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Effect of Different Zinc Fertilization Methods on Growth and Productivity of Summer Maize (*Zea mays* L.)

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ABSTRACT

Background: In recent times the micro nutrients were reported to influence the crop growth and productivity. Among them zinc is a vital micronutrient for plants, humans and animals. However, zinc use efficiency mainly depends on methods of zinc fertilization. Although there are many ways to deliver zinc to crops such as soil application, foliar sprays, fertigation, seed priming and root dipping, *etc*. The right method and proportion to apply zinc fertilizer in southern Odisha is not yet standardized. Hence, the present investigation was undertaken to choose the most efficient method of zinc fertilization for this agro climatic zone.

Methods: The present study was conducted in summer maize during 2022 at PG Experimental farm, M.S.Swaminathan school of agriculture. The experiment was laid out in randomized block design with 10 treatments and 3 replications. The treatments consisted of T_1, control (no application of zinc); T_2, soil application with $ZnSO_4.7H_2O$ at the rate 6.25kg/ha; T_3, soil application with $ZnSO_4.7H_2O$ at the rate 12.5kg/ha; T_4, soil application with $ZnSO_4.7H_2O$ at the rate 25kg/ha; T_5, seed priming with 0.5% $ZnSO_4.7H_2O$; T_6, seed priming with 1.0% $ZnSO_4.7H_2O$; T_7, seed priming with 1.5% $ZnSO_4.7H_2O$; T_8, foliar application of $ZnSO_4.7H_2O$ at the rate 1.5% knee high stage, T_9; foliar application of $ZnSO_4.7H_2O$ at the rate 1.5% knee height stage and tasseling; T_{10}, foliar application of $ZnSO_4.7H_2O$ at the rate 1.5% knee height stage, tasseling and grain filling stage.

Result: The results showed that application of zinc in soil at the rate of 25kg/ha through soil application could be recommended to the farmers for growing maize during summer season in southern Odisha to achieve higher growth and productivity

Key words: Foliar application, Seed Priming, Soil application, Yield, Zinc.

INTRODUCTION

Maize (*Zea mays*. L) is the third most important cereal crop belonging to the family poaceae which is widely adapted to different agro-ecological regions (Richard *et al*., 2017). According to an estimate, 70-80% of maize production worldwide is used as an animal feed and serves as a staple food grain especially in dry land regions of Asia, Africa and Latin America (Murdia *et al*., 2016). Globally, maize is grown over 243.28 million hectares, with an average production of 1423.23 million tonnes and a productivity of 8.29 t/ha (FAOSTAT, 2020). However, in India maize occupies around 9.87 million hectares in area, 30.16 million tonnes in production and 3057.3kg/ha in productivity (FAOSTAT, 2020). In Odisha the total area under maize cultivation was 251.43 thousand hectares with a production and productivity of 752.57 thousand tonnes and 2993 kg/ha respectively (OAS, 2018). As the national and state productivity is comparatively lower than global productivity, hence there is an urgent need to fill the yield gap and assure the food security to the rapidly growing population across the world (Farooq *et al*., 2023).

Nutrient management is a key strategy for maintaining food and nutritional security (Sagar *et al*., 2022a). In recent times the micro nutrients were reported to influence the crop growth and productivity markedly (Shukla *et al*., 2018). Zn is a vital micronutrient for plants, humans and animals (Batool *et al*., 2022). In plants, Zn helps in maintaining healthy root structure, enzyme activation, detoxification of free radicals and retaining tolerance to plant stress (Cabot *et al*., 2019; Nile *et al*., 2022). Zinc functions as a co-factor in the process of photosynthesis, respiration and other metabolic process especially in nitrogen metabolism by improving protein quality in grains (Mallikarjuna *et al*., 2020). The influence of zinc on growth and productivity of maize is attributed mainly to its nutrient interaction with macronutrients *viz*., nitrogen, phosphorous and potassium (Imsong and Newmai, 2022). The impact of zinc is synergistic with nitrogen and potassium while antagonistic to phosphorous (Sagar *et al*., 2022b). The zinc use efficiency mainly depends on methods of zinc fertilization. Although there are many ways to deliver zinc to crops such as soil

