**Effect of Integrated Nutrient Management on Growth, Yield and Quality of Chickpea (*Cicer arietinum* L.) crop**

**Abstract**

A field experiment was conducted to evaluate the impact of various organic and inorganic fertilizer combinations on the growth, yield, and quality of chickpea (*Cicer arietinum* L.). The study investigated nine different nutrient management treatments, including control, varying percentages of recommended doses of fertilizers (RDF), vermicompost, and Rhizobium inoculation, both individually and in combination. Results indicated that integrated nutrient management (INM) significantly enhanced plant population, height, branching, pod and seed formation, dry matter accumulation, 100-seed weight, and ultimately grain, straw, and biological yields. Specifically, the treatment combining 75% RDF with 5 t/ha vermicompost and 20g/kg seed Rhizobium inoculation consistently outperformed other treatments, leading to the highest yields and improved seed nutrient content (NPK). Economic analysis further revealed that INM practices significantly increased gross returns and net profits, demonstrating their economic viability and sustainability. This research underscores the critical role of balanced nutrient application through INM for maximizing chickpea productivity and ensuring long-term agricultural sustainability.

Keywords: Integrated Nutrient Management, chickpea, branching, organic and inorganic fertilizer,

**1. Introduction**

Chickpea (*Cicer arietinum* L.), also known as Bengal gram or garbanzo, stands as a pivotal winter grain legume globally, serving as a primary protein source for vegetarian populations and a valuable substitute for meat. India holds a dominant position in chickpea cultivation, accounting for approximately 85% of the world's acreage and 69.75% of its production (Anonymous, 2021a). Beyond its nutritional significance, chickpea contributes to soil fertility by fixing atmospheric nitrogen, making it an integral component of sustainable agricultural systems (Kumari et al., 2019). Despite its importance, chickpea productivity in many regions, including India, remains suboptimal, largely attributed to cultivation on marginal soils and imbalanced nutrient management practices (Sangma, 2018; (Gebremariam and Tesfay, 2021; Jakhar et al., 2020; Madhuri et al., 2020; Mukati et al., 2021; Sachan et al., 2021; Verma et al., 2021) The escalating reliance on chemical fertilizers in agriculture has raised environmental and health concerns, prompting a shift towards eco-friendly and sustainable practices. Integrated Nutrient Management emerges as a holistic approach that integrates organic and inorganic nutrient sources to optimize crop nutrition, improve soil health, and enhance overall productivity (Jakhar et al., 2020).

Conventional agricultural practices heavily rely on inorganic fertilizers to meet crop nutrient demands for nitrogen, phosphorus, and potassium. While essential for boosting yields, the excessive and continuous use of chemical fertilizers can lead to detrimental effects, including reduced soil fertility, environmental degradation, and diminished produce quality (Kumar et al., 2003). This highlights a pressing need for sustainable alternatives that can balance nutrient supply without compromising soil health or environmental integrity.

Integrated Nutrient Management (INM) has emerged as a promising strategy to address these challenges. INM combines the judicious use of chemical fertilizers with organic amendments and biofertilizers, fostering a holistic approach to soil fertility and plant nutrition. Organic sources like vermicompost are rich in macro and micronutrients, improving soil physical, chemical, and biological properties, such as macropore space, pH, microbial population, and enzyme activities (Asewar et al., 2003; Bajracharya & Rai, 2009). Biofertilizers, such as Rhizobium and Phosphate Solubilizing Bacteria (PSB), are cost-effective and eco-friendly, enhancing nutrient availability by fixing atmospheric nitrogen and solubilizing insoluble soil phosphates, while also producing plant growth-promoting substances (Bajracharya & Rai, 2009). Previous studies have demonstrated the positive effects of INM on various crops. For instance, Kemal et al. (2018) reported improved soil nutrient status, nutrient uptake, protein content, and yield of chickpea with INM in North Western Ethiopia. Similarly, Kumar et al. (2018) highlighted the increased productivity and profitability of chickpea through integrated nutrient management. Singh and Yadav (2022). Given these benefits, the present investigation was designed to comprehensively evaluate the "Effect of Organic and Inorganic Fertilizers on Growth, Yield, and Quality of Chickpea (*Cicer arietinum* L.). The study aims to identify optimal nutrient management strategies that enhance chickpea performance under specific agro-climatic conditions, ensuring both high productivity and environmental sustainability.

**2. Materials and Methods**

**2.1. Experimental Site and Design**

The present study was carried out at the Experimental Farm, Department of Agronomy, Faculty of Agriculture and Veterinary Sciences, Mewar University Gangrar, Chittorgarh (Rajasthan) 2024-25.

