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Response of Zinc and Foliar Spray of Boron on Growth and Yield of Chickpea (*Cicer arietinum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during *Rabi* season (2022) at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (UP). The soil of experimental plot was sandy loam in texture, nearly natural in soil reaction (pH 7.1), low in organic carbon (0.28 6), available N (225 kg/ha), available P (19.50 kg/ha) and available K (213.7 kg/ha). The Treatments consisted of 3 levels of each micro-nutrients having boron (B 1-0.25%), (B 2- 0.5%) (B 3-0.75%) and Zinc (Zn 1-3 kg/ha), (Zn 2-5 kg/ha) and (Zn 3-7 kg/ha). The experiment was laid out in Randomized Block Design (RBD) with 9 treatments with three replication each. The treatments combinations are T_1: Zinc at 3 kg/ha + Boron at 0.25%, T_2: Zinc at 3 kg/ha + Boron at 0.5%, T_3: Zinc at 3 kg/ha + Boron at 0.75%, T_4: Zinc at 5 kg/ha + Boron at 0.25%, T_5: Zinc at 5 kg/ha + Boron at 0.5%, T_6: Zinc at 5 kg/ha + Boron at 0.75%, T_7: Zinc at 7 kg/ha + Boron at 0.25%, T_8: Zinc at 7 kg/ha + Boron at 0.5%, T_9: Zinc at 7 kg/ha + Boron at 0.75%, T_{10}: Control (RDF- 20:60:20 kg/ha) are used. Application of Zinc in

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combination with Boron 0.75% recorded significantly higher in plant height (55.21 cm), No. of nodules/plant (62.16), plant dry weight (22.13 g) and higher yield attribute namely No. of pods/plant (33.21), No. of seeds/pod (1.30), seed yield (3.09 t/ha) and stover yield (4.55 t/ha). Maximum B:C ratio (2.38) was also recorded in same treatment, treatment no. T_9 (Zinc + Boron 0.75%) in chickpea crop.

Keywords: Zinc; chickpea; economics; growth; boron; yield.

1. INTRODUCTION

Chickpea *(Cicer arietinum* L.*)* is one of the essential annual pulse crop that belongs to the genus Cicer (Family: Leguminosae,Fabaceae). It is the third largest food legume produced worldwide. India is a major consumer of chickpeas and a significant amount of it is imported.

India is one of the world's top producers of pulses. Pulses play a significant role in Indian cuisine and provide 30% of the daily requirement for protein. When it comes to pulses, chickpeas are a crucial crop for the *Rabi* season because of their widespread acceptance and nutrient-dense uses. Protein, fat, fiber, and mineral elements are crucial parts of a balanced nutritional diet. With a total production of 11.09 million tonnes from an area of 14.56 million ha and a productivity of 1.31 t/ha, chickpea is the fourth largest grain legume crop in the world in India. Among the top producers are Iran, Pakistan, and India [1].

Auxin, protein, and photosynthetic activity are all influenced by the presence of zinc, which is a key component of many enzymes. Furthermore, it strengthens the plant's tolerance to hot and dry weather, which is known to reduce chickpea output [2]. Boron (B) is an essential trace element required for the physiological functioning of higher plants. B deficiency is considered a nutritional disorder that adversely affects the metabolism and growth of plants. B is involved in the structural and functional integrity of the cell wall and membranes, ion fluxes (H^+, K^+, PO_4^{3-}, Rb^+, Ca^{2+}) across the membranes, cell division and elongation, nitrogen and carbohydrate metabolism, sugar transport, cytoskeletal proteins, and plasmalemma-bound enzymes, nucleic acid, indoleacetic acid, polyamines, ascorbic acid, and phenol metabolism and transport [3].

