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Research Article

Influence of Integrated Nutrient Management on the Growth and Yield of Chickpea (*Cicer arietinum* L.) variety JG 315

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ABSTRACT

A field experiment was conducted for the duration of the Rabi season of 2024–25 at the Research Farm, Sage University, Bhopal (Madhya Pradesh), to investigate the influence of integrated nutrient management (INM) on the growth and yield performance of chickpea (Cicer arietinum L.) variety JG 315. The experiment was designed in a Randomized Complete Block Design (RCBD) with twelve treatments and three replications. Results showed that the best nutrient management strategy for enhancing chickpea growth, yield and quality attributes was the combined application of 100% RDF + Vermicompost @ 3 t ha^{-1} + Rhizobium. Among the various treatment combinations, the treatment T_7 (100% RDF + Vermicompost @ 3 t ha^{-1}+ Rhizobium) was recorded the highest values for plant height (56.17cm), number of branches/plant (4.17) and leaf area (70.15 cm²). The lowest values were observed under treatment T_1 (Control). However, in terms of yield and quality characteristics, treatment T_7 (100% RDF + Vermicompost @ 3 t ha^{-1} + Rhizobium) was recorded the highest values for number of pods per plant (57.89), number of grains per pod (2.85), seed index (19.83), grain yield (2358 kg ha^{-1}), straw yield (3273 kg ha^{-1}), harvest index (41.87 %), protein content (22.03%) and BC ratio (3.52). The lowest values were observed under treatment T_1 (Control). The objective of the investigation was to evaluate the effect of integrated nutrient management practices on the quality, yield, growth, and profitability of chickpea (Cicer arietinum L.). The findings indicated that the most effective treatment was the combination of 100% RDF + Vermicompost @ 3 t ha^{-1} + Rhizobium, which led to superior growth, yield, quality parameters and economic returns. The integration of organic, inorganic and biofertilizer sources demonstrated the sustainable nutrient management strategy for enhancing chickpea productivity.

Keywords: *Chickpea, Vermicompost, Rhizobium, Yield and Protein content*

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INTRODUCTION

The chickpea (*Cicer arietinum* L.) is a pulse crop that is extensively cultivated in temperate, subtropical, and tropical regions. However, its nutritional content and productivity are frequently restricted by soil nutrient deficiencies (Abdul et al., 2005). Chickpeas are dense in protein, containing 20-22% of the recommended daily intake. Additionally, it is rich in fiber, carbohydrates (40–50%), fat (4-5%), minerals (47%), starch (47%), crude fiber (8%), and ash (3.6%) (Ojashwani et al., 2022). Although the concentration of all essential amino acids, including lysine, is adequate, the availability of sulfur-containing amino acids, including cysteine and methionine, is restricted.

Additionally, it contains a high concentration of minerals, such as calcium, magnesium, iron, and zinc, and beta-carotene. Bajhaiya and Chaturvedi (2021) observed that pulse drops not only provide protein but also promote soil fertility through symbiotic nitrogen fixation. Despite the fact that chickpeas fix nitrogen from the atmosphere, there is compelling evidence that nitrogen fertilizer increases seed yield, including protein and amino acid yields. Nevertheless, its nitrogen fertilizer requirements are lower than those of other cereals in order to achieve a higher yield and improved seed quality (Dhima et al., 2015). As a result of their large root systems and leaf fall, pulses can keep and restore soil fertility through biological nitrogen fixation. According to Arya et al. (2022) and Arya et al. (2023), pulses are an essential protein source in the diet.

After pigeonpeas, chickpeas are the second most widely consumed legume crop worldwide for human consumption and other purposes. India, Pakistan, Turkey, Iran, Myanmar, Australia, Ethiopia, Canada, Mexico, and Iraq are some of the chief producers of chickpeas. Globally, the production exceeds 11.5 million tons annually. India accounts for the majority of the production. In 2024-25, India is contributing 86.57 million hectares of land, 126.67 lakh tons of production, and 11.42 kg ha^{-1} productivity (Ministry of Agriculture & Farmers Welfare, Govt. of India). Chickpeas are typically grown on approximately 10 million hectares of land worldwide, with an annual production of approximately 8.5 million metric tons.

