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Influence of micronutrient supplementation on yield, quality, and profitability of chickpea

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Abstract

A field experiment was conducted during rabi 2021-22 and 2022-23 to study the effect of nutrient management on quality and economics of chickpea. Application of GRDF with soil application of multi-micronutrient Grade-II @ 10 kg ha⁻¹ improved micronutrient content in grain and straw and produced higher economic returns. Although protein content remained non-significant, this treatment recorded the highest gross returns and benefit-cost ratio.

Keywords: Chickpea, nutrient management, micronutrients, grain quality, economic returns

Introduction

Chickpea (*Cicer arietinum* L.) is a cool-season annual legume in the family Fabaceae, valued globally for its high protein, carbohydrate, and mineral content, especially in vegetarian diets. As a nitrogen-fixing crop, it also contributes to soil fertility through symbiosis with *Rhizobium* spp. Chickpea is cultivated widely in winter cropping systems, often following Kharif crops, but farmers frequently limit their nutrient management to only major macronutrients, underutilizing micronutrients.

With reported protein contents ranging from ~12% to over 30% depending on variety and environment (e.g. Singh *et al.*, 2023) [13]. It also provides essential minerals such as iron (Fe), zinc (Zn), manganese (Mn), and copper (Cu), which play critical roles in plant and human physiology (Sharma *et al.*, 2023; Open *et al.*, 2025) [7, 4]. Micronutrients like Fe, Zn, Cu, B, and Mn are involved in photosynthesis, respiration, nitrogen fixation, enzyme activation, and hormonal balance. (Patel *et al.*, 2024) [15]

Zinc deficiency is among the most widespread micronutrient constraints for chickpea production. High soil pH decreases Zn solubility, and its mobility is further reduced in calcareous or low-organic-matter soils (Kumar *et al.*, 2024) [3]. Zn shortage impairs photosynthesis, disrupts nitrogen metabolism, delays flowering and maturity, decreases yield, and weakens stress tolerance. Foliar application of Zn (especially chelated forms) is often more efficient than soil application in overcoming Zn deficiency (Open *et al.*, 2025) [4]. Boron (B) is another critical micronutrient, essential for sugar transport, cell division, and reproductive development. In soils with B below ~0.3 mg kg⁻¹, chickpea yield may suffer severely, in extreme cases causing complete crop failure (Open *et al.*, 2025) [4].

Recent agronomic bio fortification studies in chickpea have shown promising results. Foliar application of Zn (0.5%), B (0.2%), and Fe (0.1%) improved growth indices, chlorophyll contents, seed yield, and profitability (Kha *et al.*, 2023) [15]. Foliar Fe + Zn sprays have also successfully enhanced grain Fe and Zn concentration while boosting yields and improving the benefit: cost ratio (Gupta *et al.*, 2021) [1]. (Kumar *et al.*, 2024) [3]. These results indicate the dual advantage of micronutrient supplementation: improving agronomic performance and enhancing nutritional quality (i.e., biofortification). Given the increasing global focus on “hidden hunger,” biofortification of staple crops with Fe and Zn has gained attention as a sustainable nutrition intervention (Kumar *et al.*, 2024 & Open *et al.*, 2023) [3, 4].

In this context, the present study aims to assess the effect of key micronutrients—namely Zn, Fe, Mn, and B—on grain quality parameters (protein, micronutrient concentration, yield components) and on the economic feasibility of chickpea production.

This integrative approach will help provide farmer-relevant recommendations for micronutrient management in chickpea cultivation. (Patel *et al.*, 2024)^[5]

Materials and Methods

The present investigation entitled “Effect of Minor Nutrients in Chick pea (*Cicer arietinum*) through Nutrient Management” was carried out Agronomy Research Farm, Department of Agronomy, Faculty of Agriculture, Bhagwant University, Ajmer, during rabi season, 2021-22 and 2022-23.

