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Response of zinc and nano urea application on growth, yield and economics of Maize. (*Zea mays* L.)

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Abstract
The experiment was carried out during *kharif* season, 2022 at CRF, Department of Agronomy, SHUATS, Prayagraj, Uttar Pradesh. The experiment was laid out in Randomised Block Design with ten treatments which are replicated thrice. Result revealed that significant and maximum plant height (195.01cm) at 80 DAS, grain yield (4.33 tha^{-1}) and B:C ratio (2.61) was found with the use of Zinc 30 kg ha^{-1} + Nano urea 4 ml l^{-1} whereas CGR (0.0662 g m^{-2} day^{-1}), RGR (0.0130 g $g^{-1}day^{-1}$) at 60-80 DAS, number of cob/plant (2.2), seed index (25.03)at 40-60 DAS was obtained by the application of zinc 30 kg ha^{-1} along with Nano urea 4 ml^{-1} was found Non-significant.

Keywords: Maize, zinc, nano urea, CGR, RGR, yield

Introduction

The term "Queen of Cereals" refers to maize since it has the highest genetic yield potential of all the cereals. It comes in third place among cereals in India, after rice and wheat. The phrase "to sustain life" alludes to the production of maize, which gives humans and other animals access to essential nutrients. It is grown all over the world and is farmed year-round in all four seasons. The nutritional value of maize is high as it contains 72% starch, 10% protein, 8.5% fiber, 4.8% oil, 3.0% sugar and 1.7% ash. It can only be harvested three times a year, during the Kharif, Rabi, and summer seasons. While maize is often planted as a standalone crop, in rare cases it may be used as an intercrop with other crops like sugar cane, cotton, vegetables, legumes, etc.

The starch in maize can be hydrolysed and enzymatically treated to produce syrups, particularly high fructose corn syrup, a sweetener and also as fermented and distilled to produce grain alcohol. (Rathore *et al*. 2022) [7]. One of the most crucial micronutrients for numerous crop plants, including rice, maize, wheat, and soybean, all of which are grown commercially all over the world, is zinc. Additionally, zinc serves as an enzyme's metal activator and catalyses the manufacture of indole acetic acid. It also aids in the synthesis of nucleic acids and proteins and encourages the development of seeds, all of which increase crop output. Nitrogen metabolism and photosynthesis are both slowed down by its absence. The supply of Zn in the crops can be done directly on the soil, as fertilizers, via foliar fertilization or seed treatments. The overall objective of the study was to assess the effect of zing as soil and foliar application on the growth and yield of maize. (Kumar *et al*. 2019) [6].

In India, urea accounts for over 82 percent of all fertiliser use, while globally, it accounts for roughly 55 percent of all nitrogen fertiliser use. Leaching, volatilization, denitrification, and runoff cause the remaining 30–40% of urea's nitrogen to be squandered due to its fast-chemical change, which results in low utilisation efficiency. Whereas, nano urea has high nitrogen use efficiency and also it is environment friendly. This fertiliser is frequently referred to as "smart fertiliser" since it lowers the emission of nitrous oxide, which is mostly to blame for polluting soil, air, and water bodies and also contributes to lowering global warming. 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 compared to traditional urea, foliar application of nano urea liquid during crucial crop growth phases of a plant effectively satisfies its nitrogen need and increases crop yield and quality. (Sahu *et al*. 2022) [8].

These properties make it a promising alternative over conventional urea, Micro-organism plays a vital role in fixing, solubilizing, mobilizing, recycling of macro and micro nutrients in an agricultural eco- system. Although, they are occurring naturally in soil but their population is generally insufficient to bring about the desired level of nutrient mobilization.

(Kanoj *et al*. 2022) [4]. Keeping the above aspects in view, the present investigation entitled "Response of zinc and nano urea application on growth, yield and economics of maize (*Zea mays L.*)" was undertaken with the following objectives:

Materials and Methods

At the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P.), which is situated at 25° 39' 42"N latitude, 81° 67 56"E longitude, and 98 m height above the mean sea level (MSL), the experiment was carried out during the Kharif season 2022. The soil of the experimental plot was loamy sand in texture, slightly alkaline with pH 8.0, EC 0.56 dS/m, organic carbon (0.62%) and available nitrogen (225 kg N/ha), phosphorus (38.2 kg /ha) and potassium (287 kg/ha). The experiment comprised of total ten treatment combinations in which three levels of Zinc (20, 25 and 30 kg S/ha) and three levels of nano urea (2, 3 and 4 ml/l) with three replications of a Randomised Block Design layout. At the time of seeding, maize received the necessary amount of fertiliser (120:60:40 kg NPK/ha). Using a 60 cm x 15 cm spacing and a 25 kg/ha seed rate, the variety of maize was sown in the final week of July. The Gomez and Gomez (1984) [2] statistical approach was used to compute and assess the data.

