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Response of Soil and Foliar Application of Zinc Sulphate on Soil Properties in Maize *(Zea mays* L.*)*

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ABSTRACT

The field experiment was carried out during Kharif, 2024 at Instructional FarmB1 Block (Agronomy), Rajasthan College of Agriculture, MPUAT, Udaipur. The experiment laid out under factorial RBD design with three replications. The two factors were soil and foliar application of zinc sulphate heptahydrate. Soil application of zinc sulphate included 4 levels i.e control, 6.25 kgha^{-1}, 12.5 kg ha^{-1} and 25 kgha^{-1} and 4 levels of foliar application i.e. control ,0.25% $ZnSO_4.7H_2O$, 0.50% $ZnSO_4$. $7H_2O$ and 0.75% $ZnSO_4.7H_2O$. The major challenge of was that how supply the balance diet to rural people and mitigate the problem of micronutrient deficiency in soil. Soil and foliar utilization of zinc didn't give any significant effect on soil's physical and chemical properties. Soil pH, EC, organic carbon, particle density, bulk density as well as porosity were nonsignificant with soil and foliar utilization of zinc. In contrast, the highest N, P, K, Zn, Fe, Mn and Cu were found with soil application of 25 kg $ZnSO_4.7H_2O$ and foliar application of 0.75% $ZnSO_4.7H_2O$. Judicious soil and foliar application of zinc increase the Zinc status in soil as well as in grain of maize.

Keywords*: Zinc, Physical and Chemical Properties, Soil and Foliar Application.*

Introduction

Among cereal crops, maize after wheat and rice is the most important cultivated grain worldwide because of its improved adaptability to the arid and semi-arid conditions. Maize is also called as a miracle crop or “Queen of Cereals” due to its high productivity, easy to process, low cost than other cereals (Jaliya *et al.*, 2008). Maize grain has raised nutritive worth as it contains about 72% starch, 10% protein, 4.8% oil, 5.8% fibre and 3.0% sugar (Rafiq *et al.*, 2010). It is a versatile crop that fits well in the existing cropping systems.

In India, maize is cultivated on roughly 11.2 million hectares, with a record production estimated at 37.25 mt in 2024–25, and an average national yield of about 3.3 t ha^{-1} (Protect Our Livelihood, 2024). The crop serves multiple purposes: approximately 47% is used as poultry feed, 13% for livestock feed, 13% for direct human consumption, and the remaining 27% for industrial processing and exports.

Zinc is the most important micronutrient for normal and healthy plant growth (Tahir *et al*., 2018). Zinc is a structural component or cofactor of various enzymes involved in many biochemical processes. In plants, it is involved in photosynthesis, carbohydrate metabolism, protein metabolism, pollen formation, auxin metabolism, maintenance of membrane integrity, and induction of tolerance against various stresses (Alloway, 2008). It is also essential for nitrogen metabolism and important for the stability of cytoplasmic ribosome’s, cell division, as co factor to enzymes like dehydrogenase, proteinase and peptidase in the synthesis of tryptophan, a component of some proteins and a compound needed for production of growth hormones (auxin) such as indole acetic acid (Singh and Singh, 1981).

Plant response to Zn deficiency occurs in terms of decrease in membrane integrity, susceptibility to heat stress, decreased synthesis of carbohydrates, cytochromes nucleotide auxin and chlorophyll. Zn-containing enzymes are also inhibited, which include alcohol dehydrogenase, carbonic anhydrase, Cu-Zn-superoxide dismutase, alkaline phosphatase, phospholipase, carboxypeptidase, and RNA polymerase. Depending on the zinc level, zinc deficiency status of plants can be classified as follows: less than 10 mg kg^{-1} definite zinc deficiency, between 10 and 20 mg kg^{-1} likely to be zinc deficient, more than 20 mg kg^{-1} Zn sufficient.

Materials and Methods

- **Field Location and Materials**

The experiment was laid out during *kharif* season of 2024 at Instructional Farm B1 Block (Agronomy), Rajasthan College of agriculture, Udaipur, which is situated at 24º35' latitude and 73º42' longitude with an average altitude of 582.2 m above mean sea level. The region falls under agro-climatic zone-IVa of Rajasthan *i.e*. Sub-humid Southern Plain and Aravalli Hills Zone. To obtain basic soil chemical and physical properties (Table 1), soil samples were collected from the field according to prescribed standard procedures

Table 1: Effect of Soil and Foliar Application of Zinc on Physical Properties of Soil after Harvest of Maize

