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

Madasu Kalyani [a++*], Biswarup Mehera [b#] and Prateek Kumar [a†]

[a] *Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, 211007, India.*
[b] *Naini Agricultural Institute, SHUATS, Prayagraj, Uttar Pradesh, 211007, India.*

Authors' contributions

This work was carried out in collaboration among all authors. Author MK designed the study and performed the statistical analysis. Author BM guided to the author PK. All authors read and approved the final manuscript.

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ABSTRACT

The field experiment was conducted during *Zaid* season of 2022 at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P) India. To study the effect of Zinc and foliar application of silicon on growth and yield of maize. The treatment consist of the 3 levels of Zinc (5,10,15 kg/ha) and three levels of Silicon (200,350,500 ppm) as a foliar spray are included respectively. The experiment was laid out in Randomized Block Design with 10 treatments and replicated thrice. The results showed that Zn 15kg/ha + Si 500ppm (Treatment -9) plant height (187.78cm), No. of leaves

[++] *M.Sc. Scholar;*
[#] *Dean;*
[†] *PhD in Agronomy;*
**Corresponding author: E-mail: kalyanimadasu5@gmail.com;*

per plant (12.0) plant dry weight (181.62 g/plant), No. of cobs/plant (1.63/plant), Length of the cob/plant (15.43 cm), No. of rows/cob (14.82), No. of grains/cob (317.54), seed yield (7.92 t/ha) and Stover yield (11.34 t/ha), test weight (241.96 g).

Keywords: Zinc; silicon; growth attributes; yield attributes; Zaid.

1. INTRODUCTION

Maize is the third most important cereal crop in India after wheat and rice. It is grown all over the world under a wide range of climate. Currently it is cultivated in an area of 9.2 m ha with a production of 27.8 m t and productivity of 2965 kg/ha in Indian Institute of Maize Research (2022). It is popularly known as "miracle crop" and "Queen of Cereals." Maize is recognized as the "golden food" because of its higher potentiality of grain yield and higher nutritional value. It plays very important role in the daily calorie intake of humans World Health Organization (1948). "Several million people, particularly in developing countries, derive their protein and calorie requirements from maize" (Prasad, *et al.* 2005). Maize is a high yielding crop, easy to process, readily digestible and cheaper than other cereals. It has got much industrial importance and used as basic raw material for the starch, oil, protein, alcoholic beverages, and food sweeteners [1-6]. More recently maize is known for its bio-fuel value too. Monocropping and monoculture of maize, its exhaustive nature, less awareness about micronutrients application and indiscriminate use of major nutrients led to the imbalance in soil nutrient states and as a result micronutrients deficiency is noticed in many parts in general and zinc [7-9].

"Zinc is the important micronutrient for cereals particularly maize, as it plays a major role in synthesis of tryptophan, which is a precursor of indole acetic acid" (Tsui, 1998). "Zinc deficiency causes loss in yield up to 50% in maize. Nearly half of the world's cereal-growing area is affected by soil Zn deficiency. Zinc deficit is a chief worldwide problem damaging cultivation of plant, and this difficulty is due to exacerbated in alkaline soils, these soil types are mostly found in semi-arid and arid parts of the world", Cakmak, [10]. Zinc deficiency is rated as the widest spread micronutrient problem in Indian soils as it is deficient in 50 per cent soils of 14 Indian states and among cereals maize has been found to respond to zinc application.

"Silicon enhances disease resistance in plants, imparts turgidity to the cell walls and has a purative role in mitigating the metal toxicities. Transpiration from leaves of some plants is considerably reduced by the application of Si" [11]. Several studies revealed that Si application significantly increased the water-use efficiency (WUE) of maize plants [12-18]. However, information on types of silicate fertilizer, extent and time of their usage, their effect on growth and yield of maize is very limited. Members of the grass family accumulate large amounts of Si in the form of silica that is localized in specific cell types. It is also suggested that Si plays a crucial role in preventing or minimizing the lodging in crop, a matter of great importance in term of agriculture productivity [19-22].

