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ORIGINAL ARTICLE

Synergistic effects of green manure and soil amendments on growth, yield, and sustainability of green gram (*Vigna radiata* L.)

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ABSTRACT
The study was carried out at research farm of School of Agricultural Sciences, G.D. Goenka University, Sohna Road, Gururam, Haryana, India during Kharif season of 2025. The field experiment was conducted in Randomised Block Design (RBD) with eight treatments viz.T_1: Control, T_2: Green Manure (Dhaincha), T_3: Green Manure (Dhaincha) + Cowpea, T_4: Green Manure (Dhaincha) + FYM, T_5: Green Manure (Dhaincha) + Gypsum, T_6: Green Manure (Cowpea) +FYM, T_7: Green Manure (Cowpea) +Gypsum, T_8: Gypsum + FYMwith three replications. Results showed that all growth and yield parameters were significantly influenced by different treatments, with T_5 (Dhaincha green manure + gypsum) recording the best performance in terms of plant height (46.2 cm), branches per plant (7.1), pods per plant (31.2), seeds per pod (12.4), grain yield (948 kg ha^{-1}), straw yield (2025 kg ha^{-1}), and harvest index (39.9%). The superior performance of T_5 was attributed to improved soil fertility, nutrient availability, biological nitrogen fixation, and better root nodulation. Similarly, protein and nitrogen content and economic returns were also highest under T_5, resulting in maximum profitability. The study concludes that the integrated use of Dhaincha green manure with gypsum is an effective and sustainable nutrient management practice for enhancing productivity, quality, and profitability of green gram under Haryana conditions.
Keywords: *Green manure, Soil amendment, Gypsum, Productivity and Quality*

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INTRODUCTION

Green gram (*Vigna radiata* L.), commonly known as mung bean, is an important short-duration pulse crop widely cultivated in tropical and subtropical regions due to its high adaptability, nutritional value, and biological nitrogen-fixing ability [5]. It belongs to the family Fabaceae and is believed to have originated in the Indian subcontinent, where it has been cultivated for thousands of years [1]. The crop is highly valued for its high protein content (20–25%) and balanced amino acid profile, making it an essential component of human nutrition, particularly in developing countries [3].

In addition to its nutritional importance, green gram plays a crucial role in sustainable agriculture by improving soil fertility through symbiotic nitrogen fixation and contributing to soil health improvement [2]. It is a short-duration crop (60–70 days), making it suitable for multiple cropping systems and intercropping practices [4]. Its ability to thrive under rainfed and low-input conditions further enhances its significance in resource-poor farming systems [6].

Despite its importance, the productivity of green gram remains low due to factors such as declining soil fertility, imbalanced fertilizer application, and reduced soil organic matter content [4]. Continuous use of chemical fertilizers without organic supplementation has led to soil degradation and reduced microbial activity, affecting long-term soil productivity [6]. Therefore, improving soil health through sustainable nutrient management practices is essential for enhancing crop productivity.

Integrated nutrient management (INM), which combines organic sources such as green manures and soil amendments with inorganic fertilizers, has been recognized as an effective strategy for improving soil fertility, nutrient availability, and crop productivity [7].
Green manuring improves soil structure and microbial activity, while organic amendments enhance nutrient cycling and water retention [8]. In this context, the present study was undertaken to evaluate the effect of integrated green manure and soil amendment strategies on the growth, yield, quality, nitrogen uptake, and economic performance of green gram under agro-climatic conditions.

