International Journal of Environment and Climate Change

Volume 13, Issue 5, Page 108-113, 2023; Article no.IJECC.97524
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Effect of Soil Application of Zinc and Foliar Application of Boron on Growth and Yield of Maize (*Zea mays* L.)

Gampa Sai Ram [a++*] and Joy Dawson [a#]

[a] *Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, India.*

Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i51751

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/97524

Original Research Article

Received: 17/01/2023
Accepted: 20/03/2023
Published: 23/03/2023

ABSTRACT

The experiment was conducted in CRF in Department of Agronomy during summer season of 2022 on Maize crop. The aim was to study the effect of soil application of zinc and foliar application of boron and growth and yield of maize. The Treatments consisted of 3 levels of Zinc (5,10 and 15 kg/ha) and Boron (0.5, 1 and 1.5%) as foliar spray and a control. The experiment was laid out in a Randomized Block Design (RBD) with Ten treatments each replicated thrice. Application of 15 kg Zinc with Boron 1.5% as foliar spray recorded highest Plant height (209.16 cm), No. of Leaves/plant (12.83), Plant dry weight (183.65 g/plant), No. of Cobs/plant (2.33), No. of Grains/Cob (523.93), No. of row/cob (14.74), No. of Grains/row (41.53), Test weight (27.5g), Grain yield (6.33 t/ha), Stover yield (14.30 t/ha) Harvest Index (30.7%).

Keywords: Zinc; boron; growth; yield.

[++] *M. Sc. Scholar;*
[#] *Professor;*
**Corresponding author: E-mail: gampasairam25@gmail.com;*

1. INTRODUCTION

“Maize (*Zea mays* L.) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Given that it possesses the largest genetic yield potential of all the cereals, maize is considered as the "queen of cereals" internationally. Next to wheat and rice, maize is one of the most significant cereal crops grown worldwide. Nutrient management is the key variable impacting maize productivity”. [1]. “Maize is a C4 plant, which means it can absorb solar energy more efficiently than other cereals. Every state in the country produces maize all year around for a variety of uses, including animal fodder, food grain, sweet corn, baby corn, green cobs, popcorn, and corn flour, which is a common ingredient in Indian cuisine. After rice and wheat, maize ranks third in importance among cereals as a food source in India. In order to obtain more agricultural production, either more lands should be cultivated, which is not applicable in most cases, or a higher yield must be produced in the currently cultivated lands. Maize is one of the crops most sensitive to Zinc deficiency” [2]. **“**Zn is a micronutrient it increases the production of maize grain productivity. Zn can be supplied to crops directly on the soil, in fertilizers, through foliar fertilization, or through seed treatments. Soil application of zinc sulphate may be attributed to the improvement of plant growth and an increase in the rate of photosynthetic and other metabolic activities which led to increasing in various plant metabolites that are responsible for cell division and cell elongation due to optimum supply of nutrients and also increased growth of internodal section with higher synthesis of growth hormones like indole acetic acid (IAA) and metabolizing gibberellic acid” as reported by Arya and Singh, [3]. “As an essential nutrient, zinc is involved in a number of physiological activities, including the synthesis of protein and carbohydrates. It also regulates stomata, which helps plants use less water by maintaining ionic balance in their systems. Zinc is most crucial among the micronutrients that take part in plant growth and development due to catalytic action in metabolism of almost all crops” [4]. “Zinc fertilizers applications to maize crops not only increase production but also improve zinc contents in tissues. The use of boron enhances plant stress tolerance, growth, and grain yield. The worldwide deficiency of boron is more severe than any other micronutrient shortage for crops. Boron deficiency caused sterility in maize, insufficient levels of available boron soil reduce crop yield, impair grain quality, and increase the susceptibility of crops to diseases. Boron is considered as an essential element for plant growth and development, sexual reproduction in plant is more sensitive to B deficiency, then vegetative growth” [5].

