Effect of Foliar Application of Zinc and Boron on Growth Attributes and Yield of Chickpea (*Cicer arietinum* L.) Varieties

ABASTRACT

A field experiment was conducted on loamy sandy soil during the winter season at Agricultural Farm of Palli Siksha Bhavana, Visva-Bharati, Sriniketan, Birbhum, West Bengal, India to evaluate the effect of foliar application of zinc and boron on growth attributes and yield of chickpea. In this experiment, 4 varieties of chickpea (Anuradha, ICPK, JSKB and RVSJ4-102) were applied with Zn and B ((Zinc 0.5%, Boron 0.1%, Zinc 0.5%+Boron 0.1% along with control) through foliar application at branching time and pre-flowering stage. The experiment findings revealed that the Variety RVSJ4-102 gave higher plant height (20.98cm), dry matter accumulation (114.49 g/m^{-2}), leaf area index (1.27), chlorophyll content (2.25 mg/g fresh leaf) and yield (26.28 q/ha) of chickpea compared to other variety. However, foliar application of (zinc 0.5%+boron 0.1%) had significant effect in influencing the growth attributes and yield of chickpea followed by single application of zinc 0.5% and boron 0.1% as compared to control. Foliar application of (zinc 0.5%+boron 0.1%) produced 26.47 % higher seed yield than control. This experiment suggested that the combined single foliar application of (zinc 0.5% + boron 0.1%) prove best treatment as compared to individual application of zinc 0.5% and boron 0.1%.

Keyword: Chickpea, zinc; boron, growth attributes, yield

INTRODUCTION

"Chickpea as a legume crop plays a significant role in improving soil fertility by fixing the atmospheric nitrogen" (Kuldeep et al., 2017). "It leaves substantial amount of residual nitrogen for subsequent crops and adds huge amount of organic matter to improve soil health. Due to deep tap root system, chickpea can withstand drought conditions by extracting water from deeper layers in the soil profile.Essentiality of Zinc (Zn) and Boron (B) for plants has been well established as both are essential micronutrients involved in number of essential functions.Zinc helps in elongation of internodes, flower initiation, seed production and maturation and protein synthesis. It plays important role in metabolic, regulatory, and developmental processes" (Math et al., 2022). "The Zn deficiency led to reduction in pollen viability, changes stigmatic size, morphology and exudations and further inhibiting pollen-stigma interaction" (Pandey et al., 2009). "Boron plays a vital role for chickpea growth especially flowering, fruit and seed set and yields" (Ahlawat et al., 2007). "Boron influences the absorption of N, P, K and its deficiency affects the optimum levels of these three macronutrients" (Raj, 1985). So, use of suitable variety dose of B can ensure higher yield of chickpea. Rahman (et al., 2017) reported that " foliar application of micronutrients mixtures (Zn, Fe, Mg, Cu, B and Mn) in combination with nitrogen improved the plant growth, yield and yield attributes were number of pods plant^{-1}, number of seed plant^{-1}, and seed weight plant^{-1}. The same application also produced maximum seed yield ha^{-1}, harvest index and 100-seed weight". (Kachavet al., 2018) indicated that "foliar application by multi micronutrients gave the maximum seed yield and seed protein content of chickpea”. Also, Menaka et al., (2018) found that “spray of boron resulted in an increase of 24.7 and 12.6% in pod number plant^{-1} ad 100 seed weight, respectively”. The present study was undertaken to evaluate the response of chickpea varieties to foliar application of Z and B to find out the suitable dose of boron for yield maximization of chickpea in loamy sandy soil of West Bengal.

MATERIALS AND METHODS

The experiment was conducted at Agriculture farm, Palli Siksha Bhavana Visva-Bharati University, Sriniketan, West Bengal. The farm is located at 230 39‘‘ North latitude and 870 42‘‘ East longitude and at an average altitude of 58.9 m above the mean sea level. The Agricultural farm is positioned at the sub –humid, sub-tropical, belt in the western part of South Bengal.The experiment was carried out in split plot design with three replications. In this experiment, 4 varieties of chickpea (Anuradha, ICPK, JSKB and RVSJ4-102 were applied in main plot whereas micronutrients spraying (Zinc 0.5%, Boron 0.1%, Zinc 0.5%+Boron 0.1% with control) in sub plot. The experimental site had pH 5.42, bulk density 1.53, organic carbon (.53 % with sandy loam soil texture along with available nitrogen, phosphorus and potassium of 195.40, 23.68 and 165.24 kg/ha, respectively whereas zinc availability was 0.495 ppm. After the finishing of layout, recommended dose of fertilizer @ 20:60:40 (N: P_2O_5: K_2 O) kg/ha have been supplied in each plot just before sowing and subsequently blended them thoroughly with the soil. Nitrogen in the form of urea phosphorus in the form of single super phosphate (SSP) and potassium in the form of murate of potash (MOP) was applied in this experiment. Zinc in the form of zinc sulphate and boron in the form of borax was sprayed @ 500 liter water/ha at branching time and pre-flowering stage respectively.