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application, foliar sprays, fertigation, seed priming and root dipping, *etc* (Rehman *et al*., 2018). Among them, application of zinc through foliar spray, soil application and seed priming are widely gaining popularity (Mondal and Bose, 2019). However, information available to choose the most efficient method of zinc fertilization for this agro climatic zone is meager. The present study was conducted in light of the above mentioned circumstances in order to determine the most promising Zinc application strategy to improve, yield and productivity of summer maize in southern Odisha.

MATERIALS AND METHODS

The field experiment was conducted at PG Experimental farm, M.S. Swaminathan school of agriculture, Gajapati district, Odisha (18° 48′16″N latitude, 84°10′48″E longitude and at 64m altitude above men sea level) during summer season of 2022. The sowing of experimental crop was done on January, 2022 and harvested on June, 2022.The weekly minimum and maximum temperature during that crop growth period ranged between 12°C and 42°C with a weekly relative humidity ranging from 23% to 97%, respectively. The soil of the experimental field was sandy clay loam in texture having sandy loam soil. The experiment was laid out in randomized block design (RBD) with ten treatments such as T_1, control (no application of zinc); T_2, soil application with $ZnSO_4.7H_2O$ at the rate 6.25 kg/ha; T_3, soil application with $ZnSO_4.7H_2O$ at the rate 12.5 kg/ha; T_4, soil application with $ZnSO_4.7H_2O$ at the rate 25 kg/ha; T_5, seed priming with 0.5% $ZnSO_4.7H_2O$; T_6, seed priming with 1.0% $ZnSO_4.7H_2O$; T_7, seed priming with 1.5% $ZnSO_4.7H_2O$; T_8, foliar application of $ZnSO_4.7H_2O$ at the rate 1.5% knee high stage, T_9; foliar application of $ZnSO_4.7H_2O$ at the rate 1.5% knee height stage and tasseling; T_{10}, foliar application of $ZnSO_4.7H_2O$ at the rate 1.5% knee height stage, tasseling and grain filling stage and three replications. Maize hybrid NMH-450 (Ganga) was sown in 60 cm x 25 cm spacing with seed rate of 25 kg/ha and all the recommended agronomic practices were practiced for successful raising of crop. The recommended fertilizer dose of 120:60:60 kg N, P_2O_5, K_2O and the whole dose of P and K were applied as basal while N was applied in two equal splits *i.e*,, basal and knee high stages, respectively. The data were analyzed statistically by following the standard ANOVA techniques and the difference between the treatment means was tested as for their statistical significance with appropriate critical difference (CD) values at 5% level of significance (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Influence of different zinc fertilization methods on morphological parameters of maize

The morphological parameters such as plant height (cm) and dry matter accumulation (g/m^2) were noted to be influenced significantly with different methods of application of zinc (Table 1). The results indicated that the highest plant height in maize (253 cm) was obtained by the application of $ZnSO_4.7H_2O$ at the rate of 25 kg/ha through soil application and reported a significant superiority in plant height over foliar application of $ZnSO_4.7H_2O$ at the rate of 1.5 per cent at knee height, tasseling and grain filling stages (225 cm) which remained on par with foliar application of $ZnSO_4.7H_2O$ at the rate of 1.5 per cent at knee height stage and tasseling stage and knee height stage alone, respectively. Further, it was also indicated that the seed priming in maize with different $ZnSO_4.7H_2O$ concentrations *viz*., 1.5, 1.0 and 0.5 per cent in the tune of 193 cm, 191 cm and 189 cm, respectively could not bring any marked influence on maize plant height of maize. The shortest plant height was obtained with absolute control (no zinc fertilization) which remained at par with all the seed priming treatments under comparison. Similar trend was obtained by dry matter accumulation at harvest. The marked influence of soil applied zinc at the rate of 25 kg/ha on plant height of maize might have

Table 1: Effect of different zinc fertilization methods on morphological parameters of maize.

