Original Research Article

Influence of Zinc And Gibberellic Acid on Growth and Yield of Maize (Zea mays L.)

Abstract

A field experiment was carried out during *Kharif* season of 2022 on Maize crop at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, (U.P.). The treatments consisted of 3 levels of Zinc (Soil application 20kg/ha, Foliar application 0.5% and Soil application 10kg/ha + Foliar application 0.25%) and Gibberellic Acid (50, 100 and 150ppm) as foliar spray and a control. The experiment was laid out in Randomized Block Design (RBD) with 10 treatments and replicated thrice. The results revealed that application of Zinc Soil application (10kg/ha) + Foliar application (0.25%) and GA_3 at 150ppm produced higher Plant height (187.73 cm), more dry weight (184.05 g), maximum number of cobs per plant (1.60), maximum number of rows per cob (14.67), maximum number of grains per row (26.33), test weight (215.78 g), higher grain yield (6.76 t/ha), higher stover yield (13.80) higher harvest index (32.87%), maximum gross return (2,18,280.00 INR/ha), net return (1,49,997.00 INR/ha) and B:C ratio (2.20) .

Keywords: Maize, Zinc, Gibberellic Acid, Growth, Yield and Economics

INTRODUCTION:

Maize or corn (*Zea mays* L.) is the world's leading crop and is widely cultivated as cereal grain that was domesticated in Central America. It is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions.. The wider adaptability and high yield potential of maize and its utility as food, feed and forage crop signifies the importance of maize. The plant (*Zea mays* L.) is a monoic annual plant which belongs to maideas tribe and the grass family of *gramineae,* and their cells have 2n chromosomes. Among the maize growing countries, India rank 4th in area and 7th in production, representing around 4% of the world maize area and 2% of total production. Maize is the third most important crop after wheat and rice and is grown in more countries than any other crop in the world. Amongst the cereals, maize is a rich source of essential nutrients needed by both human beings and animals. Maize is a heat climate plant, aleven though in India, it's far grown in nearly all of the states representing 21 exceptional agro-ecological areas and in all of the 3 crop seasons- *Kharif* (June-October), *Rabi* (November-April) and *Zaid* (February- May) **National Academy of Agricultural Research Management (2013).**

The nutritional value of maize is high. Maize grain incorporates approximately 72% starch, 10% protein, 8.5% fibre, 4.8% oil, 3.0% sugar and 1.7% ash **(Hokmalipour *et al*. 2010**). Maize protein, "Zein" is rich in tryptophan and lysine, the two essential amino acids. Besides its use as meals and fodder, maize is now additionally gaining expanded significance as a result of its capability makes use of in the production of starch, plastic, rayon, textile, adhesives, dyes, resins, boot polish, syrups, ethanol, oil, proteins, alcoholic liquids, meals sweeteners, pharmaceutical, cosmetic, film, textile, gum, bundle and paper industries etc. As it's far a potential crop in India, it occupies essential area as meals (25%), fowl feed (49%) animal feed (12%), business merchandise usually starch (12%) and (1%) every in seeds and brewery, ethanol, oil, alcoholic liquids, meals sweeteners, pharma, cosmetics etc. (**Das *et al*. 2009).**

Maize has tremendous market potential not only in India but also in the international market. It has also enormous potential to provide food security, nutritional security and income to maize growers. Maize qualifies as potential crop for doubling farmer's income. By growing maize farmers save 90% of water, 70% of power compared to paddy.

Zinc is an essential element for higher plants, and its importance in agriculture is increasingly being recognized. Low zinc availability in soil is common worldwide, and zinc deficiency leads to reductions in crop. Maize is one of the crops most sensitive to zinc deficiency (**Mattiello *et al.* 2015**). Zinc deficiency has increased from 44% to 48%, and is expected to further increase up to 63% by 2025 in India. Zinc deficiency in maize is known as "White bud". Zinc is most crucial among the micronutrients that take part in plant growth and development due to its catalytic action in metabolism of almost all crops (**George *et al*. 2002**). Zinc play a key role in pollination and seed set processes; so that their deficiency can cause decrease in seed formation and subsequent yield reduction. Zinc is important in photosynthesis and respiration, and zinc deficiency decreases the photosynthetic rate, chlorophyll content, activity of carbonic anhydrase, and protein biosynthesis. Soil applied zinc is effective in enhancing the grain yield where as zinc concentration in grain improves via foliar spray of zinc fertilizer. Based on particular studies, (**Mortvedt *et al*. 1991**) is of the view that soil and foliar application of zinc enhances the yield of crops. Therefore application of zinc fertilizer may be an important measure for improving the yield and quality of maize. Zinc is now being reported as third most limiting nutrient elements in crop production after N and P.

