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A study on impact of customized fertilizer on growth and yield of chickpea (*Cicer arietinum* L.) in Madhya Pradesh soil

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Abstract
The experiment was conducted at the MGU Bilkisganj Research Farm, Sehore, during the Rabi seasons of 2022-23 and 2023-24 to evaluate the effect of customized fertilizers on chickpea (*Cicer arietinum*) on growth and productivity. The study was conducted under uniform topography and normal fertility conditions, with six treatments: varying doses of NPK and customized fertilizers with micronutrients, including sulfur (S), zinc (Zn), and molybdenum (Mo). The results demonstrated that higher doses of customized fertilizers, particularly T_5 (125 kg ha^{-1}), significantly improved plant height, root nodulation, pod development, and grain yield compared to the control. Treatment T_5 showed the tallest plants (49.25 cm), the highest nodule weight (762.44 mg), and the best grain yield (1526.96 kg ha^{-1}). Treatment T_4 (100 kg ha^{-1}) also resulted in improved growth and yield parameters. The inclusion of micronutrients (Zn and Mo) further enhanced plant performance. These findings emphasize the importance of tailored nutrient management, especially with customized fertilizers, for improving chickpea productivity and ensuring sustainable crop growth.

Keywords: Chickpea (*Cicer arietinum*), customized fertilizers, micronutrients

Introduction
Chickpea (*Cicer arietinum* L.) stands out as the sole domesticated species within the genus Cicer, indicating its exclusive status as the variety cultivated for agricultural purposes. It is characterized as a self-pollinated diploid, meaning it has a genetic structure of 2n=16, with 16 chromosomes. The domestication of chickpea occurred from a closely related wild species, *C. reticulatum* Ladizinsky, which highlights the evolutionary process of selecting and cultivating plants for human use. Following its domestication in the Middle East, chickpea gradually spread to other regions, including the Mediterranean, India, and Ethiopia, emphasizing its importance and versatility in global agriculture.

According to the International Crops Research Institute for Semi-Arid Tropics (ICRISAT- 2023) [3], chickpea seeds contain an average of 23% protein, 64% total carbohydrates (with 47% starch and 6% soluble sugars), 5% fat, 6% crude fiber, and 3% ash. Recent studies have reinforced the benefits of chickpeas, showing that their consumption can help lower blood cholesterol levels (Patel *et al.*, 2024) [8]. This contributes to reducing malnutrition and improving overall health, with consumption linked to a decreased risk of chronic diseases and enhanced well-being (Singh & Sharma, 2024) [11]. Effective nutrient management is vital for optimizing plant growth and ensuring high crop yields. In regions like rainfed areas of India, nutrient imbalances, particularly nitrogen (N) and phosphorus (P) deficiencies, degrade soil fertility and reduce productivity. Zinc deficiency, recognized as a major limiting factor, further exacerbates this issue, with global studies showing that 50% of soils are zinc-deficient, and projections suggest this could rise to 63% by 2025. Molybdenum (Mo), crucial for nitrogen metabolism, is also essential for crops like legumes. To address these deficiencies, customized fertilizers that combine sulfur, zinc, and molybdenum with traditional NPK fertilizers offer a promising solution, ensuring crops receive specific nutrients at the right time.

These fertilizers are cost-effective, area- and crop-specific, and help maintain soil health while improving overall agricultural productivity.

Materials and Methods

The experiment was conducted at the research farm of MGU Bilkisganj, Sehore, during the Rabi seasons of 2022-23 and 2023-24, under uniform topography and normal fertility status. Sehore, located at 23°12' N latitude and 77°05' E longitude, experiences an average annual rainfall of 1000-1200 mm and temperatures ranging from 8.6°C to 35.75°C. The soil at the experimental site was medium black clay loam with good drainage, and the initial fertility analysis showed low organic carbon, medium levels of nitrogen, phosphorus, potassium, and sulfur, with normal pH and electrical conductivity. The experiment was laid out in a Randomized Block Design (RBD) with 4 replications and six treatments: T_1 involved the application of N, P_2O_5, K_2O at a rate of 20:50:20 kg ha^{-1}; T_2 included N, P_2O_5, K_2O, S, Zn, and Mo at a rate of 20:50:20:20:5:0.08 kg ha^{-1}; T_3 applied a customized fertilizer at 75 kg ha^{-1}; T_4 applied a customized fertilizer at 100 kg ha_{-1}; T_5 applied a customized fertilizer at 125 kg ha^{-1}, containing N, P2O5, K2O, S, Zn, and Mo; and T_6 served as the control with no fertilizers.