Treatments	pH	EC (dSm^{-1})	Organic carbon (%)	Bulk density (Mg m^{-3})	Particle density (Mg m^{-3})	Porosity (%)
Soil Application						
S1	8.09	0.61	0.63	1.349	2.424	44.15
S2	8.17	0.62	0.65	1.361	2.464	44.73
S3	8.22	0.63	0.67	1.370	2.536	45.89
S4	8.33	0.63	0.67	1.388	2.535	45.16
S.Em.±	0.07	0.01	0.01	0.013	0.035	0.91
C.D. (P = 0.05)	NS	NS	NS	NS	NS	NS
Foliar Application						
F1	8.11	0.61	0.64	1.352	2.449	44.72
F2	8.18	0.62	0.65	1.363	2.486	44.96
F3	8.25	0.63	0.66	1.374	2.514	45.30
F4	8.27	0.63	0.66	1.380	2.510	44.95
S.Em.±	0.07	0.01	0.01	0.013	0.035	0.91
C.D. (P = 0.05)	NS	NS	NS	NS	NS	NS

- **Experimental detail**

During the *kharif* of 2024, an experiment was conducted using a factorial randomized block design with three replications. In soil application four treatments were applied: S_1 (control) received no zinc, while S_2, S_3 and S_4 received zinc sulphate at rates of 6.25 $kgha^{-1}$, 12.5 kg ha^{-1} and 25 $kgha^{-1}$, respectively. The treatments of foliar application included F_1 (control) with no spray, F_2 with 0.25% $ZnSO_4.7H_2O$ solution, F_3 with 0.50% $ZnSO_4$. $7H_2O$and F_4 with 0.75% $ZnSO_4.7H_2O$concentration. Add lime @ half dose of $ZnSO_4.7H_2O$ as per treatment to avoid scotching effect. The recommended dose of nitrogen (120 kg/ha) was applied in three equal splits, the 1/3 dose as basal and the remaining 1/3 at knee stature stage and remaining 1/3 at 50 % tasseling stage as top dressing at the time of first irrigation through urea. The whole quantity of phosphorus (60 kg/ha) through SSP and potassium (30 kg/ha) through muriate of potash was drilled as basal dose at 8-10 cm depth along with 1/3 dose of nitrogen before sowing. Zinc sulphate in the form of $ZnSO_4 \cdot 7H_2O$ was broadcast uniformly over the designated plots in soil application and foliar application was done at a critical crop growth stage (30, 45 and 60 DAS) using a knapsack sprayer to ensure uniform coverage of the foliage.

- **Chemical Analysis of Soil Parameters**

The pH and EC of soil samples were determined by pH and EC meter, respectively (Richards, 1954). Furthermore the organic carbon was determined by the rapid titration method of Walkley and Black (1934). Particle density and Bulk density were determined by the relative density bottle method (Richards, 1954), and porosity was calculated by the formula given by Richards (1954). The available nitrogen was determined by the alkaline permanganate method given by Subbiah and Asija (1956), whereas available phosphorus was determined by Olsen (1954) method. Available potassium was determined using 1 N neutral ammonium acetate at pH 7.0 (Merwin and Peech, 1951). Available micronutrients determined by 0.005*M* DTPA + 0.001*M* $CaCl_2$ + 0.1*M* triethanolamine at pH 7.3 (Lindsay and Norvell, 1978).