PGR's are being used extensively in agriculture for the growth and development of various crops. Plant growth hormones so far have been emerged as "magic chemicals" that could increase agricultural production at an unprecedented rate and help in removing and circumventing many of the barriers imposed by genetics and environment. PGR in the form of foliar spray at the flowering stage helps in improving physiological efficiency along with crop productivity. Dwarfing depends upon gibberellins deficiency and dwarfing gene effects on gibberellins biosynthesis. So, by applying gibberellic acid on dwarf maize mutant, they showed normal growth after hormone treatment. In addition, long stems have more bioactive gibberellins than short stems (**Naghashzadeha *et al*. 2009**). Gibberellic acid increases the growth of root, shoot and number of leaves by altering the process of cell division and cell elongation, it improves the pigment content and reduces the Na+ concentration in shoots and roots as well as yield in various crops. In maize, GA_3 application caused a remarkable increase in total chlorophyll contents.

MATERIALS AND METHODS:

A field experiment was conducted during *kharif* season 2022 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj (U.P).The soil of the experimental field was sandy loam in texture, nearly neutral in soil reaction (pH 7.6), organic carbon level in medium condition (0.87%), medium available N (225 Kg/ha), high in available P (41.8 kg/ha) and medium available K (261.2 kg/ha). The treatment consisted of three levels of zinc viz. Soil application 20kg/ha, Foliar application 0.5% and Soil application (10kg/ha + Foliar application 0.25%) and Gibberellic Acid (50, 100 and 150ppm). The experiment was laid out in randomized block design with ten treatments, each were replicated thrice and was laid out with the different treatments allocated randomly in each replication. The treatment combinations are T_1-Soil application of Zinc (20kg/ha) + GA_3 50ppm, T_2 - Soil application of Zinc (20kg/ha) + GA_3 100ppm, T_3- Soil application of Zinc (20kg/ha) + GA_3 150ppm, T_4- Foliar application of Zinc (0.5%) + GA_3 50ppm, T_5- Foliar application of Zinc(0.5%) + GA_3 100ppm, T_6- Foliar application of Zinc (0.5%) + GA_3 150ppm, T_7- Soil application of Zinc (10kg/ha)+ Foliar (0.25%) + GA_3 50ppm, T_8- Soil application of Zinc (10kg/ha)+ Foliar (0.25%)+ GA_3 100ppm, T_9- Soil application of Zinc (10kg/ha)+ Foliar (0.25%)+ GA_3 150ppm, T_{10}- Control N:P:K 120:60:40 kg/ha. All agronomic practices are followed as per requirements and in order during the crop period. During the course of the experiment, random sampling technique was adopted for recording the observations on various morphological characters of the plant .The frequency of observations and the parameter on which the observations were taken are divided into pre – harvest (pertaining to growth attributes) and post-harvest (relating to yield attributes, quality parameter, soil parameter and economics) and was examined accordingly. Experimental data collected was subjected to statistical analysis by adopting Fisher's method of analysis of variance (ANOVA) as outlined by Gomez and Gomez (1984). Critical Difference (CD) values were calculated wherever the 'F' test was found significant at 5 percent level.

RESULTS AND DISCUSSION

Growth parameters

Plant height (cm)

At 100 DAS, the significantly higher plant height (187.73 cm) [Table 1] was recorded in treatment 9 with Soil application of Zinc (10 kg/ha)+ Foliar (0.25%) + GA_3 150ppm over all the other treatments. However, plant height in treatment 6 with Foliar application of zinc (0.5%) + GA_3 150ppm (186.06 cm), treatment 7 with Soil application of Zinc (10 kg/ha) + Foliar (0.25%) + GA_3 50ppm (186.45 cm) and treatment 8 with Soil application of Zinc (10 kg/ha)+ Foliar (0.25%) + GA_3 100ppm (187.50 cm) was found to be statistically at par with treatment 9. From the data, it is evident that the plant height at 40, 60, 80 and 100 DAS significantly increased due to increase in levels of zinc and change in methods of application of zinc from soil application and foliar application. Among the micronutrients, the combined application of zinc both as soil application and foliar spray significantly increased the plant height in all stages. Similar findings were reported by **Chand *et al*. (2017)**. The increase in plant height maybe the balanced application of zinc along with NPK fertilizer, as many researchers state that zinc is involved in a number of physiological processes of plant growth and metabolism.

