EFFECT OF NANO ZINC ON GROWTH AND QUALITY OF SWEET CORN IN SOUTHERN TELANGANA ZONE, INDIA

ABSTRACT

A field experiment was conducted atCollege farm, College of Agriculture, Rajendranagar, Hyderabad during *rabi* season of 2022. The objective was to assess the impact of nano zinc on the growth, yield and quality of sweet corn in soils deficient in zinc.The experiment encompassed9 treatments with 3 forms of Zn fertilizer *viz*., $ZnSO_4$, Zn EDTA and Nano Zn. Findings of the study revealed that foliar application of Zn EDTA at 5 g L^{-1} recorded significantly highestvalues for growth, Zn uptake and quality parameters while basal application of $ZnSO_4$ at 25 kgha^{-1} was the next best treatment. Foliar application of Nano Zinc performed significantly superior over control; however, it was not comparable with the most effective treatment (T_9).

Key words: *chelate,nano fertilizer, sweet corn, zinc*

INTRODUCTION

Maize is the third mostimportantcereal cropafter riceandwheat inIndia. It is extensively grown in Karnataka, Telangana, Andhra Pradesh, Maharashtra, Bihar, Rajasthan and Madhya Pradesh.In India,maizeiscultivatedoveranareaof99.6lakh hawithanannual production of 33.72 Mt and average productivity of 3,387 kg ha^{-1}, while inTelanganaState; it is grown in 4.12 lakh ha with total production of 2.23 Mt andproductivity of 5,403 kg ha^{-1} (Indiastat, 2022). Sweet corn (*Zea mays* L.*saccharata*) is a specialty maize speciesthataccountsfor8and25%oftheworld'sareaandproductionrespectively. Sweet corn crops are harvested while their corn-ears have just attained themilky stage at 80- 90 DAS. Its kernels are tender and eaten as a vegetable in manycuisinesworldwide. Sugarcornfeaturesahigh-qualityphyto-nutritionprofilecomprisingofdietaryfiber,mineralsvitaminsandantioxidants.

Zinc is essential for several physiological and enzymatic activities of the plantsystem; it involves inconversionofcarbohydrates,proteinsandchlorophyllsynthesis and induces many catalytic functions. The crucial role played by the micronutrient makes its application and availability essential for the growth, yield and quality of produce in sweet corn.

Maize with its sensitivity to zinc deficiency in thesoil, results in disorder called "white bud" manifested as white parallel bands between themidribandmarginofleaves.The magnitude of

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zincdeficiency varies among soil types with reduction in crop yield and quality to the tune of25-30%.Soil applied zinc is fixed into different insoluble forms within a week of application. Hence the application of nano scale zinc fertilizer is expected to alleviate the micronutrient deficiency and improve use efficiency. Nano fertilizers have unique physicochemical properties and the potential to enhance ~~the~~ plant metabolism (Giraldo *et al*., 2014). They release the nutrients slowly that regulate the plant growth and boost the target activity (DeRosa*et al*., 2010). Therefore, the present study was conducted to investigate the efficacy of nano zinc on the growth and quality of sweet corn.

METHODOLOGY

The experiment was conducted in *rabi* season of 2022 on sandy clay loam soils at College farm, College of Agriculture, Rajendranagar, Professor JayashankarTelangana State Agricultural University, Hyderabad, India. The experimental site was located at 17° 19' 18" N latitude and 78° 24' 31" E longitude, within the Southern Telangana Agro Climatic Zone of Telangana State. The soil at the site was low in available nitrogen (168.3 kg N ha^{-1}), medium in phosphorus (48.7 kg P_2O_5 ha^{-1}) and high in potassium (495.7 kg K_2O ha^{-1}) and low in available zinc (0.49 mg kg^{-1}). Throughout the crop growth period, there was no rainfall and the mean weekly maximum and minimum temperatures were recorded as 29.6°C and 16.0°C, respectively. The experimental layout included nine zinc management practices, arranged in a randomized block design with three replications.

Table 1.Details of treatments included in the experiment

T_1	:	Control
T_2	:	100 % basal application of Zn
T_3	:	75% basal application of Zn + Foliar spray with Nano Zn at 2 ml L^{-1} (20 DAS)
T_4	:	50% basal application of Zn + Foliar spray with Nano Zn at 2 ml L^{-1} (45 DAS)
T_5	:	75% basal application of Zn + Foliar spray with Nano Zn at 3 ml L^{-1} (20 DAS)
T_6	:	50% basal application of Zn + Foliar spray with Nano Zn at 3 ml L^{-1} (45 DAS)
T_7	:	75% basal application of Zn + Foliar spray with Nano Zn at 4 ml L^{-1} (20 DAS)
T_8	:	50% basal application of Zn + Foliar spray with Nano Zn at 4 ml L^{-1} (45 DAS)
T_9	:	Zn EDTA spray at 5g L^{-1} (20 and 45 DAS)
Note	–	100 % basal application of Zn indicates 25 kg ha^{-1} $ZnSO_4$