Table 1: Treatment combinations

Treatment no.	Treatment combinations
T_1	Zinc 20 kg ha^{-1} + Nano urea 2 ml l^{-1}
T_2	Zinc 20 kg ha^{-1} + Nano urea 3 ml l^{-1}
T_3	Zinc 20 kg ha^{-1} + Nano urea 4 ml l^{-1}
T_4	Zinc 25 kg ha^{-1} + Nano urea 2 ml l^{-1}
T_5	Zinc 25 kg ha^{-1} + Nano urea 3 ml l^{-1}
T_6	Zinc 25 kg ha^{-1} + Nano urea 4 ml l^{-1}
T_7	Zinc 30 kg ha^{-1} + Nano urea 2 ml l^{-1}
T_8	Zinc 30 kg ha^{-1} + Nano urea 3 ml l^{-1}
T_9	Zinc 30 kg ha^{-1} + Nano urea 4 ml l^{-1}
T_{10}	Control

Results and Discussions

Plant height (cm)

The data resulted that there was an increase in plant height. At 80DAS, significantly higher grain yield (70.08 g) was observed in T_9 (Zinc 30 kg ha^{-1} + Nano urea 4 ml l^{-1}). However, T_8 (Zinc 40 kg ha^{-1} + Nano urea 3 ml l^{-1}), T_7 (Sulphur 30 kg ha^{-1} + Nano urea 2 ml l^{-1}), T_5 [Zinc (25 kg ha^{-1}) + Nano urea 3 ml l^{-1}), T_4 [Zinc (25 kg ha^{-1}) + Nano urea (2 ml l^{-1}), was found to be statistically at par with T_9 (Zinc 25 kg ha^{-1} + Nano urea 4 ml l^{-1}). It might be due to zinc role as an essential component of several enzymes, involvement in nitrogen metabolism, cellular proteins, and nucleic acid synthesis, along with its encouragement of crop meristematic activities and increased uptake of all nutrients, may account for the increased plant height caused by the application of zinc. This improved plant growth led to higher chlorophyll contents, the maximum number of leaves, and dry matter accumulation/plant, which in turn helped in better plant growth to increase in chlorophyll contents, maximum number of leaves, reported by Abhiram *et al.* (2014) [1]. Further, increasing dose of nano urea increase cell division, cell metabolism and growth of cells. Similar results was reported by Singh *et al*. (2019) [9].

Crop growth rate (g/m 2/day): At 60-80 DAS, the highest CGR was obtained in T_8 (Zinc 30 kg ha^{-1} + Nano urea 3ml l^{-1}) i.e., 6.66 g m^{-2} day^{-1} which was 20% higher than the lowest CGR though it was non-significant. At 40-60 DAS, the highest crop growth rate was obtained in T_8 (Zinc 30 kg ha^{-1} + Nano urea 3 ml l^{-1}) i.e., 16.81 g/m^{-2}/day and lowest CGR was obtained in T_3 (Zinc 20 kg ha^{-1} + Nano urea 4 ml l^{-1}) though it was non-significant. At 20-40 DAS, the highest CGR was obtained in T_8 (Zinc 30 kg ha^{-1} + Nano urea 3 ml l^{-1}) i.e.,5.80 g m-2 day^{-1} which was 18.7% higher than the lowest CGR though it was non-significant among the treatments.

It might be due to foliar application of micronutrients, which increased dry matter production, to increase in chlorophyll contents, the maximum number of leaves, and dry matter accumulation/plant. This resulted in activation of various physiological processes, including stomatal regulation, chlorophyll formation, enzyme activation, and biochemical processes. It was resulted by Kumar *et al.* (2019) [6].