The experiment was laid out in a Randomized Block Design (RBD) with three replications. Nine different treatment combinations were evaluated:

* **T1:** Control (no fertilizer application)
* **T2:** 50% Recommended Dose of Fertilizers (RDF)
* **T3:** 75% RDF
* **T4:** 50% RDF + Rhizobium @ 20 g/kg seed
* **T5:** 75% RDF + Rhizobium @ 20 g/kg seed
* **T6:** 50% RDF + Vermicompost @ 5 t/ha
* **T7:** 75% RDF + Vermicompost @ 5 t/ha
* **T8:** 50% RDF + Vermicompost @ 5 t/ha + Rhizobium @ 20 g/kg seed
* **T9:** 75% RDF + Vermicompost @ 5 t/ha + Rhizobium @ 20 g/kg seed

**2.2. Crop Management**

Chickpea Daftri-21 was used for the experiment. Seeds were sown at a rate of 95 kg/ha with a row spacing of 30 cm. Each plot measured 4×3 m (gross plot size), with a net plot size of 3.7×2.5 m. All other agronomic practices, such as irrigation, weeding, and pest management, were carried out uniformly across all treatments as per standard recommendations for chickpea cultivation in the region to ensure optimal growth conditions.

**2.3. Data Collection**

Data were systematically collected on various growth parameters, yield attributes, actual yield, and economic returns.

* **Growth Parameters:** Plant population (at 20 DAS and at harvest), plant height (at 30 DAS and 60 DAS), and number of branches per plant at maturity.
* **Yield Attributes:** Number of pods per plant, number of seeds per pod, dry matter weight (g/plant) at maturity, and 100-seed weight (g).
* **Yield:** Grain yield (kg/ha), straw yield (kg/ha), and biological yield (kg/ha).
* **Quality Parameters:** Nitrogen (N), phosphorus (P), and potassium (K) content (%) in chickpea seeds.
* **Economics:** Gross return (₹/ha), cost of cultivation (₹/ha), net profit (₹/ha), and benefit-cost (B:C) ratio were calculated based on prevailing market prices of inputs and produce.

**2.4. Statistical Analysis**

The collected data were subjected to appropriate statistical analysis using a suitable statistical software package. Analysis of Variance (ANOVA) was performed to assess the significance of treatment effects. Treatment means were compared using Critical Difference (C.D.) at a 5% level of significance (P=0.05). Standard Error of Mean (SEm) and Coefficient of Variation (C.V.) were also calculated to determine the precision and reliability of the experimental results.

**3. Results and Discussion**

The experimental findings consistently demonstrated the profound positive influence of Integrated Nutrient Management (INM) practices, particularly the combined application of inorganic fertilizers, organic amendments (vermicompost), and biofertilizers (Rhizobium).

**3.1. Influence of Integrated Nutrient Management on Growth Parameters of Chickpea**

The study revealed a significant enhancement in all measured growth parameters. Plant population at both 20 days after sowing (DAS) and at harvest was markedly higher in treatments receiving integrated nutrient inputs. Specifically, treatment T9 (75% Recommended Dose of Fertilizers (RDF) + Vermicompost @ 5 t/ha + Rhizobium @ 20g/kg seed) consistently recorded the maximum plant stand (33.583 plants/m² at 20 DAS and 31.383 plants/m² at harvest), indicating improved seed germination, early seedling vigor, and better survival rates. This aligns with findings by Ahmed et al. (2017), Singh et al. (2017), and Kumar et al. (2018), who also reported improved crop establishment with INM.

Similarly, plant height at 30 DAS and 60 DAS showed a robust increase under INM, with T9 again leading the way (17.883 cm at 30 DAS and 36.950 cm at 60 DAS), followed closely by T8 and T7. This sustained vegetative growth was attributed to enhanced nutrient availability and improved soil health, consistent with observations by Ahmed et al. (2017), Singh et al. (2017), and Kumar et al. (2018). Furthermore, the number of branches per plant at maturity was significantly boosted by INM, with T9 demonstrating the highest branching (7.800 branches/plant), crucial for increased photosynthetic area and yield potential. These results underscore that balanced nutrition fosters vigorous plant development from early stages through maturity.

