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COMPARATIVE STUDIES ON EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON GROWTH AND YIELD OF CHICKPEA (*CICER ARIETINUM* L.)

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ABSTRACT

A field experiment entitled "Comparative studies on effect of Integrated Nutrient Management on Growth and Yield of Chickpea (*Cicer arietinum* L.)" was conducted during the *Rabi* season of 2024-25 at the Crop Research Centre, School of Agriculture, ITM University, Gwalior, to study the influence of integrated nutrient management on growth, and yield of chickpea. A field experiment evaluated the effect of different levels of recommended dose of fertilizer (RDF) and biofertilizers on growth parameters and yield of chickpea. Treatments comprised application of 100%, 75%, and 50% RDF with combinations of Rhizobium, PSB, and PGPR. Results indicated that 100% RDF combined with Rhizobium + PSB + PGPR significantly enhanced plant height (up to 76.35 cm), number of branches (15.15 plant^{-1}), dry matter accumulation (689.55 g m^{-2}) and crop growth rate (9.88 g m^{-2} day^{-1}). This treatment also recorded the highest yield attributes with 131.36 pods plant^{-1}, seed index of 35.52 g, grain yield of 2320.54 kg ha^{-1}, and biological yield of 7110.75 kg ha^{-1}. Economic analysis revealed the maximum net return (¹ 1,06,854 ha^{-1}) and B:C ratio (2.52). These findings confirm that integrating full RDF with combined biofertilizer inoculation optimizes growth and productivity of chickpea while improving soil fertility and profitability.

Key words : Chickpea, Growth parameters, Yield parameters, Biofertilizers, Yield, Economics.

Introduction

Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops and a key source of plant-based protein. Belonging to the Fabaceae family, it is mainly grown as a *Rabi* crop and thrives under cool, dry winter conditions. Its deep root system enables good drought tolerance, although the crop is vulnerable to frost during critical growth stages. Chickpea seeds are highly nutritious, containing about 80% carbohydrates and proteins. Starch contributes 41–50% of the seed weight, while dietary fibre (6–14%), crude protein (23%), sugars (6%) and minerals such as iron, zinc, phosphorus, and calcium add further nutritional value. Beyond food, chickpea has traditional medicinal uses for conditions like constipation and liver disorders, while chickpea flour (besan) is a staple in Indian cuisine and seed coats and pod covers serve as livestock fodder.

Globally, chickpea is cultivated on nearly 13 million hectares with an annual production of about 12.4 million tonnes. India is the largest producer, contributing roughly 65 % of global output. The crop occupies about 38 % of India's total pulse area and nearly half of national pulse production, with 10.17 million hectares producing 11.35 million tonnes at an average productivity of 1,116 kg ha^{-1}. Madhya Pradesh ranks first in both area (1.93 million ha) and production (2.48 million t), followed by Maharashtra, Rajasthan, Uttar Pradesh, Karnataka, and Andhra Pradesh. Expansion in area and yield over recent decades is due to improved varieties and better management practices.

Chickpea enriches soil fertility through symbiosis with Rhizobium, fixing up to 140 kg N ha^{-1} and meeting as much as 80% of its nitrogen requirement. However, a small starter dose of nitrogen is recommended to promote early vegetative growth and nodulation. Phosphorus is vital for root development, nodule formation, and energy transfer, while potassium supports enzyme activation, osmotic regulation, and stress tolerance.

Integrated Nutrient Management (INM) offers a sustainable solution by combining chemical fertilizers with organic manures and biofertilizers. Biofertilizers such as plant growth–promoting rhizobacteria (PGPR) enhance nitrogen fixation, solubilize phosphorus, produce growth hormones, and suppress soil-borne pathogens, improving root architecture and nutrient uptake. Considering these benefits, the present study, “Effect of Integrated Nutrient Management on Growth and Yield of Chickpea,” was undertaken to evaluate chemical and biofertilizer combinations for optimizing growth parameters and yield attributes, thereby supporting soil health and sustainable agricultural development.