Data collection procedure

Plant heights of the tagged plants were measured in centimeters as the distance from ground level to the tip of the plant at harvest. The number of branches emerging directly from the main shoots were counted at the time of maturity on three randomly selected plants and the average was recorded.The dry matter accumulation (stems and leaves) for each plot was being measured using an electrical digital balanced for determining the dry matter accumulation (g/m^{-2}). Samples are being obtained at the intervals of 30 DAS, 50 DAS, and 70 DAS and at harvest from 30 cm length of a row in each plots allocated for destructive sampling in each plot.Watson (1852) has defined that the leaf area index has been determined by multiplying the ratio of area /weight with the dry weight of green leaf produced per unit area (square meter) of land surface.Chlorophyll a as well as Chlorophyll b and total chlorophyll content were measured adopting the method of (Hiscox and Israelstam 1979) using Dimethyl Sulfoxide (DMSO) and the following procedure. Leaf material of 50mg was taken from fully emerged leaf and placed in a test tube, and 10 ml of DMSO was added. This was kept in an oven at 65^{0}C for about 4 hours. After 4 hours the chlorophyll was expressed in the liquid form without any grinding. The extract was taken in a measuring cylinder and final volume was made up to 10 ml by using DMSO. The absorbance of the solution was read at 663nm and 645nm using spectrophotometer against the DMSO blank.

The crop growth rate estimation was done by Watson (1952) methods the crop growth rate between 30- 50 DAS, 50-70 DAS and 70- harvest has been estimated as follows:

$$CGR = \frac{W2-W1}{t2-t1} \times g/m^2/day$$

Where w_2 and w_1 are final and initial total dry weights of plants per unit land of area (square meter) and the time t_2 and t_1 respectively.

STATISTICAL ANALYSIS

The data was statistically analyzed using the procedure appropriate for split plot design. Means were compared using least significance difference (LSD) test at 5 %.

RESULTS AND DISCUSSION

Plant Height (cm)

The plant height was significantly affected by cultivars throughout the growing season (Table-1). The highest plant height was recorded for variety RVSJ4-102 (52.10 cm) followed by variety JSKB (49.13cm), ICPK (48.23 cm) while the lowest height was recorded for variety Anuradha (37.23 cm) at all the dates of observation. The variation in height might be due to genetic characteristics of the varieties for this trait. This result was in agreement with (Shamsi et al., 2009; Rasul et al. 2012) who reported significant differences among the genotypes of chickpea in plant height. Therefore, combined spraying of (zinc 0.5%+boron0.1%) at branching and pre-flowering stage recorded significantly higher plant height (RVSJ4-102) than that of only zinc 0.5% or boron 0.1% and no spraying (control).As described by (Egamberdieva et al., 2017) that the increase in plant length might be due to the role of Zn foliar application in the synthesis of IAA, metabolism of auxins, biological activity, stimulation of an enzyme activity and photosynthetic pigments because of that, encourage vegetative growth of plants. B plays a crucial role in multiplication of cell in meristematic tissues in legumes (Dashadi et al., 2013; Kayan et al., 2015). Zn is also involved in the hormone synthesis; as a result, it's indirectly linked to carbohydrate translocation and metabolism, which contributes to more growth in comparison to control (Blesseena et al., 2019).

Number of Branches Plant $^{-1}$

The number of branches varied significantly due to genetic character of the cultivars. Among the cultivars Anuradha showed the highest number of branches followed by ICPK, RVSJ4-102 and JSKB cultivar. The findings were in agreement with that of (Vanderpuye, 2010). Similarly, the number of branches per plant was affected significantly by zinc and boron spraying. The highest number of branches was obtained under combine foliar application of zinc 0.5% + boron 0.1% and followed by Zinc 0.5%, boron 0.1% and control treatment. Verma et al. (2004) reported the similar result. This enhancement could be attributed to the promotional effects of micronutrients on vegetative growth, ultimately leading to increased photosynthetic activity. Additionally, it may result from the availability of the required quantity of essential plant nutrients at various growth stages, accelerating plant metabolic processes and consequently leading to the production of more branches. These findings align with the study by (Pradhan et al., 2018).

