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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). A field experiment was conducted to evaluate the impact of customized fertilizer treatments on the growth and yield parameters of chickpea (*Cicer arietinum* L.). The study revealed significant differences among treatments in terms of plant growth and productivity. Application of customized fertilizer at 125 kg ha⁻¹ (T5), enriched with N, P₂O₅, K₂O, sulfur, zinc, and molybdenum, consistently produced the highest values across all measured parameters. T5 recorded the maximum number of branches per plant (6.76), highest dry weight (80.56 g plant⁻¹), seed index (23.59 g), biological yield (3586.25 kg ha⁻¹), grain yield (1526.96 kg ha⁻¹), and straw yield (2119.75 kg ha⁻¹). This was followed by T4 (100 kg ha⁻¹), which also showed enhanced performance. Treatments containing micronutrients (T2 and T5) outperformed those with only macronutrients (T1 and T3), highlighting the importance of balanced nutrient management. The control treatment (T6), with no fertilizer application, consistently recorded the lowest values.

Keywords: Customized fertilizer, biological yield, strow yield, seed index and branches

Introduction

Chickpea (*Cicer arietinum* L.) is the only cultivated species within the *Cicer* genus, making it unique as the sole domesticated variant developed for agricultural production. It is a self-pollinating diploid species with 16 chromosomes (2n=16). Chickpea was domesticated from its wild relative, *Cicer reticulatum* Ladizinsky, a process that reflects the broader agricultural practice of selecting and cultivating wild species for human benefit. Originating in the Middle East, chickpea gradually spread to the Mediterranean region, India, and Ethiopia, underscoring its global agricultural significance and adaptability (Verma, 2022)^[10].

According to the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT, 2023)^[2], chickpea seeds contain approximately 23% protein, 64% total carbohydrates (including 47% starch and 6% soluble sugars), 5% fat, 6% crude fiber, and 3% ash. Recent research highlights chickpea's nutritional value, with evidence showing that regular consumption can reduce blood cholesterol levels (Patel *et al.*, 2024)^[7], combat malnutrition, and lower the risk of chronic diseases, ultimately supporting overall health and well-being (Singh & Sharma, 2024)^[8]. (Joshi, 2023)^[3].

Optimal nutrient management plays a critical role in enhancing plant growth and crop yield, particularly in rainfed areas like those in India. Soil fertility in these regions often suffers due to imbalances in essential nutrients, especially nitrogen (N) and phosphorus (P). Zinc (Zn) deficiency is also a major limiting factor for productivity; global assessments indicate that around 50% of agricultural soils are zinc-deficient—a figure projected to rise to 63% by 2025. Molybdenum (Mo), essential for nitrogen metabolism in legumes, is another crucial micronutrient (Meena, 2021)^[5].

To combat these deficiencies, the use of customized fertilizers enriched with sulfur (S), zinc (Zn), and molybdenum (Mo), alongside traditional NPK fertilizers, is emerging as a sustainable and efficient approach. These fertilizers are not only cost-effective and crop-specific but also support long-term soil health and agricultural productivity. Their adoption, especially in legume-based systems like chickpea, holds promise for improving both yield and nutritional outcomes in resource-limited environments (Tiwari, 2023) [9].

Materials and Methods

The field experiment was conducted during the Rabi seasons of 2022-23 and 2023-24 at the research farm of MGU Bilkisganj, Sehore. The site is located at 23°12' N latitude and 77°05' E longitude, with an average annual rainfall of 1000-1200 mm and temperature ranges from 8.6°C to 35.75°C. The soil at the site was classified as medium black clay loam with good drainage. Initial soil fertility analysis revealed low organic carbon content, medium levels of nitrogen, phosphorus, potassium, and sulfur, along with neutral pH and normal electrical conductivity. The experimental design followed a Randomized Block Design (RBD) with four replications and six treatments:

- **T1:** Application of N, P₂O₅, and K₂O at 20:50:20 kg ha⁻¹
- **T2:** Application of N, P₂O₅, K₂O, S, Zn, and Mo at 20:50:20:20:5:0.08 kg ha⁻¹
- **T3:** Customized fertilizer at 75 kg ha⁻¹
- **T4:** Customized fertilizer at 100 kg ha⁻¹
- **T5:** Customized fertilizer at 125 kg ha⁻¹, including N, P₂O₅, K₂O, S, Zn, and Mo
- **T6:** Control (no fertilizer application)

Results

Growth Parameters of Chickpea

The impact of various customized fertilizer treatments on chickpea growth parameters as presented in Table: 1, including the number of branches per plant and dry weight per plant at different growth stages, is presented in Table 01.

