Response of zinc and nano urea on growth and yield of maize (*Zea mays L.*)

ABSTRACT

In Prayagraj, Uttar Pradesh, at the Crop Research Farm of the Naini Agriculture Institute of the Sam Higginbottom University of Agriculture, Technology, and Sciences, Department of Agronomy, during the Kharif season of 2022, the field experiment titled "Response of zinc and nano urea on growth and yield of maize (Zea mays L.)" was carried out. The results showed that the application of Zinc 30 kg/ha + Nano urea 4 ml/l considerably increased the growth parameters viz. plant height (195.01 cm), dry weight (90.62 g), number of grains per cob (476.79), cob length (21.2 cm), grain yield (4.33 t/ha), and storage yield (6.65 t/ha).

Keyword: Maize, zinc, nano urea, growth, yield

1. INTRODUCTION

“The most extensively grown crop in the world is maize, which provides enough calories and protein for more than a billion people worldwide. Because it has the largest genetic yield potential among the cereals, maize is referred to as the "Queen of Cereals". Following rice and wheat, it is the third most popular cereal in India. The phrase "to sustain life" refers to the provision of nutrients for both people and animals globally by the crop known as maize. It is grown all around the world and is grown all through the year in all the seasons. Maize has a high nutritional value because to its 72% starch, 10% protein, 8.5% fibre, 4.8% oil, 3.0% sugar, and 1.7% ash content. In comparison to other cereals like rice, wheat, etc., maize produces a higher yield. In India, it is a significant staple food that is also grown for fodder. Aside from gluten, cooking oil, and starch, maize also yields starch. Grain alcohol can be made by fermenting and distilling maize starch, which has been hydrolyzed and enzyme-treated to generate syrups, particularly high-fructose corn syrup, a sweetener” [1].

“There are 197 million hectares of maize worldwide, with a production of 1210 million tonnes in 2021. After rice and wheat, maize is the third-most significant food crop in India. With an output of 31.51 million tonnes and an average productivity of 3195 kg/ha, it is cultivated on an area of roughly 9.86 million hectares, making it the fifth greatest producer in the world and accounting for 3% of total global production. With a production of 1.80 million tonnes and an area of roughly 0.77 million hectares, Uttar Pradesh provides 7.98% to the total area of India"[2]**.**

In Indian soil zinc shortage issue. Zinc helps to make auxin, activates a number of enzymes, and increases meristematic activity. The majority of this crop's nutrition study has concentrated on major components, whereas micronutrients still receive little attention despite being just as important. The fields of nanoscience and nanotechnology represent a new frontier for the scientific community. Nano fertiliser offers promises for enhancing agricultural productivity by addressing problems that cannot be remedied naturally by using the smallest feasible particles. Nutrients are lost when fertilisers are applied directly to soil through a number of processes, such as photolysis, hydrolysis, leaching, and degradation. In order to promote the best growth and production of crops, it's likely that the applied fertiliser won't be able to reach the intended spots in the plant's system. To increase the efficiency of applied fertiliser in the form of nano fertiliser, an effort was made to spray foliar fertiliser onto the crop" [3].

"Zinc plays a very important role in plant metabolism by influencing the activities of hydrogenase and carbonic anhydrase and stabilization of ribosomal proteins. Zn has a noticeable impact on key plant functions like photosynthesis and defence against reactive oxygen species. Carbonic anhydrase activity, chlorophyll synthesis, nitrogen metabolism, and resilience to biotic and abiotic stressors. One of the crops most vulnerable to a Zn deficit is maize. A vitamin called zinc raises grain productivity in the growing of maize. Zn can be provided to crops directly on the soil, as fertilizers, through foliar fertilization, or through seed treatments. The study's main goal was to determine how applying zing to the soil and the leaves of maize affected its development and yield" [4].

"Around 30-40 per cent of nitrogen from urea is utilized by plants and the rest gets wasted due to quick chemical transformation as a result of leaching, volatilization, denitrification and run off, thereby low use efficiency. While nano urea is both environmentally friendly and has a high nitrogen utilisation efficiency. Because it lessens the emission of nitrous oxide, which is mostly to blame for polluting soil, air, and water bodies as well as contributing to global warming, this fertilizer is referred to as "smart fertilizer" in the popular culture. The greatest substitute for urea fertilizer right now is liquid nano fertilizer. One 500 ml bottle of nano urea is equal to 45 kg of urea fertilizer, which is 10% less than a bag of regular urea. It might reduce urea fertilizer imports. One nano urea liquid particle has a diameter of 30 nano meters and a surface area to volume ratio that is 10,000 times greater than that of regular granular urea. In comparison to conventional urea, foliar application of nano urea liquid at crucial crop growth stages of a plant effectively satisfies its nitrogen requirement and results in greater crop productivity and quality [5]. Due to these characteristics, it offers a possible substitute for traditional urea. In an agricultural eco-system, microorganisms are essential for fixing, solubilizing, mobilizing, and recycling both macro and micronutrients. Although they are present in soil naturally, their population is typically too low to achieve the appropriate degree of nutrient mobilization [6]. Keeping the above aspects in view, the present investigation entitled "Effect of different levels of zinc and nano urea application on growth and yield of Maize (*Zea mays L.*)".