Table1: Effect of zinc and boron spraying on plant height and number of primary branches per plant of chickpea cultivars at different days after sowing

Treatments	Plant height (cm)				Number of primary branches /plant			
	30 DAS	50 DAS	70 DAS	At harvest	30 DAS	50 DAS	70 DAS	At harvest
Variety								
Anuradha	11.60	27.72	34.58	37.23	3.02	3.52	6.26	7.33
ICPK	19.30	39.45	47.69	48.23	2.09	3.14	6.00	6.93
JSKB	18.09	39.40	48.13	49.13	1.83	3.01	5.51	6.48
RVSJ4-102	20.98	41.41	50.36	52.10	1.93	3.26	5.10	6.78
SEm (±)	0.62	0.48	0.13	0.81	0.09	0.08	0.23	0.08
CD (p=0.05)	2.16	1.66	2.54	2.81	0.32	0.29	0.80	0.28
Micronutrients spraying								
Control	17.10	34.60	43.18	44.86	2.03	3.15	5.49	6.56
Zinc 0.5%	17.12	37.12	45.38	46.56	2.16	3.25	5.68	6.79
Boron 0.1%	17.21	37.14	45.35	47.21	2.26	3.18	5.86	6.90
Zn 0.5%+ B 0.1%	18.44	39.02	46.83	48.04	2.40	3.30	5.91	7.20
SEm (±)	0.48	0.13	0.66	O.65	0.08	0.09	0.32	0.12
CD (p=0.05)	NS	0.33	1.92	1.91	0.23	NS	0.94	0.35

Chlorophyll Content

Chlorophyll content of the chickpea cultivars also found statically different under micronutrients sprayings. Among the cultivars grown, the chlorophyll content is also influenced significantly by genotypes. The chlorophyll content was recorded maximum at 50 flowering stage in RVSJ4-102 cultivar flowed by JSLB, ICPK and lowest in Anuradha cultivar. Thereafter at 100 % flowering stage chlorophyll content was decreasing in each cultivar and highest content observed in RVSJ4-102 followed by JSKB ICPK and Anuradha at both the dates of observations. Micronutrient spraying also had significant influence on chlorophyll content of the cultivars. At 50% flowering, the maximum chlorophyll content was obtained in combine treatment of zinc 0.5%+boron 0.1% and which was followed by zinc 0.5% alone, boron 0.1% alone and control treatment. Similar trend was observed at 100% flowering stage. The results were conformity with the findings of (Pandey and Gautam, 2009). They found that foliar application of B enhance leaf chlorophyll content. These micronutrients, Zn and B are involved in root growth, synthesis of proteins and carbohydrates, increase flower setting (Wahid et al. 2011).

Dry Matter Accumulation

Dry matter production and its transformation into economic yield is the ultimate outcome of various physiological, phenological and morphological events occurring in the plant system. Seed yield of a variety is the result of interplay of its genetic makeup and environmental factors in which plant grow. In this experiment, it was found that the cultivar RVSJ 4-102 produced statistically higher dry matter accumulation at 30, 50, 70, and at harvest stage immediately followed by ICPK, JSKB and Anuradha. The dry matter accumulation varied significantly due to foliar application of zinc and boron at branching and pre-flowering. The result indicates that dry weight was maximum under combined application of zinc 0.5%+boron 0.1% followed by zinc 0.5%, boron 0.1% and control treatment irrespective of dates of observation. Soil enrichment with micronutrients facilitated their efficient utilization, with iron enhancing chlorophyll metabolism, zinc aiding in carbohydrate and protein synthesis, and protecting the chickpea crop against photo oxidative damage. Boron played a crucial role in regulating sugar transport across membranes and contributed significantly to cell division and development. These results are in line with the findings of (Velenciano et al., 2010).

Leaf Area Index and Crop Growth Rate

The cultivar performance affected the leaf area index significantly at all the dates of observations. RVSJ4-104 and JSKB cultivars showed similar leaf area index at 30, 50 DAS but at 70 DAS RVSJ4-102 and recorded higher leaf area index whereas Anuradha showed the lowest leaf area index throughout the growth period. (Singh and Singh 2014) also reported similar findings. Micronutrient spraying significantly influenced the leaf area index of chickpea cultivars at different growth stages. The maximum leaf area index was observed under the combined spraying of zinc 0.5%+boron 0.1% followed by boron 0.1%, zinc 0.5% as compared to control treatment except at 30 DAS.

