To study the combined effect of organic and biofertilizer sources, T_{11} consisted of 50% RDF + 0.5 t ha^{-1} vermicompost + *Rhizobium* + PSB, while T_{12} was a comprehensive treatment with 50% RDF + 1 t ha^{-1} vermicompost + 1 t ha^{-1} FYM + *Rhizobium* + PSB. Fertilizers were applied as per the treatment plan. FYM and vermicompost were incorporated manually prior to sowing. Biofertilizers were used for seed treatment. Standard recommendations for cultural and plant protection practices were followed throughout the crop season.

2.3 Determination methods:

Field data were recorded during experimentation, to assess the effect of different treatments on growth and yield performance of green gram. For measuring plant height at 45 DAS and at harvest, five plants were randomly selected and tagged in each plot. The height was measured from the base to the tip of the main shoot using a meter scale, and the average was computed. Number of branches plant^{-1} were also recorded at harvest from the same five tagged plants. To determine the number of effective root nodules plant^{-1} at 40 DAS, five randomly selected plants plot^{-1} were uprooted carefully, and the nodules were counted and averaged. For yield attributes, the number of pods plant^{-1} were counted from the same tagged plants, and number of seeds pod^{-1} were determined by counting seeds from ten randomly selected pods plot^{-1}. Test weight was calculated by counting and weighing 1000 seeds taken from each treatment and expressed in grams. Seed yield (kg ha^{-1}) was obtained by harvesting and threshing produce from the net plot area and converting it to per hectare basis. Haulm yield was calculated by subtracting seed yield from the corresponding biological yield, which was recorded by weighing the sun-dried total biomass from each net plot. Finally, the harvest index (%) was computed using the formula given by Donald and Hamblin (1976), i.e.,

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Where:

Economic yield = Seed yield (kg ha^{-1})

Biological yield = Seed yield + Haulm yield (kg ha^{-1})

III. RESULT AND DISCUSSION

4.1 Effect of Integrated Nutrient Management on Growth, Yield Attributes and Productivity of Green Gram

The application of integrated nutrient management (INM) significantly influenced the growth, yield attributes, and productivity of green gram (*Vigna radiata* L.) under field conditions (Tables 1–3). Among all treatments, the combined application of 50% RDF + 1 t ha^{-1} vermicompost + 1 t ha^{-1} FYM + *Rhizobium* + PSB (T_{12}) consistently recorded the highest values across all studied growth parameters and yield attributes, followed closely by T_{11}.

4.1.1 Growth Parameters

Plant height was recorded at 45 DAS and at harvest, was highest in T_{12} (50.75 and 64.11 cm), showing an increase of 67.82% and 66.82%, respectively, over the control T_1 (30.24 cm and 38.43 cm). T_{11} (48.71 and 61.59 cm) also showed a substantial improvement T_1. Similarly, number of branches plant^{-1} was highest in T_{12} (6.06), followed by T_{11} (5.82), which recorded 66.94% and 60.33% more branches, respectively, over T_1 (3.63).The number of effective root nodules plant^{-1} at 40 DAS was also significantly affected by INM and T_{12} produced the highest number of nodules plant^{-1} (37.75), followed by T_{11} (36.18), both significantly greater than T_1 (22.62), this corresponded to 66.88% and 59.94% increases in T_{12} and T_{11}, respectively (Table 1 and Fig. 1). The increase may be attributed to improved biological nitrogen fixation and enhanced microbial activity from *Rhizobium* and organic sources (Mehandi *et al*., 2019; Sharma *et al*., 2017).

4.1.2 Yield Attributes

Among the treatments (Table 2 and Fig. 2), T_{12} recorded the highest number of pods plant^{-1} (32.14), an increase of 66.27% over control (T_1: 19.33), followed by T_{11} (30.87), which showed a 59.69% increase. The number of seeds pod^{-1} also increased significantly, with T_{12} (12.64) and T_{11} (12.17) recording 65.66% and 59.50% higher values, respectively, compared to T_1 (7.63). The test weight followed a similar trend, with the maximum weight in T_{12} (43.80 g), showing a 50.51% increase over control (T_1: 29.10 g) and T_{11} recorded a 47.18% increase. The improvements in these yield attributes indicate better nutrient translocation and seed filling under integrated nutrient regimes, corroborating Verma *et al*. (2017) and Tomer *et al*. (2021).