In this research, nano Zinc was administered using Nano-Zinc (liquid) produced by Indian Farmers Fertilizer Cooperative Limited (IFFCO). According to the manufacturer's claim, the

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nano zinc liquid contains 1% of Zn and was applied by spraying at a rate of 2- 4 ml per litreof water. Other sources of Zn were Zinc sulphate (36% Zn) and Zn EDTA chelate (12% Zn). Urea, single superphosphate (SSP) and muriate of potash (MOP) were applied to the soil as sources of nitrogen (N), phosphorus (P) and potassium (K), respectively. The complete dose of P was applied during sowing, while N and K were applied in three split doses at different phenophases of the crop.

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From each plot, five plants were selected randomly in the net plot periodical observations on growth characters were recorded while, leaf area and dry matter production were recorded using plants selected from the border rows.

Crude protein (%): The 1g of oven dried and ground kernel was digestedin Kelplus digestion unit and 10 ml distilled water was added to it which was used for distillation. Nitrogen evolved as ammonia was collected in a receiver containing boric acid (2%) solution and mixed indicator (Bromocresol green and methyl red). It was titrated against standard (0.02N) H_2SO_4 in an automatic titration unit to get crude protein percentage.

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Total Soluble Solids(%): 1 or 2 drops of sweetcorn kernel sap were placed onto the refractometer and the Total Soluble Solids (TSS) values displayed were recorded as TSS %.

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Zinc uptake (mg kg^{-1}): Plant samples collected and dried were digested in di-acid mixture *i.e.*, HNO_3: $HClO_4$ in the proportion of 3:1. The di-acid digested plant samples were analyses for Zinc content using Inductively Coupled Plasma Optical Emission Spectroscopy method at the wavelength of 213.857 nm and the results were expressed in mg kg^{-1} (Lindsay and Norvell, 1978).The data obtained from various parameters under study was analyzed by the method of analysis of variance (ANOVA) as given by Gomez and Gomez (1984).

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RESULTS AND DISCUSSION

Table 2. Plant height (cm) of sweet corn as influenced by foliar application of Nano Zinc

TREATMENT	Plant height (cm)			
	30 DAS	**45 DAS**	**60 DAS**	**Harvest**
T_1 : Control	43.7	74.4	96.8	142.4
T_2 : 100 % basal application of Zn	**56.1**	**94.7**	**135.2**	**189.2**
T_3 : 75% basal application of Zn + Foliar spray with Nano Zn at 2 ml L^{-1} (20 DAS)	49.9	84.5	115.9	162.8
T_4 : 50% basal application of Zn + Foliar spray with Nano Zn at 2 ml L^{-1} (45 DAS)	48.4	83.3	113.4	158.2

T_5 : 75% basal application of Zn + Foliar spray with Nano Zn at 3 ml L^{-1} (20 DAS)	50.5	85.1	118.3	165.7
T_6 : 50% basal application of Zn + Foliar spray with Nano Zn at 3 ml L^{-1} (45 DAS)	49.3	82.6	117.7	159.4
T_7 : 75% basal application of Zn + Foliar spray with Nano Zn at 4 ml L^{-1} (20 DAS)	55.2	93.5	131.8	183.6
T_8 : 50% basal application of Zn + Foliar spray with Nano Zn at 4 ml L^{-1} (45 DAS)	50.8	83.1	124.5	175.2
T_9 : Zn EDTA spray at 5g L^{-1} (20 and 45 DAS)	**60.9**	**104.0**	**150.7**	**205.2**
S Em (±)	1.5	2.2	3.5	4.9
CD (5%)	4.5	7.4	10.6	14.8

Table 3.Number of leaves plant^{-1}of sweet corn as influenced by foliar application of Nano Zinc

TREATMENT	Number of leaves plant^{-1}			
	30 DAS	45 DAS	60 DAS	Harvest
T_1 : Control	4.5	8.0	10.1	4.5
T_2 : 100 % basal application of Zn	**5.4**	**9.8**	**11.3**	**5.4**
T_3 : 75% basal application of Zn + Foliar spray with Nano Zn at 2 ml L^{-1} (20 DAS)	4.5	8.1	10.2	4.5
T_4 : 50% basal application of Zn + Foliar spray with Nano Zn at 2 ml L^{-1} (45 DAS)	4.5	8.0	10.3	4.5
T_5 : 75% basal application of Zn + Foliar spray with Nano Zn at 3 ml L^{-1} (20 DAS)	4.5	8.2	10.1	4.5
T_6 : 50% basal application of Zn + Foliar spray with Nano Zn at 3 ml L^{-1} (45 DAS)	4.6	8.1	10.1	4.6
T_7 : 75% basal application of Zn + Foliar spray with Nano Zn at 4 ml L^{-1} (20 DAS)	5.0	8.9	10.3	5.0
T_8 : 50% basal application of Zn + Foliar spray with Nano Zn at 4 ml L^{-1} (45 DAS)	4.9	8.9	10.2	4.9
T_9 : Zn EDTA spray at 5g L^{-1} (20 and 45 DAS)	**5.6**	**9.9**	**12.1**	**5.6**
S Em (±)	0.4	0.7	0.7	0.4
CD (5%)	NS	NS	NS	NS

