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Fortification of chickpea with foliar micronutrients

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Abstract
An field experiment was conducted during the rabi season of 2024-2025 at the Research Farm, College of Agriculture, Nagpur, to evaluate the effect of foliar application of micronutrient Grade-X on yield and quality of chickpea (*Cicer arietinum* L.). The study was laid out in a Factorial Randomized Block Design comprising eight treatment combinations with three replications. Foliar nutrition significantly influenced yield attributes and yield. Among the levels, 7.5 ml L^{-1} (L_3) recorded the highest seed yield (19.19 q ha^{-1}) and straw yield (24.89 q ha^{-1}), while three sprays (S_2) further enhanced productivity. The interaction L_3S_2 proved most effective, producing maximum seed yield (19.46 q ha^{-1}) and straw yield (25.29 q ha^{-1}). Quality traits were also improved, with test weight (20.90 g), protein content (19.79%), and crude fiber (3.37%) being highest in L_3S_2. The findings highlight that foliar application of micronutrient Grade-X at 7.5 ml L^{-1} with three sprays optimizes both yield and quality of chickpea.

Keywords: Chickpea micronutrient foliar application yield quality

Introduction
Chickpea (*Cicer arietinum* L.), also known as Bengal gram or *chana*, is a major pulse crop in India and an important source of protein for predominantly vegetarian populations in South Asia (Kulkarni, 2022) [19]. Apart from its nutritional value, chickpea improves soil fertility through biological nitrogen fixation. Chickpea is one of the major Rabi pulse crops, known for its high digestible dietary protein. It is universally accepted that the use of chemical fertilizers is an integral part of a package of practices for raising agricultural production to a higher level. Chemical fertilizers supply essential nutrients like nitrogen, phosphorus, potassium, sulphur, and micronutrients to plants, promoting better growth and higher yields. Among micronutrient deficiencies, zinc is particularly widespread in India (Pradhan *et al.*, 2025) [17] and Indian soils typically lack essential micronutrients along with nitrogen and phosphorus. These nutrient gaps, however, can be mitigated through appropriate supplementation to the plants, as highlighted by Mayuri *et al.* (2022), and Kuchanwar *et al.* (2022) [15, 13].

Micronutrients play a vital role in plant growth and quality by regulating enzymatic activity, photosynthesis, and protein synthesis (Kuchanwar *et al.*, 2021; Ingle *et al.*, 2019) [13, 9]. Their application not only increases yield but also enhances crude protein, amino acids, and energy value in pulses such as chickpea, soybean, and black gram (Yaseen *et al.*, 2010) [18]. However, deficiencies are becoming more pronounced under intensive cropping systems due to continuous nutrient removal and low soil fertility (Singh *et al.*, 2018; Ingle *et al.*, 2018, 2024) [8, 10]. Previous studies have reported that foliar nutrition improves seed yield, test weight, protein content, and overall grain quality in chickpea and other legumes (Yaseen *et al.*, 2010; Meena *et al.*, 2016; Ingle *et al.*, 2016) [7, 18, 16].

Considering the importance of micronutrients in legume production, the present study was undertaken to evaluate the effect of different levels and number of sprays of micronutrient foliar Grade- X on yield and quality of chickpea under field conditions.

Materials and methods
A field experiment was conducted during the rabi season of 2024-2025 at the Research Farm, Soil Science Section, College of Agriculture, Nagpur, to study the effect of micronutrient foliar Grade-X on yield and quality of chickpea (*Cicer arietinum* L.).

The experiment was laid out in a Factorial Randomized Block Design (FRBD) with eight treatment combinations replicated three times. Factor A included four concentrations of foliar Grade-X (0, 5, 7.5, and 10 ml L^{-1}), while Factor B comprised two spray schedules: two sprays (vegetative stage and 50% flowering) and three sprays (vegetative stage, 50% flowering, and pod development). The crop was sown at recommended spacing and raised under uniform agronomic practices. Seed yield was recorded from the produce of each net plot after threshing and cleaning, and the values were converted to a hectare basis and expressed in quintals per hectare (q ha^{-1}). The produce of each net plot was threshed separately, cleaned and the seed yield was recorded in kilogram per net plot. The seed yield received from each net plot was converted on hectare basis in q ha-1.

Straw yield was derived by subtracting the seed yield from the total biological yield and expressed on a hectare basis. After threshing, straw yield was calculated plot wise by subtracting seed yield from biological weight and expressed in q ha-1. For quality assessment, protein content in the seed was estimated by digesting the samples with a di- acid mixture consisting of concentrated H2SO4 and 30% H_2O_2, followed by nitrogen determination using the distillation method in a nitrogen analyzer.