4.1.3 Productivity

As shown in (Table 3 and Fig. 3) Treatment T_{12} significantly enhanced seed yield (1350.60 kg ha^{-1}), showing a 91.20% increase over T_1 (706.35 kg ha^{-1}), while T_{11} recorded 80.74% higher seed yield (1276.71 kg ha^{-1}). Similarly, haulm yield was highest in T_{12} (2040.29 kg ha^{-1}), with a 92.66% increase over control (T_1: 1059.01 kg ha^{-1}), followed by T_{11} (80.72 % increase). The trend continued in biological yield, where T_{12} and T_{11} produced 92.08 % and 80.72 % more yield, respectively, compared to control. Although harvest index (%) did not differ significantly among treatments. The consistent improvements in productivity parameters under INM treatments confirm earlier findings by Singh *et al*. (2017), Kalal *et al*. (2020), and Kumar *et al*. (2024), highlighting the role of combined nutrient sources in improving legume yield under semi-arid conditions.

Table 1: Effect of INM on plant height, number of branches plant^{-1} and number of effective root nodules plant^{-1}

Treatments	**Plant height (cm)** at 45 DAS	**Plant height (cm)** at harvest	**Number of branches plant^{-1}**	**Number of effective root nodules plant^{-1} at 40 DAS**
T_1: Absolute control	30.24	38.43	3.63	22.62
T_2: 50% RDF (NPK @ 10:20:10 kg ha^{-1})	34.05	43.11	4.07	25.31
T_3: 75% RDF (NPK @ 15:30:15 kg ha^{-1})	39.48	49.95	4.72	29.35
T_4: 100% RDF (NPK @ 20:40:20 kg ha^{-1})	43.99	55.64	5.25	32.70
T_5: 50% RDF + 2 t ha^{-1} FYM	34.91	44.16	4.17	25.95
T_6: 75% RDF + 1 t ha^{-1} FYM	39.11	49.47	4.67	29.08
T_7: 50% RDF + 1 t ha^{-1} vermicompost	38.17	48.23	4.55	28.33
T_8: 75% RDF + 0.5 t ha^{-1} vermicompost	40.24	50.87	4.80	29.89
T_9: 50% RDF + Rhizobium + PSB	37.80	47.79	4.51	28.07
T_{10}: 75% RDF + Rhizobium + PSB	43.20	54.61	5.16	32.09
T_{11}: 50% RDF + 0.5 t ha^{-1} vermicompost + Rhizobium+ PSB	48.71	61.59	5.82	36.18
T_{12}: 50% RDF + 1 t ha^{-1} vermicompost + 1 t ha^{-1} FYM + Rhizobium+ PSB	50.75	64.11	6.06	37.75
SEm±	1.59	1.40	0.14	0.91
CD at 5%	4.65	4.12	0.40	2.67

Table 2: Effect of INM on number of pods plant^{-1}, number of seeds pod^{-1} and test weight (g)

Treatments	**Yield attributes**		
	Number of pods plant^{-1}	**Number of seeds pod^{-1}**	**Test weight (g)**
T_1: Absolute control	19.33	7.63	29.10
T_2: 50% RDF (NPK @ 10:20:10 kg ha^{-1})	21.63	8.53	31.42
T_3: 75% RDF (NPK @ 15:30:15 kg ha^{-1})	25.04	9.87	35.90
T_4: 100% RDF (NPK @ 20:40:20 kg ha^{-1})	27.90	11.00	39.59
T_5: 50% RDF + 2 t ha^{-1} FYM	22.14	8.73	32.73
T_6: 75% RDF + 1 t ha^{-1} FYM	24.80	9.78	36.16
T_7: 50% RDF + 1 t ha^{-1} vermicompost	24.16	9.52	35.18
T_8: 75% RDF + 0.5 t ha^{-1} vermicompost	25.49	10.05	36.96
T_9: 50% RDF + *Rhizobium* + PSB	23.95	9.44	34.72
T_{10}: 75% RDF + *Rhizobium* + PSB	27.37	10.79	39.44
T_{11}: 50% RDF + 0.5 t ha^{-1} vermicompost + *Rhizobium*+ PSB	30.87	12.17	42.83
T_{12}: 50% RDF + 1 t ha^{-1} vermicompost + 1 t ha^{-1} FYM + *Rhizobium*+ PSB	32.14	12.64	43.80
SEm±	0.60	0.34	1.28
CD at 5%	1.76	1.01	3.74