The experiment was lied in Experimental field of Bhagwant University, Ajmer, Rajasthan. during rabi season 2021-22 and 2022-23 and Climatic condition during experiment was cold in November with minimum average temperature was (4.9 °C) and highest Temperature recorded in March with average of (39.0 °C).

The topography of the experimental field was uniform levelled and uniform in depth up to 60 cm. The type of soil is black soil developed from Volcanic rocks and lava-flow. the soil comes under the vertisole order. The soil of the experimental field was slightly saline in nature, pH was 7.01 and 6.67, moderately alkyl in EC 0.484 and 0.433 (dSm⁻¹) and low organic carbon 0.30 and 0.31 (%) as well as the initial soil fertility of the experimental field was low in available nitrogen 210.2 and 208.1 kg ha⁻¹, Low in available phosphorus 20.5 and 19 kg ha⁻¹ and low in available potassium 142.2 and 139 kg ha⁻¹.

The experiment was laid out in randomized complete block design with 3 replications. There were ten treatments consisting of T₁ Control T₂ RDF (25:50:30 N: P₂O₅: K₂O kg ha⁻¹), T₃ GRDF (25:50:30 N: P₂O₅: K₂O kg ha⁻¹ + FYM 5 t ha⁻¹), T₄ GRDF + Chelated Zn EDTA 0.2% (foliar spray) T₅ GRDF + Chelated Zn EDTA 0.2% (foliar spray) T₆ GRDF + Boric acid 0.1% (foliar spray) T₇ GRDF + Multi micronutrient Grade-II 0.5% (foliar spray) T₈ GRDF + Multi micronutrient Grade-II @ 10 kg ha⁻¹ (soil application) In order to soil sampling was done at before sowing of crop and harvesting of the crops, the soil samples (0-15 cm depth) was taken from each plot using single auger. The samples were air dried, crushed and gravel and other particles of size more than 2 mm were removed with the help of a sieve. Field moist soil was used for analyzing all the biological parameters. All the methods and materials of the physio-chemical and biological parameters’ of soil listed in the below (Table 1). The statistical analysis of the experimental data was carried out as per the methods suggested by Gomez.

Results and Discussion

Protein content

Data regarding protein content of chickpea as influenced by different treatments during rabi season, 2021-2022 and 2022-23. The data in respect protein content in chickpea were not influenced significantly due to different nutrient treatments.

Chickpea fertilized with GRDF along with soil application of multi-micronutrient Grade-II @ 10 kg ha⁻¹ recorded the highest protein content (21.23% and 21.29%) compared to all other nutrient management treatments during both years of study, respectively. The lowest protein content was observed in the treatment where no fertilizer was applied.

The improved protein content under GRDF combined with multi-micronutrient application can be attributed to the

adequate supply of both macro-and micronutrients. Zinc plays an important role in protein synthesis, while copper and manganese are involved in energy transfer processes. Moreover, copper enhances nodulation and nitrogen fixation, which is reflected in the observed results. These findings are in close agreement with those reported by and Morad *et al.* (2018)^[8].

Iron content in grain and straw

Here is a paraphrased version of your paragraph with the same meaning and references preserved:

Data on iron content in grain and straw of chickpea as affected by different treatments during the rabi seasons of 2021-2022 and 2022-23 are presented in and illustrated in. The results revealed that iron content in both grain and straw was significantly influenced by various nutrient management treatments.

Chickpea fertilized with GRDF along with soil application of multi-micronutrient Grade-II @ 10 kg ha⁻¹ recorded significantly higher iron content in grain (58.91 and 59.62 ppm) and straw (18.84 and 18.84 ppm) compared to the other treatments during both years of study, respectively. In contrast, the control treatment (no fertilizer application) resulted in the lowest iron content in both grain and straw. The initial iron content in chickpea grain was 50.90 and 51.12 ppm, which remained at a comparatively lower level during both years of investigation.

The higher iron content in grain and straw under GRDF combined with soil application of multi-micronutrient Grade-II @ 10 kg ha⁻¹ and GRDF with multi-micronutrient Grade-II @ 0.5% (foliar spray) may be attributed to improved iron availability and its efficient utilization in the presence of both macro-and micronutrients. These findings are in close agreement with those reported by Gupta *et al.* (2021)^[1].