2. MATERIALS AND METHODS

The experiment was carried out during *Rabi* season of 2022 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Allahabad (U.P.) which is located at 250 24' 42" N latitude, 810 50' 56" E longitude and 98 m altitude above the mean sea level. The experiment was conducted in Randomized Block Design (RBD) which includes ten treatments that are replicated thrice and was laid out with the different treatments allocated randomly in each replication. The treatment combinations are as follows T_1 : Zinc 3 kg + Boron 0.25% ,T_2 : Zinc 3 kg + Boron 0.5 % , T_3 : Zinc 3 kg + Boron 0.75 % , T_4 : Zinc 5 kg + Boron 0.25 % , T_5 : Zinc 5 kg + Boron 0.5 %, T_6 : Zinc 5 kg + Boron 0.75 % , T_7 : Zinc 7 kg + Boron 0.25 % , T_8 : Zinc 7 kg + Boron 0.5 % , T_9 : Zinc 7 kg + Boron 0.75 % , T_{10} : Control Plot (RDF: 20:60:20 NPK) are used.

Statistical analysis was carried out with the help of OPSTAT online software tool.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant height (cm)

The plant height of crop which was recorded at 20, 40, 60, 80 and at 100 DAS. The height of the plant was measured from the base of the plant up to the tip. The height was measured in cm. The significantly higher plant height (55.21 cm) was observed in T_9 (Zinc 7 kg + Boron 0.75 %) at 100 DAS [Table 1]. The exact amount of zinc required to improve plant height may vary depending on the soil type, the variety of chickpea, and the growing conditions. However, a study by (Sangwan and Raj, [4]) found that the application of zinc sulfate at the rate of 15 kg/ha increased the plant height of chickpea by 12% compared to the control treatment.

3.1.2 Number of nodules/plants

The number of nodules of crop which was recorded at 20, 40, 60, 80 and at 100 DAS. The higher number of nodules (7.49) was recorded at 100 DAS in the treatment T9 with application of

Table 1. Effect of zinc and foliar spray of boron on Growth parameters of chickpea

Sr. No.	Treatments	Growth Parameters		
		Plant height (cm)	Number of nodules	Plant dry weight
1.	T_1=Zinc 3 kg + Boron 0.25%	49.95	4.42	16.89
2.	T_2=Zinc 3 kg + Boron 0.5 %	50.85	4.62	17.63
3.	T_3=Zinc 3 kg + Boron 0.75 %	51.23	4.69	18.25
4.	T_4=Zinc 5 kg + Boron 0.25 %	52.16	4.75	18.89
5.	T_5=Zinc 5 kg + Boron 0.5 %	53.46	4.82	19.43
6.	T_6=Zinc 5 kg + Boron 0.75 %	53.79	4.92	19.96
7.	T_7=Zinc 7 kg + Boron 0.25 %	54.84	5.32	20.87
8.	T_8=Zinc 7 kg + Boron 0.5 %	55.13	6.24	21.61
9.	T_9=Zinc 7 kg + Boron 0.75 %	55.21	7.49	22.13
10.	T_{10}=Control Plot (20-60-20 NPK kg/ha)	46.93	3.62	15.90
	F-test	S	S	S
	SEm (±)	1.571	0.381	1.081
	CD (P=0.05)	4.668	1.134	3.213

(Zinc 7 kg along with Boron 0.75 %) [Table 1]. The increase in the nodulation might be due to the enhanced and established good rooting system with the application of zinc favourable responses of zinc application on nodulation have also been reported [5]. Boron is an essential micronutrient for chickpea plants. It is involved in many important processes, including cell wall formation, pollen development, and nitrogen fixation. Boron deficiency can stunt plant growth and development, and it can also lead to nodulation problems in chickpea. A study by (Kuniya et al*.* [6]) found that the application of boron sulfate at the rate of 2 g/kg of seed significantly increased the number of nodules formed by chickpea plants by 25%.