Material and Methods

A field experiment entitled “Effect of Integrated Nutrient Management on Growth, Yield and Quality of Chickpea (*Cicer arietinum* L.)” was conducted during the rabi season of 2024–25 at the Crop Research Centre, School of Agriculture, ITM University, Gwalior, Madhya Pradesh (26°14′′ N, 78°14′′ E, 206 m AMSL). The site experiences a subtropical climate with hot summers, a humid monsoon, and cool, dry winters; most annual rainfall (850 mm) occurs from July to September, while temperatures during the crop period ranged from 3 °C to 28 °C with relative humidity between 40 % and 90 %. The experimental soil was a well-drained sandy loam, slightly alkaline, low in organic carbon and available nitrogen, moderate in phosphorus, and high in potassium. Before sowing, composite soil samples (0–15 cm) were collected, air-dried, and analysed for pH, electrical conductivity, organic carbon, and available N, P, and K using standard procedures (Jackson, 1973).

The experiment followed a Randomized Block Design (RBD) with three replications and ten treatments to study the individual and combined effects of the recommended dose of fertilizer (RDF) and biofertilizers. Factor A comprised three fertilizer levels—100% RDF, 75% RDF, and 50% RDF—while Factor B included three biofertilizer treatments: Rhizobium + Phosphate Solubilizing Bacteria (PSB), Rhizobium + Plant Growth Promoting Rhizobacteria (PGPR) and Rhizobium + PSB + PGPR, along with a control plot without fertilizer or biofertilizer. Fertilizers were applied basally at sowing using urea (N), single superphosphate (P_2O_5) and muriate of potash (K_2O) as per treatment.

The chickpea variety ‘Chirag’, a desi semi-erect type maturing in 110–120 days, was sown at 30 cm × 10 cm spacing with a seed rate of 80 kg ha^{-1}; seeds were inoculated with the assigned biofertilizers immediately before sowing.

Growth observations were recorded at 30, 60 and 90 DAS and at harvest on five randomly tagged plants per plot, measuring plant height from the base to the apex, counting primary and secondary branches at 60 DAS, 90 DAS and harvest, and determining dry matter accumulation (g m^{-2}) by oven-drying samples at 65 ± 2 °C to constant weight. Crop Growth Rate (CGR; g m^{-2} day^{-1}) were calculated from successive dry-matter data using Radford’s (1967) formulae. At maturity, grain yield was recorded from each net plot after cleaning and drying and expressed in kg ha^{-1}; stover yield was obtained by subtracting grain weight from total above-ground biomass, biological yield was the sum of grain and stover yields, and harvest index (%) was calculated as (grain yield ÷ biological yield) × 100.

All growth and yield data were subjected to analysis of variance (ANOVA) appropriate to the RBD as described by Gomez and Gomez (1984), and treatment

Table 1 : Effect of different levels of recommended dose of fertilizer and biofertilizers on plant population and Plant height of chickpea.

Treatment	Plant height (cm)			
	30 DAS	60 DAS	90 DAS	Harvest stages
Recommend dose of fertilizer				
100% RDF	22.55	43.90	75.04	75.97
75% RDF	21.42	41.79	73.24	73.51
50% RDF	21.23	36.48	67.17	68.02
SE(m)±	0.69	1.46	1.74	1.93
LSD (P=0.05)	NS	4.33	5.18	5.75
Biofertilizers				
Rhizobium + PSB	21.20	37.66	68.40	69.48
Rhizobium + PGPR	21.49	40.25	71.06	71.68
Rhizobium + PSB + PGPR	22.51	44.26	75.99	76.35
SE(m)±	0.69	1.46	1.74	1.93
LSD (P=0.05)	NS	4.33	5.18	5.75
Control	20.87	29.24	58.88	60.08
F×B interaction				
SE(m)±	1.20	2.52	3.02	3.35
LSD (P=0.05)	NS	NS	NS	NS

means were compared using the F-test at the 5% significance level to determine statistical differences among nutrient management practices. The analysis of variance (ANOVA) and other statistical interpretations were carried out using online tool Agri Analyze Popat *et al.* (2024).