2. MATERIALS AND METHODS

A field experiment was conducted during Zaid season 2022 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, UP, which is located at 25.28^{o}N latitude, 81.54^{o}E longitude and 98 m altitude above the mean sea level. The experiment laid out in Randomized Block Design which consists of ten treatments with T_1: Zinc 5 kg/ha + Boron 0.5 %, T_2: Zinc 5 kg/ha + Boron 1 %, T_3: Zinc 5 kg/ha + Boron 1.5 %, T4:Zinc 10 kg/ha + Boron 0.5 %, T_5: Zinc 10 kg/ha + Boron 1 %, T_6: Zinc 10 kg/ha + Boron 1.5 %, T_7: Zinc 15 kg/ha + Boron 0.5 %, T_8: Zinc 15 kg/ha + Boron 1 %, T_9: Zinc 15 kg/ha + Boron 1.5 %, T_{10}: Control are used. The experimental site was uniform in topography and sandy loam in texture, nearly neutral in soil reaction (P^H 7.1), low in Organic carbon (0.38%), medium available N (225 kg ha^{-1}), higher available P (19.50 kg ha^{-1}) and medium available K (213.7 kg ha^{-1}). From germination to harvest, several plant growth characteristics were recorded at regular intervals. At harvest, several yield parameters were recorded, including plant height, No. of leaves/plant, and dry weight. The yield parameters like No. of cobs/plant, No. of rows/cob, No. of grains/row, No. of grains/cob, Test weight, seed yield, stover yield, and harvest index were recorded and statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design [6].

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

3.1.1 Plant height

At harvest, significantly maximum Plant height (209.16 cm) was recorded in T_9 with the application of Zinc 15 kg/ha + Boron 1.5 % superior over all the other treatments. However, T_6 with Zinc 10 kg/ha + Boron 1.5 % (208.23 cm) and T_8 with Zinc 15 kg/ha + Boron 1 % (208.65 cm) which were found to be statistically at par with T_9 Zinc 15 kg/ha + Boron 1.5 % as compared to other treatments. The information made it very clear that zinc fertilization treatments enhance the leaf stem ratio when compared to no zinc treatment. There is growing evidence that foliar and soil applications of zinc fertilizers together are the most effective and beneficial ways to maximize zinc uptake and accumulation in plants. Due to the timely availability of the required nutrients to the plant at the critical growth stages and the application of zinc, which produced the generation of IAA and enhanced plant height, there is a significant variance in plant height. The results were found in resonance with Chand et al. [7].

3.1.2 Number of leaves/plant

At harvest, significantly maximum No. of Leaves/plant (12.83) was recorded in T_9 with the application of Zinc 15 kg/ha + Boron 1.5 % superior over all the other treatments. However, T_6 with Zinc 10 kg/ha + Boron 1.5 % (12.67) and T_8 Zinc 15 kg/ha + Boron 1 % (12.75) which was found to be statistically at par with T_9 Zinc 15 kg/ha + Boron 1.5 % as compared to other treatments.

3.1.3 Plant dry weight (g/plant)

At harvest, significantly maximum Dry weight (183.65 g/plant) was recorded in T_9 with the application of Zinc 15 kg/ha + Boron 1.5 %, superior over the other treatments. However, T_6 Zinc 10 kg/ha + Boron 1.5 % (182.00 g/plant) and T_8 Zinc 15 kg/ha + Boron 1 %, (182.80 g/plant), which were found to be statistically at par with T_9 Zinc 15 kg/ha + Boron 1.5 %, as compared to other treatments. Following zinc's application as a foliar spray, maize's dry matter increased significantly. Long plant height, large stem girth, and heavy roots cause the treatments' high dry matter. These findings are in harmony with those obtained by Palai et al. [8].

With increasing levels of boron, dry weight increased significantly. Since boron often influences cell division and nitrogen uptake from the soil may promote plant growth as measured by plant dry weight. These findings are in harmony with those obtained by Kumar et al. [9].

3.2 Yield Attributes and Yield

3.2.1 Number of cobs/plant

Significantly maximum number of cobs/plant (2.33) was recorded in T_9, with the application of Zinc 15 kg/ha + Boron 1.5 % superior over all the treatments. However, T_5 with Zinc 10 kg/ha + Boron 1 % (2.10), T_6 with Zinc 10 kg/ha + Boron 1.5 % (2.17), and T_8 with Zinc 15 kg/ha + Boron 1 % (2.27) which were found to be statistically at par with T_9 Zinc 15 kg/ha + Boron 1.5 %. “The increase in the number of cobs/plant due to the soil and foliar application of Boron and positive effect of boron may be due to key role in plant metabolism and in the synthesis of nucleic acid” Tahir et al. [10].

