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Nutrient Concentration and Accumulation of Single Cross Hybrid Maize influenced under Foliar Application of Zinc based Nanofertilizer and Varying Fertility Levels in Southern Rajasthan

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ABSTRACT: In the present study, a field experiment was conducted in a FRBD with three (3) replications comprising four (4) foliar application of nanofertilizer (F_1: Control; F_2: at knee high stage; F_3: at 50% tasseling stage and F_4: both at knee high stage + at 50% tasseling stage) and four fertility levels (F_1: 100% RDF; F_2: 90% RDF; F_3:80% RDF & F_4: control) to study the effect of foliar application of zinc based nanofertilizer and varying fertility levels on nutrient concentration and accumulation of nutrients along with of maize in Southern Rajasthan. Nitrogen content (1.782 %, 1.760%), phosphorus content (0.391%, 0.403%) and zinc content (63.76 ppm, 67.11 ppm) of maize grain and nitrogen content (0.798 %, 0.793%), phosphorus content (0.182%, 0.173%) and zinc content (66.78 ppm, 70.40 ppm) of maize stover increased significantly by the foliar application zinc based nanofertilizer at dual stage *viz.*, at knee high stage and at 50 per cent tasseling stage as compared to single stage application and application of 90 per cent RDF in maize, respectively. Similarly, foliar application zinc based nanofertilizer at dual stage *viz.*, at knee high stage & at 50 per cent tasseling stage and 90 % RDF in maize had significant effect on nutrient accumulation by grain and stover of maize.

Keywords: Nanofertilizer, Zinc, Yield, nutrient content and uptake, Maize.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most decisive cereals crop and is one of the most versatile crops. It can be grown over diverse environmental conditions and diversified uses in human food, animal feed, and raw materials for many industrial products. It is a versatile crop that fits well in the existing cropping systems. Currently, maize crop is versatile crop not only in terms of acreage but also for adoption under wide range of agro-climatic conditions. In India, it is cultivated over 9.72 million hectare area with 28.64 million tone production & an average yield of 29.45 q ha^{-1} (Govt of India, 2020). In Southern Rajasthan climate is very much favorable for cultivation of maize crop wherein it is predominantly cultivated under rainfed condition during *kharif* season. In Rajasthan, maize crop is cultivated over 0.97 million hectare area with an annual production of 2.70 million tone and average yield of 27.69 q ha^{-1} (Govt. of Rajasthan, 2021).

In today's era, nanotechnology plays a vital role in modern agriculture to address the limited availability of important plant nutrients (Parisi *et al.,* 2015). Chitosan based nanomaterials like Copper, Zinc and salicylic acid has great potential to be used in crop plants as nutrient source. The Zinc based chitosan nanofertilizer used in this present study contain 7.40 per cent Nitrogen as $-NH_2$ group in chitosan backbone and 4.89 per cent Phosphorus as $-PO_4$ group in TPP cross-linker (Sharma *et al.,* 2020). It has been proved that

various nanomaterials used in various crops can be exploited as nanonutrients. It is wise to evaluate the potential of nanomaterials for their ability to fulfil the need of nutrients for plants in much efficient manner as compared to traditional fertilizers (Raliya *et al.*, 2018).

In major nutrients, Nitrogen is a major nutrient which provide lush green plant colour on account of increase in chlorophyll and nutrient concentration. Being an essential element it plays a vital role in crop development and yield. The deficiency of this element has been found as one of the major yield limiting factors for maize production. Application of nitrogen at lower rates adversely affects growth, concentration and grain yield of this crop. The losses of nitrogen is mainly higher due to surface runoff, volatilization, leaching, de-nitrification and even through plant canopy as NH_3 which is an important part of N cycling in plants (Fageria and Baligar 2015). Therefore, for full exploitation of the higher yield potential of high yielding maize varieties, increases rate of nitrogen fertilization is of prime importance. In addition to nitrogen, phosphorous is of paramount importance for energy transfer in living cells by means of high energy phosphate bonds of ATP. Thus, it plays a pivotal role in formation and translocation of carbohydrates, fatty acids, glyceroids and other essential intermediate compounds. With the intensification of agriculture by the use of high yielding short duration varieties and high analysis fertilizer, the deficiency of micro nutrient in general and zinc in particular has turned out to be an important limiting factor in agriculture. At present deficiency of zinc has become so widespread that it ranks next to Nitrogen and Phosphorus in Rajasthan as well as many other states under intensive cropping systems (Zhu *et al.*, 2012). Zinc is most vital micronutrient for crop as per it's imperative role in plant's enzymes system as co-factor, for various enzymatic; physiological activities and affects many catalytic functions in plants cells besides transformation of carbohydrates, chlorophyll, nitrogen metabolism and protein synthesis (Alloway, 2008).