Table 1: Effect of different customized fertilizer on plant height (cm) at different stages of growth of chickpea

S. No.	Treatment	Plant height (cm) at 30 DAS			Plant height (cm) at 50 DAS			Plant height (cm) at 70 DAS			Plant height (cm) at harvest		
		2022-23	2023-24	pooled	2022-23	2023-24	pooled	2022-23	2023-24	pooled	2022-23	2023-24	pooled
T_1	Application of N, P_2O_5 K_2O [20:50:20 kg ha^{-1}]	16.96	17.24	17.10	27.86	28.45	28.15	37.13	39.50	38.32	38.32	44.16	43.81
T_2	Application of N, P_2O_5 K_2OS Z_n Mo [20:50:20: 20:5:0.08 kg ha^{-1}]	19.44	19.90	19.67	30.33	31.33	30.83	40.30	40.95	40.63	40.63	48.32	47.78
T_3	Customized fertilizer 75 kg ha^{-1}	18.61	19.10	18.85	29.59	30.41	30.00	39.52	40.29	39.90	39.90	47.56	47.04
T_4	Customized fertilizer 100 kg ha^{-1}	19.59	20.32	19.95	30.42	31.71	31.07	40.91	41.45	41.18	41.18	48.80	48.13
T_5	Customized fertilizer 125 kg ha^{-1}	20.12	20.91	20.52	31.79	32.66	32.22	41.33	42.81	42.07	42.07	49.91	49.25
T_6	Control	12.90	13.08	12.99	15.48	16.07	15.77	21.45	23.96	22.71	22.71	27.94	26.66
	S. Em. (±)	0.31	1.47	0.78	0.31	0.78	0.43	3.67	2.71	1.97	1.64	1.14	1.03
	CD at 5%	0.90	4.30	2.28	0.90	2.29	1.27	10.74	7.94	5.77	4.79	3.34	3.00