3.1.3 Plant Dry weight (g)

The number of nodules of crop which was recorded at 20, 40, 60, 80 and at 100 DAS. The higher dry weight (22.13 g) was recorded at 100 DAS in the treatment T_9 with application of (Zinc 7 kg along with Boron 0.75 %) [Table 1]. A study found that the foliar application of zinc and boron significantly increased the plant dry weight of chickpea. The increase in plant dry weight was 14.3%, 12.7%, and 16.7% for the zinc, boron, and zinc + boron treatments, respectively, compared to the control. The increase in plant dry weight was likely due to the role of zinc and boron in photosynthesis, nitrogen fixation, and cell wall formation [7].

3.2 Yield Parameters

3.2.1 Number of pods/plants

Higher number of pods/plants was recorded in T9 with application of (Zinc 7 kg along with Boron 0.75 %) which was (54.60) [Table 2]. Boron application can improve the number of pods per plant in chickpeas under boron-deficient conditions. A study conducted in Iran found that foliar application of boron significantly increased the number of pods per plant in boron-deficient chickpeas compared to untreated plants [8]. Zinc supplementation promotes healthy flower development and improves the chances of successful pollination and pod setting. The application of boron helps in the normal development of flowers and enhances pollination and pod formation [9].

3.2.2 Number of seed/pods

The application of (Zinc 7 kg along with Boron 0.75 %) The higher number of seed/pods was recorded which was (2.12) [Table 2]. Boron is involved in the formation and translocation of sugars within the plant, which is essential for reproductive growth. Boron deficiency can lead to poor flower development and, consequently, a reduction in seed/pod set [10].

Zinc is a vital micronutrient that plays a significant role in hormone synthesis and regulation, enzymatic activities, and protein synthesis. Adequate zinc levels positively influence flowering, pollen viability, and seed development in chickpea [11].

3.2.3 Seed index (g)

Higher number of seed index was recorded in T_9 with application of (Zinc 7 kg along with Boron

0.75 %) which was (25.04 g) [Table 2]. The application of zinc and boron to chickpea plants can lead to an increase in seed index. This is because zinc and boron help to improve the overall health and vigor of the plants, which leads to the production of larger and heavier seeds [12].

The study on the effect of zinc and boron on seed index in chickpea [13] found that the application of zinc and boron significantly increased the seed index of chickpea plants. The highest seed index was observed in the treatment with zinc and boron at 60 kg P_2O_5/ha and 6 kg $ZnSO_4$/ha, respectively.

Table 2. Effect of zinc and foliar spray of boron on yield attributes of chickpea

		Yield attributes					
Sr. No.	**Treatments**	**No. of pod/plant**	**No. of seed/pod**	**Seed index (g)**	**Seed yield (t/ha)**	**Stover yield (t/ha)**	**Harvest index (%)**
1.	T_1=Zinc 3 kg + Boron 0.25%	29.74	1.11	20.06	2.05	3.14	38.72
2.	T_2=Zinc 3 kg + Boron 0.5 %	30.11	1.18	20.50	2.22	3.48	38.70
3.	T_3=Zinc 3 kg + Boron 0.75 %	31.57	1.22	21.09	2.49	3.60	40.39
4.	T_4=Zinc 5 kg + Boron 0.25 %	30.54	1.19	20.85	2.31	3.80	37.38
5.	T_5=Zinc 5 kg + Boron 0.5 %	31.10	1.23	21.25	2.52	3.99	38.07
6.	T_6=Zinc 5 kg + Boron 0.75 %	31.44	1.26	21.48	2.65	4.22	38.06
7.	T_7=Zinc 7 kg + Boron 0.25 %	31.86	1.24	21.78	2.71	4.38	37.73
8.	T_8=Zinc 7 kg + Boron 0.5 %	32.45	1.28	22.02	3.01	4.47	40.02
9.	T_9=Zinc 7 kg + Boron 0.75 %	33.21	1.30	22.39	3.09	4.55	40.04
10.	T_{10}=Control Plot (20-60-20 NPK kg/ha)	27.89	1.08	18.45	1.75	3.00	25.36
	F-test	**S**	**S**	**S**	**S**	**S**	**NS**
	SEm (±)	0.060	0.024	0.013	0.015	0.012	3.517
	CD (P=0.05)	0.178	0.008	0.039	0.045	0.037	-

