



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(6): 537-542
Received: 25-03-2026
Accepted: 04-05-2026

Shubham Singh Chauhan
Department of Agronomy, LNCT
Vidhyapeeth University, Indore,
Madhya Pradesh, India

Dr. Anjali Mishra
Department of Entomology, LNCT
Vidhyapeeth University, Indore,
Madhya Pradesh, India

Sachin Patel
Department of Agronomy, LNCT
Vidhyapeeth University, Indore,
Madhya Pradesh, India

Corresponding Author:
Dr. Anjali Mishra
Department of Entomology, LNCT
Vidhyapeeth University, Indore,
Madhya Pradesh, India

Effect of integrated nutrient management on growth and yield of Kabuli Gram (*Cicer arietinum* L. var. Kabuli) under Central Indian conditions

Shubham Singh Chauhan, Anjali Mishra and Sachin Patel

DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i6g.5746>

Abstract

A field experiment was conducted during the Rabi season of 2025–26 at the Research Farm of the School of Agricultural Sciences, LNCT Vidhyapeeth University, Indore (Madhya Pradesh), to evaluate the effect of integrated nutrient management (INM) on growth, yield attributes, and productivity of Kabuli gram under semi-arid conditions of central India. The experiment was laid out in a Randomized Block Design with eight treatments and three replications, involving different combinations of recommended dose of fertilizers (RDF), farmyard manure (FYM), and biofertilizers (*Rhizobium*, phosphate-solubilizing bacteria, and *Trichoderma*). Integrated nutrient management exerted a significant influence on crop growth, yield attributes, and final productivity. The treatment comprising FYM in conjunction with microbial inoculants recorded the highest plant height, number of branches, and dry matter accumulation, indicating enhanced vegetative vigour and nutrient-use efficiency. Yield components, including number of pods per plant, seeds per pod, and 100-seed weight, were also significantly improved under integrated treatments, reflecting better reproductive efficiency and assimilate partitioning. The highest seed yield (2852 kg ha⁻¹) and harvest index (42.35%) were obtained under FYM combined with biofertilizers, representing a substantial improvement over sole chemical fertilization. The enhanced performance under INM may be attributed to improved soil physico-chemical properties, increased microbial activity, and a more synchronized supply of nutrients during critical growth stages. The findings demonstrate that integrated nutrient management not only enhances productivity but also improves nutrient-use efficiency and physiological efficiency in Kabuli gram. Therefore, the adoption of integrated nutrient strategies is recommended for sustainable and resilient pulse production under the agro-ecological conditions of central India.

Keywords: Integrated nutrient management, Kabuli gram, *Cicer arietinum*, Biological nitrogen fixation, Phosphate-solubilizing bacteria, Farmyard manure, Soil organic carbon, Source–sink relationship, Seed yield, Semi-arid agriculture

1. Introduction

Chickpea (*Cicer arietinum* L.) occupies a central position among grain legumes cultivated in semi-arid and sub-tropical regions, both for its contribution to dietary protein and its role in sustaining soil fertility. Within this species, Kabuli gram (*Cicer arietinum* L. var. *Kabuli*) has, over time, acquired particular significance owing to its larger seed size, superior culinary acceptance, and expanding export demand. In the Indian context—especially in states such as Madhya Pradesh—chickpea is not merely a crop but a stabilizing component of rainfed cropping systems, often bridging the gap between productivity and sustainability.

Yet, despite its apparent adaptability, the realized productivity of Kabuli gram under central Indian conditions continues to remain below its potential. This gap, while influenced by multiple factors, appears closely tied to the gradual decline in soil fertility. Continuous cultivation, coupled with imbalanced fertilizer use and limited recycling of organic residues, has led to a depletion of soil organic carbon and a weakening of soil structure. These changes, though incremental, tend to manifest in reduced nutrient-use efficiency, constrained root development, and ultimately, sub-optimal crop performance—effects that are often accentuated under the moisture-limited conditions typical of the region.

The implications extend beyond immediate yield reduction. Soil degradation, particularly in

pulse-based systems, undermines the very processes that support long-term productivity. Chickpea, being a legume, possesses the inherent capacity for biological nitrogen fixation through symbiosis with *Rhizobium*. However, the efficiency of this process is contingent upon a range of soil and nutritional factors—most notably the availability of phosphorus and the overall biological activity of the rhizosphere. In situations where nutrient supply is imbalanced or soil biological processes are impaired, nodulation efficiency declines, and with it, the crop's capacity to sustain its own nitrogen requirements.