Treatments	Morphological parameters	
	Plant height (cm)	Dry matter accumulation (g/m^2)
Control (No $ZnSO_4$)	182	1324
Soil application with $ZnSO_4.7H_2O$ @ 6.25 kg/ha	193	1371
Soil application with $ZnSO_4.7H_2O$ @ 12.5 kg/ha	221	1516
Soil application with $ZnSO_4.7H_2O$ @ 25 kg/ha	253	1679
Seed priming with 0.5% $ZnSO_4.7H_2O$	189	1346
Seed priming with 1% $ZnSO_4.7H_2O$	191	1358
Seed priming with 1.5% $ZnSO_4.7H_2O$	193	1370
Foliar application of $ZnSO_4.7H_2O$ @ 1.5% knee height stage	223	1522
Foliar application of $ZnSO_4.7H_2O$ @ 1.5% knee height stage and tasseling	224	1531
Foliar application of $ZnSO_4.7H_2O$ @ 1.5% knee height stage, tasseling and grain filling stage	225	1537
SEm+	8.83	45.56
CD (5%)	26.23	135.37

contributed to higher zinc availability resulting in improved auxin synthesis that entails elongation of internodes through rapid cell division. Furthermore, the improved plant height with increased availability of zinc might have ascribed to result in higher dry matter accumulation in maize. These results are in conformation with Wasaya *et al*. (2017) in maize and Krishnasree *et al*. (2022) in cowpea.

Influence of different zinc fertilization methods on yield attributes of maize

Apart from 100 grain weight (g), all other yield attributes varied significantly with different methods of zinc fertilization (Table 2). Among all the treatments soil application with $ZnSO_4$. $7H_2O$ at the rate 25 kg/ha resulted to be superior in terms of length of the cob (20.93 cm), girth of the cob (15.00cm), number of cobs per plant (1.57), number of grain rows per cob (12.91), and number of grains per row (24.96) than control. Among the treatments with foliar application of zinc sulphate at the rate 1.5 per cent at different growth stages did not vary the yield attributes significantly with variation in stage of application. However, significant superiority was noted by treatments with foliar application compared to seed priming with $ZnSO_4.7H_2O$ at different concentrations *viz*., 0.5, 1.0 and 1.5 per cent, respectively. Among all the treatments least length of the cob (16.43 cm), girth of the cob (13.23 cm), number of cobs per plant (1.39), number of grain rows per cob (10.18), number of grains per row was noted with no application of zinc. The significant influence of zinc applied as $ZnSO_4$ in increasing the number of grain rows per cob and number of grains per row was mainly due to fact that it activates several plant enzymes that are involved in carbohydrate metabolism, protein synthesis and pollen formation which might have contributed to increase in length of the cob and girth of the cob,

Table 2: Effect of different zinc fertilization methods on yield attributes of maize.

Treatments	Yield attributes					
	Length of the cob (cm)	Cob girth (cm)	No.of grain rows/ cob	No.of grains/row	No.of cobs/plant	Seed index
Control (No $ZnSo_4$)	16.43	13.23	10.18	21.47	1.39	22.72
Soil application with $ZnSO_4.7H_2O$ @ 6.25 kg/ha	17.00	14.53	10.54	22.00	1.51	21.40
Soil application with $ZnSO_4.7H_2O$ @ 12.5 kg/ha	18.81	14.63	11.66	23.34	1.53	21.90
Soil application with $ZnSO_4.7H_2O$ @ 25 kg/ha	20.93	15.00	12.91	24.96	1.57	21.30
Seed priming with 0.5% $ZnSO_4.7H_2O$	16.70	14.00	10.35	21.50	1.47	22.80
Seed priming with 1% $ZnSO_4.7H_2O$	16.85	14.16	10.44	21.70	1.47	23.10
Seed priming with 1.5% $ZnSO_4.7H_2O$	16.99	14.42	10.53	21.89	1.52	22.50
Foliar application of $ZnSO_4.7H_2O$ @ 1.5% knee height stage	18.89	14.70	11.71	23.45	1.53	21.30
Foliar application of $ZnSO_4.7H_2O$ @ 1.5% knee height stage and tasseling	18.99	14.72	11.77	23.49	1.54	21.30
Foliar application of $ZnSO_4.7H_2O$ @ 1.5% knee height stage, tasseling and grain filling stage	19.07	14.74	11.81	23.59	1.56	21.40
SEm±	0.62	0.36	0.35	0.44	0.02	1.41
CD (5%)	1.85	1.06	1.04	1.31	0.07	NS

