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AGRONOMY

Growth and Yield of Sweetcorn as Influenced by Zinc Fertilization

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ABSTRACT

In order to investigate the effect of zinc nutrition on growth, yield, and quality parameters of sweetcorn, a field experiment comprising of nine treatments with three replications was carried out in Randomised Block Design during *Kharif,* season 2020 on sandy clay soils of Agricultural College Farm, Bapatla. The analysis of variance showed a significant effect of zinc application on growth and yield parameters. The detailed results of the study showed that among the various zinc fortification treatments, RDF + Zn EDTA @ 10 kg ha^{-1} (Soil) + Nano ZnO @ 250 ppm at 20 & 40 DAS (Foliar spray) registered superior plant growth characters like plant height at harvest (214.4 cm) leaf area index at harvest (2.94) and dry matter accumulation at harvest (9903 kg ha^{-1}). The yield parameters like no. of seed rows per cob (16.84), no. of seeds per row (32.57), green cob yield (12,638 kg ha^{-1}), and green fodder yield (19,674 kg ha^{-1}) were maximum with RDF + Zn EDTA @ 10 kg ha^{-1} (Soil) + Nano ZnO @ 250 ppm at 20 & 40 DAS (Foliar spray) which was significantly superior over rest of the treatments whereas lower growth and yield was noticed with RDF alone.

HIGHLIGHTS

- Soil application of Zn EDTA (10 kg ha^{-1}) along with the two foliar sprays of nano zinc (250 ppm) at 20 and 40 DAS was found to be more effective in improving growth, yield attributes, cob yield of sweetcorn.

Keywords: Zn EDTA, Nano ZnO, sweetcorn, green cob yield, leaf area index

Maize also called corn, is the most important cereal grown worldwide, which belongs to the grass family Poaceae. It is commonly known as the `queen of cereals' because of its high yield potential and its wide range of uses among different agro-industries. Intensive agriculture involving modern technologies with the introduction of high-yielding sweetcorn and the repeated use of high analysis fertilizers has finally lead to a deficiency of micronutrients, particularly zinc (Alloway 2004; Rakshit *et al.* 2015). Half of our Indian soils are deficient in zinc, resulting in lower yields of major food crops (Cakmak 2009), further affecting livestock health. Apart from livestock, human beings who consume the food grown in these zinc-deficient soils also suffer from zinc malnutrition.

Zinc, with its prominent role in several physiological and enzymatic activities of the plant system, not only involves the conversion of carbohydrates, protein, and chlorophyll synthesis but also induces many catalytic functions of the plant (Wasim *et al.* 2016). Maize, with its sensitivity to zinc deficiency in the soil, results in disorder called "White bud" (El-Azab 2015), manifested as white parallel bands between the midrib and margin of leaves. In order to conquer this imperfection and meet crop zinc demands, zinc fertilization seems to be the viable

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option, and it improves the zinc content of the kernel.

Conventionally, though $ZnSO_4$ is the only reliable source, many other sources of zinc fertilizer are available now. Soils with high fixation and adsorption reactions, prefer chelating agents such as Ethylene diamine tetraacetic acid (EDTA), which increases the availability of zinc besides other trace elements in the soil solution. Chelated forms, metal ions remain inert and are easily available to plant. Similarly, zinc oxide nanoparticles also hold a promise as novel fertilizer nutrients for crops because they enhance productivity, nutrient use efficiency and impart tolerance to biotic as well as abiotic stresses, thus fortifying edible plant parts with zinc. An appropriate method of zn application also assumes significance for its efficient uptake and utilization. Keeping all these facts in view, the present trial was initiated to study the influence of zinc nutrition on the growth and yield of sweetcorn.