Test weight (g) after harvesting and threshing of all samples from each treatment, from composite sample of net plot 1000 seeds were counted and weighted on analytical weighing balance and values were recorded and expressed in gram. The protein percentage was subsequently calculated by multiplying the nitrogen content with a conversion factor of 5.28. Crude fibre consists largely of cellulose, variable proportion of hemicelluloses and highly variable proportion of lignin along with some minerals. It represents only 60% to 80% of the cellulose and 4% to 6% of the lignin. The crude fibre content is commonly used as measures of the nutritional value of livestock feeds and also in the analysis of various food products to detect quality, quantity and adulteration.

Result and Discussion

Yield Parameters

The data in table 1 revealed that Application of PDKV Micronutrient Foliar Grade-X significantly enhanced both seed and straw yield of chickpea. The highest seed yield (19.19 q ha^{-1}) was recorded with 7.5 ml L^{-1} (L3), followed by 10 ml L^{-1} (19.04 q ha^{-1}), while the lowest was in control (18.26 q ha^{-1}). Similarly, maximum straw yield (24.89 q ha^{-1}) was obtained at 7.5 ml L^{-1}, followed by 10 ml L^{-1} (24.74 q ha^{-1}). Three sprays (S2) were significantly superior to two sprays (S1) for both seed (18.94 q ha^{-1}) and straw yield (24.62 q ha^{-1}). The interaction effect was also significant, with L_3S_2 (7.5 ml L^{-1} + 3 sprays) recording the highest seed (19.46 q ha^{-1}) and straw yield (25.29 q ha^{-1}). The improvement in yield may be attributed to enhanced metabolic activity, nutrient translocation, and biomass accumulation due to the supply of Fe, Zn, Cu, Mn, and B through foliar application, in agreement with findings of Sarbandi and Madani (2014) in chickpea and Kumari *et al.*, (2025); Verma *et al.* (2020) in mungbean [14, 20, 21].

Table 1: Effect of different levels of PDKV micronutrient foliar grade -X on yield parameters of chickpea.

Treatment	Seed yield plot^{-1} (q ha^{-1})	Straw yield plot^{-1} (q ha^{-1})
Levels of PDKV micronutrient foliar Grade - X fertilizer		
L1 - 0 ml L^{-1}	18.26	23.85
L2 - 5 ml L^{-1}	18.57	24.13
L3 - 7.5 ml L^{-1}	19.19	24.89
L4 -10 ml L^{-1}	19.04	24.74
SE (m)±	0.05	0.15
CD at 5%	0.15	0.41
Number of sprays		
S1 - 2 sprays	18.59	24.18
S2 - 3 sprays	18.94	24.18
SE (m)±	0.03	0.10
CD at 5%	0.12	0.33
Interaction		
SE (m)±	0.09	0.24
CD at 5%	0.29	0.81

Quality Parameters

The data in table 2 revealed that, the quality parameters in Chickpea was significantly influenced by different levels of micronutrient. The quality parameters of chickpea were significantly influenced by foliar application of PDKV micronutrient Grade-X. Among different levels, 7.5 ml L^{-1} (L_3) recorded the highest test weight (20.90 g) and protein content (19.79%), which was statistically at par with 10 ml L^{-1} (L_4), while the lowest values were obtained in control (L_1). Crude fibre content was also improved with micronutrient application, being maximum (3.37%) at 10 ml L^{-1} (L_4). With respect to the number of sprays, three sprays (S_2) proved significantly superior over two sprays (S_1), registering higher test weight (20.71 g), protein content (19.48%), and crude fibre (3.35%). The interaction effect (L × S) was not found significant for protein content, wherein treatment combination L_3S_2 (7.5 ml L^{-1} with three sprays) recorded the highest protein percentage (19.99%).

Table 2: Effect of different levels of PDKV micronutrient foliar grade -X on quality parameters of chickpea.

Treatment	Test weight (g)	Protein (%)	Crude fibre (%)
Levels of PDKV micronutrient foliar Grade - X fertilizer			
L1 - 0 ml L^{-1}	20.32	18.89	3.32
L2 - 5 ml L^{-1}	20.47	19.06	3.34
L3 - 7.5 ml L^{-1}	20.90	19.79	3.37
L4 -10 ml L^{-1}	20.78	19.54	3.36
SE (m)±	0.12	0.20	0.019
CD at 5%	0.33	0.53	0.051
Number of sprays			
S1 - 2 sprays	20.53	19.16	3.34
S2 - 3 sprays	20.71	19.48	3.35
SE (m)±	0.08	0.13	0.012
CD at 5%	0.26	0.43	0.042
Interaction			
SE (m)±	0.19	0.32	0.030
CD at 5%	-	-	-

Conclusions

It is concluded that, Foliar application of PDKV micronutrient Grade-X at 7.5 ml L^{-1} with three sprays proved most effective in enhancing yield attributes and quality (test weight and protein) of chickpea. Hence, it can be recommended as the optimum dose for better productivity and qualityimprovement.

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