Result and Discussion

The EC, pH, organic carbon, bulk density, particle density and porosity of soil after crop harvest were not significantly affected by soil application and foliar application of $ZnSO_4$. The soil and foliar application of zinc sulphate significantly reduced available P content in soil and increased DTPA-Zn in the soil after crop harvest. The highest nitrogen, potassium, zinc content were found with soil application of 25 kg $ZnSO_4$ ha^{-1} and foliar application of 0.75% $ZnSO_4$. In contrast, available iron, manganese and copper were found non-significant with zinc sulphate application. The trial soil being low in accessible zinc and press may have expanded accessible zinc with the increment in the degree of zinc sulfate application. The increase in the accessible status of Zn may likewise be because of higher sum consumption of Zn coming about because of low fertilizer use effectiveness of the crop with applied micronutrient fertilizer. The soil's available phosphorus content after the maize crop's harvest decreased significantly with the increase in the level of zinc sulphate application up to 25 kg ha^{-1} and 0.75% $ZnSO_4$. The decrease in the available phosphorus due to the increasing level of zinc could be ascribed to the fact that phosphorus has an antagonistic relationship with zinc which might have worked in the present case. The combined application of RDF with micronutrient Zn non significantly increased nitrogen in the soil after harvest of the crop control. A higher amount of available N and K analyzed might be due to increased micro-organism activity, leading to more significant mineralization of applied and inherent nutrients. Application of Zn increased the available nitrogen content in the soil after crop harvest. It might be due to the synergistic effect of Zn on nitrogen content in the soil. Application of Zn increased the DTPA-Zn content in the soil, possibly due to higher solubility, diffusion, and mobility of the applied inorganic Zn fertilizer, leading to increased soil Zn status (Chatterjee *et al.,* 1983). Since some nitrogen as amino acids released in soil which ultimately increased nitrogen content of the soil. These findings are also in line with Patil *et al.* (2006); Kumar and Salakinkop (2017); Fulpagare *et al.* (2018); Karrimi *et al.* (2018); and Daphade *et al.* (2019). The application of zinc significantly increased the amount of zinc available in the soil. Following crop harvest, a linear increase in soil-available zinc was observed with the application of zinc sulfate heptahydrate ($ZnSO_4 \cdot 7H_2O$). This trend is especially notable in soils initially low in available zinc. The increased zinc application rates not only supply additional Zn but may also trigger a “priming effect,” enhancing the solubilization of native zinc fractions in the soil. Maximum available Zn in soil was recorded under soil application of 25 kg $ZnSO_4.7H_2O$ ha^{-1} which was significantly higher over soil application of 12.5, 6.25 kg $ZnSO_4.7H_2O$ ha^{-1} and control. The magnitude of increase in available Zn in soil was 7.83, 15.23 and 21.42 per cent over soil application of 12.5, 6.25 kg $ZnSO_4.7H_2O$ ha^{-1} and control, respectively. The available Zn in soil was significantly increased with foliar application of 0.75% $ZnSO_4.7H_2O$ over foliar application of 0.25% $ZnSO_4.7H_2O$ and control by 6.17 and 10.25 per cent, respectively. Foliar application of 0.50 % $ZnSO_4.7H_2O$ was at par with foliar application of 0.75% $ZnSO_4.7H_2O$. A similar result was observed with Fulpagare *et al.* (2018); Jain *et al.* (2018); karrimi *et al.* (2018), and Daphade *et al.* (2019).

Table 2: Effect of Soil and Foliar Application of Zinc on Chemical Properties of Soil after Harvest of Maize

Treatments	N (kg ha^{-1})	P(kg ha^{-1})	K (kg ha^{-1})	Zn (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Cu (mg kg^{-1})
Soil Application							
S1	258.38	18.33	294.55	0.57	3.53	2.14	0.657
S2	261.66	18.22	301.86	0.60	3.57	2.19	0.660
S3	263.46	18.17	303.55	0.64	3.57	2.20	0.662
S4	263.96	18.09	304.24	0.69	3.59	2.21	0.664
S.Em.±	2.40	0.07	2.66	0.01	0.03	0.02	0.006
C.D. (P = 0.05)	NS	NS	NS	0.02	NS	NS	NS
Foliar Application							
F1	258.95	18.27	297.73	0.59	3.53	2.17	0.654
F2	261.06	18.25	300.13	0.62	3.56	2.18	0.659
F3	263.32	18.18	302.70	0.64	3.59	2.20	0.665
F4	264.13	18.11	303.63	0.65	3.59	2.20	0.667
S.Em.±	2.40	0.07	2.66	0.01	0.034	0.02	0.006
C.D. (P = 0.05)	NS	NS	NS	0.02	NS	NS	NS

Conclusion

The result concluded that soil and foliar application of zinc non significantly increase the N, P, K, Fe, Cu, Mn and significantly the Zn concentration in soil. Still, there was nonsignificant effect on other physical and chemical properties of soil.

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- **Conflict of Interests.** None.