The foundational principle of integrated nutrient management is the optimization of the benefits from all potential sources of plant nutrients in an integrated manner to maintain the desired crop productivity by preserving soil fertility and providing plant nutrients at an optimal level. Furthermore, the application of Rhizobium and Vermicompost (VC) enhances soil health by enhancing microbial activity, soil physical properties, and nutrient availability (Ojashwani et al., 2022). Furthermore, *Rhizobium* and PSB are both eco-friendly, low-cost bio-fertilizer inputs that are critical components of integrated nutrient management (INM) for pulse production. This led to the design and implementation of an experiment. Through the implementation of biofertilizers and inorganic fertilizers, agricultural productivity must be improved. The potential for nitrogen fixation in the atmosphere is substantial when *Rhizobium* is present. As an outcome, the implementation of nutrient management has become increasingly popular and effective in recent years when approached as an integrated strategy. Therefore, the present study was undertaken to ascertain the optimal dosage of chickpea when combined with biological organisms and fertilizers, as well as to examine its growth, yield, and qualitative characteristics.

MATERIALS AND METHODS

A field study was conducted duringthe Rabi season of 2024–25 at the Research Farm of School of Agriculture, Sanjeev Agrawal Global Educational University, Bhopal (MP), to investigate the influence of integrated nutrient management on the growth and yield performance of chickpea (*Cicer arietinum* L) variety JG 315. The experimentation was laid out in a Randomized Complete Block Design

(RCBD) with twelve treatments, including one control, and three replications. The experimental site is 500 meters above mean sea level and is located 35.75°N latitude and 77.24°E longitude. The soil of the experimental site was a black soil. The chickpea (*Cicer arietinum* L.) variety JG 315 was sown on 26 December 2024 at a spacing of 30 cm × 10 cm (row to row and plant to plant) with a recommended fertilizer dose of 20:40:25 kg N:P:K ha^{-1}. Urea, single super phosphate, and muriate of potash were the fertilizer sources used for NPK; they provided 20 kg N ha^{-1}, 40 kg P ha^{-1}, and 25 kg K ha^{-1}, respectively. Uniformly, these were applied to each plot (excluding control plots) during the sowing process as a basal dose. Additionally, biofertilizers, including Rhizobium, PSB, and KSB, were implemented in the experiment. The seeds of chickpeas were inoculated with Rhizobium, PSB, and KSB cultures in accordance with the treatments at a rate of 20 g kg^{-1} seed. Eight packets (200 g each) were used to dispense the 80 kg of seed necessary for sowing one hectare. Integrated nutrient management was assessed through twelve treatments, viz., T_1 (Control), T_2 (RDF fertilizer @ 20:40:20), T_3 (125% RDF + Vermicompost @ 3 t ha^{-1}), T_4 (125% RDF + FYM @ 2.5 t ha^{-1}), T_5 (125% RDF + Poultry manure @ 2 t ha^{-1}), T_6 (125% RDF + *Rhizobium*), T_7 (100% RDF + Vermicompost @ 3 t ha^{-1}+ *Rhizobium*), T_8 (100% RDF + FYM @ 2.5 t ha^{-1}+ *Rhizobium*), T_9 (100% RDF + Poultry manure @ 2 t ha^{-1}+ *Rhizobium*), T_{10} (75% RDF + Vermicompost @ 3 t ha^{-1}+ *Rhizobium*), T_{11} (75% RDF + FYM + *Rhizobium*) and T_{12} (75% RDF + Poultry manure@ 2 t ha^{-1} + *Rhizobium*). Additional crop management practices were implemented in accordance with conventional guidelines, and the crop was harvested at physiological maturity. The agronomic practices were implemented consistently across all treatments.

Statistical Analysis

The collected data on various traits were statistically analyzed using the standard procedures given in (AOAC 2012). Software OPSTAT, CCS HAU, was used to statistically analyze the data for different fruit characteristics. The results were evaluated for significance at a level of $P \leq 0.05$. It was possible to compare treatment means with the critical difference.