Plant dry weight (g/plant)

At 100 DAS, the significantly higher dry weight (184.05 g/plant) [Table 1] was recorded in treatment 9 with Soil application of Zinc (10 kg/ha) + Foliar (0.25%) + GA_3 150ppm over all the other treatments. However, dry weight in treatment 8 with Soil application of Zinc (10 kg/ha)+ Foliar (0.25%) + GA_3 100ppm (181.97 g/plant) was found to be statistically at par with treatment 9. The increase in yield could be attributed to proper supply of Zn upto harvesting stages in soil which might have led to increased photosynthetic activity for longer period and their beneficial effect on metabolism of plants thereby finally increased dry matter accumulation. Similar findings were reported by **Singh *et al*. (2021)**. Further increase in dry weight with the application of gibberellic acid as GA_3 promotes cell proliferation in plant developmental stages due to their own metabolism regulation and promotes the development of cells by increasing turgour pressure and it also activates different enzymes and has a positive effect on plant growth and dry matter accumulation. The results were found in accordance with **Islam *et al*. (2014)**.

Yield parameters

No of cobs/plant

The data revealed that maximum number of cobs (1.60) [Table 2] was observed in treatment 9 with Soil application of Zinc (10 kg/ha) + Foliar (0.25%) + GA_3 150ppm. However treatment 6 with foliar application of zinc (0.5%) + GA_3 150ppm (1.40), treatment 7 with Soil application of Zinc (10 kg/ha) + Foliar (0.25%) + GA_3 50ppm (1.46) and treatment 8 with Soil application of Zinc (10 kg/ha)+ Foliar (0.25%) + GA_3 100ppm (1.53) was found to be statistically at par with treatment 9. The zinc application to maize is a factor affecting positively its yielding potential. The yield forming effect of this nutrient prevailed in early stages of maize growth resulting in high number of cobs/plant. Similar result has also been reported by **Humtsoe *et al*. (2018).**

No of rows/plant

The data revealed that the maximum Number of row /cob (14.67) [Table 2], was observed in treatment 9 with Soil application of Zinc (10 kg/ha) + Foliar (0.25%) + GA_3 150ppm. However treatment 8 with Soil application of Zinc 10 kg/ha+ Foliar (0.25%) + GA_3 100ppm (14.40) was found to be statistically at par with treatment 9. Number of grain rows per cob directly affects the number of grains per cob and ultimately grain yield of maize. The study showed that foliar application of zinc at anthesis produced the maximum number of grains per cob. The results are in accordance with **Ehsanullah *et al*. (2015).** Further the application of growth hormones at 4-5 leaf stage has mostly affected the strength of physiological sources so that improves yield attributes of plants such as number of rows/cob. Similar results have been reported by **Ghodrat *et al.* (2012)**

No of grains/row

The data revealed that maximum Number of grains/row (26.33) [Table 2], was observed in treatment 9 with Soil application of Zinc (10 kg/ha)+ foliar (0.25%) + GA_3 150ppm. However treatment 7 with Soil application of Zinc (10 kg/ha) + foliar (0.25%) + GA_3 50ppm (25.73) and treatment 8 with Soil application of Zinc (10 kg/ha) + foliar (0.25%) + GA_3 100ppm (26.06) was found to be statistically at par with treatment 9. The increment in Number of grains/row may be resulted due to due to application of Zinc was caused by higher chlorophyll contents, and this 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 attributes. Similar results have been reported by **Das *et al.* (2020).** The plant growth regulators also increase mobilization of reserve food materials to the developing sink through increases in hydrolyzing and oxidizing enzyme activities and lead to yield increases. Similar findings have been reported earlier by **Anjum *et al*. (2017)** and **Thuc *et al.* (2021).**

Test weight

The data revealed that the maximum Test Weight (215.78 g) [Table 2], was observed in treatment 9 with Soil application of Zinc (10 kg/ha) + Foliar (0.25%) + GA_3 150ppm. However treatment 8 Soil application of Zinc (10 kg/ha) + Foliar (0.25%) + GA_3 100ppm (215.21 g) was found to be statistically at par with treatment 9. The results exhibited that thousand grain weight was significantly affected by Zn application because Zn stimulates metabolic processes in seed. Increase in size of cob might have accommodated number of grains providing sufficient space for development of individual grain, leading to higher test weight resulting in higher grain weight /cob. These results are in line with the findings of **Shahab *et al.* (2016)** and **Kumar *et al*. (2019).**