Zinc content in grain and straw

Data on zinc content in grain and straw of chickpea as influenced by different treatments during the rabi seasons of 2021-2022 and 2022-23 are presented in and depicted in. The results indicated that zinc content in both grain and straw was significantly affected by the various nutrient management treatments.

The chickpea fertilized with GRDF + soil application of multi-micronutrient Grade-II @ 10 kg ha⁻¹ exhibited significantly higher zinc content in grain (33.01 and 33.51 ppm) and straw (18.75 and 19.86 ppm) as compared to other nutrient management treatments during both the years of investigation, respectively. No application of fertilizer to chickpea produced significantly minimum zinc content in grain and straw of chickpea. The initial value of zinc content in chickpea grain was (15.81 and 16.29 ppm) which was at lower magnitude during both the years of investigation, respectively.

The chickpea fertilized with GRDF + soil application of multi-micronutrient Grade-I @ 10 kg ha⁻¹ found superior which supplied essential quantity of zinc to chickpea crop and its efficient use reflected in enrichment of zinc content grain and straw of chickpea. The results are in close association with, Khan *et al.* (2000)^[7].

Copper content in grain and straw

Data pertaining to copper content in grain and straw of chickpea as influenced by various treatments during the rabi

seasons of 2021-2022 and 2022-23. The results indicated that copper content in both grain and straw was significantly affected by different nutrient management treatments.

Chickpea fertilized with GRDF along with soil application of multi-micronutrient Grade-II @ 10 kg ha⁻¹ recorded significantly higher copper content in grain (16.96 and 17.68 ppm) and straw (39.44 and 40.19 ppm) compared to other treatments during both years of investigation, respectively. In contrast, the control treatment (no fertilizer application) resulted in the lowest copper content in both grain and straw. The initial copper content in chickpea grain was 12.90 and 13.28 ppm, which remained comparatively lower during both years of study.

The application of GRDF along with soil application of multi-micronutrient Grade-I @ 10 kg ha⁻¹ proved effective in supplying copper to the crop, and its efficient utilization was reflected in the enhanced copper content in both grain and straw. These findings are in close agreement with those reported by Jozedaemi *et al.* (2014)^[4].

Manganese content in grain and straw (ppm)

Data on manganese content in grain and straw of chickpea under different treatments during the rabi seasons of 2021-2022 and 2022-23 are presented in Table 1 and depicted in The results showed that manganese content in both grain and straw was significantly influenced by nutrient management treatments.

Chickpea fertilized with GRDF along with soil application of multi-micronutrient Grade-II @ 10 kg ha⁻¹ recorded significantly higher manganese content in grain (28.04 and 28.94 ppm) and straw (47.90 and 47.32 ppm) compared to other treatments during both years, respectively. The lowest manganese content in grain and straw was observed in the control treatment (no fertilizer application). The initial manganese content in chickpea grain was 23.02 and 23.29 ppm, which was relatively low during both years.

The treatment involving GRDF along with soil application of multi-micronutrient Grade-I @ 10 kg ha⁻¹ showed superiority in enhancing manganese content in grain and straw due to better availability and efficient utilization of manganese. These results are in agreement with and Jozedaemi *et al.* (2014)^[4].

Boron content in grain and straw (ppm)

Data regarding boron content in grain and straw of chickpea as influenced by different treatments during the rabi seasons of 2021-2022 and 2022-23 are presented in Table 1. The results indicated that boron content in grain and straw was significantly affected by various nutrient management treatments.

Chickpea fertilized with GRDF along with soil application of multi-micronutrient Grade-II @ 10 kg ha⁻¹ recorded significantly higher boron content in grain (18.56 and 19.94 ppm) and straw (74.35 and 75.21 ppm) compared to other treatments. However, it remained at par with GRDF + multi-micronutrient Grade-II @ 0.5% (foliar spray) for boron content in grain during both years of study. The control treatment (no fertilizer application) showed the lowest boron content in grain and straw. The initial boron content in chickpea grain was 13.17 and 14.28 ppm, which was comparatively lower during both years.