Maximum crop growth rate was found at 50 to 70 DAS after that at harvest stage it was declined in all cultivars. At 30-50 DAS, significantly higher CGR was recorded in JSKB followed by RVSJ 4 -102 and ICPK whereas it was found lowest in Anuradha. However, during the peak period of growth stage i.e. 50-70 DAS, RVSJ 4-104 cultivar recorded the highest CGR and the lowest was in Anuradha.

Yield Attributes

Number of pods/plant

The experimental data number of pods/plant of chickpea as affected by foliar application of zinc and boron on different cultivars is presented in (Table 4). The cultivars performance affect the number of seeds /plant significantly at maturity after harvesting. Anuradha cultivar showed significantly higher number of pods/plant than that of other cultivar under investigation. The number of pods/plant was recorded lowest in RVSJ4-102. Under combined foliar application of zinc 0.5%+boron 0.1% at branching and pre-flowering stage was produced maximum number of pods/plant due to optimum availability of zinc and boron throughout the growing season helped the crop to produce higher number of pods in each plant. On other hand, control treatment recorded the lowest number of pods/plant. (Jadhave et al., 2019)reported that the increase in pods No. /plant as a result to spraying of nutrients could be due to significant effect of micronutrients on organs of reproductive such as pollens and stamens.

Number of seeds/pod

Anuradha cultivar of chickpea showed significantly higher number of seeds/ pod than that of other cultivars under investigation. However, number of seeds/pod was found minimum in ICPK and JSKB cultivars though the result was statically at par with RVSJ 4-104 cultivar. Combined foliar application of zinc 0.5% + boron 0.1% at branching and pre flowerings stage produced maximum number of seeds/pod. Zinc and boron helped the crop to produce higher number of seed in each pod. On the other hand, control treatment recorded the lowest number of seeds/pod. (Takle et al., 2009) also reported similar study.

Test weight

Significant increases in test weight were found in zinc treated plot @ 0.5% compared to control plot. Under Chickpea cultivar RVSJ4-102 produced significantly higher test weight due to bold seed followed by JSKB, ICPK and the lowest test weight was observed in Anuradha due to genetic cultivar character. Boron is involved in the retention of flowers, pollen tube growth, seed formation, seed setting, and plays an important role in transportation of metabolites from source to sink. Application of Zn enhance quality and yields of chickpea reported by (Khan et al., 2003). Crop responses in terms of productivity have been assorted through micronutrient fertilization. (Valenciona et al., 2010) also found a significant increase in Harvest index with the application of Zn and B.

Table 2: Effect of zinc and boron spraying on chlorophyll content and dry matter accumulation of chickpea cultivars at different days after sowing

Treatments	Chlorophyll Content (mg/g fresh leaf)		Dry Matter Accumulation (g/m$^{-2)}$			
	At 50% flowering	At 50% flowering	30 DAS	50 DAS	70 DAS	At harvest
Variety						
Anuradha	2.03	0.49	23.63	70.03	138.89	220.87
ICPK	2.20	1.57	33.48	109.97	189.76	250.72
JSKB	2.19	1.58	34.22	114.49	192.18	249.17
RVSJ4-102	2.25	1.68	37.87	115.03	193.55	253.27
SEm (±)	0.04	0.048	1.23	2.18	2.77	2.27
CD (p=0.05)	0.13	1.65	3.88	7.54	9.59	7.85
Micronutrients Spraying						
Control	1.91	1.29	30.26	99.38	177.98	134.18
Zinc 0.5%	2.18	1.69	31.43	101.94	182.77	244.48
Boron 0.1%	2.14	1.59	32.38	102.54	178.84	244.01
Zn 0.5%+B 0.1%	2.43	1.73	32.06	105.93	174.77	251.33
SEm (±)	0.04	0.04	0.99	1.51	1.65	1.43
CD (p=0.05)	0.13	0.13	2.89	4.42	4.88	4.19

Table 3: Effect of zinc and boron spraying on leaf area index and crop growth rate of chickpea cultivars at different days after sowing

Treatments	Leaf Area Index (LAI)			Crop Growth Rate (g/m^2/day)		
	30 DAS	50 DAS	70 DAS	30-50	50-70	70 – At harvest
Variety						
Anuradha	0.23	0.34	0.58	2.32	3.40	2.14
ICPK	0.39	0.61	1.07	2.82	3.80	2.44
JSKB	0.44	0.59	1.11	4.03	3.97	2.28
RVSJ4-102	0.44	0.58	1.27	3.86	4.16	2.39
SEm (±)	0.004	0.018	0.028	0.13	0.15	0.06
CD (p=0.05)	0.014	0.061	0.100	0.45	0.53	0.20
Micronutrients Spraying						
Control	0.36	0.48	0.92	3.45	3.55	2.00
Zinc 0.5%	0.41	0.53	0.97	3.52	3.80	2.19
Boron 0.1%	0.32	0.54	1.03	3.50	3.87	2.31
Zn 0.5% + B 0.1%	0.40	0.57	1.03	3.54	4.08	2.74
SEm (±)	0.004	0.018	1.09	0.08	0.11	0.05
CD (p=0.05)	0.011	0.052	0.029	NS	0.33	0.14