2. MATERIALS AND METHODS

This experiment was carried out during the zaid season of 2022 at Crop research farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.). The crop research farm is situated at 25.570° N latitude, 87.190^o E longitude and at an altitude of 98 m above mean sea level. The experiment was laid out in Randomized Block Design consisting of 10 treatment combinations with three replications and was laid out with the different treatments allocated randomly in each replication. The soil of the experimental field was sandy loam in texture, slightly alkaline reaction (pH 7.1) with a low level of organic carbon (0.28%), available N (225 kg/ha), P (19.50 kg/ha) and higher level of k (92.00kg/ha). T_1 - Zn 5kg/ha + Si 200 ppm, T_2 – Zn 5kg/ha + Si 350 ppm, T_3 - Zn5kg/ha + Si 500 ppm, T_4 - Zn 10kg/ha + Si 200 ppm, T_5 - Zn10kg/ha + Si 350 ppm, T_6 – Zn 10kg/ha+ Si 500 ppm, T_7 - Zn15kg/ha + Si 200 ppm, T_8 - Zn15kg/ha + Si 350 ppm, T_9 - Zn15kg/ha + Si 500 ppm, T_{10} - Control (120:60:40 NPK kg/ha). The observations were recorded several plant growth parameters to harvest those parameters are growth parameters plant height, dry weight, no of leaves per plant. the yield parameters like no. of cobs per plant, length of the cob(cm), no. of rows per cob, no. of grains per cob, Test weight (g), seed yield (t/ha), stover yield (t/ha).

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

At 80 DAS, highest plant height in cm (187.78cm) was recorded in treatment no. 9 with application of Zn 15kg/ha + Si 500 ppm which was significantly superior over all other and treatments with the application of Zn 10kg/ha + Si 500ppm (185.56 cm) is statistically at par with treatment with application of Zn 15kg/ha +Si 500 ppm. Soil application of zinc in the form of $ZnSO_4$ results in enhanced plant growth and increased rate of photosynthesis and other metabolic activities and increases plant height [23]. At 80 DAS, maximum no. of leaves per plant (12.0) was observed in the application of Zn 15 kg /ha +Si 500 ppm which was significantly superior over all other and treatments with application of Zn 10kg/ha combination with Si 500 ppm (11.8) is statistically at par with the application of Zn 15 kg /ha +Si 500 ppm. silicon (500 ppm) has enhanced plant height, number of leaves, yield, and some biochemical constituents in maize (Boarse et al. 2018). At 80 DAS, maximum plant dry weight in grams (181.62 g) was recorded with the application of Zn 15kg /ha +500ppm which is significantly over the rest of the other and the treatments with the application of Zn 10kg /ha +Si 500ppm (175.31g) is statistically at par with the application of Zn 15kg/ha +Si 500ppm Treatment (T_9) represented in (Table 1) Phyto hormones which stimulate the formation of lateral roots and absorbent root hairs, which eventually helped in uptake of higher nutrients and minerals by plants and leads to increase in higher biomass accumulation and higher plant dry weight. The results were found to be in consonance with Zhou et al. [24].

3.2 Yield Attributes and Yield

Significantly Maximum no. of cobs/ plant was recorded in treatment no. 9 with application of Zn15kg/ha with the combination of Si 500ppm which was significantly over the rest of other and treatments with the application of Zn 10kg/ha +Si 500ppm was statistically at par with the application of Zn 15kg/ha +Si500 ppm. Treatment with Zn 15kg/ha+Si500 ppm (15.43cm) was recorded maximum no. of length of the cob in cm which was significantly over rest of the other treatment with application of Zn 10kg/ha combination with Si500 ppm (15.30cm) statistically at par with the application of Zn 15kg/ha +500 ppm. maximum no. of rows per cob was observed with application of Zn15kg/ha +Si500 ppm (14.82) which was significantly superior over all other. maximum no. of grains per cob was recorded with the application of Zn 15kg /ha +Si500 ppm (317.54) which was significantly superior over all the other and treatment with application of Zn10kg/ha +Si500ppm (311.86) statistically at par with application of Zn 15kg/ha +Si500 ppm . maximum test weight in grams was observed with application of Zn 15kg /ha +Si 500ppm (241.96 g) significantly superior over all other and treatment with application of Zn10kg /ha +Si500ppm (237.30 g) statistically at par with application of Zn 15kg/ha +Si500ppm. maximum seed yield in t/ha was recorded with application