MATERIAL AND METHODS

The field study was carried out in RBD Design with three replications, comprising eight treatments, T_1:Control, T_2: Green Manure (Dhaincha), T_3: Green Manure (Dhaincha) + Cowpea, T_4: Green Manure (Dhaincha) + FYM, T_5: Green Manure (Dhaincha) + Gypsum, T_6: Green Manure (Cowpea) +FYM, T_7: Green Manure (Cowpea) +Gypsum, T_8: Gypsum + FYM.The gross plot size was 4.20 m x 3.30 m = 16.50 $m^2$and net plot size was 3.60 m x 3.00 m= 13.20 m^2. The green manure crops (Dhaincha and cowpea) were sown on 10 April 2025 and incorporated into the soil at the appropriate stage before sowing of green gram. Subsequently, green gram was sown on 20th May 2025 to evaluate the residual and integrated effects of green manures and soil amendments. During the crop period, the weather conditions were generally favourable for green gram growth, with maximum and minimum temperatures ranging from 30–35°C and 24–26°C, respectively, relative humidity of 70–86%, and adequate sunshine hours (5.5–8.5 h day^{-1}). The soil of the experimental field was sandy loam in texture, slightly alkaline in reaction, low in available nitrogen, medium in phosphorus, and adequate in potassium. Prior to sowing, composite soil samples (0–15 cm depth) were collected and analysed for physicochemical properties. Standard agronomic practices were followed throughout the crop growth period to ensure proper crop establishment and development under field conditions. Therefore, it is the most suitable integrated nutrient management practice for sustainable green gram cultivation under Haryana conditions.

RESULT AND DISCUSSION

Growth parameters

Plant growth parameters of green gram showed significant variation among treatments at different growth stages, with T_5 (Dhaincha green manure + gypsum) consistently recording superior performance (Table 1).

Table 1: Effect of INM and soil amendments strategies of plant height (cm) and no. of branches/plant

Treatments	Plant height (cm)			Number of branches/plant		
	30 DAS	45 DAS	At harvest	30 DAS	45 DAS	At harvest
T_1	11.5	21.6	35.7	2.1	3.8	4.9
T_2	12.4	22.9	37.1	2.3	4.1	5.3
T_3	13.7	24.2	38.3	2.5	4.5	5.8
T_4	14.5	25.4	40.3	2.8	4.9	6.2
T_5	19.4	31.2	46.2	3.2	5.7	7.1
T_6	16.5	28.3	42.8	3	5.3	6.7
T_7	17.6	29.7	44.5	2.9	5.1	6.5
T_8	15.4	27.6	41.3	2.6	4.7	6.1
S. Em±	0.28	0.24	0.36	0.12	0.18	0.22
C.D.	0.86	1.02	1.08	0.36	0.18	0.66

The highest plant height under T_5 was observed at 30 DAS (19.4 cm), 45 DAS (31.2 cm) and at harvest (46.2 cm), which may be attributed to improved nutrient availability, better soil physical conditions, and enhanced microbial activity due to decomposition of green manure and the beneficial effect of gypsum. Similarly, T_5 recorded the maximum number of branches per plant (3.2, 5.7 and 7.1) and leaves per plant (13.9, 22.1 and 28.1) at 30 DAS, 45 DAS and harvest, respectively, indicating enhanced vegetative growth and photosynthetic efficiency. Root nodulation was also highest under T_5 at 30 DAS (14.6), 45 DAS (27.8) and harvest (22.3), reflecting improved biological nitrogen fixation, although a slight decline at harvest may be due to natural nodule senescence.

Table 2: Effect of INM and soil amendments strategies of growth parameters

Treatments	Number of leaves/ plant			Number of root nodules/plant	Fresh weight (g)/plant	Dry weight (g)/plant
	30 DAS	45 DAS	At harvest	At harvest	At harvest	At harvest
T_1	8.5	14.2	18.6	13.4	21.2	7.6
T_2	9.3	15.6	20.1	14.8	23.1	8.4
T_3	10.4	17.3	22.4	16.7	25.6	9.6
T_4	11.6	18.9	24.3	18.5	28.1	10.8
T_5	13.9	22.1	28.1	22.3	34.2	13.6
T_6	12.2	19.6	25.1	19.6	30.2	11.5
T_7	12.8	20.5	26.2	20.6	3	12.2
T_8	11	18	23.2	17.8	27.2	10.2
S. Em±	0.42	0.68	0.85	0.76	1.1	0.42
C.D.	1.26	2.04	2.55	2.28	3.3	1.26

Fresh and dry biomass accumulation followed a similar trend, with T_5 recording the highest values at all stages, indicating superior assimilate production and efficient nutrient utilization (Table 2). Overall, T_5 outperformed all other treatments, while T_6 (Cowpea + FYM) and T_7 (Cowpea + gypsum) remained statistically comparable, demonstrating the effectiveness of integrated green manure and soil amendment practices in enhancing growth attributes of green gram. In addition, Kumar and Singh [4] reported that the combined application of green manure and soil amendments such as gypsum created favourable conditions for plant growth, resulting in significant improvement in growth attributes and physiological efficiency of pulse crops.