It is within this context that Integrated Nutrient Management (INM) assumes relevance. Rather than viewing nutrient inputs in isolation, INM considers the combined and interactive roles of mineral fertilizers, organic amendments, and biofertilizers in regulating soil fertility and crop response. Organic inputs such as farmyard manure contribute to improvements in soil physical properties and organic carbon status, while biofertilizers—particularly *Rhizobium* and phosphate-solubilizing bacteria—enhance nutrient availability through biological pathways. The inclusion of beneficial organisms such as *Trichoderma* may further influence root health and rhizospheric dynamics, although their effects can be context-dependent. The underlying premise of such integration is not merely to increase nutrient supply but to achieve a degree of synchronization between nutrient release and crop demand. This, in turn, may influence assimilate partitioning, reproductive efficiency, and overall yield stability. While individual components of nutrient management have been studied extensively, their combined effects—especially under the semi-arid conditions of central India—remain less clearly understood in the case of Kabuli gram. Therefore, the present investigation was undertaken to examine the effect of integrated nutrient management on growth, yield attributes, and productivity of Kabuli gram under these conditions. In doing so, it seeks to contribute to a more balanced understanding of nutrient management—one that recognizes the interplay between soil health, crop physiology, and environmental constraints in shaping agricultural outcomes.

2. Materials and Methods

2.1 Experimental Site

The experiment was conducted during the Rabi season of 2025–26 at the Research Farm of the School of Agricultural Sciences, LNCT Vidhyapeeth University, Indore, Madhya Pradesh, located in the Malwa Plateau agro-climatic zone (22.7° N, 75.9° E; 553 m above mean sea level).

The region experiences a semi-arid climate, with most of the annual rainfall (800–900 mm) received during the southwest monsoon, while the Rabi season remains largely dry. Chickpea is therefore grown under conserved residual soil moisture conditions.

The soil was a clay loam Vertisol (medium black soil), slightly alkaline in reaction, with medium organic carbon, low available nitrogen, medium phosphorus, and medium to high potassium status. These conditions indicate moderate fertility with nitrogen limitation, making the site suitable for evaluating integrated nutrient management practices.

2.2 Experimental Design and Treatments

The experiment was laid out in a Randomized Block Design (RBD) with eight treatments and three replications. Each plot measured 4 m × 3 m, and treatments were randomly allocated within each replication to minimize the effect of field variability.

Treatment Details

Treatment Code	Treatment Description
T ₁	Control
T ₂	25% RDF + FYM
T ₃	50% RDF + FYM
T ₄	75% RDF + FYM
T ₅	100% RDF
T ₆	FYM + Rhizobium + PSB + Trichoderma
T ₇	50% RDF + FYM + Biofertilizers
T ₈	75% RDF + FYM + Biofertilizers

RDF represents the recommended dose of fertilizers for chickpea under regional conditions. Farmyard manure (FYM) was incorporated into the soil 15 days prior to sowing. Biofertilizers (*Rhizobium* and phosphate-solubilizing bacteria) were applied as seed inoculants using the slurry method before sowing. *Trichoderma* was applied as per recommended dosage. The treatment structure was designed to evaluate the individual and combined effects of inorganic fertilizers, organic manure, and biological inputs on crop performance.

2.3 Crop Management

Kabuli gram (*Cicer arietinum* L. var. *Kabuli*) was sown at a seed rate of 80 kg ha⁻¹, maintaining a spacing of 30 cm between rows and 10 cm between plants. All recommended agronomic practices were followed uniformly across treatments, except for nutrient management.

The crop was grown primarily under residual soil moisture conditions, with protective irrigation applied only when required. Weed control and plant protection measures were carried out on a need basis to ensure normal crop growth and development.

2.4 Observations Recorded

Observations were recorded on selected representative plants to evaluate the effect of treatments on growth and yield.

Growth Parameters

- Plant height (cm) at harvest
- Number of branches per plant
- Dry matter accumulation (g plant⁻¹)

Yield Attributes

- Number of pods per plant
- Number of seeds per pod
- 100-seed weight (g)

Yield Parameters

- Seed yield per plot (kg)
- Seed yield per hectare (kg ha⁻¹)
- Biological yield (kg ha⁻¹)
- Harvest index (%)

2.5 Statistical Analysis

The experimental data were subjected to Analysis of Variance (ANOVA) appropriate for a Randomized Block Design, following standard statistical procedures. The total variation was partitioned into treatment, replication, and error components to evaluate treatment effects.