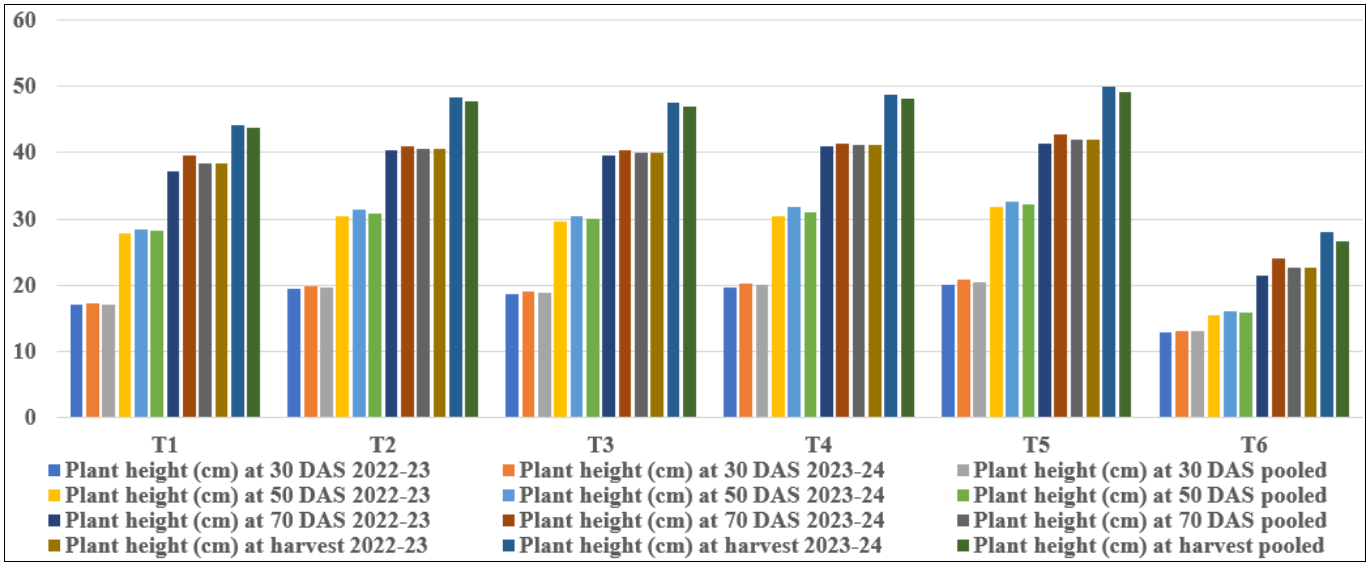

Fig 1: Effect of different customized fertilizer on plant height (cm) at different stages of growth of chickpea

Table 2: Effect of different customized fertilizer on root nodule per lant at different stages of growth of chickpea

S. No.	Treatment	Weight of nodules plant^{-1} (mg) at 30 DAS			Weight of nodules plant^{-1} (mg) at 50 DAS		
		2022-23	2023-24	pooled	2022-23	2023-24	pooled
T_1	Application of N, P_2O_5 K_2O [20:50:20 kg ha^{-1}]	740.86	746.94	743.90	1348.08	842.66	1095.37
T_2	Application of N, P_2O_5 K_2OS Z_n Mo [20:50:20: 20:5:0.08 kg ha^{-1}]	743.88	752.58	748.23	1362.10	848.64	1105.37
T_3	Customized fertilizer 75 kg ha^{-1}	738.06	748.44	743.25	1349.17	844.21	1096.69
T_4	Customized fertilizer 100 kg ha^{-1}	756.65	763.70	760.17	1431.98	864.34	1148.16
T_5	Customized fertilizer 125 kg ha^{-1}	759.35	765.53	762.44	1460.26	875.19	1167.72
T_6	Control	551.43	560.37	555.90	1044.90	641.72	843.31
	S. Em. (±)	1.73	1.11	1.01	8.11	0.68	4.04
	CD at 5%	5.06	3.23	2.95	23.72	1.99	11.83