Table 3: Effect of INM on seed, haulm, biological yield and Harvest index

Treatments	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest Index (%)
T_1: Absolute control	706.35	1059.01	1765.35	40.57
T_2: 50% RDF (NPK @ 10:20:10 kg ha^{-1})	815.71	1234.97	2050.68	39.78
T_3: 75% RDF (NPK @ 15:30:15 kg ha^{-1})	989.29	1486.99	2476.27	39.95
T_4: 100% RDF (NPK @ 20:40:20 kg ha^{-1})	1127.75	1704.92	2832.67	39.83
T_5: 50% RDF + 2 t ha^{-1} FYM	895.01	1325.18	2220.20	40.32
T_6: 75% RDF + 1 t ha^{-1} FYM	1015.37	1519.99	2535.36	40.06
T_7: 50% RDF + 1 t ha^{-1} vermicompost	987.74	1485.14	2472.89	39.94
T_8: 75% RDF + 0.5 t ha^{-1} vermicompost	1046.79	1574.45	2621.24	39.95
T_9: 50% RDF + *Rhizobium* + PSB	983.33	1472.17	2455.50	40.04
T_{10}: 75% RDF + *Rhizobium* + PSB	1145.10	1729.71	2874.82	39.85
T_{11}: 50% RDF + 0.5 t ha^{-1} vermicompost + *Rhizobium*+ PSB	1276.71	1913.86	3190.57	39.99
T_{12}: 50% RDF + 1 t ha^{-1} vermicompost + 1 t ha^{-1} FYM + *Rhizobium*+ PSB	1350.60	2040.29	3390.90	39.76
SEm±	30.75	52.04	53.01	1.62
CD at 5%	90.19	152.61	155.48	**NS**

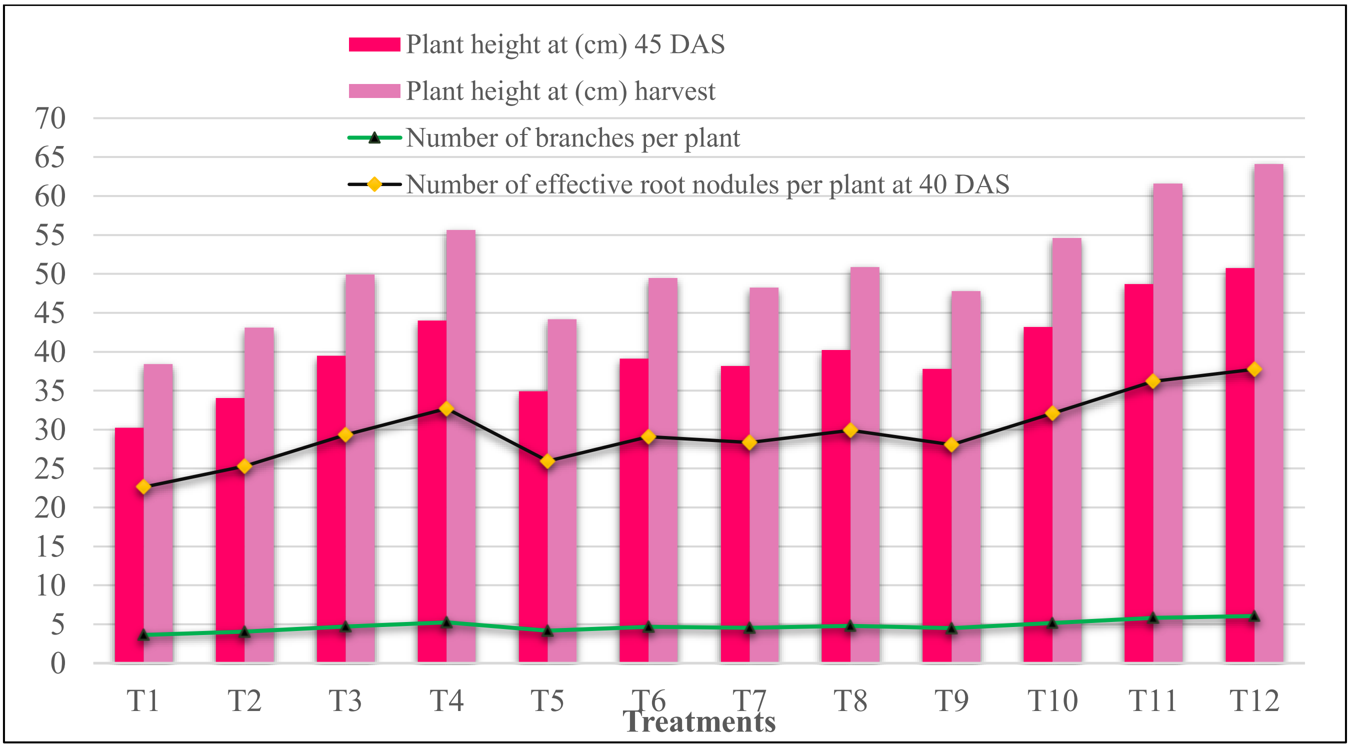

Fig. 1: Effect of INM on plant height, number of branches plant^{-1} and number of effective root nodules plant^{-1}