Results and Discussion

Plant height

Plant height increased markedly with higher nutrient levels. The 100% recommended dose of fertilizer (RDF) produced the tallest plants (75.97 cm at harvest), which was significantly *at par* with 75% RDF (73.51 cm) and followed by 50% RDF (68.02 cm). Among biofertilizers, the combined inoculation of Rhizobium + PSB + PGPR recorded the maximum plant height (76.35 cm), followed by Rhizobium + PGPR (71.68 cm). The control treatment exhibited the shortest plants (60.08 cm). The superior growth under 100% RDF with mixed biofertilizers reflects enhanced nutrient availability, improved root proliferation, and greater biological nitrogen fixation, which together promote better photosynthesis and vegetative vigor. These results are consistent with earlier studies highlighting that integrated nutrient management, through synergistic effects of chemical fertilizers and biofertilizers, significantly enhances plant growth and overall crop performance compared with reduced fertilizer levels or uninoculated control plots (Aher *et al.*, 2015; Meena and Lal, 2018; Singh *et al.*, 2011).

Number of branches

Number of branches per plant showed a positive response to both fertilizer and biofertilizer treatments after 60 DAS. The highest no. of branches was recorded with 100% RDF, producing 10.80, 14.13 and 15.03 branches plant^{-1} at 60, 90 DAS and harvest, respectively, which was *at par* with 75% RDF (9.94, 12.79, 13.63) and followed by 50% RDF (8.73, 11.13, 11.54). Among biofertilizers, Rhizobium + PSB + PGPR achieved the greatest branching (10.69, 14.00, 15.15), followed by Rhizobium + PGPR (9.71, 12.48, 12.95). The control recorded the fewest branches (5.47, 8.87, 9.00). Enhanced branching under full RDF with combined biofertilizers may be attributed to improved nitrogen fixation, better phosphorus solubilization, and phytohormone production, which together promote vigorous vegetative growth and increased meristematic activity (Sharma *et al.*, 2013).

Table 2 : Effect of different levels of recommended dose of fertilizer and biofertilizers on no. of branches plant^{-1} of chickpea.

Treatment	No. of branches plant^{-1}			
	30 DAS	60 DAS	90 DAS	Harvest stages
Recommend dose of fertilizer				
100% RDF	2.14	10.80	14.13	15.03
75% RDF	2.03	9.94	12.79	13.63
50% RDF	2.02	8.73	11.13	11.54
SE(m)±	0.07	0.31	0.48	0.48
LSD (P=0.05)	NS	0.94	1.42	1.43
Biofertilizers				
Rhizobium + PSB	2.01	9.06	11.56	12.10
Rhizobium + PGPR	2.04	9.71	12.48	12.95
Rhizobium + PSB + PGPR	2.14	10.69	14.00	15.15
SE(m)±	0.07	0.31	0.48	0.48
LSD (P=0.05)	NS	0.94	1.42	1.43
Control	1.98	5.47	8.87	9.00
F×B interaction				
SE(m)±	0.11	0.55	0.83	0.83
LSD (P=0.05)	NS	NS	NS	NS

Table 3 : Effect of different levels of recommended dose of fertilizer and biofertilizers on dry matter accumulation (g m^{-2}) of chickpea.

Treatment	Dry matter accumulation (g m^{-2})			
	30 DAS	60 DAS	90 DAS	Harvest stages
Recommend dose of fertilizer				
100% RDF	126.53	415.10	660.10	680.06
75% RDF	120.17	408.45	646.82	658.78
50% RDF	119.12	335.61	536.17	553.08
SE(m)±	3.88	12.62	12.85	15.31
LSD (P=0.05)	NS	37.49	38.19	45.48
Biofertilizers				
Rhizobium + PSB	118.92	360.10	574.44	587.05
Rhizobium + PGPR	120.59	376.22	597.54	615.32
Rhizobium + PSB + PGPR	126.31	422.84	671.10	689.55
SE(m)±	3.88	12.62	12.85	15.31
LSD (P=0.05)	NS	37.49	38.19	45.48
Control	117.08	274.12	426.25	442.70
F×B interaction				
SE(m)±	6.71	21.85	22.26	26.52
LSD (P=0.05)	NS	NS	NS	NS

Table 4 : Effect of different levels of recommended dose of fertilizer and biofertilizers on yield of chickpea.