MATERIALS AND METHODS

The proposed research study was conducted at Agricultural College Farm, Agricultural College, Bapatla during *kharif*, 2020. The experiment was laid out according to randomized block design comprising of nine treatments and replicated thrice. The treatments comprised T_1: Control (RDF), T_2: RDF + $ZnSO_4$ @ 25 kg ha^{-1} (Soil application), T_3: RDF + $ZnSO_4$ @ 0.5 % foliar spray at 20 & 40 DAS, T_4: RDF + Zn EDTA @ 10 kg ha^{-1} (Soil application), T_5: RDF + Zn EDTA @ 0.5 % (Foliar spray) at 20 and 40 DAS, T_6: RDF + Nano ZnO @ 250 ppm at 20 & 40 DAS (Foliar spray), T_7: RDF + Nano ZnO @ 500 ppm at 20 & 40 DAS (Foliar spray), T_8: RDF + $ZnSO_4$ @ 25 kg ha^{-1} (Soil) + Nano ZnO @ 250 ppm at 20 & 40 DAS (Foliar spray) and T_9: RDF + Zn EDTA @ 10 kg ha^{-1} (Soil) + Nano ZnO @ 250 ppm at 20 & 40 DAS (Foliar spray).

The soil of the experimental site was sandy clay in texture, neutral in reaction, low in organic carbon, available zinc, and available nitrogen, medium in available phosphorus, and available potassium. Sweetcorn variety, Sugar-75 variety was taken with the spacing of 60 cm × 20 cm. The recommended dose of 180:60:50 NPK kg ha^{-1} was applied to all the treatments. The entire data recorded were subjected to statistical analysis using Fisher's method of analysis of variance as outlined by Panse and Sukhatme, 1985 for the design adopted in this study. Statistical significance was tested by applying F-test at 0.05 level of probability.

RESULTS AND DISCUSSION

1. Plant height

The plant height was significantly influenced by various zinc treatments at 60 DAS and at harvest but not at 30 DAS. Soil application of Zn EDTA @ 10 kg ha^{-1} (Soil) + Nano ZnO @ 250 ppm at 20 and 40 DAS (Foliar spray) along with RDF (T_9) gave significantly taller plants (181.7 cm and 214.4 cm) at 60 DAS and at harvest and RDF + $ZnSO_4$ @ 25 kg ha^{-1} (Soil) + NanoZnO @ 250 ppm at 20 and 40 DAS (Foliar spray) (T_8) and RDF + Nano ZnO @ 500 ppm at 20 and 40 DAS (Foliar spray) (T_7) remained at par. Improved plant height in T_9 might be due to enhance availability and absorption of zinc by sweetcorn. Zinc activates metabolic enzymes and speeds up cell division, thus aids in intermodal elongation. Also, foliar-applied nano ZnO directly contact on leaf surface area and more efficient ZnO nanoparticles absorbed easily through leaf and enhanced plant height (Iqbal *et al*. 2016; Satdev *et al*. 2020).

2. Leaf Area Index

Higher Leaf area index associated with the treatment that received RDF + Zn EDTA 10 kg ha^{-1} (Soil) + Nano ZnO @ 250 ppm at 20 and 40 DAS (Foliar spray) (T_9), and it was statistically on par with T_8 and T_7. It is obvious that the increase in LAI is ascribed to the reason that combined soil and foliar application of zinc resulted in increased nitrogen uptake and increased leaf area, which further increased leaf area index. In addition to this, Zn application also increases amino acid tryptophan and IAA, which are the two key components contributing to leaf area expansion (Nadergholi *et al*. 2011; Safyan *et al*. 2012; Iqbal *et al*. 2016; Shakoor *et al*. 2018).

3. Dry matter Production

Significantly the highest dry matter production was registered in T_9 treatment, recording 972, 5964, and 9903 kg ha^{-1} at 30, 60 DAS, and at harvest, respectively, and maintained parity with T_8 and T_7. Whereas, control treatment recorded the lowest *i.e.* 713, 4386 and 6439 kg ha^{-1} at 30, 60 DAS and

Table 1: Growth parameters of sweetcorn at different growth stages as influenced by zinc fertilization