Application of GRDF along with soil application of multi-micronutrient Grade-I @ 10 kg ha⁻¹ and GRDF + multi-micronutrient Grade-II @ 0.5% (foliar spray) ensured adequate availability of boron and its efficient utilization, resulting in increased boron concentration in grain and straw. These findings are in close agreement with, Gupta *et al.* (2021)^[1], and Alam *et al.* (2017)^[3].

Economics

The economic analysis of chickpea cultivation, including gross monetary returns, cost of cultivation, net monetary returns, and benefit-cost ratio during rabi 2021-2022 and 2022-23

Gross returns

The mean gross monetary returns of chickpea during rabi 2021-22 and 2022-23 were Rs. 92,902.75 ha⁻¹. Gross returns were significantly influenced by different nutrient management treatments. Chickpea fertilized with GRDF along with soil application of multi-micronutrient Grade-II @ 10 kg ha⁻¹ recorded the highest gross returns (Rs. 116,932 and 119,620 ha⁻¹) during both years, respectively. The control treatment recorded significantly lower gross returns (Rs. 52,520 and 54,862 ha⁻¹). Higher returns under this treatment were due to increased grain and straw yield resulting from improved growth and yield attributes. These findings are in close agreement with and Balai *et al.* (2017)^[2].

Cost of cultivation

The highest cost of cultivation (Rs. 49,870 and 51,984 ha⁻¹) was recorded in the treatment with GRDF + chelated Zn EDTA @ 0.2% (foliar spray). The lowest cost of cultivation (Rs. 34,170 and 35,640 ha⁻¹) was observed in the control treatment (no fertilizer application).

Net monetary returns

Net monetary returns were significantly influenced by nutrient management treatments. Chickpea fertilized with GRDF along with soil application of multi-micronutrient Grade-I @ 10 kg ha⁻¹ recorded the highest net returns (Rs. 68,748 and 69,938 ha⁻¹) during both years. The lowest net returns (Rs. 18,350 and 19,222 ha⁻¹) were observed in the control treatment. Higher net returns were associated with increased grain and straw yield under improved nutrient management. These results are in agreement with Balai *et al.* (2017)^[2].

Benefit-cost ratio

The benefit-cost ratio was significantly higher in chickpea fertilized with GRDF along with soil application of multi-micronutrient Grade-II @ 10 kg ha⁻¹ (2.43 and 2.64) compared to other treatments. The lowest B:C ratio (1.54 and 1.59) was observed in the control treatment.

The benefit-cost ratio depends on both gross returns and cost of cultivation. Higher gross returns under GRDF + multi-micronutrient application resulted in improved B:C ratio. This treatment also recorded the highest incremental B:C ratio compared to the recommended dose of fertilizers. These findings are in close agreement with Balai *et al.* (2017)^[2].