3.2.2 Number of rows/cob

Significantly Maximum Number of Rows/Cob (14.74) was recorded in T_9, with the application of Zinc 15 kg/ha + Boron 1.5 %, superior over all the treatments. However, T_6 Zinc 10 kg/ha + Boron 1.5 % (14.44) and T_8 Zinc 15 kg/ha + Boron 1 % (14.55), which were found to be statistically at par with T_9, Zinc 15 kg/ha + Boron 1.5 %.

3.2.3 Number of grains/cob

Significantly maximum number of grains/cob (525.93) was recorded in T_9, with the application of Zinc 15 kg/ha + Boron 1.5 %, superior over all the treatments. However, T_6 with Zinc 10 kg/ha + Boron 1.5 % (520.92) and T_8 with Zinc 15 kg/ha + Boron 1 % (524.62) which were found to be statistically at par with T_9, Zinc 15 kg/ha + Boron 1.5 %. Increase in this attribute by foliar spray might be due to the involvement of the boron in enzyme activation, membrane integrity, chlorophyll formation, stomatal balance and starch utilization at early stages which enhanced accumulation of assimilate in the grains resulting in heavier grains. These results are in agreement with the findings of Khan et al. [11].

3.2.4 Number of grains/row

Significantly maximum number of grains/row (41.53) was recorded in T_9, with the application of Zinc15 kg/ha + Boron 1.5% superior over all the treatments. However, T_8 Zinc 10 kg/ha + Boron 1.5% (40.80), which were found statistically at par with T_9 Zinc 15 kg/ha + Boron 1.5%.

3.3 Seed Index

Significantly maximum seed index (27.5g) was recorded in T_9 with application of Zinc 15 kg/ha +Boron 1.5% superior over all the treatments. However, T_8 Zinc 10 kg/ha +Boron1.5% (27.2g) which were found statistically at par with T_9 Zinc 15kg/ha +Boron 1.5%.

Table 1. Effect of zinc and boron on growth attributes of maize

Treatments	Plant height (cm)	Leaves/plant	Dry weight (g/plant)
1. Zinc 5 kg/ha + Boron 0.5 %	204.59	12.07	175.03
2. Zinc 5 kg/ha + Boron 1 %	205.34	12.27	176.85
3. Zinc 5 kg/ha + Boron 1.5 %	206.30	12.45	178.89
4. Zinc 10 kg/ha + Boron 0.5 %	205.41	12.38	177.97
5. Zinc 10 kg/ha + Boron 1 %	207.51	12.61	180.79
6. Zinc 10 kg/ha + Boron 1.5 %	208.23	12.67	182.00
7. Zinc 15 kg/ha + Boron 0.5 %	206.98	12.51	180.02
8. Zinc 15 kg/ha + Boron 1 %	208.65	12.75	182.80
9. Zinc 15 kg/ha + Boron 1.5 %	209.16	12.83	183.65
10. Control	204.40	11.96	174.06
F- test	S	S	S
S. Em (±)	0.32	0.05	0.55
CD (P = 0.05)	0.96	0.16	1.65

Table 2. Effect of soil application of zinc and foliar application of boron on yield attributes and yield of maize

Treatments	Cobs /plant	Rows /cob	Grain /cob	Grains /row	Seed index (g)	Grain yield (t/ha)	Stover yield (t/ha)	Harvest Index (%)
1. Zinc 5 kg/ha + Boron 0.5 %	1.83	13.89	506.52	37.47	25.3	5.31	12.96	29.1
2. Zinc 5 kg/ha + Boron 1 %	1.87	13.96	507.35	37.98	25.5	5.47	13.13	29.4
3. Zinc 5 kg/ha + Boron 1.5 %	1.97	14.16	512.04	38.80	25.9	5.85	13.59	30.1
4. Zinc 10 kg/ha + Boron 0.5 %	1.93	14.08	509.48	38.20	25.7	5.58	13.30	29.6
5. Zinc 10 kg/ha + Boron 1 %	2.10	14.36	517.05	39.63	26.3	6.05	13.95	30.3
6. Zinc 10 kg/ha + Boron 1.5 %	2.17	14.44	520.92	40.25	26.8	6.18	14.12	30.4
7. Zinc 15 kg/ha + Boron 0.5 %	2.00	14.21	514.56	39.29	26.2	5.93	13.79	30.1
8. Zinc 15 kg/ha + Boron 1 %	2.27	14.55	524.62	40.80	27.2	6.26	14.22	30.5
9. Zinc 15 kg/ha + Boron 1.5 %	2.33	14.74	525.93	41.53	27.5	6.33	14.30	30.7
10. Control	1.73	13.76	502.24	36.64	24.9	5.21	12.48	29.5
F test	S	S	S	S	S	S	S	S
S. Em (±)	0.10	0.11	1.88	0.25	0.18	0.12	0.07	0.24
CD (P = 0.05)	0.29	0.32	5.58	0.74	0.53	0.38	0.20	0.49