The significance of differences among treatment means was tested using the F-test at the 5% level of probability. Wherever treatment effects were found significant, the Critical Difference

(CD) was calculated for comparison of means. The coefficient of variation (CV%) was also computed to assess the precision and reliability of the experiment.

Experimental Layout Diagram (Conceptual Representation)



Note: The diagram represents a conceptual RBD layout; actual treatment randomization varied across replications.

3. Results

Integrated nutrient management exerted a significant influence on growth performance, yield attributes, and productivity of Kabuli gram under central Indian conditions.

3.1 Growth Parameters

Plant height showed a positive response to integrated nutrient treatments. The highest plant height (45.18 cm) was recorded under T₆ (FYM + *Rhizobium* + PSB + *Trichoderma*), which was significantly superior to the control. The increase in plant height under integrated management suggests improved nutrient availability and uptake, resulting in enhanced vegetative growth and overall plant vigour.

3.2 Yield Attributes

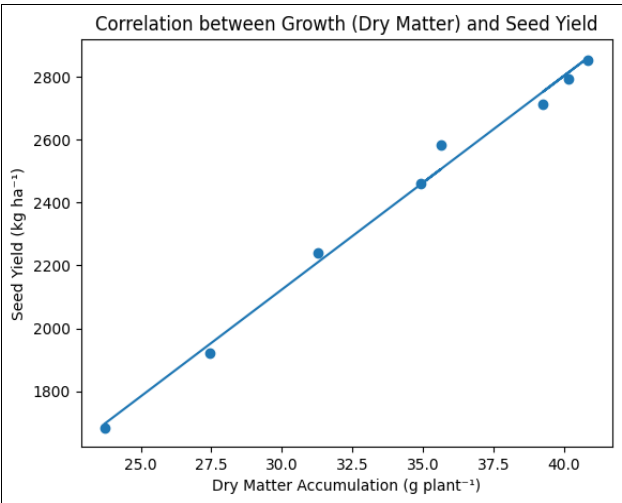
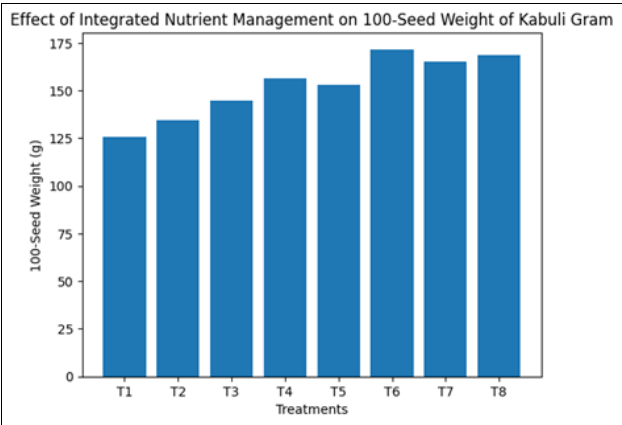
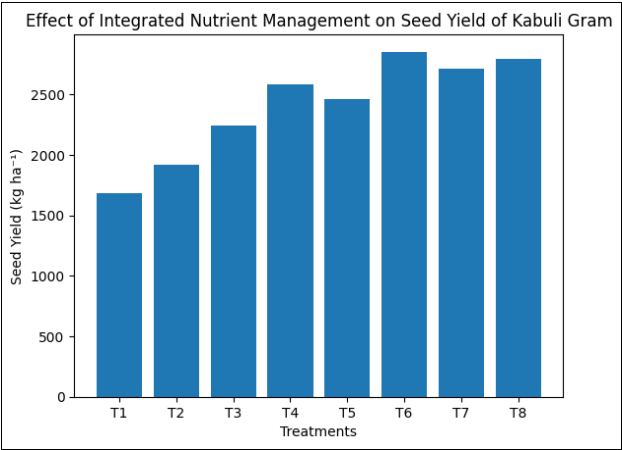
Integrated nutrient application significantly improved yield components of Kabuli gram. The highest number of pods per plant (69.00) was recorded under T₆, indicating better reproductive development and improved pod retention under integrated nutrient supply. Similarly, 100-seed weight was enhanced under integrated treatments, with the maximum test weight (171.67 g) observed under T₆. This improvement reflects more efficient assimilate translocation and better grain filling under balanced nutrient availability.