Table 3: Effect of different zinc fertilization methods on yield of maize.

Treatments	Grain yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest Index (%)
Control (No $ZnSo_4$)	5.09	8.15	13.24	29.11
Soil application with $ZnSO_4.7H_2O$ @ 6.25 kg/ha	5.27	8.43	13.61	31.97
Soil application with $ZnSO_4.7H_2O$ @ 12.5 kg/ha	5.83	9.33	15.16	32.19
Soil application with $ZnSO_4.7H_2O$ @ 25 kg/ha	6.46	10.33	16.78	33.00
Seed priming with 0.5% $ZnSO_4.7H_2O$	5.18	8.28	13.46	30.80
Seed priming with 1% $ZnSO_4.7H_2O$	5.22	8.36	13.58	31.14
Seed priming with 1.5% $ZnSO_4.7H_2O$	5.27	8.43	13.61	31.71
Foliar application of $ZnSO_4.7H_2O$ @ 1.5% knee height stage	5.85	9.37	15.22	32.34
Foliar application of $ZnSO_4.7H_2O$ @ 1.5% knee height stage and tasseling	5.89	9.42	15.30	32.39
Foliar application of $ZnSO_4.7H_2O$ @ 1.5% knee height stage, tasseling and grain filling stage	5.91	9.45	15.36	32.44
SEm±	0.175	0.281	0.456	0.787
CD (5%)	0.521	0.834	1.355	2.338

respectively. Similar findings were obtained by Jeet *et al.*, (2012) in maize and Jolli *et al*. (2020) in sweet corn. However, 100 seed weight being a most stable parameter directly influenced by genetic makeup of maize therefore, it might not vary with different methods of zinc fertilization. Similar findings were obtained by Saboor *et al*. (2021) in maize.

Influence of different zinc fertilization methods on yield of maize

The perusal of data on yield parameters differed significantly with different methods of zinc application presented in (Table 3).The maximum grain yield (6455t/ha) were recorded in Soil application with $ZnSO_4.7H_2O$ at the rate 25 kg/ha and the minimum grain yield (5091 t/ha) were recorded with control (no application of zinc) grain yield obtained from the treatment Foliar application of $ZnSO_4.7H_2O$ at the rate 1.5% knee height stage, tasseling and grain filling stage was found at par with grain yield obtained from Foliar application of $ZnSO_4$. $7H_2O$ at the rate 1.5% knee height stage and tasseling stages and Foliar application of $ZnSO_4.7H_2O$ at the rate 1.5% knee height stage. A similar trend was followed by stover yield, biological yield and harvest index. This higher yield attributes as influenced by increased zinc availability through soil application might have ascribed to higher grain yield and harvest index in maize. Similarly, the dry matter accumulation at harvest as influenced by increased zinc availability through soil application might have contributed for increased stover and biological yield. These results are in collaboration with Singh *et al*. (2021) and Li *et al*. (2023) in rice.

CONCLUSION

Based on the findings of the current inquiry into the effect of zinc fertilization, it can be deducted that maize performs substantially better when zinc is applied through soil or foliar spray, increasing morphological parameters and productivity. Among the treatments, applying $ZnSO_4$. $7H_2O$ at the rate of 25 kg/ha produced good results. Thus in order to obtain greater growth and production of summer maize, application of 25 kg/ha $ZnSO_4$. $7H_2O$ is best recommended to the farmers of southern Odisha.

Conflict of interest: None.

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