Yield and Yield attributes:Yield attributes of green gram showed significant variation among treatments, with T_5 (Dhaincha green manure + gypsum) consistently performing better than other treatments (Table 3). The maximum number of pods per plant (31.2) and seeds per pod (12.4) were recorded under T_5.

Table 3: Effect of INM and soil amendments strategies of yield attributes

Treatments	Number of pods/plants	Number of seeds/plants	Test weight (g)
T_1	18.4	9.2	34.2
T_2	20.1	9.8	35.6
T_3	22.7	10.5	37.1
T_4	25.3	11.1	38.8
T_5	31.2	12.4	42.3
T_6	27.4	11.8	39.7
T_7	28.6	11.5	40.5
T_8	24.1	10.9	38
S. Em±	1.02	0.38	1.12
C.D.	3.06	1.14	3.36

Table 4: Effect of INM and soil amendments strategies of yield and quality parameters

Treatments	Grain Yield (kg/ha)	Straw Yield (kg/ha)	Harvest index (%)	N content (%)	Protein content (%)
T_1	552	1450	37.1	2.84	17.75
T_2	618	1520	37.7	3.12	19.5
T_3	684	1625	38.5	3.28	20.5
T_4	731	1740	38.8	3.36	21.0
T_5	948	2025	39.9	3.46	21.63
T_6	901	1820	39.4	3.52	22.0
T_7	842	1880	39.4	3.61	22.56
T_8	796	1705	38.6	3.41	21.31
S. Em±	18.45	58	0.8	0.055	0.35
C.D.	55.82	174	2.4	0.119	0.76

This improvement may be due to enhanced nutrient availability, better vegetative growth, increased photosynthetic activity, and improved soil health resulting from the combined application of green manure and gypsum. The integrated use of these inputs also enhanced assimilate translocation during

reproductive stages, leading to better seed development. Test weight was highest under T_5 (42.3 g), indicating superior seed filling and grain development. Consequently, T_5 recorded the highest grain yield (948 kg ha^{-1}), which may be attributed to improved nodulation, enhanced biological nitrogen fixation, reater nutrient uptake, and superior yield attributes.

Straw yield was also maximum under T_5 (2025 kg ha^{-1}), reflecting vigorous vegetative growth and higher biomass accumulation (Table 4). The harvest index was highest under T_5 (39.9%), suggesting efficient partitioning of assimilates towards economic yield. In addition to higher yield, T5 also improved grain quality by recording significantly higher protein and nitrogen content. The increase in protein content may be attributed to enhanced nitrogen availability through green manure incorporation and increased biological nitrogen fixation, as protein synthesis is directly dependent on nitrogen nutrition. Improved nodulation and nutrient mineralization under this treatment resulted in greater nitrogen accumulation in plant tissues and seeds, thereby enhancing grain nutritional quality. Gypsum application further promoted root growth and nutrient absorption, contributing to better nitrogen uptake and utilization. Treatments T_6 (Cowpea + FYM) and T_7 (Cowpea + gypsum) were statistically at par with T_5, indicating the effectiveness of integrated nutrient management practices in enhancing both productivity and quality of green gram. The findings of the present investigation are in conformity [4-8], who reported that integrated nutrient management practices improved yield attributes, nutrient uptake, protein content, biomass production, and overall crop productivity in pulse crops.

CONCLUSION

The present study concluded that green manure and soil amendment treatments significantly improved the growth, yield attributes, and yield of green gram. Among all treatments, T5 (Dhaincha green manure + gypsum) proved most effective by recording superior growth, nodulation, biomass accumulation, grain yield, straw yield, and harvest index due to improved soil fertility, nutrient availability, and biological nitrogen fixation. Treatments T6 (Cowpea + FYM) and T7 (Cowpea + gypsum) also performed comparably with T5 for several parameters. Hence, the integrated application of Dhaincha green manure and gypsum can be recommended as a sustainable nutrient management practice for enhancing productivity and soil health in green gram cultivation.

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