1. MATERIAL AND METHODS

"The experiment was conducted during the *Kharif* season 2022, at the Crop Research Farm (CRF), Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) which is located at 25° 39' 42"N latitude, 81° 67 56" E longitude, and 98 m altitude above the mean sea level (MSL). The experiment was laid out in Randomised Block Design with ten treatments which are replicated thrice with three levels of application of Zinc 20, 25, 30 kg/ha and three levels of foliar application of Nano Urea 2, 3, 4ml/l and control. Treatment combinations are T1: Zinc (20kg/ha) + Nano Urea (2ml/l), T2: Zinc (20kg/ha) + Nano Urea (3ml/l), T3: Zinc (20kg/ha) + Nano Urea (4ml/l), T4: Zinc (25kg/ha) + Nano Urea (2ml/l), T5: Zinc (25kg/ha) + Nano

Urea (3ml/l), T6: Zinc (25kg/ha) + Nano Urea (4ml/l), T7: Zinc (30kg/ha) + Nano Urea (2ml/l), T8: Zinc (30kg/ha) + Nano Urea (3ml/l), T9: Zinc (30kg/ha) + Nano Urea (4ml/l), T10: Control (RDF 120-60-40 Kg/ha NPK) are used. The soil in the experimental area was sandy loam with pH (8.0), organic carbon (0.42%), available N (180.58 kg/ha), available P (15.54 kg/ha), and available K (198.67 kg/ha). Seeds are sown at a spacing of 60*25 cm to a seed rate of 25 kg/ha. The recommended dose of nitrogen (20 kg/ha), phosphorus (30 kg/ha) and potassium (60 kg/ha) were applied as basal dose just before sowing and Zinc and Nano urea (Foliar spray at 35 and 55 DAS) were applied as per the treatments. Data recorded on different aspects of crop, viz., growth, yield attributes were subjected to statistically analysed by analysis of variance method [7].

3. RESULT AND DISCUSSION

3.1 GROWTH ATTRIBUTES

3.1.1 Plant height(cm)

The data revealed that significant and higher plant height (195.01cm) was observed in treatment 9 (Zinc 30 kg/ha + 4ml/l Nano Urea). However, treatment 8(30 kg/ha Zinc + 3ml/l Nano Urea), was found to be statistically at par with treatment 9 (30 kg/ha Zinc + 4ml/l Nano Urea) in (table 1). Significant and higher plant height was observed with application of Nano urea (4 ml/l) might be due to increasing dose of nano urea increase cell division, cell metabolism and growth of cells. Similar results was reported by Singh et al. [8]. Additional evidence of significantly higher plant height was seen with the application of zinc (30 kg/ha).

This increase in plant height may be attributable to zinc, which is an activator of plant nutrients and is crucial for the growth and metabolism of microorganisms. Zinc is also present in the enzyme system as a co-factor and a mental activator of many enzymes. Similar findings was “Zinc plays a very important role in plant metabolism by influencing the activities of hydrogenase and carbonic anhydrase and stabilization of ribosomal proteins. Zn has a noticeable impact on key plant functions like photosynthesis and defense against reactive oxygen species. Carbonic anhydrase activity, chlorophyll synthesis, nitrogen metabolism, and resilience to biotic and abiotic stressors. One of the crops most vulnerable to a Zn deficit is maize. A vitamin called zinc raises grain productivity in the growing of maize. Zn can be provided to crops directly on the soil, as fertilizers, through foliar fertilization, or through seed treatments. The study's main goal was to determine how applying zing to the soil and the leaves of maize affected its development and yield’’ [4].