**3.2. Effect of Integrated Nutrient Management on Yield Attributes and Yield**

The positive impact of INM extended significantly to yield-contributing attributes. The number of pods per plant, a critical determinant of yield, was highest in T9 (55.267 pods/plant), followed by T8 (54.600) and T7 (52.150), showcasing the effectiveness of integrated approaches in promoting reproductive development. This was further supported by the increased number of seeds per pod, with T9 again yielding the maximum (1.950 seeds/pod), indicating improved reproductive efficiency and seed set. Dry matter accumulation, a measure of overall biomass production, also peaked in T9 (35.133 g/plant), signifying enhanced physiological activity and nutrient utilization. Importantly, the 100-seed weight, a key quality parameter, was significantly improved under INM, with T9 recording the highest value (25.000 g). This suggests that the synergistic action of chemical fertilizers, vermicompost, and Rhizobium facilitated better nutrient partitioning towards seed development, leading to bolder and higher-quality seeds. These findings are in line with Ahmadi et al. (2010), Jat et al. (2012), Tripathi et al. (2013), and Singh et al. (2017).

The ultimate measure of agricultural success, yield, was profoundly influenced by the adopted nutrient management strategies. Grain yield, the primary economic output, reached its zenith in T9 (2,420.00 kg/ha), demonstrating a substantial increase compared to the control (1,325.46 kg/ha) and even treatments with sole nutrient applications. This superior performance was consistently observed across straw yield (3,458.52 kg/ha in T9) and total biological yield (5,878.95 kg/ha in T9), where T9 also registered the highest values. The significant increases in all yield components highlight that INM creates an optimal environment for chickpea, maximizing both reproductive and vegetative growth, thereby translating into higher overall productivity. These results are consistent with the observations of Ahmadi et al. (2010).

**3.3. Effect of Integrated Nutrient Management on Nutrient Uptake and Quality**

The results presented in Table 3 demonstrate that the nitrogen (N), phosphorus (P), and potassium (K) content in chickpea seeds was significantly enhanced by the application of integrated nutrient management (INM). The highest nitrogen content (3.35%) was recorded in treatment T9, followed by T8 (3.33%) and T7 (3.32%), while the control treatment (T1) showed the lowest nitrogen content (3.117%). This increase in nitrogen content is likely due to better nutrient availability, enhanced biological nitrogen fixation, and improved soil fertility from the combined use of chemical fertilizers, vermicompost, and biofertilizer.

Similarly, phosphorus and potassium contents were also significantly influenced by INM practices. The maximum phosphorus content (0.46%) was observed in T9, followed by T8 (0.45%) and T7 (0.43%), with the lowest value (0.25%) in the control. Potassium content followed the same pattern, reaching its highest level (0.75%) in T9. The consistent improvement in seed nutrient composition across these treatments suggests that balanced nutrient supply not only enhanced seed yield but also improved seed quality by increasing the accumulation of essential minerals, proteins, and carbohydrates. This led to the production of bold, high-quality seeds with better nutritional value. These findings are in agreement with the observations of Raissi et al. (2012), who also reported that the integrated application of organic and inorganic inputs improves seed quality in legumes.

**3.4. Economics of Chickpea Cultivation**

The economic analysis provided compelling evidence for the profitability of INM. Treatment T9 consistently recorded the highest gross return (₹121,000/ha) and net profit (₹74,223/ha), showcasing its economic viability. While T9 offered the highest absolute profit, T5 (75% RDF + Rhizobium) achieved the highest benefit-cost (B:C) ratio (2.91), suggesting it was the most resource-efficient option relative to investment, even without vermicompost. This implies that even without vermicompost, significant economic gains can be achieved when Rhizobium is included with a reduced chemical fertilizer dose. Such practices reduce input costs while maintaining high levels of productivity, making them ideal for resource-constrained farmers.

In stark contrast, the control treatment (T1) exhibited the lowest economic returns across all parameters (gross return: ₹39,763.80/ha, net profit: ₹19,763.80/ha, and B:C ratio: 1.99), underscoring the economic inefficiency of nutrient omission. These economic findings strongly advocate for the adoption of INM practices to ensure both ecological sustainability and tangible financial benefits for farmers. Overall, the results support the broader agricultural principle that combining organic and biological inputs with chemical fertilizers leads to a more sustainable and economically viable cropping system. This aligns with previous studies (Raissi et al., 2012), which highlight the role of integrated nutrient management in improving seed quality and maximizing returns. Therefore, strategies that promote partial substitution of chemical fertilizers with organic and biofertilizers should be encouraged for profitable chickpea cultivation Subhasmita *et al.,* (2023).

**4. Conclusion**

The findings of this research unequivocally demonstrate that Integrated Nutrient Management (INM) is a superior and sustainable approach for enhancing the growth, yield, quality, and economic returns of chickpea (*Cicer arietinum* L.) under irrigated conditions. The synergistic application of inorganic fertilizers, organic manure (vermicompost), and biofertilizers (Rhizobium) proved to be far more effective than individual nutrient sources or the control.

