EFFECT OF SOIL APPLICATION OF ZINC AND FOLIAR APPLICATION OF BORON ON GROWTH AND YIELD OF MAIZE (*ZEA MAYS* L.)

Abstract

A field experiment was conducted during *Zaid* 2022 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.1), low in organic carbon (0.36 %), available N (171.48 kg/ha), available P (15.2 kg/ha) and available K (232.5 kg/ha). The experiment was laid out on Randomized Block Design with Ten treatments each replicated thrice on the basis of one year experimentation. The treatments which are 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 results showed that application of Zinc 15 kg/ha + Boron 1.5 % was recorded significantly higher growth parameters like ~~Plant~~ plant height (209.16 cm), No. of ~~Leaves~~leaves/plant (12.83), ~~Plant~~ plant dry weight (183.65 g/plant), whereas significantly highest ~~Crop~~ crop growth rate (6.76 g/m^2/day) was recorded with the treatment Zinc 5 kg/ha + Boron 1 %. However, high yield attributes and yield parameters like No. of ~~Cobs~~cobs/plant (2.33), No. of ~~Rows~~rows/~~Cob~~ cob (14.74), No. of ~~Grains~~grains/cob (525.93), No of ~~Grains~~grains/row (41.53), ~~Seed~~ seed index (27.5g), ~~Grain~~ grain yield (6.33 t/ha), ~~Stover~~ stover yield (14.30 t/ha), ~~Harvesting~~ harvesting index (30.7%), were recorded with the treatment -9, Zinc 15 kg/ha + Boron 1.5 %.

Comment [p1]: Add the objectives of the study

Keywords: Zinc, Boron, Growth, yield

Introduction

Maize (*Zea mays* L.) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Globally, maize is known as “queen of cereals” because it has the highest genetic yield potential among the cereals. Maize is one of the important cereal crops next to wheat and rice in the world. The productivity of maize mainly depends on its nutrient management **(Kumar *et al.*, 2007).** Being a C_4 plant,

maize is capable of utilizing solar radiation more efficiently compared to other cereals. Maize is grown throughout the year in all states of the country for various purposes including fodder for animals, food grain, sweet corn, baby corn, green cobs ~~and,~~ popcorn~~,~~ and corn flour, which is consumed widely in Indian cooking. Among the cereals in India, maize occupies the third most important food crops after rice and wheat. In order to obtain more agricultural production, either more lands should be cultivated, which is not applicable in most cases, or higher yield must be produced in the currently cultivated lands. Maize is one of the crops most sensitive to Zinc deficiency (Mattiello *et al.*, 2015). Zn is a micronutrient which enhances the grain productivity in the maize production. The supply of Zn in the crops can be done directly on the soil, as fertilizers, via foliar fertilization or seed treatments. Zinc being essential nutrient plays a significant role in stomata regulation and reducing the tensions of less water by creating ionic balance in plants system and is involved in various physiological processes such as synthesis of protein and carbohydrates. Application of zinc fertilizers to maize crop not only boost its production, but also improve zinc contents in tissues. Boron application improves growth, and enhances stress tolerance in plants and improves grain production. World-wide Boron deficiency is more extensive then the any other plant micro nutrient deficiency boron deficiency caused sterility in maize, in sufficient 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 (Goldbach *et al.*, 2007).

Comment [p2]: Add the objectives of the study

Materials and Methods

The present examination was carried out during *Zaid* 2022 at Crop Research Farm, Department of Agronomy, SHUATS, 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 consisting 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}). In the period from germination to harvest several plant growth parameters were recorded at frequent intervals along with it after harvest several yield parameters were recorded those parameters are growth parameters, plant height, leaves/plant and plant dry weight are recorded. 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 (Gomez K.A. and Gomez A.A. 1984).

Results and Discussion

Growth attributes

Plant height

At ~~Harvest~~harvest, significantly maximum Plant height (209.16 cm) was recorded in treatment-9 with application of Zinc 15 kg/ha + Boron 1.5 % superior over all the other treatments. However, treatment-6 with Zinc 10 kg/ha + Boron 1.5 % (208.23 cm) and treatment-8 with Zinc 15 kg/ha + Boron 1 % (208.65 cm) which were found to be statistically at par with treatment-9 Zinc 15 kg/ha + Boron 1.5 % as compared to other treatments. The data clearly indicated that different zinc fertilization treatments increase the leaf stem ratio over no zinc treatment. There is increasing evidence showing that combined soil + foliar application of zinc fertilizers under field conditions are highly effective and very practical way to maximize uptake and accumulation of zinc in plants. Significant variation in the plant height is due to in time availability of the needed nutrients to the plant at the important growth stages and application of zinc has led to production of IAA resulting in increased plant height. The results were found in resonance with Chand *et al.* (2017).

Number of leaves /plant

At ~~Harvest~~hyarvest, significantly maximum No. of Leaves/plant (12.83) was recorded in treatment-9, with application of Zinc 15 kg/ha + Boron 1.5 % superior over all the other treatments. However, treatment-6 with Zinc 10 kg/ha + Boron 1.5 % (12.67) and treatment-8 Zinc 15 kg/ha + Boron 1 % (12.75) which was found to be statistically at par with treatment-9, Zinc 15 kg/ha + Boron 1.5 %, as compared to other treatments.