3.4 Grain Yield (t/ha)

Significantly maximum grain yield (6.33 t/ha) was recorded in T_9 with application of Zinc 15 kg/ha + Boron 1.5 % superior over all the treatments. However, T_6 Zinc 10 kg/ha + Boron 1.5 % (6.18 t/ha) and T_8 Zinc 15 kg/ha + Boron 1 % (6.26 t/ha) which were found to be statistically at par with T_9, Zinc 15 kg/ha + Boron 1.5 %. Production of photosynthates and their translocation to sink depends upon availability of mineral nutrients whose availability has increased the zinc uptake also. Most of the photosynthetic pathways are dependent on enzymes and co-enzymes, which are synthesized by mineral nutrients such as nitrogen, phosphorus, and potassium activated by zinc. The increase in yield attributes due to the application of zinc was caused by higher chlorophyll contents, which had apparently a positive effect on photosynthetic activity, synthesis of metabolites and growth-regulating substances, oxidation and metabolic activities and ultimately better growth and development of crop, which led to increase in yield of maize. These results are in agreement with the findings of Anjum et al. [12]. Boron plays a vital role in increasing seed yield because zinc and boron takes place in many physiological process of plant such as chlorophyll formation, stomatal regulation, starch utilization which enhance seed yield. Boron is required for many physiological processes and plant growth, also adequate nutrition is critical for increasing yields and quality of crops. These results are in confirmatory with the work of Alimuddin et al. [13].

3.5 Stover Yield (t/ha)

Significantly maximum stover yield (14.30 t/ha) was recorded in T_9, with application of Zinc 15 kg/ha + Boron 1.5 % superior over all the treatments. However, T_6 Zinc 10 kg/ha + Boron 1.5 % (14.12 t/ha) and T_8 Zinc 15 kg/ha + Boron 1 % (14.22 t/ha) which were found to be statistically at par with T_9 Zinc 15 kg/ha + Boron 1.5 %. Zinc fertilization has beneficial effect on physiological process, plant metabolism and plant growth, which leads to higher yield. Increase in green cob and green fodder yield with application of zinc and the results were supported by the findings Das et al. [14].

3.6 Harvest Index (%)

Significantly maximum harvest index (30.7 %) was recorded in T_9 with the application of Zinc 15 kg/ha + Boron 1.5 % superior over all the treatments. However, T_5 Zinc 10 kg/ha + Boron 1 % (30.3 %), T_6 Zinc 10 kg/ha + Boron 1.5 % (30.4 %), and T_8 Zinc 15 kg/ha + Boron 1 % (30.5%) which were found to be statistically at par with T_9 Zinc 15 kg/ha + Boron 1.5 %. Porter et al. [15] have reported that "supra optimal temperature during anthesis reduce seed set which leads to sink limitation and decreased harvest index. High temperature during crop season might have affected translocation efficiency which resulted into poor harvest index". The weak source-sink relationship due to high temperature was also reported by suwa et al. [16]. This finding was in close agreement with those of Shrestha et al. [17] and Jasemi et al. [18]. Further, favourable influence of zinc application on physiological and metabolic process of the plants, which ultimately enhanced stover yield leading to higher harvest index.

4. CONCLUSION

Based on the findings of the investigation it is concluded that the treatment with Zinc 15 kg/ha + Boron 1.5 %, recorded significantly higher growth and yield parameters and in obtaining seed yield of maize.