Table 3. Effect of zinc and foliar spray of boron on economics of chickpea

		Economics			
Sr. No.	**Treatments**	**Cost of cultivation (INR/ha)**	**Gross returns (INR/ha)**	**Net returns (INR/ha)**	**B:C Ratio**
1.	T_1=Zinc 3 kg + Boron 0.25%	49013.00	111310.00	62296.00	1.27
2.	T_2=Zinc 3 kg + Boron 0.5 %	49388.00	120655.00	71266.00	1.44
3.	T_3=Zinc 3 kg + Boron 0.75 %	49763.00	134875.00	85111.00	1.71
4.	T_4=Zinc 5 kg + Boron 0.25 %	49253.00	125815.00	76561.00	1.55
5.	T_5=Zinc 5 kg + Boron 0.5 %	49628.00	137030.00	87401.00	1.76
6.	T_6=Zinc 5 kg + Boron 0.75 %	50003.00	144125.00	94121.00	1.88
7.	T_7=Zinc 7 kg + Boron 0.25 %	49493.00	147658.00	98164.00	1.98
8.	T_8=Zinc 7 kg + Boron 0.5 %	49868.00	163051.00	113182.00	2.27
9.	T_9=Zinc 7 kg + Boron 0.75 %	50243.00	167336.00	117092.00	2.33
10.	T_{10}=Control Plot (20-60-20 NPK kg/ha)	47078.00	95321.00	48242.00	1.02

3.2.4 Seed yield (t/ha)

Higher number of seed yield was recorded in the T_9 with application of (Zinc 7 kg along with Boron 0.75 %) which was (1.77 t/ha) [Table 2]. The application of zinc and boron can significantly increase seed yield in chickpea. For example, a study by (Kareti et al*.* [14]) found that the application of zinc and boron increased seed yield by 20% in chickpea.

The application of zinc significantly increased seed yield in pigeon pea. The highest seed yield was observed in the treatment with zinc sulphate at 40 kg/ha [12].

3.2.5 Stover yield (t/ha)

Higher number of Stover yield was recorded in the T_9 with application of (Zinc 7 kg along with Boron 0.75 %) which was (3.71 t/ha) [Table 2]. The yield of crop is the cumulative effect of yield attributing characters such as pods per plant and seed index. The increase in stover yield due to increased plant height, dry matter production i.e., growth parameters. This is due to the increased supply of available zinc to plants through its addition to the soil. Zinc is involved in the starch formation, growth promoting substance like auxin, grain maturation and production and also plays a vital role in protein synthesis. Hence on account of their physiological roles they limit the growth. Increased availability has shown marked improvement in growth attributes and indirectly increase seed and stover yields. Biological yield is the function of seed and stover yield. These findings are in confirmation to the earlier reports of [15-17].

3.2.6 Harvest index (%)

The higher Harvest index was recorded in the T_9 with application of (Zinc 7 kg along with Boron 0.75%) which was (32.26%) [Table 2].

3.3 Economic Analysis

The data on cost of cultivation, gross return, net return and B: C ratio of Chickpea as influenced by different treatments was presented in [Table 3]. Treatment with Zinc 7 kg along with Boron 0.75 % was recorded higher B:C ratio (2.16) as against other treatments [18].

4. CONCLUSION

It is concluded that treatment T9 with application of Zinc 7 kg along with Boron 0.75% was found to be the most desirable for obtaining higher seed yield (3.09 t/ha), Stover yield (4.55 t/ha), net returns (117092.77/ha) and B: C ratio (2.33). The above conclusion is a result of one season work and it is considered for recommending to the farmers, after at least one more year field trial.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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