MATERIAL AND METHOD

In the present study, maize crop variety Pratap Hybrid Maize-3 was sown using 20 kg seed ha^{-1} with onset of rain on 4th July, during 2020 and 5th July 2021 in both years with a spacing of 60 × 25 cm. The experiment consisted of sixteen treatments and comprising of two factors *viz*., four level of foliar application of nanofertilizer includes control (Water Spray), at knee high stage (0.1%); at 50 per cent tasseling stage (0.1 %); at knee high stage and 50 per cent tasseling stage (0.1%) and fertility levels includes control, 100 % RDF, 90 % RDF and 80 % RDF. The recommended dose of fertilizer was applied @ 120 kg N, 60 kg P_2O_5 and 25 kg Zn ha^{-1}. The eexperimental soil was clay loam in texture, having alkaline reaction (7.6), medium in available nitrogen (292.0 kg ha^{-1}) & available phosphorus (21.8 kg ha^{-1}) but high in available potassium (303.1 kg ha^{-1}) and medium in available zinc (1.89 ppm). Application of Phosphorus was done at the time of sowing where as nitrogen application was done in three split application *viz.*, 1/3rd at sowing, 1/3rd at knee-high stage and remaining 1/3rd at 50 per cent tasseling stage as per treatment. Zn-chitosan NPs were prepared in Department of Molecular Biology and Bio-Technology, RCA, MPUAT, Udaipur based on ionic gelation between chitosan and sodium tripolyphosphate (Saharan *et al*., 2015; Kumar *et al*., 2020). The Zn-chitosan NPs 0.1 % solution was sprayed at knee high stage and at 50 per cent tasseling stage as per treatments. The grain and stover samples collected at harvest from produce of each experimental unit were oven dried at 65°C to a constant weight and ground in laboratory mill for estimating nutrient content. These samples were subjected to chemical analysis for determination of nutrient contents.

For computing the Nutrient uptake of N, P and zinc uptake use the following formula:

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient content (\%)} \times \text{Yield (kg ha}^{-1})}{100}$$

For micronutrients

$$\text{Nutrient uptake (g ha}^{-1}) = \frac{\text{Nutrient content (ppm)} \times \text{Yield (kg ha}^{-1})}{1000}$$

RESULT AND DISCUSSION

Nutrient content. Nitrogen content (1.782 %), phosphorus content (0.391%) and zinc content (63.76 ppm) of maize grain and nitrogen content (0.798 %), phosphorus content (0.182%) and zinc content (66.78 ppm) of maize stover increased significantly by the foliar application zinc based nanofertilizer at dual stage *viz*., at knee high stage and at 50 per cent tasseling stage as compared to single stage application (Table 1). This is strongly support that sink strength are advocated by higher sink activity and sink size (Choudhary *et al*., 2019). Based on these outcomes, the study hypothesizes that slow release of Zn outdoes the plant's antagonistic response by awfully synchronizing the need for zinc at the most ravenous-dynamic development (reproductive and grain filling) stages of maize plant. Furthermore, availability of nitrogen and phosphorous at the aforementioned crucial stages are also indispensable for growth and development of maize plants (Razaq *et al*., 2017). Application of 90 per cent RDF significantly influenced nutrient content of maize as compared to 80 per cent RDF and control. However, maximum nutrient content of maize was recorded with the application of 100 per cent RDF but it is at par with the application of 90 per cent RDF (Table 1). An affable cellular environment is imperative for sustained source-activity and sink-strength and the slow release of Zn plays an elite role in enhancing the cellular homeostasis of maize plant for higher growth, yield and nutrient content in grain and stover (Choudhary *et al*., 2019). The present results are in close accordance with the findings of Kumar *et al*. (2020); Van *et al*. (2020); Rodinpuia *et al.* (2019).

Table 1: Effect of foliar application of zinc based nanofertilizer and varying fertility levels on nutrient content of maize.

Treatment	Nitrogen content (%)		Phosphorus content (%)		Zinc content (ppm)	
	Grain	Stover	Grain	Stover	Grain	Stover
Foliar application						
Control	1.483	0.672	0.335	0.155	57.96	61.20
At knee high stage	1.747	0.789	0.385	0.172	61.66	64.97
At 50 per cent tasseling stage	1.743	0.785	0.381	0.167	60.88	63.96
Both stages	1.782	0.798	0.391	0.182	63.76	66.78
SEm±	0.004	0.002	0.001	0.001	0.22	0.25
C.D. (P = 0.05%)	0.012	0.005	0.004	0.003	0.63	0.72
Fertility levels (N, P and Zn kg ha^{-1})						
Control	1.511	0.678	0.310	0.160	52.05	53.70
80 per cent RDF	1.728	0.776	0.379	0.167	58.60	61.76
90 per cent RDF	1.755	0.793	0.401	0.173	66.50	70.44
100 per cent RDF	1.760	0.797	0.403	0.175	67.11	71.03
SEm±	0.004	0.002	0.001	0.001	0.22	0.25
C.D. (P = 0.05%)	0.012	0.005	0.004	0.003	0.63	0.72

Table 2: Effect of foliar application of zinc based nanofertilizer and varying fertility levels on nutrient uptake by of maize.