A significant variation was observed among treatments for both the number of branches and dry matter accumulation at all stages of crop growth. Among the treatments, T5 (application of customized fertilizer at 125 kg ha⁻¹ containing N, P₂O₅, K₂O, S, Zn, and Mo) consistently recorded the highest values across all growth stages. At harvest, T5 produced the maximum number of branches per plant (6.76) and the highest dry weight (80.56 g plant⁻¹), indicating enhanced vegetative growth due to balanced and adequate nutrient supply.

This was followed by T4 (customized fertilizer at 100 kg ha⁻¹), which also demonstrated improved performance with 5.84 branches per plant and 78.91 g dry weight per plant at harvest. T2, which included N, P₂O₅, K₂O along with S, Zn, and Mo at

conventional rates, also showed favorable results compared to T1 and T3, highlighting the importance of micronutrient supplementation in addition to macronutrients.

On the other hand, T6 (control, no fertilizer application) recorded the lowest number of branches (3.55) and minimum dry weight (70.59 g plant⁻¹) at harvest, underscoring the critical role of nutrient inputs in chickpea growth and development.

The data clearly indicate that the application of customized fertilizers, particularly at 125 kg ha⁻¹ (T5), significantly improved plant growth by promoting branching and biomass accumulation at all stages. The statistical analysis further confirms that these differences were significant at the 5% level (CD values provided), affirming the reliability of the observed treatment effects.

Yield Parameters of Chickpea

The results presented in Table 02 highlight the significant impact of different customized fertilizer treatments on the yield attributes of chickpea, including seed index, biological yield, grain yield, and straw yield.

The application of T5 (customized fertilizer at 125 kg ha⁻¹ containing N, P₂O₅, K₂O, S, Zn, and Mo) produced the most favorable outcomes across all yield parameters. T5 recorded the highest seed index (23.59 g), biological yield (3586.25 kg ha⁻¹), grain yield (1526.96 kg ha⁻¹), and straw yield (2119.75 kg ha⁻¹). This superior performance suggests that the higher dose of balanced, micronutrient-enriched fertilizer significantly enhanced the reproductive efficiency and overall biomass accumulation of chickpea plants.

Following T5, T4 (customized fertilizer at 100 kg ha⁻¹) also demonstrated improved yield attributes, with a seed index of 22.66 g, biological yield of 3358.13 kg ha⁻¹, grain yield of 1381.08 kg ha⁻¹, and straw yield of 2033.33 kg ha⁻¹. T2, which included both macro- and micronutrients at a moderate rate (20:50:20:20:5:0.08 kg ha⁻¹), performed better than T1 and T3, further confirming the importance of including sulfur, zinc, and molybdenum in the fertilization regime.

On the other hand, the control treatment (T6), where no fertilizer was applied, consistently recorded the lowest values across all yield parameters. It resulted in a seed index of just 13.56 g, biological yield of 2034.13 kg ha⁻¹, grain yield of 951.83 kg ha⁻¹, and straw yield of 1352.08 kg ha⁻¹, underscoring the critical role of adequate nutrient management in achieving optimal chickpea productivity.

The statistical analysis (CD at 5%) confirms that the observed differences among treatments were significant for all measured yield components, indicating the reliability of these results. The trend clearly shows that customized fertilizers, particularly at higher application rates, substantially enhance yield performance in chickpea by improving both grain and biomass production.