Relative growth rate (g/g/day)

At 60-80 DAS, highest RGR was obtained in T_6 (Zinc 25 kg ha^{-1} + Nano urea 4 ml l^{-1}) i.e., 0.013 g g^{-1}day^{-1} which was 16% higher than the lowest RGR though it was non-significant. At 40-60 DAS, the highest relative growth rate was obtained in T_1 (Zinc 20 kg ha^{-1} + Nano urea 2 ml l^{-1}) i.e., 0.0662 g g^{-1}day^{-1} and lowest RGR was obtained in T_3 (Zinc 20 kg ha^{-1} + Nano urea 4 ml l^{-1}) though it was non-significant. At 20-40 DAS, the highest RGR was obtained in T_3 (Zinc 20 kg ha^{-1} + Nano urea 4 ml l^{-1}) i.e., 0.120 g/g/day which was 23% higher than the lowest RGR though it was non-significant among the treatments.

Number of cob/plants

Highest number of cob/plant (2.2) was recorded in treatment 8 (Zinc 30 kg ha^{-1} + Nano urea 3 ml l^{-1}) and lowest number of cob/plant (1.7) was observed in T_1 (Zinc 20 kg ha^{-1} + Nano urea 2 ml l^{-1}) though there was no significant difference among the treatments.

Seed index (g)

At harvest, highest seed index (23.89) was recorded in T_7 [Zinc (30 kg ha^{-1}) + Nano urea (3 ml l^{-1}) and lowest was observed. It was non-significant among the treatments.

Grain yield (t/ha)

Significant and maximum grain yield (4.33 t ha^{-1}) were observed in T_9 (Zinc 30 kg ha^{-1} + Nano Urea 4 ml l^{-1}). However, T_8 (Zinc 30 kg ha^{-1} + Nano Urea 3 ml l^{-1}), T_6 (Zinc 25kg ha^{-1} + Nano Urea 4 ml l^{-1}), was found to be statistically at par with T_9 (Zinc 30 kg ha^{-1} + Nano Urea 4 ml l^{-1}).

Zinc availability may have increased meristematic cell activity and cell elongation, which in turn improved vegetative growth and eventually helped produce more dry matter. This improved dry matter production was further reflected in yield-attributing characteristics, and as a result, the yield of the crop under the current treatment was significantly higher. Similar result was reported by Imsong *et al.* (2022) [3]. Further, increasing growth of plant parts and metabolic process such as photosynthesis which leads to higher photosynthates accumulation and translocation to the economic parts of the plant. The similar findings were reported by Kumar *et al*. (2020) [5] in rice.

Benefit cost ratio

Higher B:C ratio (2.14) was found in Zinc 30 kg ha^{-1} and Nano Urea 4 ml l^{-1} i.e., Treatment 9. It might be due to higher grain and strove yield which resulted in increases the gross return, ultimately increases the benefit ratio. Similar result was recorded by Singh *et al*. (2021) [10].

Table 1: Response of zinc and nano urea on Crop Growth Rate (g m^{-2} day^{-1}) at different interval of maize

S. N.	Treatment Combinations	Crop Growth Rate (g m^{-2} day^{-1})		
		20-40 DAS	40-60 DAS	60-80 DAS
1.	Zinc 20 kg ha^{-1} + Nano urea 2 ml l^{-1}	4.96	15.38	5.59
2.	Zinc 20 kg ha^{-1} + Nano urea 3 ml l^{-1}	5.62	15.54	6.24
3.	Zinc 20 kg ha^{-1} + Nano urea 4 ml l^{-1}	5.52	14.99	6.09
4.	Zinc 25 kg ha^{-1} + Nano urea 2 ml l^{-1}	5.63	15.96	6.05
5.	Zinc 25 kg ha^{-1} + Nano urea 3 ml l^{-1}	5.78	16.38	6.19
6.	Zinc 25 kg ha^{-1} + Nano urea 4 ml l^{-1}	5.36	15.01	6.34
7.	Zinc 30 kg ha^{-1} + Nano urea 2 ml l^{-1}	5.48	16.44	5.77
8.	Zinc 30 kg ha^{-1} + Nano urea 3 ml l^{-1}	5.80	16.60	6.31
9.	Zinc 30 kg ha^{-1} + Nano urea 4 ml l^{-1}	5.67	16.81	6.66
10.	Control	4.71	14.91	5.40
	F test	NS	NS	NS
	S. Em(±)	0.22	0.78	0.55
	C.D. (P=0.05)	-	-	-

Table 2: Response of zinc and nano urea on Relative Growth Rate (g g^{-1}day^{-1}) at different interval of maize