Table 1. Effect of zinc and foliar application of silicon levels on plant growth attributes on maize

S.NO.	Treatments	Plant height (cm) 80DAS	No. of leaves per plant 80DAS	Plant Dry weight (g) 80DAS
1.	Zn(5kg/ha) + Si(200ppm)	167.38	10.3	137.00
2.	Zn(5kg/ha) + Si(350ppm)	171.38	11.2	142.17
3.	Zn(5kg/ha) + Si(500ppm)	172.80	11.5	147.16
4.	Zn(10kg/ha) + Si(200ppm)	176.26	11.1	140.32
5.	Zn(10kg/ha) + Si(350ppm)	181.72	11.2	156.04
6.	Zn(10kg/ha) + Si(500ppm)	185.56	11.8	175.31
7.	Zn(15kg/ha) + Si(200ppm)	178.38	11.5	151.30
8.	Zn(15kg/ha) + Si(350ppm)	184.56	11.6	166.77
9.	Zn(15kg/ha) + Si(500ppm)	187.78	12.0	181.62
10.	Control (120:60:40 NPK kg/ha)	166.21	9.5	131.71
	F- Test	S	S	S
	SEm (±)	1.47	0.37	2.13
	CD (p=0.05)	4.37	1.1	6.33

Table 2. Effect of zinc and foliar application of silicon levels on yield attributes on maize

S. No.	Treatments	No. of cobs per plant	Length of the cob (cm)	No. of rows per cob	No. of grains per cob	Test weight (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
1.	Zn(5kg/ha) + Si(200ppm)	1.13	12.37	10.61	216.33	213.83	6.14	9.21	39.32
2.	Zn(5kg/ha) + Si(350ppm)	1.10	12.87	12.08	223.97	216.33	6.46	9.46	39.60
3.	Zn(5kg/ha) + Si(500ppm)	1.10	13.30	12.72	241.03	216.77	6.54	9.60	39.91
4.	Zn(10kg/ha) + Si(200ppm)	1.10	12.53	14.01	217.10	210.57	6.35	9.48	39.40
5.	Zn(10kg/ha) + Si(350ppm)	1.30	14.33	14.07	271.43	223.33	6.62	10.64	40.02
6.	Zn(10kg/ha) + Si(500ppm)	1.50	15.30	14.43	311.86	237.30	7.55	11.26	39.77
7.	Zn(15kg/ha) + Si(200ppm)	1.27	13.70	14.50	259.68	220.50	6.84	10.09	40.48
8.	Zn(15kg/ha) + Si(350ppm)	1.30	14.57	14.76	288.79	230.17	7.33	10.90	39.82
9.	Zn(15kg/ha) + Si(500ppm)	1.63	15.43	14.82	317.54	241.96	7.92	11.34	40.92
10.	Control (120:60:40 NPK kg/ha)	1.03	11.70	10.44	203.34	207.57	5.56	8.82	38.71
	F – Test	S	S	S	S	S	S	S	NS
	SEm (±)	0.12	0.28	0.47	3.46	1.97	0.13	0.03	0.40
	CD (p= 0.05)	0.35	0.84	1.41	10.27	5.87	0.39	0.12	-

of Zn 15kg/ha +Si500ppm (7.92t/ha) significantly superior over all other and treatment with application of Zn 10kg/ha +Si500pppm (7.55t/ha) statistically at par with the application of Zn 15kg/ha+Si500ppm. maximum stover yield in t/ha was observed with application of Zn 15kg/ha +Si500ppm (11.34t/ha) significantly superior over all other and treatment with application of Zn 10kg /ha +Si500 ppm (11.26t/ha) statistically at par with the application of Zn 15kg /ha +Si500 ppm (Table 2). This might be because of silicon during seedling growth, silicon mediated the photosynthetic rate, root activities and nitrate reductase activity. improvement in maize yield may be due to increase in length of cobs and the weight of 1000 seed weight. Shahab et al. [25] found similar effect in grain yield.

4. CONCLUSION

On the basis of one season experimentation, it may be concluded that with the application of Zn 15kg/ha +Si500ppm was found more productive (7.92 t/ha) and economically viable. the conclusion is based on data from single season of research, so additional trails are required to confirm the findings. And one of the possible ways to enhance growth and seed yield of Maize.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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