“Around 30-40 per cent of nitrogen from urea is utilized by plants and the rest gets wasted due to quick chemical transformation as a result of leaching, volatilization, denitrification and run off, thereby low use efficiency. While nano urea is both environmentally friendly and has a high nitrogen utilisation efficiency. Because it lessens the emission of nitrous oxide, which is mostly to blame for polluting soil, air, and water bodies as well as contributing to global warming, this fertilizer is referred to as "smart fertilizer" in the popular culture. The greatest substitute for urea fertilizer right now is liquid nano fertilizer. One 500 ml bottle of nano urea is equal to 45 kg of urea fertilizer, which is 10% less than a bag of regular urea. It might reduce urea fertilizer imports. One nano urea liquid particle has a diameter of 30 nano metres and a surface area to volume ratio that is 10,000 times greater than that of regular granular urea. In comparison to conventional urea, foliar application of nano urea liquid at crucial crop growth stages of a plant effectively satisfies its nitrogen requirement and results in greater crop productivity and quality [5]. Due to these characteristics, it offers a possible substitute for traditional urea. In an agricultural eco-system, microorganisms are essential for fixing, solubilizing, mobilizing, and recycling both macro and micronutrients. Although they are present in soil naturally, their population is typically too low to achieve the appropriate degree of nutrient mobilization [6]. Keeping the above aspects in view, the present investigation entitled “Effect of different levels of zinc and nano urea application on growth and yield of Maize (*Zea mays L.*)”. as also reported by Vankatakrishnan et al. [9].

3.1.2 Plant Dry weight (g)

The data revealed that significantly higher plant dry weight (90.62 g) was observed in treatment 9 (Zinc 30kg/ha + Nano Urea 4ml/l). However, treatment 8 (Zinc 30kg/ha + Nano Urea 3ml/l) was found to be statistically at par with treatment 9 (Zinc 30kg/ha + Nano Urea 4ml/l) in (Table 1). Zinc (30 kg/ha) application significantly increased plant dry weight, which may be related to the micronutrient's ability to activate the synthesis of tryptophan and a precursor to IAA, which in turn stimulates plant growth and the accumulation of biomass. In addition, because ferredoxin and electron transport are linked to chloroplasts, which accelerate photosynthesis for better vegetative growth, higher ph values were also observed. Similarly, findings were also reported by Singh et al. [10].

3.2 YIELD ATTRIBUTES

3.2.1 Number of grains/cobs

The findings (table 2) showed that the largest number of grain/cob (476.79) was significantly recorded in treatment 9 (Zinc 30 kg/ha + Nano Urea 4 ml/l). However, treatment 8 (Zinc 30 kg/ha + Nano Urea 3 ml/l) and treatment 6 (Zinc 25 kg/ha + Nano Urea 4 ml/l) were shown to be statistically comparable with treatment 9 (Zinc 30 kg/ha + Nano Urea 4 ml/l). With the application of zinc (30kg/ha), a significant and greater number of grains/cob were produced. This might be explained by the improved physiological processes in crop plants that result in higher growth and more photosynthesized silk. Kumar et al. [11] reported similar results.

3.2.2 Length of cob (cm)

The data revealed that in treatment 9 (Zinc 30 kg/ha + Nano Urea 4 ml/l) recorded significant highest length of cob (21.1 cm). However, treatment 8 (Zinc 30 kg/ha + Nano Urea 3 ml/l) and treatment 6 (Zinc 25 kg/ha + Nano Urea 4 ml/l) was found to be statistically at par with treatment 9(Zinc 30kg/ha + Nano Urea 4ml/l) in (table 2). Significant and higher length of cob was observed with the application of Zinc(30kg/ha) might be due to higher chlorophyll contents and photosynthetic activity, synthesis of metabolites and regulate growth substances oxidation and metabolic activities. These similar findings were reported by Meena et al. [12].

3.2.3 Seed Index (g)

The test weight did not show any significant difference among treatments imposed because seed are almost similar in size and morphology. which tends to exhibit similar weight. There was no discernible difference amongst the treatments, but treatment 7 [Zinc (30 kg/ha) +

Nano urea (3 ml/l)] had the numerically highest test weight (23.89). Similar results were reported by Sahu et al. [13].

3.2.4 Grain yield (t/ha)

The data revealed that in treatment 9 (Zinc 30 kg/ha + Nano Urea 4 ml/l) recorded significant highest number of grain yield (4.33 t/ha). However, treatment 8(Zinc 30 kg/ha + Nano Urea 3 ml/l), treatment 6 (Zinc 25 kg/ha + Nano Urea 4 ml/l) was found to be statistically at par with treatment 9(Zinc 30kg/ha + Nano Urea 4ml/l) in (table 2). Zinc (30 kg/ha) application significantly increased grain yield, which may be attributable to Zinc improvement of plant physiology, correction of various enzyme efficiency issues, chlorophyll content, IA hormone, and possibly improved nitrate to ammonia conversion in plants. Firdous et al. [14] reported similar results. Additionally, enhanced grain production with nano urea (4ml/1) treatment may be attributed to improved plant development and metabolic processes including photosynthesis, which results in higher photosynthates accumulation and translocation to the economically valuable sections of the plant. Similar results in rice were reported by Kumar et al. [15].