S. N.	Treatment Combinations	Relative Growth Rate(g g^{-1} day^{-1})		
		20-40 DAS	40-60 DAS	60-80 DAS
1.	Zinc 20 kg ha^{-1} + Nano urea 2 ml l^{-1}	0.110	0.0662	0.0118
2.	Zinc 20 kg ha^{-1} + Nano urea 3 ml l^{-1}	0.117	0.0625	0.0126
3.	Zinc 20 kg ha^{-1} + Nano urea 4 ml l^{-1}	0.120	0.0620	0.0126
4.	Zinc 25 kg ha^{-1} + Nano urea 2 ml l^{-1}	0.114	0.0631	0.0121
5.	Zinc 25 kg ha^{-1} + Nano urea 3 ml l^{-1}	0.110	0.0627	0.0120
6.	Zinc 25 kg ha^{-1} + Nano urea 4 ml l^{-1}	0.107	0.0621	0.0130
7.	Zinc 30 kg ha^{-1} + Nano urea 2 ml l^{-1}	0.100	0.0638	0.0113
8.	Zinc 30 kg ha^{-1} + Nano urea 3 ml l^{-1}	0.106	0.0623	0.0122
9.	Zinc 30 kg ha^{-1} + Nano urea 4 ml l^{-1}	0.092	0.0625	0.0124
10.	Control	0.097	0.0656	0.0117
	F test	NS	NS	NS
	S.Em(±)	0.0072	0.0025	0.00107
	C.D. (P=0.05)	-	-	-

Table 3: Response of zinc and nano urea on growth and yield attributes of maize.

S. N.	Treatment combinations	Plant height (cm)	No. of cob/plant	Seed index (g)	Seed index (g)
1.	Zinc 20 kg ha^{-1} + Nano urea 2 ml l^{-1}	177.88	1.7	21.50	21.50
2.	Zinc 20 kg ha^{-1} + Nano urea 3 ml l^{-1}	181.65	1.7	21.61	21.61
3.	Zinc 20 kg ha^{-1} + Nano urea 4 ml l^{-1}	177.98	1.8	21.75	21.75
4.	Zinc 25 kg ha^{-1} + Nano urea 2 ml l^{-1}	186.61	1.8	22.28	22.28
5.	Zinc 25 kg ha^{-1} + Nano urea 3 ml l^{-1}	189.63	1.9	22.65	22.65
6.	Zinc 25 kg ha^{-1} + Nano urea 4 ml l^{-1}	178.07	2.0	23.16	23.16
7.	Zinc 30 kg ha^{-1} + Nano urea 2 ml l^{-1}	186.93	1.8	22.29	22.29
8.	Zinc 30 kg ha^{-1} + Nano urea 3 ml l^{-1}	193.96	2.2	23.89	23.89
9.	Zinc 30 kg ha^{-1} + Nano urea 4 ml l^{-1}	195.01	1.9	25.03	25.03
10.	Control	163.08	1.7	19.78	19.78
	F test	S	NS	NS	NS
	S.Em(±)	7.64	0.11	1.006	1.006
	C.D. (P=0.05)	16.05	-	-	-

Table 4: Response of zinc and nano urea on economics of maize

S. N.	Treatment combinations	B:C
1.	Zinc 20 kg ha^{-1} + Nano urea 2 ml l^{-1}	1.75
2.	Zinc 20 kg ha^{-1} + Nano urea 3 ml l^{-1}	1.73
3.	Zinc 20 kg ha^{-1} + Nano urea 4 ml l^{-1}	1.71
4.	Zinc 25 kg ha^{-1} + Nano urea 2 ml l^{-1}	1.76
5.	Zinc 25 kg ha^{-1} + Nano urea 3 ml l^{-1}	1.86
6.	Zinc 25 kg ha^{-1} + Nano urea 4 ml l^{-1}	1.91
7.	Zinc 30 kg ha^{-1} + Nano urea 2 ml l^{-1}	1.77
8.	Zinc 30 kg ha^{-1} + Nano urea 3 ml l^{-1}	2.26

9.	Zinc 30 kg ha^{-1} + Nano urea 4 ml l^{-1}	2.32
10.	Control	1.86

Conclusion

From the above findings, it can be concluded that the application of Zn and nanourea foliar spray were shown to be effective. It increases growth and yield parameters positively in maize crop.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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