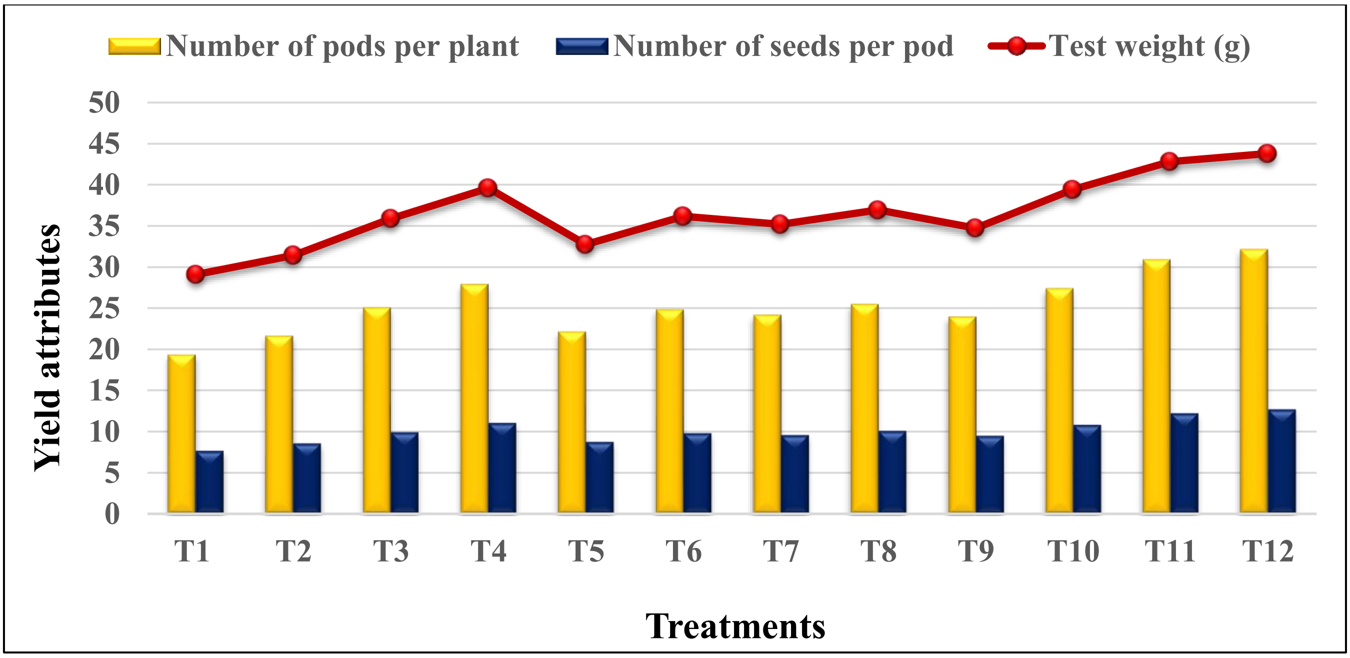

Fig. 2: Effect of INM on number of pods plant^{-1}, number of seeds pod^{-1} and test weight (g)