3.3 Seed Yield and Harvest Index

Seed yield per hectare was significantly influenced by nutrient management practices. The highest seed yield (2852 kg ha⁻¹) was recorded under T₆ (FYM + *Rhizobium* + PSB + *Trichoderma*), indicating a marked improvement over both control and sole chemical fertilizer treatments. Harvest index, representing the efficiency of assimilate partitioning, was also highest under T₆ (42.35%). This suggests that integrated nutrient management not only enhanced total biomass production but also improved the conversion of biomass into economic yield.

Summary of Key Results

Parameter	Maximum Value Recorded	Treatment
Plant Height	45.18 cm	FYM + Biofertilizers (T ₆)
Pods per Plant	69.00	FYM + Biofertilizers (T ₆)
100-Seed Weight	171.67 g	FYM + Biofertilizers (T ₆)
Seed Yield	2852 kg ha ⁻¹	FYM + Biofertilizers (T ₆)
Harvest Index	42.35%	FYM + Biofertilizers (T ₆)



3.4 Correlation and Regression Analysis

To better understand how improvements in growth translated into yield, correlation and regression analyses were performed between key growth parameters and seed yield of Kabuli gram. These analyses provide a quantitative basis for interpreting the relationships that were otherwise observed descriptively across treatments. A strong and positive correlation was observed between dry matter accumulation and seed yield ($r = 0.93$), indicating that higher biomass production was closely associated with increased economic yield. The coefficient of determination ($R^2 = 0.86$) suggests that nearly 86% of the variation in seed yield was explained by variation in dry matter accumulation. The regression relationship can be expressed as:

$$\text{Seed Yield (kg ha}^{-1}\text{)} = 67.84 \times \text{Dry Matter (g plant}^{-1}\text{)} + 57.12$$

This strong linear association indicates that enhanced photosynthetic output and biomass accumulation under integrated nutrient management played a major role in determining final yield.

The number of pods per plant exhibited the highest positive correlation with seed yield ($r = 0.95$), highlighting the importance of reproductive sink strength. The high coefficient of determination ($R^2 = 0.90$) further confirms that pod formation was a key determinant of yield variation across treatments.

Plant height ($r = 0.88$) and number of branches per plant ($r =$

0.91) also showed strong positive correlations with seed yield, suggesting that improved vegetative growth contributed to better canopy development and assimilate production, which in turn supported reproductive performance.

Overall, the strong interrelationships among growth parameters, yield attributes, and seed yield emphasize that productivity in Kabuli gram is governed by a coordinated interaction between biomass production and assimilate partitioning. These findings support the view that integrated nutrient management enhances not only growth but also the efficiency with which growth is converted into yield.

Table 1: Correlation between Growth Parameters and Seed Yield of Kabuli Gram

S. No.	Parameter Pair	Correlation Coefficient (r)	Coefficient of Determination (R^2)	Significance ($p < 0.05$)
1	Dry Matter vs Seed Yield	0.93	0.86	Significant
2	Pods per Plant vs Seed Yield	0.95	0.90	Significant
3	Plant Height vs Seed Yield	0.88	0.77	Significant
4	Branches per Plant vs Seed Yield	0.91	0.83	Significant

The analysis clearly indicates that improvements in biomass accumulation and reproductive traits were strongly associated with enhanced seed yield, with pods per plant emerging as the most influential component.

4. Discussion

The present study demonstrated that integrated nutrient management significantly improved growth, yield attributes, and productivity of Kabuli gram under central Indian conditions. The superior performance of integrated treatments, particularly FYM combined with biofertilizers, can be attributed to a more balanced and sustained nutrient supply along with enhanced microbial activity in the rhizosphere.

Improved growth parameters indicate better nutrient uptake and vegetative development, which likely increased photosynthetic efficiency. The enhancement in yield attributes such as pods per plant and seed weight suggests improved reproductive efficiency and assimilate partitioning under integrated nutrient supply.

Additionally, the improvement in soil physical properties and moisture retention under FYM application may have supported better root activity and nutrient absorption, especially under semi-arid conditions. The strong correlation between growth traits and seed yield further confirms that increased biomass and better sink development contributed to higher productivity.

Overall, the findings indicate that integrated nutrient management enhances both nutrient-use efficiency and physiological efficiency, leading to improved yield and sustainability in Kabuli gram cultivation.