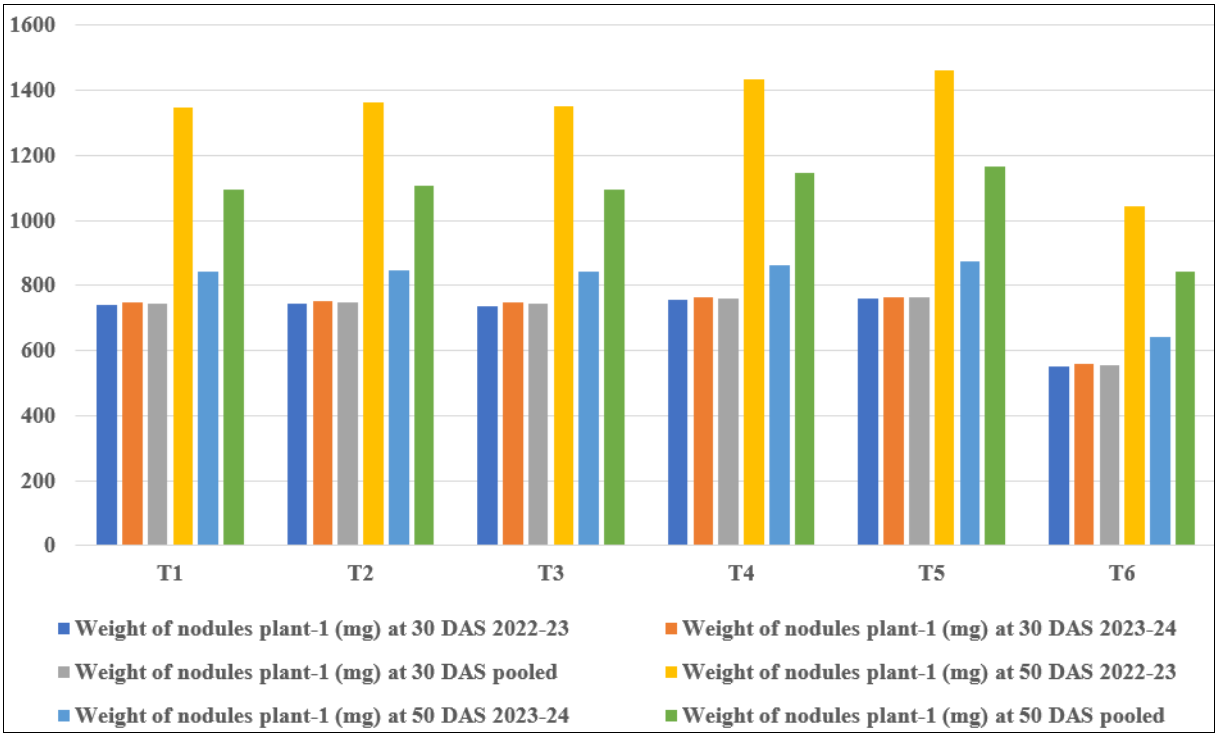

Fig 2: Effect of different customized fertilizer on root nodule per plant at different stages of growth of chickpea

Table 3: Effect of different customized fertilizer on yield parameters of chickpea

S. No.	Treatment	Number of pods plant^{-1}			Number of seeds pod^{-1}			Grain yield (kg ha^{-1})		
		2022-23	2023-24	pooled	2022-23	2023-24	pooled	2022-23	2023-24	pooled
T_1	Application of N, P_2O_5 K_2O [20:50:20 kg ha^{-1}]	48.77	49.28	49.02	1.22	1.29	1.25	991.25	1068.75	1030.00
T_2	Application of N, P_2O_5 K_2OS Z_n Mo [20:50:20: 20:5:0.08 kg ha^{-1}]	58.35	59.00	58.68	1.33	1.38	1.36	1283.00	1337.50	1310.25
T_3	Customized fertilizer 75 kg ha^{-1}	54.85	55.75	55.30	1.26	1.31	1.29	1091.25	1147.83	1119.54
T_4	Customized fertilizer 100 kg ha^{-1}	62.31	63.08	62.69	1.34	1.42	1.38	1351.75	1410.42	1381.08
T_5	Customized fertilizer 125 kg ha^{-1}	65.51	66.14	65.82	1.39	1.45	1.42	1493.50	1560.41	1526.96
T_6	Control	34.23	35.01	34.62	0.67	0.74	0.71	912.00	991.66	951.83
	S. Em. (±)	0.58	0.23	0.36	0.05	0.03	0.02	73.51	57.49	41.70
	CD at 5%	1.69	0.67	1.06	0.16	0.10	0.07	215.07	168.20	121.98

