International Journal of Plant & Soil Science

Volume 35, Issue 23, Page 117-123, 2023; Article no.IJPSS. 107060
ISSN: 2320-7035

Effect of Nano Zinc on Growth and Quality of Sweet Corn in Southern Telangana Zone, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2023/v35i234223

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/107060

Original Research Article

Received: 10/08/2023
Accepted: 14/10/2023
Published: 16/12/2023

ABSTRACT

The field experiment was conducted at the College farm, College of Agriculture, Rajendranagar, Hyderabad during *rabi* season of 2022 with an objective to assess the impact of nano zinc on the growth, yield and quality of sweet corn in Zinc deficient soil. The experiment included 9 treatments with three forms of Zn fertilizer *viz*., $ZnSO_4$, Zn EDTA and Nano Zn. The results of the study revealed that foliar application of Zn EDTA at 5 g L^{-1} recorded significantly highest values for growth, Zn uptake and quality parameters while soil application of $ZnSO_4$ at 25 kg ha^{-1} was the second best treatment. Foliar application of Nano Zinc was significantly superior to the control; however, it was not comparable to the most effective treatment (T_9).

Keywords: Chelate; nano fertilizer; sweet corn; zinc.

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1. INTRODUCTION

Maize is the third most important cereal crop after rice and wheat in India. It is extensively grown in Karnataka, Telangana, Andhra Pradesh, Maharashtra, Bihar, Rajasthan and Madhya Pradesh. In India, maize is grown on an area of 99.6 lakh ha and has an annual production of 33.72 Mt and average productivity of 3,387 kg ha^{-1}, while in Telangana State; it is grown in 4.12 lakh ha with total production of 2.23 Mt and productivity of 5,403 kg ha^{-1} [1]. Sweet corn (*Zea mays* L. *saccharata*) is a specialty maize species that accounts for 8 and 25% of the world's area and production respectively. Sweet corn crops are harvested while the corn ears are just reaching the milky stage at 80- 90 DAS. Its kernels are tender and eaten as a vegetable in many cuisines worldwide. Sugar corn features a high- quality phyto-nutrition profile consisting of dietary fiber, minerals vitamins and antioxidants.

Zinc is essential for many physiological and enzymatic activities of the plant system; it involves the conversion of carbohydrates, proteins and chlorophyll synthesis and induces many catalytic functions. The crucial role played by the micronutrient makes their application and availability essential for the growth, yield and quality of produce in sweet corn.

Maize due to its sensitivity to zinc deficiency in the soil, causes in disorder called "white bud" which appears as parallel white lines between the midrib and margin of leaves. The magnitude of zinc deficiency varies between soil types with reduction in crop productivity and quality to the tune of 25-30%. Zinc applied to the soil is stabilized in various insoluble forms within a week of application. Therefore, the application of nano scale zinc fertilizer is expected to alleviate the micronutrient deficiency and improve utilization efficiency. Nano fertilizers have unique physicochemical properties and the potential to enhance plant metabolism Giraldo et al. [2]. They slowly release nutrients that regulate the plant growth and enhance the target activity DeRosa et al. [3]. Therefore, the present study was conducted to investigate the efficacy of nano zinc on the growth and quality of sweet corn.

2. MATERIALS AND METHODS

The experiment was conducted in *rabi* season of 2022 on sandy clay loam soils at College farm, College of Agriculture, Rajendranagar, Professor Jayashankar Telangana 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.

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 nano zinc liquid contains 1% of Zn and was applied by spraying at a rate of 2- 4 ml per litre of 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.

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 digested in 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.

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 %.

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 [4].

3. RESULTS AND DISCUSSION

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 Nano Zn management treatments. The highest values of 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 showed the lowest values for the parameters. While, The number of leaves $plant^{-1}$ was not significantly affected by the treatments (Table 5).

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 [5]; Cakmak [6]. Significantly superior performance of Zn chelate foliar application over other treatments can be attributed to the enhanced of the absorption rate as the organic molecules in chelates facilitate easier the passage of zinc through cell membranes. The findings from this study align with those of Darwish et al. [7]; Mahdi et al. [8]; Rana et al. [9]; Lone et al. [10].

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} $ZnSO_4$

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

Satdev et al. [11]; Azam et al. [12]; Samui et al. [13] 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. [14] leading to inadequate supply to the plant.

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

The highest Zn uptake was recorded 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 reduce nutrient interactions, ensuring better zinc uptake and utilization. The relatively lower uptake of zinc in plants treated with nano zinc can 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. [15]; Goud et al. [16].

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

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

Table 6. Zinc uptake of sweet corn as influenced by foliar 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

Table 7. Quality parameters of sweet corn as influenced by 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

4. CONCLUSION

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

ACKNOWLEDGEMENT

I extend my sincere thanks to members of the advisory committee for their constant support and guidance. All the authorities, staff of college farm and PJTSAU administration who helped and provided an opportunity to undertake the experiment are deeply acknowledged.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/107060