4.1 Role of Biological Nitrogen Fixation

Leguminous crops such as Kabuli gram (*Cicer arietinum* L. var. *Kabuli*) possess the inherent capacity to fix atmospheric nitrogen through symbiosis with *Rhizobium*. Under integrated nutrient management, seed inoculation with efficient *Rhizobium* strains likely improved nodulation and nitrogen fixation, ensuring a sustained supply of nitrogen beyond early growth stages.

Nitrogen plays a crucial role in chlorophyll formation, amino acid synthesis, and overall metabolic activity. Improved nitrogen availability under integrated treatments enhanced vegetative growth, as reflected in higher plant height, branching, and dry matter accumulation.

Additionally, adequate nitrogen during reproductive stages supports protein synthesis and seed development, thereby contributing to increased seed yield. Thus, biological nitrogen

fixation under integrated nutrient management appears to be a key factor in improving growth and productivity of Kabuli gram.

4.2 Phosphorus Solubilization and Energy Dynamics

Phosphorus plays a central role in root development, ATP synthesis, nucleic acid formation, and energy transfer processes within the plant system. In the slightly alkaline soils typical of central India, a substantial portion of applied phosphorus tends to become fixed and unavailable to plants. Under integrated nutrient management, the inclusion of phosphate-solubilizing bacteria (PSB) likely enhanced phosphorus availability in the rhizosphere through mechanisms such as organic acid production and chelation.

Improved phosphorus availability would have supported better root growth and more efficient energy metabolism, particularly during flowering and grain filling stages. Since ATP-driven processes are essential for assimilate translocation, enhanced phosphorus nutrition likely contributed to improved movement of photosynthates towards developing seeds.

The observed increase in pods per plant and 100-seed weight under integrated treatments can thus be linked to improved phosphorus-mediated reproductive efficiency and grain filling.

4.3 Improvement in Soil Organic Carbon and Soil Physical Properties

The incorporation of farmyard manure under integrated nutrient management likely improved soil organic carbon, which plays a central role in maintaining soil health. Increased organic carbon enhances soil aggregation, porosity, water-holding capacity, and cation exchange capacity, thereby creating more favourable conditions for root growth and nutrient uptake—particularly under semi-arid environments.

Organic inputs also stimulate microbial activity and enzymatic processes, leading to improved nutrient mineralization and availability. The combined improvement in soil physical and biological properties likely contributed to a more stable rhizospheric environment, supporting sustained crop growth and better yield performance.

4.4 Improved Source–Sink Relationship and Assimilate Partitioning

Yield improvement under integrated nutrient management appears not merely as a function of increased biomass, but more importantly as a consequence of improved assimilate

partitioning. The higher harvest index recorded under integrated treatments suggests that a greater proportion of the produced biomass was effectively allocated to reproductive structures. Enhanced availability of nitrogen and phosphorus likely contributed to stronger sink establishment by improving flower retention, embryo development, and grain filling. At the same time, improved vegetative growth would have supported sustained photosynthetic activity, ensuring a continuous supply of assimilates from source tissues to developing pods and seeds. Balanced nutrient availability during the grain-filling phase may also have facilitated enzymatic processes associated with carbohydrate accumulation, thereby improving seed weight and overall yield.

Thus, integrated nutrient management appears to enhance both source strength (biomass production) and sink strength (reproductive demand), leading to more efficient assimilate translocation and utilization.

Overall Interpretation

The superiority of integrated nutrient management can be understood as the combined outcome of several interacting processes:

- Sustained nitrogen supply through biological fixation
- Enhanced phosphorus availability via microbial solubilization
- Improvement in soil organic carbon and rhizospheric activity
- Better coordination between vegetative growth and reproductive development

Together, these factors contribute to improved nutrient-use efficiency, enhanced physiological performance, and higher productivity of Kabuli gram under semi-arid conditions.

Conclusion

The findings of the present study indicate that integrated nutrient management (INM) markedly improved growth, yield attributes, and overall productivity of Kabuli gram under semi-arid conditions of central India. Treatments combining farmyard manure with microbial inoculants consistently outperformed sole chemical fertilization, suggesting that a balanced and biologically mediated nutrient supply is more effective than reliance on mineral inputs alone.

The observed improvements appear to be associated not only with enhanced nutrient availability but also with better coordination between vegetative growth and reproductive development. Increased biomass production, coupled with a higher harvest index, indicates that assimilates were more efficiently partitioned towards economic yield under integrated treatments.