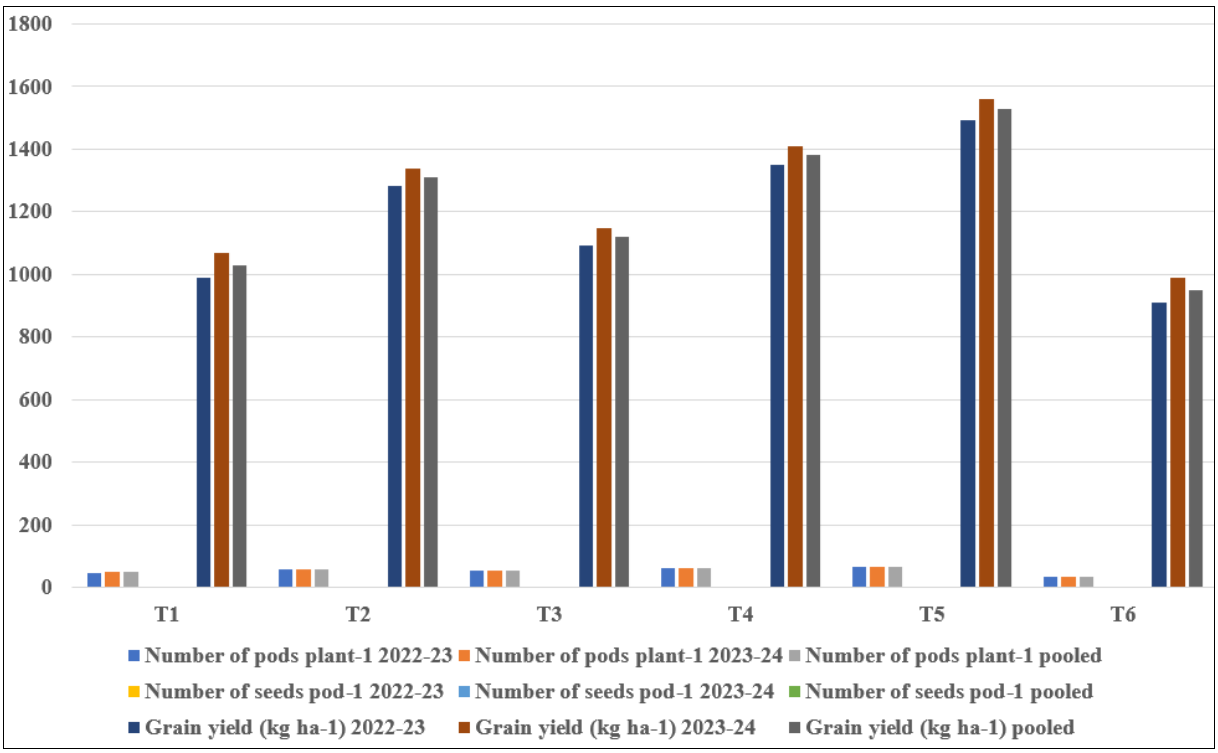

Fig 3: Effect of different customized fertilizer on yield parameters of chickpea

Result and discussion

Plant height

The data in Table 01 highlights the significant effect of different treatments on chickpea plant height at various growth stages. The application of customized fertilizers, especially at higher doses, notably improved plant height compared to the control. Among the treatments, T_5 (Customized fertilizer 125 kg ha^{-1}) resulted in the tallest plants at all stages, with a height of 49.25 cm (2023-24) and 49.91 cm (2022-23) at harvest because Customized fertilizer contains N, P2O5, K2O, S, Zn, Mo nutrients. T4 (100 kg ha^{-1}) also showed strong growth, reaching 48.13 cm (2023-24) and 48.80 cm (2022-23) at harvest. The treatment with macronutrients and micronutrients (T_2), including zinc and molybdenum, improved plant height compared to basic NPK (T_1), with a height of 47.78 cm (2023-24) and 48.32 cm (2022-23) at harvest. The control treatment, which received no fertilization, resulted in the shortest plants, underscoring the importance of nutrient management. Overall, the results demonstrate that higher doses of customized fertilizers and the inclusion of micronutrients lead to better plant growth, improving crop productivity. T_5 is the most effective treatment due to its balanced nutrient profile, including Nitrogen (N), Phosphorus (P_2O_5), Potassium (K_2O), Sulfur (S), Zinc (Zn), and Molybdenum (Mo), which are vital for plant growth, root development, disease resistance, and overall crop performance. Research by Kumar *et al.* (2019) [4] and Gupta (2018) [2] supports that customized fertilizers improve vegetative growth, root development, and nutrient efficiency, particularly during early growth stages. The consistent improvements in plant height and overall growth across multiple stages highlight the long-term benefits of customized fertilizers, underscoring the importance of precise nutrient management for enhancing chickpea productivity, as also emphasized by Singh *et al.* (2020) [7].