RESULTS AND DISCUSSION

Growth Characteristics:

Data on different aspects of growth were collected during this study. These include plant height (cm), number of leaves per plant, and leaf area (cm²). The results are shown in Table 1. The results showed that the most effective nutrient management strategy for enhancing chickpea growth and characteristics was the combined application of 100% RDF + Vermicompost @ 3 t ha^{-1} + *Rhizobium*. Among the various treatment combinations, the treatment T_7 (100% RDF + Vermicompost@ 3 t ha^{-1} +*Rhizobium*) recorded the highest values for plant height (56.17cm), number of branches per plant (4.17) and leaf area (70.15 cm²). The lowest values for all growth characteristics wererecorded under treatment T_1 (Control). The implementation of the 100% recommended fertilizer dosage in conjunction with *Rhizobium* and Vermicompost @3 t ha^{-1} likely facilitated enhanced aeration, drainage, and soil biological activity. This resulted in a soil environment that was conducive to the proliferation of deeper roots and the extraction of more nutrients, which in turn facilitated the growth of plants. The role of nutrients in cell wall development and cell differentiation, which results in the elongation of shoots and roots, may be the cause of the increase in plant height, number of branches/plant, and leaf area (cm^2). This plant may have more leaves and branches because its roots have grown deeper, which has increased light absorption and photosynthesis, leading to more plant growth. Similar results were also reported by Patil et al. (2014) and Patel et al. (2020).

Nevertheless, the crop's nutritional requirements are satisfied during the initial stages by the basal application of chemical fertilizers, which facilitates its proper establishment and growth. Bio-organics make sure that plants get enough macro- and micronutrients, vitamins, and hormones that help plants grow during later stages of development. These hormones and nutrients are advantageous for the growth and development of plants. Similar results were also reported by Meena et al. (2013) and Prajapati et al. (2017). The synthesis of phytohormones, vitamins, enhanced solar radiation interception, and increased chlorophyll content may be responsible for the beneficial effects of inorganic biofertilizers on the development of roots, leaves, and branches. These factors collectively enhanced the growth characteristics of chickpea. Additionally, biofertilizers increase the soil's ability to absorb cations and anions, which are subsequently released gradually over the course of the crop's growth. *Rhizobium*plays a specific role in fixing atmospheric nitrogen, thereby improving soil fertility with respect to nitrogen. Similar findings were also reported by Ojashwani et al. (2022) and Bajhaiya et al. (2021).

Table 1: Influence of integrated nutrient management on the growth characteristics of chickpea variety JG 315

Treatment notations	Treatment combinations	Plant height (cm)	Number of branches/plant	Leaf area (cm^2)
T_1	Control)	48.44	4.11	65.70
T_2	RDF @ 20:40:20	50.31	4.43	67.20
T_3	125% RDF + Vermicompost @ 3 t ha^{-1}	53.18	5.00	67.94
T_4	125% RDF + FYM @ 2.5 t ha^{-1}	49.28	4.66	68.73
T_5	125% RDF + Poultry manure @ 2 t ha^{-1}	50.35	4.28	69.19
T_6	125% RDF + *Rhizobium*	50.12	4.43	66.53
T_7	100% RDF + Vermicompost @ 3 t ha^{-1} + *Rhizobium*	56.17	4.71	70.15
T_8	100% RDF + FYM @ 2.5 t ha^{-1} + Rhizobium	50.77	4.68	67.03
T_9	100% RDF + Poultry manure @ 2 t ha^{-1} + *Rhizobium*	49.32	4.12	67.93
T_{10}	75% RDF + Vermicompost @ 3 t ha^{-1} + *Rhizobium*	51.20	4.45	66.60
T_{11}	75% RDF + FYM @ 2.5 t ha^{-1} + Rhizobium	54.60	4.91	67.63
T_{12}	75% RDF + Poultry manure @ 2 t ha^{-1} + *Rhizobium*	48.63	4.14	67.90
S. Em ±	-	1.45	0.25	0.52
CD (p=0.05)	-	4.28	0.75	1.52

Yield attributes and yield:

Data on a yield attributes, such as the number of pods per plant, the number of grains per pod, seed index (g), grain yield (kg/ha), straw yield (kg/ha) and harvest index (%), were collected from the study and are presented in Table 2. The results indicated that the most effective nutrient management practice for enhancing the yield attributes of chickpea was the combined application of 100% RDF + Vermicompost @ 3 t ha^{-1}, and *Rhizobium*. The treatment T_7 (100% RDF + Vermicompost @ 3 t ha^{-1} + *Rhizobium*) exhibited the highest values for the number of pods per plant (57.89), number of grains per pod (2.85), seed index (19.83g), grain yield/ha (2,358 kg), straw yield/ha (3,273 kg) and Harvest index (41.87%) among the several treatment combinations. The minimum values for all yield attributes were recorded under treatment T_1 (Control). This could be attributed to the fact that the application of the recommended dose of fertilizers (RDF) in conjunction with *Rhizobium* judiciously increased nitrogen availability, which in turn facilitated the conversion of carbohydrates into proteins, which were subsequently elaborated into protoplasm. Similar results were also stated by Ghetiya et al. (2018) and Kumar et al. (2014), and Singh et al. (2021). Moreover, the enhancement of vegetative growth had a positive impact on flowering and fruiting, which in turn resulted in more pods and grains per plant, both of which increased the grain yield per plant. The application of biofertilizers to crops led to significant improvements in yield attributes, which may be attributed to improved plant growth, vigour, and photosynthesis during the later stages of growth. Similar results were also reported by Gaurav et al. (2020) and Devendra et al. (2020). The most promising INM treatment resulted in a higher seed yield due to the combination of the main nutrients applied, which ensured continuous slow release and increased nutrient availability. This improvement in overall growth and yield parameters was achieved. Similar results were also observed by Singh et al. (2020), Ojashwani et al. (2022) and Bajhaiya et al. (2021). Increase was associated with an increase in seed weight, which led to an improvement in parameters such as the seed index and harvest index. Similar results were also stated by Ghetiya et al. (2018), Kumar et al. (2014) and Verma et al. (2017). The improvement in vegetative growth probably helped to improve yield attributes by favourably affecting flowering and fruiting, which in turn produced more pods per plant and grains per pod, raising the total yield per hectare. These parameters collectively facilitated the enhancement of the harvest index.

Table 2: Influence of integrated nutrient management on the yield attributes, yield and harvest index of chickpea variety JG 315

Treatment notations	Treatment combinations	Number of pods per plant	Number of grains per pod	Seed index (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
T_1	Control)	38.49	1.93	16.47	1,526	2,371	39.16
T_2	RDF @ 20:40:20	42.39	2.32	17.72	1,881	2,780	40.36
T_3	125% RDF + Vermicompost @ 3 t ha^{-1}	45.70	2.34	18.17	2,126	3,068	40.93
T_4	125% RDF + FYM @ 2.5 t ha^{-1}	49.52	2.38	18.32	2,167	3,146	40.78
T_5	125% RDF + Poultry manure @ 2 t ha^{-1}	53.00	2.40	18.45	2,166	3,168	40.61
T_6	125% RDF + *Rhizobium*	56.12	2.42	18.54	2,180	3,179	40.67
T_7	100% RDF + Vermicompost @ 3 t ha^{-1} + *Rhizobium*	57.89	2.85	19.83	2,358	3,273	41.87
T_8	100% RDF + FYM @ 2.5 t ha^{-1} + Rhizobium	39.79	2.67	18.58	2,236	3,171	41.35
T_9	100% RDF + Poultry manure @ 2 t ha^{-1} + *Rhizobium*	42.85	2.64	18.52	2,160	3,131	40.81
T_{10}	75% RDF + Vermicompost @ 3 t ha^{-1} + *Rhizobium*	44.84	2.19	18.30	2,050	3,018	40.44
T_{11}	75% RDF + FYM @ 2.5 t ha^{-1} + Rhizobium	42.67	2.07	17.83	2,031	2,976	40.56
T_{12}	75% RDF + Poultry manure @ 2 t ha^{-1} + *Rhizobium*	39.66	2.01	16.60	1,983	2,908	40.54
S. Em ±	-	1.09	0.08	0.12	7.49	9.27	0.11
CD (p=0.05)	-	3.22	0.25	0.36	22.12	27.37	0.33

Quality parameters:

Data shown in Table 3 indicated that, among the various treatment combinations, the treatment T_7 (100% RDF + Vermicompost @ 3 t ha^{-1} + *Rhizobium*) were observed the highest values for protein content (22.03%). The lowest value for protein content was documented under treatment T_1 (Control). This could be attributed to the fact that the application of the recommended dose of fertilizers in conjunction with *Rhizobium* effectively increased nitrogen availability, which in turn facilitated the conversion of carbohydrates into proteins. Subsequently, these proteins were converted into protoplasm, which resulted in an increase in the weight of the seed. Similar results were also reported by Jakhar et al. (2020) and Devendra et al. (2020). However, protein content also augmented significantly with the application of 100% recommended dose of fertilizer + *Rhizobium*. Protein levels may have increased following INM treatment due to nitrogen, which is a critical component of proteins and serves as a building block for certain co-enzymes that aid in protein synthesis. These results are in agreement with the findings of Verma et al. (2017) and Nandan et al. (2018).