Table 1: Micronutrient uptake in grain & straw of Chickpea

Treatments	Protien				Fe(g ha ⁻¹)				Zn(g ha ⁻¹)			
	Grain		Straw		Grain		Straw		Grain		Straw	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
T ₁ : Control	20.12	20.14	6.9	7.3	126.2	127.2	44.3	45.2	32.3	33.1	18.7	19.4
T ₂ : RDF (25:50:30N:P ₂ O ₅ :K ₂ O kg ha ⁻¹)	20.06	20.11	18.3	19.5	142.7	143.5	48.7	49.5	40.1	41.2	20.7	21.3
T ₃ : GRDF (25:50:30N:P ₂ O ₅ :K ₂ O kg ha ⁻¹ + FYM5 tha ⁻¹)	20.40	20.41	16.6	17.2	138.2	139.8	46.3	47.3	37.6	38.5	21.4	22.6
T ₄ : GRDF + Chelated FeEDTA 0.2% (foliar spray)	20.43	20.47	19.7	20.1	153.3	154.2	50.9	51.3	44.2	45.2	23.7	24.8
T ₅ : GRDF + Chelated Zn EDTA 0.2% (foliar spray)	20.71	20.76	19.8	21.1	164.6	165.3	57.8	58.9	49.6	52.0	24.3	25.3
T ₆ : GRDF + Boricacid0.1% (foliar spray)	20.74	20.78	17.7	18.5	156.4	157.8	55.8	56.2	44.5	45.2	24.3	25.8
T ₇ : GRDF + Multi micronutrient Grade-II 0.5% (foliar spray)	20.78	20.81	18.1	19.6	164.2	165.4	59.0	60.2	49.1	51.2	25.3	26.1
T ₈ : GRDF + Multi micronutrient Grade-II. @ 10 kg ha ⁻¹ (soil application)	21.23	21.29	20.5	23.1	173.6	174.3	62.1	61.1	54.5	56.2	28.2	29.3
S.Em±	0.34	0.36	18.5	18.3	152.4	153.4	53.11	53.7	43.98	45.3	23.3	24.3
C.D.aT ₅ %	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Micronutrient uptake in grain & straw of Chickpea

Treatments	Mn(kgha ⁻¹)				B(kg ha ⁻¹)				Cu(kgha ⁻¹)			
	Grain		Straw		Grain		Straw		Grain		Straw	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
T ₁ : Control	65.4	65.3	101	104	72.52	73.25	60.76	61.08	18.3	19.32	14.7	15.38
T ₂ : RDF (25:50:30N:P ₂ O ₅ :K ₂ O kg ha ⁻¹)	74.3	75.8	114	119	80.61	81.26	67.51	68.54	35.6	36.25	34.07	35.36
T ₃ : GRDF (25:50:30N:P ₂ O ₅ :K ₂ O kg ha ⁻¹ + FYM 5 tha ⁻¹)	72.8	74.2	110	114	87.33	88.56	73.31	75.24	14.07	15.53	34.80	36.81
T ₄ : GRDF + Chelated FeEDTA0.2% (foliar spray)	84.1	86.5	128	134	87.90	88.91	73.93	76.25	16.17	17.84	37.51	39.21
T ₅ : GRDF + Chelated Zn EDTA0.2% (foliar spray)	91.5	92.3	126	131	93.32	94.28	79.93	83.25	15.88	16.56	36.77	37.28
T ₆ : GRDF + Boricacid0.1% (foliar spray)	86.0	87.4	126	133	101.8	103.2	86.82	91.25	15.20	16.32	35.80	36.29
T ₇ : GRDF + Multi micronutrient Grade-II 0.5% (foliar spray)	89.6	90.2	149	155	104.0	106.5	88.36	96.25	16.74	17.81	39.12	40.21
T ₈ : GRDF + Multi micronutrient Grade-II. @ 10 kg ha ⁻¹ (soil application)	95.9	97.8	169	174	107.5	109.2	94.35	99.21	16.96	17.92	39.44	42.23
S.Em±	82.45	83.69	127.88	133.00	91.90	93.16	78.12	81.38	18.61	19.69	34.02	35.35
C.D.aT ₅ %	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Conclusion

The results of the present investigation revealed that different nutrient management treatments had a notable influence on micronutrient content and economic returns of chickpea. Although protein content was not significantly affected, the application of GRDF along with soil application of multi-micronutrient Grade-II @ 10 kg ha⁻¹ recorded comparatively higher protein content. The same treatment significantly improved the concentration of iron, zinc, copper, manganese and boron in grain and straw over other treatments. Enhanced nutrient availability and efficient utilization contributed to improved crop performance and quality. Economically, this treatment also produced the highest gross returns and benefit-cost ratio, indicating its superiority. Therefore, application of GRDF with multi-micronutrient Grade-II @ 10 kg ha⁻¹ can be recommended for improving nutrient enrichment and profitability of chickpea cultivation.

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