Table 1: Impact of different customized fertilizer treatments on growth parameters of chickpea at various stages (Mean of two years)

S. no.	Number of branches				Dry weight plant ⁻¹ (g) at 30 DAS			
	30 DAS	50 DAS	70 DAS	harvest	30 DAS	50 DAS	70 DAS	harvest
T ₁	2.12	3.23	3.95	4.46	5.66	13.58	33.34	74.52
T ₂	2.46	4.05	4.40	5.28	6.73	14.25	36.92	77.45
T ₃	2.33	3.43	4.22	4.69	6.41	14.10	35.99	75.72
T ₄	2.64	4.29	4.86	5.84	7.10	14.81	38.57	78.91
T ₅	2.99	4.90	5.26	6.76	7.39	15.32	40.46	80.56
T ₆	1.65	2.54	3.09	3.55	5.43	12.68	30.76	70.59
S. Em. (±)	0.16	0.12	0.14	0.11	0.14	0.17	0.27	0.26
CD at 5%	0.46	0.36	0.42	0.33	0.42	0.50	0.78	0.75

Table 2: Impact of different customized fertilizer treatments on yield parameters of chickpea (Mean of two years)

S. no.	Seed index (g)	Biological yield plot ⁻¹ (kg)	Grain yield plot ⁻¹ (kg)	Straw yield plot ⁻¹ (kg)	Biological yield plot ⁻¹ (kg)	Grain yield plot ⁻¹ (kg)	Straw yield plot ⁻¹ (kg)
T ₁	18.98	2.99	1.25	1.73	2494.50	1030.00	1441.37
T ₂	22.35	3.60	1.57	2.23	3003.88	1310.25	1862.50
T ₃	20.50	3.11	1.34	1.93	2626.88	1119.54	1608.33
T ₄	22.66	4.03	1.66	2.44	3358.13	1381.08	2033.33
T ₅	23.59	4.30	1.83	2.54	3586.25	1526.96	2119.75
T ₆	13.56	2.44	1.14	1.62	2034.13	951.83	1352.08
S. Em. (±)	0.35	0.11	0.05	0.09	85.99	41.70	78.23
CD at 5%	1.04	0.31	0.15	0.27	251.56	121.98	228.86

Discussion

The present study clearly demonstrates the significant role of customized fertilizer application in enhancing the growth and yield performance of chickpea (*Cicer arietinum* L.). The observed variations among treatments underscore the importance of balanced nutrient supply, particularly the inclusion of both macro- (N, P, K) and micro-nutrients (S, Zn, Mo), in optimizing crop performance under field conditions.

Growth Parameters

The growth parameters—number of branches per plant and dry weight per plant—showed a marked improvement with increasing levels of customized fertilizer application. The treatment T₅ (125 kg ha⁻¹ customized fertilizer) outperformed all others, recording the highest number of branches (6.76) and dry matter accumulation (80.56 g plant⁻¹) at harvest. This improvement is attributed to the synergistic effect of balanced nutrition, which plays a vital role in promoting vegetative growth, photosynthetic efficiency, and root development.

These findings align with the work of Kumar *et al.* (2022) [4], who reported that micronutrients such as zinc and molybdenum significantly enhance nodulation, nitrogen fixation, and biomass accumulation in legumes. Verma and Yadav (2021) [12] further emphasized that sulfur, an essential component of amino acids and enzymes, contributes directly to the enhanced vigor and chlorophyll content in chickpea, leading to improved branching and biomass.

In contrast, the control treatment (T₆), which lacked fertilizer input, showed the poorest performance across all growth stages. This supports earlier findings by Sharma *et al.* (2020) [11], who noted that nutrient-deficient soils, particularly under rainfed conditions, are incapable of supporting optimal legume development.

Yield Parameters

Similar trends were observed in the yield attributes. Treatment T₅ resulted in the highest seed index (23.59 g), grain yield (1526.96 kg ha⁻¹), and biological yield (3586.25 kg ha⁻¹), indicating that nutrient-enriched customized fertilizers not only support vegetative growth but also effectively translate it into reproductive success.

According to ICRISAT (2023) [2], the inclusion of micronutrients like Zn and Mo improves pod setting, seed development, and overall plant metabolic functions, which collectively boost yield potential. Patel *et al.* (2024) [7] highlighted that Zn plays a critical role in pollen viability and grain filling, directly contributing to improved seed index and grain yield. Meena and Singh (2021) [6] also reported that molybdenum enhances nitrate reductase activity, essential for nitrogen assimilation and protein synthesis in legumes.

T₄ and T₂ also performed significantly better than treatments with only NPK (T₁) or lower customized fertilizer rates (T₃),

confirming that a moderate to high dose of balanced fertilization is necessary for maximizing yield components. The poor performance of the control (T₆) reiterates the vital role of proper nutrient management, especially in zinc- and sulfur-deficient soils, which are increasingly prevalent across Indian rainfed regions (FAO, 2021) [1].

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