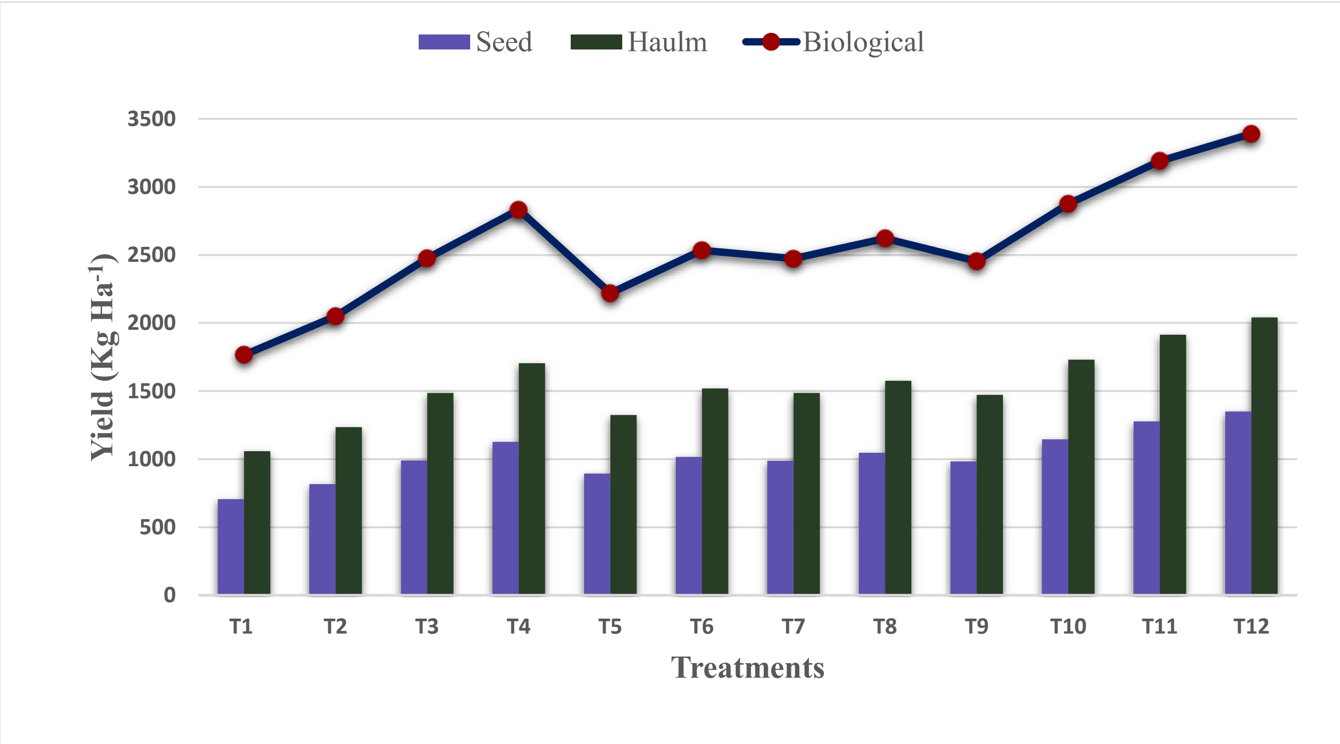

Fig. 3: Effect of INM on seed, haulm and biological yield

IV. CONCLUSION

The results of the present investigation clearly demonstrated that integrated nutrient management (INM) significantly improved the growth, yield attributes, and productivity of green gram under field conditions. Among the various treatments, the combined application of 50% RDF + 1 t ha⁻¹ vermicompost + 1 t ha⁻¹ FYM + *Rhizobium* + PSB (T_{12}) proved to be the most effective, resulting in substantial improvements in plant height, number of branches, root nodulation, yield attributes (pods plant^{-1}, seeds pod^{-1}, and test weight), and seed and haulm yield. The findings suggest that INM, especially with the combined use of organics, biofertilizers, and reduced chemical fertilizers, offers a sustainable and productive strategy for green gram cultivation. Field experimental results also revealed that treatment T_{11} (50% RDF + 0.5 t ha^{-1} vermicompost + *Rhizobium* + PSB) performed statistically similar to treatment T_{12} with respect to growth parameters, yield components (such as number of pods plant^{-1}, seeds pod^{-1} and test weight), as well as seed and haulm yield. Therefore, in situations where FYM availability is limited, T_{11} can be considered a viable alternative to improve green gram productivity under the semi-arid conditions of southern Rajasthan.

ACKNOWLEDGEMENT

The authors are grateful to the **Dr. D. P. Singh** (Assistant Professor, Department of Soil Science and Agricultural Chemistry), **Dr. K. K. Yadav** (Head & Professor, Department of Soil Science and Agricultural Chemistry) and **Dr. R.B. Dubey** (Dean, Rajasthan College of Agriculture, MPUAT, Udaipur) for their valuable guidance, support, and facilities to conduct this research experiment successfully. Finally, a special thanks to **Dr. Hari Mohan Meena**, Senior Scientist, ICAR–CAZRI, Jodhpur, for his academic guidance and support throughout research work.

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