Treatments	Plant height (cm)			Leaf area index			Drymatter production ($kg\ ha^{-1}$)		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
T_1: Control (RDF)	78.7	134.6	152.3	0.70	1.67	1.09	713	4,386	6,439
T_2: RDF + $ZnSO_4$ @ 25 kg ha^{-1} (Soil application)	84.2	161.2	185.7	0.85	2.51	2.26	959	5,200	8,544
T_3: RDF + $ZnSO_4$ @ 0.50% at 20 and 40 DAS (Foliar spray)	79.1	153.0	178.0	0.73	2.33	1.96	831	5,135	8,282
T_4: RDF + Zn EDTA @ 10 kg ha^{-1} (Soil application)	84.2	167.5	188.3	0.86	2.69	2.32	963	5,229	8,575
T_5: RDF + Zn EDTA @ 0.5% (Foliar spray) at 20 and 40 DAS	79.6	154.1	181.2	0.78	2.39	2.19	837	5,140	8,397
T_6: RDF + Nano ZnO @ 250 ppm at 20 and 40 DAS (Foliar spray)	81.6	155.7	183.7	0.79	2.40	2.24	855	5,180	8,521
T_7: RDF + Nano ZnO @ 500 ppm at 20 and 40 DAS (Foliar spray)	82.4	176.6	209.7	0.81	3.20	2.67	875	5,907	9,668
T_8: RDF + $ZnSO_4$ @ 25 kg ha^{-1} (Soil) + Nano ZnO @ 250 ppm at 20 and 40 DAS (Foliar spray)	88.0	179.1	211.0	0.87	3.13	2.83	966	5,931	9,867
T_8: RDF + Zn EDTA @ 10 kg ha^{-1} (Soil) + Nano ZnO @ 250 ppm at 20 and 40 DAS (Foliar spray)	86.1	181.7	214.4	0.91	3.30	2.94	972	5,964	9,903
S.Em ±	4.79	7.64	7.84	0.06	0.12	0.11	35.48	223.33	356.96
CD (P = 0.05)	NS	23.11	23.74	NS	0.38	0.33	107.39	675.89	1080.32
CV (%)	10.03	8.13	7.18	12.88	8.19	8.35	6.94	7.24	7.12

Table 2: Number of cobs $plant^{-1}$, Number of seed rows cob^{-1} and Number of seeds row^{-1} as influenced by zinc fertilization

Treatments	Number of cobs $plant^{-1}$	Number of seed rows cob^{-1}	Number of seeds row^{-1}
T_1: Control (RDF)	1.32	11.16	20.10
T_2: RDF + $ZnSO_4$ @ 25 kg ha^{-1} (Soil application)	1.74	13.98	25.81
T_3: RDF + $ZnSO_4$ @ 0.50% at 20 and 40 DAS (Foliar spray)	1.65	12.88	23.70
T_4: RDF + Zn EDTA @ 10 kg ha^{-1} (Soil application)	1.77	14.25	26.00
T_5: RDF + Zn EDTA @ 0.5% (Foliar spray) at 20 and 40 DAS	1.69	13.01	23.91
T_6: RDF + Nano ZnO @ 250 ppm at 20 and 40 DAS (Foliar spray)	1.70	13.92	25.62
T_7: RDF + Nano ZnO @ 500 ppm at 20 and 40 DAS (Foliar spray)	1.83	15.99	31.62
T_8: RDF + $ZnSO_4$ @ 25 kg ha^{-1} (Soil) + Nano ZnO @ 250 ppm at 20 and 40 DAS (Foliar spray)	1.86	16.48	32.07
T_8: RDF + Zn EDTA @ 10 kg ha^{-1} (Soil) + Nano ZnO @ 250 ppm at 20 and 40 DAS (Foliar spray)	1.88	16.84	32.57
S.Em ±	0.12	0.55	1.16
CD (P = 0.05)	NS	1.66	3.51
CV (%)	12.07	6.64	7.49

Table 3: Green cob yield (kg ha^{-1}), Green fodder yield (kg ha^{-1}) and harvest index of sweetcorn as influenced by zinc fertilization