ACKNOWLEDGEMENT

I express thankfulness to my advisor Dr. Joy Dawson and all the faculty members of Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj -211007, Uttar Pradesh. For providing us essential facilities to undertake the studies.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kumar P, Desai BK, Pujari BT. Effect of integrated nutrient management on economics of maize cultivation. Karnataka J. Agric. Sci. 2007;20(4):831-832.
2. Mattiello EM, Ruiz HA, Neves JCL, Ventrella MC, Araújo WL. Zinc deficiency affects physiologicaland anatomical characteristics in maize leaves. Journal of Plant Physiology. 2015;183:138-143.
3. Arya KC, Singh SN. Production of maize (*Zea mays*) as influence by different levels of phosphorus, zinc and irrigation. Indian J. Agril. Sci. 2001;71(l):57-59.
4. George R, Schmitt M. Zinc for crop production. Reagents of the University of Minnesota; 2002.
5. Goldbach H, Huang L, Wimmer M. Boronfunctions in plants and animals: Recent advances in boronresearch and open questions. In: Xu F, Goldbach HE, Brown PH, Bell RW, Fujiwara T, Hunt CD, Goldberg S, Shi L (eds) Advances in plant and animal boron nutrition. Springer, Dordrecht. 2007:3–25.
6. Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd Edn. M. Jhon Wiley and Sons Inc., New York. 1984:95-109.
7. Chand SW, Susheela R, Sreelatha D, Shanti M, Surendra Bab P. Growth and yield of baby corn (*Zea mays* L.) as influenced by zinc fertilization. International Journal of Chemical Studies. 2017;5(6): 1362-1364.
8. Palai JB, Sarkar NC, Jena J. Effect of zinc on growth, yields, zinc use efficiency and economics in baby corn. Journal of Pharmacognosy and Phytochemistry. 2018;7(2):1641-1645.
9. Kumar M, Singh S, Singh V, Singh K, Khanna R. Effect of zinc and boron on growth and yield of maize (*Zea mays* L.). Progressive Research – An International Journal. 2019;14(3):215-211.
10. Tahir M, Ali A, Khalid F, Naeem M, Fiaz M, Waseem M. Effect of applied boron boron application on growth, yield and quality of maize (*Zea mays* L.). Pakistan Journal of Scientific and Industrial Research. 2012; 55(3):117-121.

11. Khan A, Hayat Z, Khan AA, Ahmad J, Abbas MW, Nawaz H, Ahmad F, Ahmad K. Effect of foliar application of zinc and boron on growth and yield components of wheat. Agricultural Research and Technology: Open Access Journal. 2019;21(1):3-6.
12. Anjum SA, Saleem MF, Shahid M, Shakoor A, Safeer M, Khan I, Farooq A, Ali I, Nazir U. Dynamics of soil and foliar applied boron and zinc to improve maize productivity and profitability. Pakistan Journal of Agricultural Research. 2017; 30(3):294-302.
13. Alimuddin S, Musa Y, Azrai M, Asrul L. Effect of boron on flowering, yield components and grain yield of two prolific maize (*Zea mays* L.) hybrids. IOP Conference Series: Earth and Environmental Science. 2020;484.
14. Das C, Barik AK, Mondal K. Effect of zinc application on growth and yield of baby corn (*Zea mays* L.) in lateritic soil of West Bengal. International Journal of Chemical Studies. 2020;8(2):887-890.
15. Porter John R, Semenov Mikhail A. Crop responses to climatic variation. Philos Trans R Soc Lond B Biol Sci. 2005;360(1463):2012-2035.
16. Suwa Ryuichi, Hakata Hiroaki, Hara Hiromichi, et al. High temperature effects on photosynthate partitioning and sugar metabolism during ear expansion in maize (*Zea mays* L.) genotypes. Plant Physiol Biochem. 2010;48(2-3):124-130.
17. Shrestha J. Cluster analysis of maize inbred lines. J. Nepal Agric, Res. Couc. 2016;2:23-36.
18. Jasemi Maryam. Darabi Fereshteh. Naseri Rahim. Naserirad Hoshang, Bazdar Saman. Effects of planting date and nitrogen fertilizer application on grain yield and grain components in maize (SC704). American-Eurasian J Agric, & Environ. Sci. 2013;13(7):914-919.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/97524