Specifically, the combination of 75% Recommended Dose of Fertilizers (RDF) with 5 t/ha Vermicompost and 20g/kg seed Rhizobium inoculation (T9) emerged as the most effective treatment. This holistic approach significantly improved plant population, height, branching, pod and seed formation, dry matter accumulation, and 100-seed weight. Consequently, it led to the highest grain, straw, and biological yields. Beyond quantitative gains, INM also enhanced the nutritional quality of chickpea seeds by increasing their NPK content.

Economically, the integrated nutrient management practices, particularly T9, resulted in substantial increases in gross return and net profit, making chickpea cultivation highly profitable. While T9 offered the highest overall profit, T5 (75% RDF + Rhizobium) demonstrated the highest benefit-cost ratio, highlighting its efficiency for resource-constrained farmers. The study conclusively proves that INM not only supports ecological sustainability by reducing reliance on sole chemical inputs but also provides significant economic advantages, aligning with the broader agricultural principle of sustainable and economically viable cropping systems. Therefore, the adoption of integrated nutrient management is crucial for maximizing chickpea productivity and ensuring long-term agricultural sustainability.

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**Table 1. Effect of Organic and Inorganic Fertilizers on Growth Parameters and Yield Attributes of Chickpea (Cicer arietinum L.)**

| **Tr. No.** | **Treatment Description** | **Plant Pop. 20 DAS (plants/m²)** | **Plant Height at 30 DAS (cm)** | **Plant Height 60 DAS (cm)** | **Branches/ Plant** | **Pods/ Plant** | **Seeds/ Pod** | **100-Seed Wt. (g)** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| T1 | Control | 30.44 | 12.417 | 23.78 | 3.90 | 37.64 | 1.04 | 14.00 |
| T2 | 50% RDF | 31.10 | 13.467 | 27.53 | 4.42 | 38.36 | 1.10 | 15.31 |
| T3 | 75% RDF | 32.50 | 14.400 | 29.85 | 5.15 | 40.00 | 1.24 | 17.65 |
| T4 | 50% RDF + Rhizobium @ 20g/kg seed | 31.80 | 13.983 | 29.45 | 4.98 | 39.03 | 1.18 | 16.40 |
| T5 | 75% RDF + Rhizobium @ 20g/kg seed | 33.00 | 15.683 | 32.57 | 6.42 | 48.13 | 1.600 | 21.16 |
| T6 | 50% RDF + Vermicompost @ 5 t/ha | 32.75 | 15.533 | 32.38 | 5.92 | 44.58 | 1.300 | 19.35 |
| T7 | 75% RDF + Vermicompost @ 5 t/ha | 33.25 | 16.433 | 34.97 | 7.00 | 52.15 | 1.793 | 23.30 |
| T8 | 50% RDF + Vermicompost @ 5 t/ha + Rhizobium @ 20g/kg | 33.40 | 16.933 | 35.82 | 7.40 | 54.60 | 1.917 | 24.61 |
| T9 | 75% RDF + Vermicompost @ 5 t/ha + Rhizobium @ 20g/kg | 33.58 | 17.883 | 36.95 | 7.80 | 55.26 | 1.950 | 25.00 |
| **CD (P=0.05)** | — | 1.020 | 0.582 | 1.390 | 0.266 | 1.486 | 0.195 | 0.938 |
| **SE(m)** | — | 0.337 | 0.193 | 0.460 | 0.088 | 0.463 | 0.065 | 0.310 |
| **SE(d)** | — | 0.477 | 0.272 | 0.650 | 0.125 | 0.665 | 0.091 | 0.439 |
| **C.V. (%)** | — | 1.802 | 2.195 | 2.529 | 2.593 | 1.540 | 4.642 | 2.734 |

### **Table 2: Dry Matter Weight (g/plant) of Chickpea (Cicer arietinum L.) at Maturity as Influenced by Organic and Inorganic Fertilizers**

| **Treatment No.** | **Treatment Description** | **Dry Matter Weight (g/plant)** |
| --- | --- | --- |
| T1 | Control | 22.68 |
| T2 | 50% RDF | 24.65 |
| T3 | 75% RDF | 28.46 |
| T4 | 50% RDF + Rhizobium @ 20g/kg seed | 26.58 |
| T5 | 75% RDF + Rhizobium @ 20g/kg seed | 32.16 |
| T6 | 50% RDF + Vermicompost @ 5 t/ha | 30.05 |
| T7 | 75% RDF + Vermicompost @ 5 t/ha | 33.66 |
| T8 | 50% RDF + Vermicompost @ 5 t/ha + Rhizobium @ 20g/kg seed | 34.51 |
| T9 | 75% RDF + Vermicompost @ 5 t/ha + Rhizobium @ 20g/kg seed | 35.13 |
| C.D. | - | 0.968 |
| SE(m) | - | 0.320 |
| SE(d) | - | 0.453 |
| C.V. | - | 1.862 |