3.2.5 Stover yield (t/ha)

The data revealed that in treatment 9 (Zinc 30 kg/ha + Nano Urea 4 ml/l) recorded significant highest stover yield (6.65 t/ha). However, treatment 8(Zinc 30 kg/ha + Nano Urea 3 ml/l), treatment 6 (Zinc 25 kg/ha + Nano Urea 4 ml/l) was found to be statistically at par with treatment 9(Zinc 30kg/ha + Nano Urea 4ml/l) in (table 2). Zinc (30 kg/ha) application resulted in a significant and higher stover yield, which may be attributed to its crucial role in the biosynthesis of IAA and the initiation of primordial for reproductive parts. These processes created favourable conditions for metabolic reactions within the plants and stimulated the efficient translocation of assimilates towards sinks, which in turn increased the stover yield. Akhila et al. [16]. observed a similar outcome for sorghum. Additionally, higher stover yield was attained with the application of Nano Urea (4ml/I). This could be attributed to the nano fertilizer's quick uptake by the plant and ease of nutrient translocation, which may have improved photosynthesis rates and increased dry matter accumulation, leading to higher stover yield. Sahu et al. [5] reported a similar outcome.

4.CONCLUSION

It can be concluded that in maize with the application of Zinc 30 kg/ha along with the Nano urea 4ml/l. was observed highest grain yield andbenefit cost ratio.

ACKNOWLEGEMENT

The authors are thankful to Department of Agronomy, Naini Agricultural Institute, SHUATS Prayagraj (U.P.) India for providing necessary facilities to undertaken the studies.

REFERENCES

1. Rathore, R, Hasan, A, David, A A, Thomas, T and Reddy, I S. Effect of different levels of nano urea and conventional fertilizer on soil health of maize (Zea mays L.) Var, P3544 in an Inceptisols of Prayagraj, (UP) India. Pharma Innovation. 2022;11(8):560-563.
2. GOI. Agricultural Statistics at a Glance: Ministry of Agriculture, Government of India, New Delhi, 2021.
3. Kumar Y, Tiwari KN, Singh T. Sain NK, Laxmi S and Verma R. Nano fertilizers for enhancing nutrient use efficiency, crop productivity and economic returns in winter season crops of Rajasthan. Annals of Plant and Soil Research. 2020; 22(4):324-335.
4. Kumar, M, Singh, S, Singh, V, Singh, K and Khanna, R. Effect of zinc and boron on growth and yield of maize (Zea mays L.). Progressive Research-An International Journal. 2019; *14*(3), 215-221.
5. Sahu, T K, Kumar, M, Kumar, N, Chandrakar, T and Singh, D P. Effect of nano urea application on growth and productivity of rice (Oryza sativa L.) under mid land situation of Bastar region. Pharma Innovation. 2022; *11*, 185-87.
6. Kannoj, J, Jain, D, Tomar, M, Patidar, R and Choudhary, R. Effect of Nano Urea vs Conventional Urea on the Nutrient Content, Uptake and Economics of Black Wheat (Triticum aestivum L.) along with Biofertilizers. Biological Forum – An International Journal, 2022; 14(2a): 499-504.
7. Gomez, K A and Gomez, A A Statistical procedures for Agricultural Research, 2nd Edition, John Wiley and Sons, New York, 680p. 1976.
8. Singh, B and Singh, A. Response of Kharif Maize (Zea mays L.) to Planting Methods and Nitrogen Management Approach by Leaf Colour Chart. Journal of Krishi Vigyan. 2019; 7(2):206.
9. Vankatakrishnan S S, Sudlayandy R S and Savarianppan A R. Assessing in vitro solubilization potential of different zinc solubilizing Bacteria (ZSB) isolates. Brazilian Journal of Microbiology. 2003; 34: 121-125.