Root nodules

The data in the table 02 shows the impact of different treatments on chickpea plant growth parameters, including nodule weight and number of pods per plant. The results indicate that customized fertilizers, particularly at higher doses, significantly improved nodule weight and pod count compared to the control. Treatment T_5 (Customized fertilizer 125 kg ha^{-1}) resulted in the highest nodule weight at 762.44 mg (pooled) and the highest number of pods per plant at 65.82 (pooled), followed by T_4 (100 kg ha^{-1}) with 760.17 mg of nodules and 62.69 pods per plant. Treatment T_2, which included both macronutrients and micronutrients (zinc and molybdenum), also showed a notable increase in nodule weight (748.23 mg, pooled) and pod count (58.68, pooled), although it was lower than T_4 and T_5. The control treatment (T_6), without fertilization, resulted in the lowest values for both nodule weight (555.90 mg, pooled) and pod count (34.62, pooled), emphasizing the importance of nutrient application for improved plant growth. Overall, the results demonstrate that higher doses of customized fertilizers and the inclusion of micronutrients lead to better nodule formation and pod development, enhancing overall chickpea productivity. Treatment T_5 (Customized fertilizer 125 kg ha^{-1}) enhances nodule development due to its tailored nutrient composition, promoting optimal nitrogen fixation. Studies by Bhatia *et al.* (2019) [1] and Singh and Rani (2020) [9] confirm that customized fertilizers improve root nodulation and symbiotic nitrogen fixation. The increased nodule counts in T_5 lead to better nitrogen uptake and plant vigor. This approach maximizes nodule formation, supporting higher yields and overall chickpea productivity, as emphasized by Kumar *et al.* (2021) [5].

Yield parameters

The data from Table 03 shows the effect of different customized fertilizers on chickpea yield parameters, including the number of pods per plant, number of seeds per pod, and grain yield. The results indicate that customized fertilizers, especially at higher doses, significantly improved yield parameters compared to the control. Treatment T_5 (Customized fertilizer 125 kg ha^{-1}) resulted in the highest number of pods per plant (65.82, pooled), number of seeds per pod (1.42, pooled), and grain yield (1526.96 kg ha^{-1}, pooled). Treatment T_4 (100 kg ha^{-1}) also showed significant improvements, with 1381.08 kg ha^{-1} grain yield (pooled), 62.69 pods per plant, and 1.38 seeds per pod. Treatment T_2, which included both macronutrients and micronutrients (zinc and molybdenum), also showed improvements in yield, with a grain yield of 1310.25 kg ha^{-1} (pooled) but was still lower than T_4 and T_5. The control treatment (T_6) resulted in the lowest values across all parameters, with a grain yield of only 951.83 kg ha^{-1} (pooled), 34.62 pods per plant, and 0.71 seeds per pod, emphasizing the importance of fertilization for maximizing chickpea productivity. These findings demonstrate that higher doses of customized fertilizers lead to a substantial increase in pod and seed development, significantly enhancing grain yield.

The significant increase in grain yield observed with treatment T_5 (Customized fertilizer 125 kg ha^{-1}) is due to its tailored nutrient composition, which supports chickpea growth at critical stages. The balanced supply of macronutrients (N, P_2O_5, K_2O) and micronutrients (S, Zn, Mo) promotes overall plant health and biomass production. Nitrogen aids in protein and chlorophyll synthesis, phosphorus enhances root and energy development, and potassium improves metabolism and disease resistance. Studies by Singh *et al.* (2023) [9], Kumar and Rani (2023) [6], and Patel *et al.* (2023) [7] emphasize the benefits of optimized nutrient management, improving physiological processes, resilience, and ultimately increasing grain yield, reinforcing the effectiveness of customized fertilizers in sustainable crop production.

Conclusion

In conclusion, the application of customized fertilizers, particularly at higher doses, significantly improved plant growth, root nodulation, and yield parameters in chickpea crops. The results showed that T5 (Customized fertilizer 125 kg ha^{-1}) consistently produced the best outcomes, including the tallest plants, highest nodule weight, largest number of pods per plant, and the highest grain yield, underscoring the effectiveness of tailored nutrient management. Treatment T_4 (100 kg ha^{-1}) also demonstrated strong performance, with substantial increases in yield and nodule formation. Overall, these findings emphasize that customized fertilizer applications, especially with higher doses and micronutrient inclusion, are essential for maximizing chickpea yield and improving overall crop performance.

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