**Table 3. Effect of Organic and Inorganic Fertilizers on Yield and Nutrient Content of Chickpea (Cicer arietinum L.)**

| **Tr. No.** | **Treatment Description** | **Grain Yield (kg/ha)** | **Straw Yield (kg/ha)** | **Biological Yield (kg/ha)** | **Harvest Index (%)** | **N (%)** | **P (%)** | **K (%)** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| T1 | Control | 1,483.17 | 2047.94 | 3,531.11 | 43.43 | 3.117 | 0.250 | 0.597 |
| T2 | 50% RDF | 1,596.23 | 2168.45 | 3,764.68 | 43.13 | 3.197 | 0.300 | 0.633 |
| T3 | 75% RDF | 1,710.00 | 2,312.17 | 4,022.17 | 42.51 | 3.237 | 0.340 | 0.687 |
| T4 | 50% RDF + Rhizobium @ 20g/kg seed | 1,600.30 | 2,217.20 | 3,817.50 | 43.06 | 3.220 | 0.330 | 0.670 |
| T5 | 75% RDF + Rhizobium @ 20g/kg seed | 1,995.00 | 2,853.78 | 4,848.78 | 41.15 | 3.300 | 0.410 | 0.710 |
| T6 | 50% RDF + Vermicompost @ 5 t/ha | 1,890.00 | 2,577.06 | 4,467.06 | 42.30 | 3.260 | 0.390 | 0.700 |
| T7 | 75% RDF + Vermicompost @ 5 t/ha | 2,156.66 | 3,153.71 | 5,310.37 | 40.63 | 3.320 | 0.430 | 0.710 |
| T8 | 50% RDF + Vermicompost @ 5 t/ha + Rhizobium @ 20g/kg | 2,300.00 | 3,386.95 | 5,686.95 | 40.45 | 3.330 | 0.450 | 0.730 |
| T9 | 75% RDF + Vermicompost @ 5 t/ha + Rhizobium @ 20g/kg | 2,420.00 | 3,458.52 | 5,878.52 | 41.18 | 3.350 | 0.460 | 0.750 |
| **CD (P=0.05)** | — | 51.378 | 105.489 | 118.659 | 1.044 | 0.040 | 0.010 | 0.013 |
| **SE(m)** | — | 17.126 | 35.158 | 39.026 | 0.345 | 0.013 | 0.006 | 0.004 |
| **SE(d)** | — | 24.528 | 51.024 | 55.138 | 0.488 | 0.019 | 0.008 | 0.006 |
| **C.V. (%)** | — | 2.496 | 2.396 | 1.639 | 1.424 | 0.706 | 2.779 | 1.076 |

**Table 4. Economic Analysis of Chickpea Cultivation under Different Fertilizer Treatments**

| **Tr. No.** | **Treatment Description** | **Gross Return (₹/ha)** | **Cost of Cultivation (₹/ha)** | **Net Profit (₹/ha)** | **B:C Ratio** |
| --- | --- | --- | --- | --- | --- |
| T1 | Control | 39,763.80 | 20,000 | 19,763.80 | 1.99 |
| T2 | 50% RDF | 71,346.50 | 33,058 | 38,288.50 | 2.16 |
| T3 | 75% RDF | 85,500.00 | 34,227 | 51,273.00 | 2.50 |
| T4 | 50% RDF + Rhizobium @ 20g/kg seed | 80,015.00 | 33,108 | 46,907.00 | 2.42 |
| T5 | 75% RDF + Rhizobium @ 20g/kg seed | 99,750.00 | 34,277 | 65,473.00 | 2.91 |
| T6 | 50% RDF + Vermicompost @ 5 t/ha | 94,500.00 | 45,558 | 48,942.00 | 2.07 |
| T7 | 75% RDF + Vermicompost @ 5 t/ha | 107,833.00 | 46,727 | 61,106.00 | 2.31 |
| T8 | 50% RDF + Vermicompost @ 5 t/ha + Rhizobium @ 20g/kg | 115,000.00 | 45,607 | 69,393.00 | 2.52 |
| T9 | 75% RDF + Vermicompost @ 5 t/ha + Rhizobium @ 20g/kg | 121,000.00 | 46,777 | 74,223.00 | 2.59 |