Table 4: Effect of zinc and boron spraying on yield attributes and yield of chickpea cultivars

Treatments	No of pods/plant	No. of seed/plant	Test Weight (g)	Seed Yield (kg/ha)	Stalk Yield (kg/ha)	Biological Yield (kg/ha)	Harvest Index (%)
Variety							
Anuradha	14.92	1.30	104.08	2348	675	1425	28.78
ICPK	8.13	1.03	380.39	2929	1053	1532	36.05
JSKB	8.01	1.03	382.75	2886	1045	1518	36.45
RVSJ4-102	6.44	1.04	511.29	2682	1122	1234	42.07
SEm (±)	0.35	0.01	6.03	60.74	6.65	45.06	0.72
CD (p=0.05)	1.23	0.04	20.89	210.18	23.03	155.9	2.51
Micronutrients Spraying							
Control	8.22	1.06	347.84	2447	850	1322	34.75
Zinc 0.5%	9.31	1.09	348.13	2709	966	1431	35.36
Boron 0.1%	9.56	1.10	347.24	2789	1004	1465	35.84
Zn 0.5%+ B 0.1%	10.39	1.13	335.30	2899	1075	33.05	37.97
SEm (±)	0.27	0.03	13.15	65.47	7.28	96.48	0.80
CD (p=0.05)	0.79	0.05	NS	191.12	2126	8.02	NS

Yield of chickpea

Seed Yield (kg/ha)

Seed yield from each plot was recorded after threshing, hulling of pods and drying the seed samples then it was statistically analyzed (Table-4). The result revealed that the seed yields of different cultivars were varied themselves significantly. Seed yield of chickpea influenced by cultivars. RVSJ4-102 cultivar improved the dry matter accumulation with more chlorophyll content; yield attributes especially high test weight than the other tested cultivars. Hence, RVSJ4- 102 cultivars showed highest seed yield whereas Anuradha produced the lowest seed yield as very low test weight of this variety.Among the micronutrients, the foliar application of Zinc @ 0.5% and Boron @ 0.2% consistently recorded significantly higher seed yields. This increase can be attributed to improved nutrient availability at crucial growth stages due to the application of various micronutrient combinations. Consequently, this enhances metabolic activity rates and efficiency, leading to increased protein and carbohydrate assimilation, facilitating better nutrient absorption by plants and, ultimately, higher yields. These results are in line with studies by (Gupta et al., 2012).

Stalk Yield (kg/ha)

The stalk yield of chickpea was influenced significantly by the varietal treatment (Table-4). ICPK cultivar showed significantly higher stalk yield of crop whereas, RVSJ4-102 showed the lowest stalk yield. Improvement growth of ICPK helped to produce the highest stalk yield. Similarly, micronutrient spraying affected the stalk yield of chickpea. Micronutrient spraying, spraying of zinc 0.5% + boron 0.1% showed the highest stalk yield followed by Boron 0.1%, zinc 0.5% and control treatment. (Patel et al. 2009) also reported similar study.

Biological Yield (kg/ha)

Biological yield of chickpea was affected significantly by the genetic variability of chickpea cultivars. ICPK cultivar showed significantly higher biological yield than that of Anuradha and RVSJ 4-104 but the effect was found at par with JSKB. The lowest biological yield was recorded under Anuradha due to the fact that lower growth attributes observed in this variety. The result corroborated with the findings of (Shamsi, 2009).

CONCLUSION

Based on the above experimental findings, it is concluded that the various varieties, the RVSJ4-104 variety exhibited the most significant improvements in plant height, chlorophyll content, dry matter accumulation, leaf area index, crop growth rate, yield attributes, and overall yield but highest number of branches per plant recorded in Anuradha variety. The foliar application of Zinc @ 0.5% and Boron @ 0.1% proved to be superior to other treatments in terms of growth attributes, yield attributes as well as yield of chickpea. Based on these findings, farmers are advised to cultivate the RVSJ4-104 chickpea variety and apply Zinc @ 0.5% and Boron @ 0.1% through foliar application to achieve higher yields and improved profitability.

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