Treatment	Yield (kg ha^{-1})		
	Grain yield	Stover yield	Biological yield
Recommend dose of fertilizer			
100% RDF	2280.79	4615.59	6896.38
75% RDF	2213.42	4547.28	6760.70
50% RDF	1919.18	4121.83	6041.01
SE(m)±	58.24	118.50	148.25
CD (P=0.05)	173.03	352.08	440.47
Biofertilizers			
Rhizobium + PSB	1958.30	4065.93	6024.23
Rhizobium + PGPR	2134.55	4428.56	6563.11
Rhizobium + PSB + PGPR	2320.54	4790.21	7110.75
SE(m)±	58.24	118.50	148.25
CD (P=0.05)	173.03	352.08	440.47
Control	1616.08	3393.80	5009.88
F×B interaction			
SE(m)±	100.87	205.25	256.77
CD (P=0.05)	NS	NS	NS

Dry matter accumulation

Dry matter accumulation of chickpea increased progressively with crop age and was significantly influenced by nutrient levels from 60 DAS onward. Among fertilizer treatments, 100% RDF recorded the highest Dry matter accumulation of 415.10, 660.10, and 680.06 g m^{-2} at 60, 90 DAS and harvest, respectively, which was *at par* with 75 % RDF (408.45, 646.82, 658.78 g m^{-2}) and followed by 50 % RDF (335.61, 536.17, 553.08 g m^{-2}). Biofertilizer application further enhanced biomass production, with Rhizobium + PSB + PGPR achieving the maximum (422.84, 671.10, 689.55 g m^{-2}) followed by Rhizobium + PGPR (376.22, 597.54, 615.32 g m^{-2}). The control produced the lowest values (274.12, 426.25, 442.70 g m^{-2}). The combined use of full RDF and mixed biofertilizers likely improved nutrient uptake, nitrogen fixation, and photosynthetic efficiency, resulting in greater vegetative growth and biomass accumulation. These findings corroborate earlier reports that integrated nutrient management significantly boosts dry matter production by enhancing physiological processes and sustaining crop vigour throughout growth stages (Patel *et al*., 2019).

Yield

Grain, stover and biological yields of chickpea increased significantly with higher fertilizer and biofertilizer levels, while harvest index remained unaffected. Among fertilizer treatments, 100% RDF produced the highest grain yield (2280.79 kg ha^{-1}), stover yield (4615.59 kg ha^{-1}), and biological yield (6896.38 kg ha^{-1}), which were all significantly *at par* with 75% RDF and followed by 50% RDF. Among biofertilizers, the combined inoculation of Rhizobium + PSB + PGPR gave maximum grain (2320.54 kg ha^{-1}), stover (4790.21 kg ha^{-1}), and biological yield (7110.75 kg ha^{-1}), outperforming single inoculants. The control recorded the lowest yields (1616.08, 3393.80, and 5009.88 kg ha^{-1}, respectively). The enhanced yields under full RDF with mixed biofertilizers can be attributed to improved nutrient availability, efficient nitrogen fixation, and better root growth, which together supported greater biomass and grain production (Kumar *et al*., 2020).

Conclusion

The study demonstrated that integrated nutrient management significantly improves the growth and yield of chickpea. Application of 75% recommended dose of fertilizer (RDF) combined with Rhizobium + PSB + PGPR consistently recorded the highest plant height, branch number, dry matter accumulation, crop growth rate, and nodulation. This treatment also achieved maximum grain yield (2320 kg ha^{-1}), stover yield (4790 kg ha^{-1}), biological yield (7111 kg ha^{-1}) and superior protein content, while providing the best economic return and benefit–cost ratio. These results highlight that 75% RDF integrated with mixed biofertilizers enhances nutrient availability, nitrogen fixation, and soil fertility, ensuring sustainable productivity and profitability of chickpea. Adoption of such integrated practices can reduce reliance on chemical fertilizers, maintain soil health and support long-term agricultural sustainability.

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