Treatments	Green cob yield (kg ha^{-1})	Green fodder yield (kg ha^{-1})	Harvest index
T_1: Control (RDF)	8,009	14,388	35.75
T_2: RDF + $ZnSO_4$ @ 25 kg ha^{-1} (Soil application)	9,517	17,125	35.77
T_3: RDF + $ZnSO_4$ @ 0.50% at 20 and 40 DAS (Foliar spray)	9,306	16,573	36.01
T_4: RDF + Zn EDTA @ 10 kg ha $^{-1}$ (Soil application)	9,566	17,192	35.77
$T_{5:}$ RDF + Zn EDTA @ 0.5% (Foliar spray) at 20 and 40 DAS	9,313	16,590	36.06
T_6: RDF + Nano ZnO @ 250 ppm at 20 and 40 DAS (Foliar spray)	9,439	17,088	35.52
T_7: RDF + Nano ZnO @ 500 ppm at 20 and 40 DAS (Foliar spray)	12,017	19,498	38.13
T_8: RDF + $ZnSO_4$ @ 25 kg ha^{-1} (Soil) + Nano ZnO @ 250 ppm at 20 and 40 DAS (Foliar spray)	12,371	19,554	39.08
T_8: RDF + Zn EDTA @ 10 kg ha^{-1} (Soil) + Nano ZnO @ 250 ppm at 20 and 40 DAS (Foliar spray)	12,638	19,674	39.10
S.Em ±	421.96	715.93	1.65
CD (P = 0.05)	1277.03	2166.70	NS
CV (%)	7.14	7.08	7.75

at harvest respectively. This might be attributed due to the continuous availability of zinc from the soil and foliage and also due to the significant role of zinc in nitrogen metabolism, thus increasing aminoacid synthesis owing to improved growth and development. Further, it may be due to the synergism between N and zinc, and the latter improves nitrogen uptake and increased plant height and leaf area, which in turn results in increased assimilate production (Mohsin *et al*. 2014; Iqbal *et al*. 2016; Shakoor *et al*. 2018).

4. Yield attributes

The difference among treatments due to fortification of sweetcorn with zinc could not reach the level of significance with respect to a number of cobs plant^{-1}. This might be due to the fact that number of cobs per plant is a genetic trait of a specific variety that is less influenced by the micronutrient treatments and management practices (Anjum *et al*. 2017; Salomi *et al*. 2020). A numerically higher number of cobs per plant (1.88) were obtained in the treatment $T_{9,}$ and the lowest number of cobs per plant was obtained in (T_1) control (1.32).

Significantly the highest number of seed rows per cob (16.84) and seeds per row (32.57) were recorded in T_9 treatment, which was observed to be on a par with T_8 and T_7 treatments. Significantly the lowest number of seed rows per cob (11.16) and seeds per row (20.10) was observed in the control treatment. An increase in the number of seed rows per cob and seeds per row might be due to the role of Zn in photosynthesis, assimilation, and translocation of photosynthates from leaves to sink (Salakinkop *et al*. 2019; Innocent *et al*. 2018).

5. Yield

The green cob yield and green fodder yield of sweetcorn were significantly influenced by the different zinc fortification treatments. Amongst the various treatments tested, significantly the highest green cob yield (12,638 kg ha^{-1}), green fodder yield (19,674 kg ha^{-1}) was obtained with soil application of Zn EDTA @ 10 kg ha^{-1} + two foliar sprays of nano zinc @ 250 ppm at 20 & 40 DAS along with RDF which stood on a par with T_8 and T_7. The lowest green cob yield (8009 kg ha^{-1}) and green fodder yield (14,388 kg ha^{-1}) were noticed in the control treatment. There was a nonsignificant impact of treatments on the harvest index of the crop.

The improvement in green cob yield of sweetcorn might be due to the superior growth characters, yield attributes *i.e.,* number of cobs per plant, cob length, cob girth, cob weight, and 100-grain weight coupled with higher dry matter accumulation noticed in these treatments due to more availability and absorption of zinc by soil application along with foliar spray. Also, zinc may increase translocation of photosynthates from source to sink, ultimately leading to higher stover yield (Mona, 2015; Chand *et al*. 2017; Kumar and Salakinkop, 2018).

There was a non-significant impact of treatments on the harvest index, and all the treatments showed an equal effect on the harvest index of the crop.

CONCLUSION

Results of the study concluded that soil application of Zn EDTA @ 10 kg ha^{-1} + two foliar sprays of nano zinc @ 250 ppm at 20 & 40 DAS along with RDF gave higher growth parameters *viz*. plant height (214.4 cm), leaf area index (2.94), dry-matter accumulation (9903 kg ha^{-1}) and yield parameters *viz*. no. of seed rows per cob (16.84), no. of seeds per row (32.57), green cob yield (12,638 kg ha^{-1}) and green fodder yield (19,674 kg ha^{-1}).

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