Plant dry weight (g/plant)

At ~~Harvest~~harvest, significantly maximum Dry weight (183.65 g/plant) was recorded with the treatment-9, with application of Zinc 15 kg/ha + Boron 1.5

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%, superior over the other treatments. However, treatment-6, with Zinc 10 kg/ha + Boron 1.5 % (182.00 g/plant) and treatment-8, Zinc 15 kg/ha + Boron 1 %, (182.80 g/plant), which were found to be statistically at par with treatment-9, Zinc 15 kg/ha + Boron 1.5 %, as compared to other treatments. The application of zinc as foliar spray to maize increased its dry matter significantly~~,~~. High dry matter in those treatments is due to long plant height, high stem girth~~,~~ and high root weights. These findings are in harmony with those obtained by Palai *et al.* (2018).

Yield attributes and Yield

Number of Cobs/Plant

Significantly ~~Maximum~~ maximum ~~Number~~ number of ~~Cobs~~cobs/Plant (2.33) was recorded in treatment -9 with application of Zinc 15 kg/ha + Boron 1.5 % superior over all the treatments. However, the treatment-5 with Zinc 10 kg/ha + Boron 1 % (2.10), treatment-6 with Zinc 10 kg/ha + Boron 1.5 % (2.17) and treatment-8 with Zinc 15 kg/ha + Boron 1 % (2.27) which were found to be statistically at par with treatment-9 with Zinc 15 kg/ha + Boron 1.5 %.

Number of Rows/Cob

Significantly Maximum Number of Rows/Cob (14.74) was recorded in treatment-9, with application of Zinc 15 kg/ha + Boron 1.5 %, superior over all the treatments. However, the treatment-6 Zinc 10 kg/ha + Boron 1.5 % (14.44) and treatment-8 Zinc 15 kg/ha + Boron 1 % (14.55), which were found to be statistically at par with treatment-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.* (2019).

Number of Grains/Cob

Significantly ~~Maximum~~ maximum ~~Number~~ number of ~~Grains~~grains/~~Cob~~ cob (525.93) was recorded with the treatment-9, with application of Zinc 15 kg/ha + Boron 1.5 %, superior over all the treatments. However, the treatment-6 with Zinc 10 kg/ha + Boron 1.5 % (520.92) and treatmet-8 with Zinc 15 kg/ha + Boron 1 % (524.62) which were found to be statistically at par with treatment-9, Zinc 15 kg/ha + Boron 1.5 %.

Number of Grains/Row

Significantly ~~Maximum~~ maximum ~~Number~~ number of ~~Grains~~grains/row (41.53) was recorded in treatment-9 with application of Zinc15 kg/ha + Boron 1.5% superior over all the treatment. However,

the treatment -8 Zinc 10 kg/ha + Boron 1.5% (40.80), which were found statistically at par with treatment-9 Zinc 15 kg/ha + Boron 1.5%.

Seed index

Significantly ~~Maximum~~ maximum seed index (27.5g) was recorded with the treatment -9 with application of Zinc 15 kg/ha +Boron 1.5% superior over all the treatments. However, the treatment-8 Zinc 10 kg/ha +Boron1.5% (27.2g) which were found statistically at par with treatment-9 Zinc 15kg/ha +Boron 1.5%.

Grain yield (t/ha)

Significantly ~~Maximum~~ maximum ~~Grain~~ grain yield (6.33 t/ha) was recorded in treatment-9 with application of Zinc 15 kg/ha + Boron 1.5 % superior over all the treatments. However, the treatment-6 Zinc 10 kg/ha + Boron 1.5 % (6.18 t/ha) and treatment-8 Zinc 15 kg/ha + Boron 1 % (6.26 t/ha) which were found to be statistically at par with treatment-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 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.* (2017). 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 a required for many physiological processes and plant growth, also adequate nutrition is a critical for increase yields and quality of crops. These results are in confirmatory with the work of Alimuddin *et al*. (2020).

Stover yield (t/ha)

Significantly m~~M~~aximum ~~Stover~~ stover yield (14.30 t/ha) was recorded in treatment-9, with application of, Zinc 15 kg/ha + Boron 1.5 % superior over all the treatments. However, the treatment-6 Zinc 10 kg/ha + Boron 1.5 % (14.12 t/ha) and treatment-8 Zinc 15 kg/ha + Boron 1 % (14.22 t/ha) which were found to be statistically at par with treatment-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.* (2020).

Harvest Index (%)

Significantly ~~Maximum~~ maximum ~~Harvest~~ harvest ~~Index~~ index (30.7 %) was recorded in treatment-9 with application of Zinc 15 kg/ha + Boron 1.5 % superior over all the treatments. However, the treatment-5 Zinc 10 kg/ha + Boron 1 % (30.3 %), treatment-6 Zinc 10 kg/ha + Boron 1.5 % (30.4 %) and treatment-8 Zinc 15 kg/ha + Boron 1 % (30.5%) which were found to be statistically at par with treatment-9 Zinc 15 kg/ha + Boron 1.5 %.

CONCLUSION

It is concluded that application of treatment No.9, Zinc 15 kg/ha + Boron 1.5 %, was recorded significantly with higher ~~Seed~~ seed yield (6.33 t/ha) as compared to other treatments. Since, the findings based on the research done in one season, further trails are needed to confirm the results.

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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
C. D. (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