Economics of chickpea variety JG 315:

Based on the findings, the capital investment required for the cultivation of the chickpea variety JG 315 varied among the various treatments. The analysis of the benefit-cost ratio for each treatment was conducted and is presented in Table 3. Based on experimental results, the maximum cost of cultivation (₹ 33888.65) was estimated for treatment T_7 (100% RDF + Vermicompost @ 3 t ha^{-1} + *Rhizobium*), while the lowest cost of cultivation (₹ 30916.65) was observed in treatment T_1 (Control). Furthermore, maximum gross return (₹ 153270.0) was recorded under the treatment T_7 (100% RDF + Vermicompost @ 3 t ha^{-1}+ *Rhizobium*), while lowest gross return (₹ 99190.0) was determined in the treatment T_1 (Control). Similarly, the maximum net return (₹ 122381.35) was calculated in the treatment T_7 (100% RDF + Vermicompost @ 3 t ha^{-1} + *Rhizobium*), while the lowest net return (₹ 68273.35) was estimated under treatment T_1 (Control). However, the highest B: C ratio (3.52) was calculated in the treatment T_7 (100% RDF + Vermicompost @ 3 t ha^{-1}+ *Rhizobium*), whereas the minimum B: C ratio (2.21) was calculated in treatment T_1 (Control). This outcome may be attributed to the combined application of 100% RDF + Vermicompost @ 3 t ha^{-1} + *Rhizobium*, which was the most appropriate nutrient management practice for enhancing the yield characteristics of chickpea and was the most effective approach for maximizing net returns and the benefit-cost ratio (B:C ratio). This may be attributed to the higher yields that were achieved under the recommended practices in comparison to the control. This treatment not only generated substantial gross and net returns but also achieved the highest benefit-cost ratio, ensuring that each rupee invested yielded optimal returns. Similar results are in agreement with the findings of Tomar (2010), Patel et al. (2014), Singh et al. (2016) and Singh et al. (2022).

Table 3: Influence of integrated nutrient management on the protein content and economic performance of chickpea variety JG 315

Treatment notation	Protein content (%)	Cost of cultivation (₹ ha^{1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C Ratio
Control)	18.92	30916.65	99190.0	68273.35	2.21
RDF @ 20:40:20	20.87	31391.30	122265.0	90873.70	2.89
125% RDF + Vermicompost @ 3 t ha^{-1}	21.49	31754.60	138190.0	101435.40	3.35

125% RDF + FYM @ 2.5 t ha^{-1}	20.43	33020.85	140855.0	107834.15	3.27
125% RDF + Poultry manure @ 2 t ha^{-1}	20.67	31900.52	140790.0	109889.48	3.41
125% RDF + *Rhizobium*	21.83	32910.23	141700.0	110789.77	3.31
100% RDF + Vermicompost @ 3 t ha^{-1} + *Rhizobium*	22.03	33888.65	153270.0	122381.35	3.52
100% RDF + FYM @ 2.5 t ha^{-1} + Rhizobium	21.31	32957.65	145340.0	114382.35	3.41
100% RDF + Poultry manure @ 2 t ha^{-1} + *Rhizobium*	19.87	31500.41	140400.0	109199.59	3.46
75% RDF + Vermicompost @ 3 t ha^{-1} + *Rhizobium*	20.53	32942.98	133250.0	102307.02	3.04
75% RDF + FYM @ 2.5 t ha^{-1} + Rhizobium	20.86	31949.56	132015.0	101065.44	3.13
75% RDF + Poultry manure @ 2 t ha^{-1} + *Rhizobium*	20.08	30969.45	128895.0	97925.55	3.16
S. Em ±	0.16	-	-	-	-
CD (p=0.05)	0.48	-	-	-	-

CONCLUSION

Based on the results of the present study, it can be concluded that the combined application of 100% RDF + Vermicompost @ 3 t ha^{-1} + *Rhizobium* culture under treatment (T_7) was the most effective nutrient management practice for enhancing growth, yield attributes, productivity, and the benefit-cost (B:C) ratio of chickpea. The integrated nutrient management approach exhibited superior results in terms of productivity, growth, yield parameters, and the benefit-cost (B: C) ratio. Thus, the most effective method for increasing chickpea yield and profitability was the combination of inorganic fertilizer and organic inputs (100% RDF + Vermicompost @ 3 t ha^{-1} + *Rhizobium*), and this combination is strongly advised for commercial cultivation.

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