References

1. Cakmak, I., Torun, B., Erenoglu, B., Ozturk, L., Marscher, H., Kalayci, M., Ekiz, H. and Yilmaz, A. (1998). Morphological and physiological differences in the response of cereals to zinc deficiency. *Euphytica, 100*: 349-357.
2. Chatterjee, A. K., Mondal, L. N. and Holdar, H. (1983). Effect of phosphorus and zinc application on the extractable Zn, Cu, Fe, Mn and P in water logged rice soils. *Journal of Indian Society of Soil Science, 31*: 135-137.
3. Daphade, S. T., Hanwate, G. R. and Gourkhede, P. H. (2019). Influence of Zn, Fe and B applications on nutrient availability in soil at critical growth stages of maize (*Zea mays*) in Vertisol of Marathawada region of Maharashtra, India. *International Journal of Current Microbiology and Applied Sciences, 8* : 206-212.
4. Fulpagare, D. D., Patil, T. D. and Thakare. R. S. (2018). Effect of application of iron and zinc on nutrient availability and pearl millet yield in vertisols. *International Journal of Chemical Studies, 6*: 2647- 2650.
5. Jain, A. K., Shrivastava, S. and Arya, V. (2018). Response of organic manure, zinc and iron on soil properties, yield and nutrient uptake by pearlmillet crop grown in inceptisol. *International Journal of Pure and Applied Bioscience, 6*: 426-435.
6. Jaliya, M. M., Falaki, A. M., Mahmud, M., Abubakar, I. U. and Sani, Y. A. (2008). Response of Quality Protein Maize (QPM) (*Zea mays* L.) to sowing date and NPK fertilizer rate on yield & yield components of Quality Protein Maize. *Savannah Journal of Agriculture*, *3*: 24- 35.
7. Karrimi, A. S., Reddy, A. P. K., Babazoi, F. and Kohistani, T. (2018). Growth, yield and post-harvest soil available nutrients in sweet corn (*Zea mays* L.) as influenced by zinc and iron nutrition. *Journal of Pharmacognosy and Phytochemistry, 7*: 2372-2374.
8. Kumar, N. and Salakinkop, S. R. (2017). Influence of agronomic bio-fortification of zinc and iron on their density in maize grain and nutrients uptake. *International Journal of Environmental Sciences & Natural Resources*, *7*: 1-5.
9. Lindsay, W. L. and Norvell, W. A. (1978). Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal*, *42*: 421-442.
10. Malhotra, S. K. (2017). Diversification in Utilization of Maize and Production. *Gyan Manthan-Perspective of Maize Production and Value Chain- A Compendium, 5*: 49- 57.
11. Merwin, H. D. and Peech, M. (1951). Exchangeability of soil potassium in the sand, silt and clay fractions, as influenced by the nature of complimentary exchangeable cations. *Soil Science Society of America Proceedings*, *15*: 125-128.
12. Metson, A. J. (1956). Methods of chemical analysis for soil survey samples. *New Zealand Soil Bureau Bulletin No. 12.*
13. Olsen, S. R., Cole, C. V., Frank, S. W. and Dean, L. A. (1954). Estimation of available Phosphorus by extraction with sodium bicarbonate, United States Development of Agriculture, *Circular number*, 939.
14. Patil, P. L., Radder, S. G., Patil, Y. R., Meti, A. C. B. and Khot, A. B. (2006). Effect of moisture regimes and micronutrients on yield, water use efficiency and nutrients uptake by maize in vertisol of Malaprabha command, Karnataka. *Journal of the Indian Society of Soil Science*, *54*: 261-264.

15. Rafiq, M. A., Ali, A., Malik, M. A. and Hussain, M. (2010). Effect of fertilizer levels and plant densities on yield and protein contents of autumn planted maize. *Pakistan Journal of Agriculture Science, 47*: 201-208.
16. Rattan, R. K., Patel, K. P., Manjaiah, K. M. and Datta, S. P. (2009). Micronutrients in soil, plant, animal and human health. *Journal of the Indian Society of Soil Science, 57*(4): 546-558.
17. Richards, L. A. (1954). Diagnosis and improvement of saline- alkali soils. Agriculture Handbook No. *60*, USDA, Washington.
18. Salunke, R., Rawat, N., Tiwari, V. K., Neelam, K. R., Gursharn, S. D., Singh, H. and Roy, P. (2012). Determination of bioavailable-zinc from biofortified wheat using a coupled in vitro digestion/Caco-2 reporter-gene based assay. *Journal of Food Composition and Analysis, 25*: 149-159.
19. Subbiah, B. V. and Asija, G. L. (1956). A rapid procedure for determination of available nitrogen in soil. *Current Science, 25*: 259-260.
20. Veihmeyer, F. J. and Hendrickson, A. H. (1931). The moisture equivalent as a measure of field capacity of soils. *Soil Science*, *32*: 181-194.
21. Walkley, A. J. and Black, I. A. (1934). Estimation of soil organic carbon by chromic acid titration method. *Soil Science*, *37*: 29-38.
22. Waters, B. M. and Sankaran, R. P. (2011). Moving micronutrients from the soil to the seeds: Genes and physiological processes from a biofortification perspective. *Plant Science, 180*: 562–574.
23. White, P. J. and Broadley, M. R. (2005). Biofortifying crops with essential mineral elements. *Trends in Plant Science, 10*: 586-593.

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