Treatment	Yields (q ha^{-1})		Nitrogen uptake (kg ha^{-1})		Phosphorous uptake (kg ha^{-1})		Zinc uptake (g ha^{-1})	
	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover
Foliar application								
Control	45.09	68.80	67.60	47.63	15.43	10.69	265.39	426.99
At knee high stage	47.79	75.43	84.43	60.62	18.67	13.09	298.87	499.25
At 50 per cent tasseling stage	46.62	71.95	81.79	56.44	18.05	12.08	288.21	467.44
Both stages	51.90	82.32	93.71	65.42	20.77	15.10	338.94	564.38
SEm±	0.62	0.93	1.06	0.75	0.25	0.17	4.41	6.16
C.D. (P = 0.05%)	1.74	2.63	2.99	2.12	0.72	0.49	12.47	17.42
Fertility levels (N, P and Zn kg ha^{-1})								
Control	34.07	53.25	51.55	36.33	10.58	8.56	177.57	286.08
80 per cent RDF	48.82	75.95	84.60	58.95	18.52	12.77	286.40	470.60
90 per cent RDF	53.70	84.11	94.64	66.65	21.63	14.63	358.56	594.28
100 per cent RDF	54.80	85.17	96.75	68.18	22.19	15.00	368.88	607.09
SEm±	0.62	0.93	1.06	0.75	0.25	0.17	4.41	6.16
C.D. (P = 0.05%)	1.74	2.63	2.99	2.12	0.72	0.49	12.47	17.42

Yield and nutrient uptake. The grain and stover (51.90 and 82.32 q ha^{-1}) of maize significantly increased cent with the foliar application of zinc based nanofertilizer at knee high stage & 50 per cent tasseling stage over control, respectively (Table 2). Application of 90 per cent RDF had significant affected grain; stover & biological yield of maize over 80 percent RDF and control. Grain yield depends on the synthesis and accumulation of photosynthates and their distribution among various plant parts. The production and translocation of synthesized photosynthates depend upon mineral nutrition through soil or foliar application. The synthesis, assembly, and translocation of photosynthates depend upon the efficient photosynthetic structure and the extent of translocation into the sink (grains) and plant growth and development during the early crop growth stages. Zinc is indispensable for plants as it acts as a structural, catalytic and co-catalytic component in many enzymes (Singh *et al*., 2015).

Nitrogen uptake (93.71 kg ha^{-1}), phosphorus uptake (20.77 kg ha^{-1}) and zinc uptake (338.94 kg ha^{-1}) of maize grain and nitrogen uptake (65.42 kg ha^{-1}), phosphorus uptake (15.10 kg ha^{-1}) and zinc uptake (564.38 kg ha^{-1}) of maize stover increased significantly by the foliar application zinc based nanofertilizer at dual stage *viz*., at knee high stage and at 50 per cent tasseling stage as compared to individual application (Table 1). 90 per cent RDF application significantly affected the nutrient uptake of maize by grain and stover as compared to 80 per cent RDF and control. Due to greater availability of nutrients in soil environment along with better extraction and translocation towards plant system there was significant enhancement in nutrient concentration of maize leaves, grain and stover. Application of nitrogen and phosphorus supported native available nutrients that

increase nitrogen and phosphorus concentration in soil with enhancing the soil fertility which was sufficient to meet the requirement of maize crop. While foliar application of zinc based chitosan nanofertilizer directly enhanced zinc concentration in leaves. The significantly improvement in nitrogen, phosphorus and zinc uptake of stover at harvest seems to be account of capabilities of fodder maize plants for efficient absorption, translocation and utilization of absorbed nutrients. The present results are in close relation with the findings of Singh *et al*. (2011); Suthar *et al*. (2013). The simultaneous enhancement in both of these components resulted in higher uptake of nitrogen, phosphorus and zinc with increasing fertility levels from control to 100 per cent RDF. The present results are in close accordance with the findings of Rodinpuia *et al*. (2019); Van *et al*. (2020).

CONCLUSION

The present study's finding indicates that foliar application of 0.1% zinc based nanofertilizer at knee high stage and 50 per cent tasseling stage significantly enhanced the nutrient concentration and accumulation of maize. Further, application of 90 per cent recommended dose of fertilizer had statistically significant influenced nutrient concentration and accumulation of maize.

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Conflict of Interest. None.

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