Grain Yield

The data revealed that maximum Grain Yield (6.76 t/ha) [Table 2] was observed in treatment 9 with Soil application of Zinc (10 kg/ha) + Foliar (0.25%) + $GA_3$150ppm. However treatment 7 with Soil application of Zinc (10 kg/ha)+ Foliar (0.25%) + GA_3 50ppm (5.93) and treatment 8 with Soil application of Zinc (10 kg/ha)+ Foliar (0.25%) + $GA_3$100ppm (6.34 t/ha) was found to be statistically at par with treatment 9. The increase in grain yield maybe due to the adequate supply of Zn both as soil and foliar application during the various growth stages of the plant, which might have led to increased photosynthetic activity for longer period and their beneficial effect on metabolism of plants thereby, increasing dry- matter accumulation. The results are in conformity with **Shahab *et al*.(2016).** Further increase in the yield in response to the foliar application of GA_3 150ppm, might be due to the reduction in flower and fruit drop, increase in vegetative growth, fruit length and fruit thickness. Similar results have also been reported by **Singh *et al*. (2018)**

Stover yield

The data revealed that the maximum Stover Yield (13.80 t/ha) [Table 2] was observed in treatment 9 with Soil application of Zinc (10 kg/ha) + Foliar (0.25%) + GA_3 150ppm. However treatment 7 with Soil application of Zinc (10 kg/ha) + Foliar (0.25%) + GA_3 50ppm (12.92) and treatment 8 with Soil application of Zinc (10 kg/ha) + Foliar (0.25%) + GA_3 100ppm (13.45) was found to be statistically at par with treatment 9. The increase in stover yield might be due to application of plant growth regulators as it increase mobilization of reserve food materials to the developing sink through increases in hydrolyzing and oxidizing enzyme activities and lead to yield increases as well as stover yield. Similar results were obtained by **Ramesh *et al*.(2019).**

Harvest index (%)

The data revealed that the maximum harvest index (32.87%) [Table 2] was observed in treatment 9 with Soil application of Zinc (10 kg/ha)+ Foliar (0.25%) + GA_3 150ppm. However treatment 7 with Soil application of Zinc (10 kg/ha) + Foliar (0.25%) + GA_3 50ppm (31.45%) and treatment 8 with Soil application of Zinc (10 kg/ha) + Foliar (0.25%) + GA_3 100ppm (32.00%) was found to be statistically at par with treatment 9. The probable reasons for recording maximum growth and yield were recorded in treatment 9 with Soil application of Zinc (10 kg/ha) + Foliar (0.25%) + GA_3 150ppm, might be due to higher mineralization potential of Zinc + GA_3 enabling it to actively and quickly release its nutrients for plant uptake and use.

ECONOMICS

The result showed that [Table 3] maximum gross return (2,18,280.00 INR/ha), net return (1,49,997.00 INR/ha) and B:C ratio (2.20) was recorded in treatment 9 with Soil application of Zinc (10 kg/ha)+ Foliar (0.25%) + GA_3 150ppm. The probable reasons for recording maximum net returns (1,49,997.00 INR/ha) and maximum benefit cost ratio (2.20), might be due to the higher yields and net returns associated with the respective treatments.

CONCLUSION

In the light of the above study, it is concluded that the use of various levels of Zinc and GA_3 improved the growth, yield and economics of maize. Among the studied treatments, treatment 9 with Soil application of Zinc (10 kg/ha) + foliar (0.25%) + GA_3 150ppm was found to have profound effect on growth and yield resulting in higher growth parameters, yield attributes and economics. Since the findings are based on the research done in one season, the experiment may be repeated for confirmation.

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Table 1. Effect of zinc and gibberellic acid on growth parameters of Maize.