10. Singh, S, Singh, V, & Mishra, P. Effect of NPK, boron and zinc on productivity and profitability of late sown kharif maize (Zea mays L.) in western Uttar Pradesh, India. Annals of Agricultural New Series. 2017; *38*(3), 310-313.
11. Kumar Y, Tiwari KN, Singh T, Sain NK, Laxmi S and Verma R. Nano fertilizers for enhancing nutrient use efficiency, crop productivity and economic returns in winter season crops of Rajasthan. Annals of Plant and Soil Research. 2020;22(4):324-335.
12. Meena SK, Mundra SL, Singh P. Response of maize (Zea mays) to nitrogen and zinc fertilization. Indian Journal of Agronomy. 2013; 58(1):127-128.
13. Sahu, T K, Kumar, M, Kumar, N, Chandrakar, T and Singh, D P. Effect of nano urea application on growth and productivity of rice (Oryza sativa L.) under mid land situation of Bastar region. Pharma Innovation. 2022; *11*, 185-87.
14. Firdous, S, Agarwal, B K, & Chhabra, V. Zinc-fertilization effects on wheat yield and yield components. Journal of Pharmacognosy and Phytochemistry. 2018; *7*(2), 3497-3499.
15. Kumar Y, Tiwari KN, Singh T, Sain NK, Laxmi S and Verma R. Nano fertilizers for enhancing nutrient use efficiency, crop productivity and economic returns in winter season crops of Rajasthan. Annals of Plant and Soil Research. 2020;22(4):324-335.
16. Akhila, M, Navya, P P, & Dawson, J. Effect of zinc and iron on growth and yield of sorghum (Sorghum bicolor L.). Journal of Pharmacognosy and Phytochemistry. 2021; *10*(2), 1292-1295.

Table 1. Effect of Different Levels of Zinc and Foliar Application of Nano urea on Dry Weight (g) of Maize.

S.no.	Treatment combinations	Plant height (cm)	Plant dry weight (g)
1.	Zinc 20kg/ha + Nano urea 2ml/l	177.88	79.67
2.	Zinc 20kg/ha + Nano urea 3ml/l	181.65	84.03
3.	Zinc 20kg/ha + Nano urea 4ml/l	177.98	81.59
4.	Zinc 25kg/ha + Nano urea 2ml/l	186.61	84.88
5.	Zinc 25kg/ha + Nano urea 3ml/l	189.63	87.25
6.	Zinc 25kg/ha + Nano urea 4ml/l	178.07	82.40
7.	Zinc 30kg/ha + Nano urea 2ml/l	186.93	85.66
8.	Zinc 30kg/ha + Nano urea 3ml/l	193.96	88.65
9.	Zinc 30kg/ha + Nano urea 4ml/l	195.01	90.62
10.	Control (120:60:40 NPK kg/ha)	163.08	77.47
	F test	S	S
	SEm(±)	7.64	2.46
	CD (p=0.05)	16.05	7.33

Table 2. Effect of different levels of zinc and foliar application of nano urea on yield attributes of maize.

S.No.	Treatment combination	No. of cob/ plant	No. of grains /cob	Length of Cob (cm)	Seed Index (g)	Grain Yield (t/ha)	Stover yield (t/ha)	Harvest Index (%)
1.	Zinc 20kg/ha + Nano urea 2ml/l	1.7	348.82	16.2	21.50	3.18	6.13	34.13
2.	Zinc 20kg/ha + Nano urea 3ml/l	1.7	367.94	16.4	21.61	3.19	6.18	33.60
3.	Zinc 20kg/ha + Nano urea 4ml/l	1.8	377.49	17.5	21.75	3.20	6.20	34.01
4.	Zinc 25kg/ha + Nano urea 2ml/l	1.8	409.76	17.6	22.28	3.24	6.21	34.24
5.	Zinc 25kg/ha + Nano urea 3ml/l	1.9	423.23	18.0	22.65	3.39	6.46	34.17
6.	Zinc 25kg/ha + Nano urea 4ml/l	2.0	443.25	19.0	23.16	3.54	6.49	35.20
7.	Zinc 30kg/ha + Nano urea 2ml/l	1.8	422.40	17.9	22.29	3.27	6.35	34.00
8.	Zinc 30kg/ha + Nano urea 3ml/l	2.2	443.95	20.6	23.89	4.18	6.51	39.00
9.	Zinc 30kg/ha + Nano urea 4ml/l	1.9	476.79	21.2	25.03	4.33	6.65	39.41
10.	Control (RDF 120:60:40 NPK kg/ha)	1.7	338.66	14.3	19.78	3.16	5.96	34.69
	F test	NS	S	S	NS	S	S	NS
	SEm (±)	0.11	11.67	0.49	1.006	0.26	0.12	1.94
	CD (p=0.05)	-	34.69	1.45	-	0.78	0.38	-