At the same time, the role of organic inputs in improving soil properties and supporting microbial activity cannot be overlooked. These effects, though sometimes gradual, contribute to a more stable and resilient production environment—particularly under the moisture-limited conditions typical of the region.

Taken together, the study suggests that integrated nutrient management provides a practical pathway for improving productivity while maintaining soil health. Its adoption in Kabuli gram cultivation may therefore support both immediate yield gains and longer-term sustainability, although its performance may still vary with soil conditions, climate variability, and management practices.

References

1. Ahlawat IPS, Gangaiah B. Integrated nutrient management in pulse crops. *Indian Journal of Agronomy*. 2017;62(4):453–461.
2. Ali M, Kumar S. Chickpea research and development in India: status and prospects. *Agricultural Reviews*. 2018;39(2):91–102.
3. Balai RC, *et al.* Effect of integrated nutrient management on growth and yield of chickpea under semi-arid conditions. *Legume Research*. 2020;43(3):382–388.
4. Bhat MA, *et al.* Integrated nutrient management improves productivity and soil health in chickpea-based systems. *Journal of Soil Science and Plant Nutrition*. 2021;21:1560–1572.
5. Food and Agriculture Organization. Pulses: nutritional and sustainability benefits. Rome: Food and Agriculture Organization; 2022.
6. Ghosh PK, *et al.* Integrated nutrient management for sustainable pulse production. *Indian Journal of Fertilisers*. 2019;15(5):24–36.
7. Gupta R, Singh R. Soil organic carbon dynamics under integrated nutrient management. *Soil Use and Management*. 2022;38:1123–1134.
8. Indian Council of Agricultural Research. Annual report on pulses production in India. New Delhi: Indian Council of Agricultural Research; 2023.
9. Jat SL, *et al.* Nutrient-use efficiency in legumes under integrated nutrient management. *Field Crops Research*. 2018;216:60–70.
10. Kaur R, *et al.* Role of biofertilizers in enhancing productivity of pulse crops. *Agronomy Journal*. 2020;112(4):2805–2815.
11. Kumar V, *et al.* Effect of vermicompost and chemical fertilizers on chickpea yield. *International Journal of Plant Production*. 2019;13:263–275.
12. Lal R. Soil health and carbon management for sustainable agriculture. *Science of the Total Environment*. 2020;704:135–148.
13. Meena BL, *et al.* Integrated nutrient management improves soil biological properties. *Archives of Agronomy and Soil Science*. 2021;67(9):1211–1225.
14. Mohanty M, *et al.* Soil carbon sequestration under integrated nutrient management. *Agriculture, Ecosystems & Environment*. 2017;245:23–31.
15. Patel HK, Meena RS. Effect of biofertilizers and fertilizers on chickpea productivity. *Legume Research*. 2017;40(6):1058–1063.
16. Ramesh P, *et al.* Sustainable nutrient management in pulses. *Agricultural Research*. 2018;7:187–199.
17. Sharma A, *et al.* Integrated nutrient management in chickpea. *Indian Journal of Agricultural Sciences*. 2015;85(9):1174–1180.
18. Singh B, *et al.* Influence of Rhizobium and PSB on nodulation and yield of chickpea. *Journal of Plant Nutrition*. 2021;44(6):842–856.
19. Singh RP, *et al.* Integrated nutrient management enhances yield stability in pulses. *Agronomy*. 2022;12:1145.
20. Sinha NK, *et al.* Microbial-mediated nutrient dynamics in legume cropping systems. *Frontiers in Microbiology*. 2023;14:1123456.
21. Subbarao GV, *et al.* Biological nitrogen fixation and nutrient efficiency in legumes. *Plant and Soil*. 2019;435:1–22.

22. Tiwari R, *et al.* Integrated nutrient management for improving chickpea productivity. *Journal of Soil and Water Conservation*. 2020;19(3):265–272.
23. Verma S, *et al.* Effect of organic and inorganic nutrient sources on growth and yield of chickpea. *International Journal of Chemical Studies*. 2018;6(4):2154–2158.
24. Yadav RK, *et al.* Integrated nutrient management under rainfed pulse production systems. *Sustainability*. 2023;15:8342.
25. Zhang X, *et al.* Soil microbial communities under integrated nutrient management. *Applied Soil Ecology*. 2021;165:103981.