	Treatment combinations	At 100 DAS	
		Plant height (cm)	Dry weight (g/plant)
1.	Soil application of Zinc (20 kg/ha) + GA_3 50ppm	182.63	170.29
2.	Soil application of Zinc (20 kg/ha) + GA_3 100ppm	183.20	172.41
3.	Soil application of Zinc (20 kg/ha) + GA_3 150ppm	183.94	172.90
4.	Foliar application of Zinc (0.5%) + GA_3 50ppm	184.47	173.19
5.	Foliar application of Zinc (0.5%) + GA_3 100ppm	185.27	176.96
6.	Foliar application of Zinc (0.5%) + GA_3 150ppm	186.06	178.04
7.	Soil application of Zinc (10 kg/ha)+ Foliar(0.25%) + GA_3 50ppm	186.45	179.61
8.	Soil application of Zinc (10 kg/ha)+ Foliar (0.25%) + GA_3 100ppm	187.50	181.97
9.	Soil application of Zinc (10 kg/ha)+ Foliar (0.25%) + GA_3 150ppm	187.73	184.05
10.	Control N:P:K 120:60:40 kg/ha	173.86	165.42
	F test	S	S
	SEm(±)	1.13	1.42
	CD (p = 0.05)	2.34	2.93

Table 2: Effect of zinc and gibberellic acid on yield attributes and yield of Maize.

	Treatment combinations	Number of Cob/Plant	Number of rows / cob	Number of grains /row	Test Weight (g)	Grain Yield (t/ha)	Stover Yield (t/ha)	Harvest index (%)
1.	Soil application of Zinc (20 kg/ha) + GA_3 50ppm	1.20	12.4	22.56	205.32	3.63	9.52	27.60
2.	Soil application of Zinc (20 kg/ha) + GA_3 100ppm	1.26	12.67	22.86	208.1	3.96	10.06	28.21
3.	Soil application of Zinc (20 kg/ha) + GA_3 150ppm	1.33	12.93	23.32	206.88	4.36	10.82	28.72
4.	Foliar application of Zinc (0.5%) + GA_3 50ppm	1.26	13.07	24.36	209.16	4.39	11.56	27.60
5.	Foliar application of Zinc (0.5%) + GA_3 100ppm	1.37	13.2	24.86	211.03	4.90	11.83	29.25
6.	Foliar application of Zinc (0.5%) + GA_3 150ppm	1.40	13.47	25.26	212.52	5.33	12.10	30.05
7.	Soil application of Zinc (10 kg/ha)+ Foliar (0.25%) + GA_3 50ppm	1.46	14.00	25.73	213.26	5.93	12.92	31.45
8.	Soil application of Zinc (10 kg/ha)+ Foliar (0.25%) + GA_3 100ppm	1.53	14.40	26.06	215.21	6.34	13.45	32.00
9.	Soil application of Zinc (10 kg/ha)+ Foliar (0.25%) + GA_3 150ppm	1.60	14.67	26.33	215.78	6.76	13.80	32.87
10.	Control N:P:K 120:60:40	1.06	12.4	21.96	204.47	3.13	8.50	26.91

F- test	S	S	S	S	S	S	S
SEm±	0.09	0.23	0.48	0.96	0.57	0.64	0.77
C. D. (P = 0.05)	0.20	0.47	1.00	1.99	1.18	1.32	1.60

Table 3: Effect of zinc and gibberellic acid on economics of Maize.

Treatment combinations	Total cost of Cultivation (INR)	Gross return (INR/ha)	Net Return (INR/ha)	Benefit cost ratio (B:C)
1. Soil application of Zinc (20 kg/ha) + GA_3 50ppm	65,784.00	1,31,980.00	66,196.50	1.01
2. Soil application of Zinc (20 kg/ha) + GA_3 100ppm	67,034.00	1,41,700.00	74,666.50	1.11
3. Soil application of Zinc (20 kg/ha) + GA_3 150ppm	68,284.00	1,54,220.00	85,936.50	1.26
4. Foliar application of Zinc (0.5%) + GA_3 50ppm	65,609.00	1,59,940.00	94,331.50	1.44
5. Foliar application of Zinc (0.5%) + GA_3 100ppm	66,859.00	1,71,010.00	1.04,152.00	1.56
6. Foliar application of Zinc (0.5%) + GA_3 150ppm	68,109.00	1,80,640.00	1,12,532.00	1.65
7. Soil application of Zinc (10 kg/ha)+ Foliar (0.25%) + GA_3 50ppm	65,784.00	1,97,180.00	1,31,397.00	2.00
8. Soil application of Zinc (10 kg/ha)+ Foliar (0.25%) + GA_3 100ppm	67,034.00	2,08,270.00	1,41,237.00	2.11
9. Soil application of Zinc (10 kg/ha)+ Foliar (0.25%) + GA_3 150ppm	68,284.00	2,18,280.00	1,49,997.00	2.20
10. Control N:P:K 120:60:40 kg/ha	63,834.00	1,31,500.00	67,667.00	1.06