Table 4. Dry matter production (kg ha^{-1}) of sweet corn as influenced by foliar application of Nano Zinc

TREATMENT	Dry matter production (kg ha^{-1})			
	30 DAS	45 DAS	60 DAS	Harvest
T_1 : Control	216	3462	6012	7234
T_2 : 100 % basal application of Zn	**320**	**4876**	**8143**	**9651**

T_3 : 75% basal application of Zn + Foliar spray with Nano Zn at 2 ml L^{-1} (20 DAS)	259	4031	6851	8127
T_4 : 50% basal application of Zn + Foliar spray with Nano Zn at 2 ml L^{-1} (45 DAS)	246	3913	6665	7998
T_5 : 75% basal application of Zn + Foliar spray with Nano Zn at 3 ml L^{-1} (20 DAS)	263	4114	6925	8196
T_6 : 50% basal application of Zn + Foliar spray with Nano Zn at 3 ml L^{-1} (45 DAS)	247	3923	6723	8043
T_7 : 75% basal application of Zn + Foliar spray with Nano Zn at 4 ml L^{-1} (20 DAS)	294	4540	7591	8962
T_8 : 50% basal application of Zn + Foliar spray with Nano Zn at 4 ml L^{-1} (45 DAS)	269	3907	7196	8642
T_9 : Zn EDTA spray at 5g L^{-1} (20 and 45 DAS)	**351**	**5312**	**8812**	**10403**
S Em (±)	10	142	213	249
CD (5%)	29	427	639	746

Table 5. Leaf area plant^{-1} (cm^2) of sweet corn as influenced by foliar application of Nano Zinc

TREATMENT	Leaf area plant^{-1} (cm^2)			
	30 DAS	**45 DAS**	**60 DAS**	**Harvest**
T_1 : Control	2147	3648	4031	4400
T_2 : 100 % basal application of Zn	**2956**	**4789**	**5458**	**5536**
T_3 : 75% basal application of Zn + Foliar spray with Nano Zn at 2 ml L^{-1} (20 DAS)	2481	4186	4632	4965
T_4 : 50% basal application of Zn + Foliar spray with Nano Zn at 2 ml L^{-1} (45 DAS)	2373	4053	4453	4858
T_5 : 75% basal application of Zn + Foliar spray with Nano Zn at 3 ml L^{-1} (20 DAS)	2428	4215	4696	5023
T_6 : 50% basal application of Zn + Foliar spray with Nano Zn at 3 ml L^{-1} (45 DAS)	2400	4105	4519	4910
T_7 : 75% basal application of Zn + Foliar spray with Nano Zn at 4 ml L^{-1} (20 DAS)	2708	4597	5142	5489
T_8 : 50% basal application of Zn + Foliar spray with Nano Zn at 4 ml L^{-1} (45 DAS)	2687	4350	4986	5238
T_9 : Zn EDTA spray at 5g L^{-1} (20 and 45 DAS)	**3204**	**5202**	**5924**	**6046**
S Em (±)	74	124	139	149
CD (5%)	220	373	417	447

Growth parameters *viz.*, plant height (Table 2), leaf area (Table 3) and dry matter production (Table 4) were significantly influenced with $ZnSO_4$, Zn EDTA and NanoZn management treatments.Highest values for the parameters were recorded with Zn EDTA spray at 5g L^{-1}(20 and 45 DAS) (T_9) followed by 100 % basal application of Zn (T_2) which was on par with 75% basal application of Zn + Foliar spray with Nano Zn at 4 ml L^{-1} (20 DAS) (T_7). Control manifested least values for the parameters. While, number of leaves $plant^{-1}$ was not significantly impacted with the treatments (Table 5).

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Zinc fertilizer has a positive effect on auxin biosynthesis which stimulates cell division and better absorption of other minerals, thus promotes internodal elongation and plant growth (El-Tohamy and El-Greadly, 2007; Cakmak, 2000). Significantly superior performance of Zn chelate foliar application over other treatments may beattributed toenhancedabsorption rate as the organic molecules in chelates facilitate easierpassage of zinc through ~~the~~ cell membranes.The findings from this study align with those of Darwish *et al.* (2002), Mahdi *et al.* (2012), Rana *et al.* (2013)and Lone *et al.* (2022).

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Satdev*et al.* (2020), Azam*et al.* (2022) andSamui *et al.* (2022) reported significantly higher plant height in plants treated with nano fertilizers. However, results obtained in the present investigation are contrary to these findings which might be attributed to lower concentration of Zn (1% Zn) in the product (Kumar *et al.*,2021) leading to inadequate supply to the plant.

Table 6. Zinc uptake of sweet corn as influenced byfoliar application of Nano Zinc

TREATMENT	Zinc uptake (mg kg^{-1})			
	30 DAS	**45 DAS**	**60 DAS**	**Harvest**
T_1 : Control	14.23	14.31	14.38	14.42
T_2 : 100 % basal application of Zn	**17.49**	**18.2**	**18.45**	**18.62**
T_3 : 75% basal application of Zn + Foliar spray with Nano Zn at 2 ml L^{-1} (20 DAS)	16.33	16.48	16.56	16.59
T_4 : 50% basal application of Zn + Foliar spray with Nano Zn at 2 ml L^{-1} (45 DAS)	15.76	15.83	16.33	16.47
T_5 : 75% basal application of Zn + Foliar spray with Nano Zn at 3 ml L^{-1} (20 DAS)	16.64	16.76	16.81	16.86
T_6 : 50% basal application of Zn + Foliar spray with Nano Zn at 3 ml L^{-1} (45 DAS)	15.72	15.8	16.51	16.63
T_7 : 75% basal application of Zn + Foliar spray with Nano Zn at 4 ml L^{-1} (20 DAS)	17.02	17.13	17.21	17.24
T_8 : 50% basal application of Zn + Foliar spray with Nano Zn at 4 ml L^{-1} (45 DAS)	15.73	15.81	16.84	16.91
T_9 : Zn EDTA spray at 5g L^{-1} (20 and 45 DAS)	**18.98**	**19.65**	**20.05**	**20.33**
S Em (±)	0.47	0.48	0.52	0.56

CD (5%)	1.4	1.43	1.56	1.69

Zn uptakewas recorded highest with T_9 (Zn EDTA spray at 5g L^{-1} at 20 and 45 DAS) while the next superior treatment was 100 % basal application of Zn (T_2). T_2 was recorded to be on par with 75% basal application of Zn + Foliar spray with Nano Zn at 4 ml L^{-1} (20 DAS) (T_7).

Foliar applications minimizenutrient interactions, ensuring better zinc uptake and utilization.The relatively lesser absorption of zinc in plants treated with nano zinc could be linked to the insufficient zinc concentration in the product as mentioned earlier (1% Zn), as well as the adequate supply of micronutrient from zinc sulphate (36%) and Zn EDTA (12%).The results are in consonance with Apoorva *et al*. (2017) and Goud *et al*. (2022).

Table 7. Quality parameters of sweet corn as influencedby foliar application of Nano Zinc

TREATMENT	TSS (%)	Crude protein (%)
T_1 : Control	10.5	7.2
T_2 : 100 % basal application of Zn	**13.4**	**9.7**
T_3 : 75% basal application of Zn + Foliar spray with Nano Zn at 2 ml L^{-1} (20 DAS)	11.9	8.4
T_4 : 50% basal application of Zn + Foliar spray with Nano Zn at 2 ml L^{-1} (45 DAS)	11.7	8.0
T_5 : 75% basal application of Zn + Foliar spray with Nano Zn at 3 ml L^{-1} (20 DAS)	12.0	8.6
T_6 : 50% basal application of Zn + Foliar spray with Nano Zn at 3 ml L^{-1} (45 DAS)	11.8	8.1
T_7 : 75% basal application of Zn + Foliar spray with Nano Zn at 4 ml L^{-1} (20 DAS)	13.2	9.4
T_8 : 50% basal application of Zn + Foliar spray with Nano Zn at 4 ml L^{-1} (45 DAS)	12.2	8.7
T_9 : Zn EDTA spray at 5g L^{-1} (20 and 45 DAS)	**14.8**	**10.5**
S Em (±)	0.4	0.3
CD (5%)	1.1	0.8

Zinc plays critical role in various physiological processes like enzyme activity, protein synthesis and carbohydrate metabolism, thereby manifestingsignificant influence on crude protein percent and TSS percent of sweetcorn. Hence,quality parameters exhibit a pattern similar to that of Zinc uptake.

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CONCLUSION

Significantly highest plant growth, Zn uptakeand quality parameters were recorded with Zn EDTA spray at 5g L^{-1} (20 and 45 DAS) (T_9). The Nano Zinc foliar application resulted in significantly higher values over control,however, the increase was not comparablewith the values registered in the most effective treatment. Nano Zinc can be recommended for emergency corrections when standard chelate products are unavailable.

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