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Effect of Soil and Foliar Application of Zn and Fe on Soil Fertility after Harvest of Maize

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ABSTRACT: A field trial was directed at Instructional Farm, Rajasthan College of Agriculture, Udaipur, in two consecutive *Kharif* seasons of 2018 and 2019. The experiment laid out under split plot design with three replications included 7 levels of soil application (control, 12.5 kg $ZnSO_4$ ha^{-1}, 25 kg $ZnSO_4$ ha^{-1}, 12.5 kg $FeSO_4$ ha^{-1}, 25 kg $FeSO_4$ ha^{-1}, 12.5 kg $ZnSO_4$ ha^{-1} + 12.5 kg $FeSO_4$ ha^{-1} and 25 kg $ZnSO_4$ ha^{-1} + 25 kg $FeSO_4$ ha^{-1}) in main plots whereas four level of foliar spray (control, 0.5% $ZnSO_4$ ha^{-1}, 0.5% $FeSO_4$ ha^{-1} and 0.5% $ZnSO_4$ ha^{-1} + 0.5% $FeSO_4$ ha^{-1}) in sub plot. 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 and iron didn't give any significant effect on soil's physical and chemical properties. Soil pH, EC, organic carbon, CEC, WHC, particle density, bulk density as well as porosity were non significant with soil and foliar utilization of zinc and iron. In contrast, the highest N, P, K, Zn and Fe were found with soil application of 25 kg $ZnSO_4$ + 25 kg $FeSO_4$ in the main plot and foliar application of 0.5 % $ZnSO_4$ + 0.58 % $FeSO_4$ in sub plot. Judicious soil and foliar application of zinc and iron increase the Zinc and Iron status in soil as well as in grain of maize.

Keywords: Zinc, Iron, Physical and chemical properties, Soil and foliar application.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal, next to wheat and rice in the world and India. It is solitary most versatile crops. It can be grown over diverse environmental conditions and diversified uses in human food, animal feed, and natural substances for many industrial products. It is a versatile crop that fits well in the existing cropping systems. The huge potential for export has added the demand for maize all over the world. Maize is a miracle crop called as "Queen of Cereals" due to high productiveness, 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 the essential wellspring of calories and minerals for most provincial populaces in southern Rajasthan. However, sadly, maize is intrinsically poor in protein and minerals, on the whole in zinc and iron. It is a high nutrient-demand crop touchy to micronutrient inadequacy, especially zinc and iron. In India, maize is used as human food (23%), poultry feed (49%), animal feed (12 %), industrial (starch) products (15%), beverages and seed (1 % each) (Malhotra, 2017).

Further, the preamble of the green revolution, with high yielding crop cultivars, has annoyed this situation. Maize is known as a marker plant for assessing Zn deficiency of soil. Micronutrient malnutrition is one of the attention-drawing problems in the developing world. Zinc deficiency is currently listed as a major risk factor for human health and cause of death globally (Cakmak *et al.*, 1998; Salunke *et al.*, 2012). Deficiencies of micronutrient drastically affect the growth, metabolism and reproductive phase in plants, animal and human beings (Rattan *et al.*, 2009). In India, about 230 million people are estimated to be undernourished, accounting for more than 27 % of the world's undernourished population (Chakraborti *et al.*, 2011). Biofortification is a recent approach to increasing the bio-available nutrients, such as Fe and Zn, in the staple crops rather than using fortificants or supplements (Waters and Sankaran, 2011; White and Broadley, 2005). Producing micronutrient enriched cereals (biofortification), either agronomically or genetically and improving their bioavailability, are considered promising and cost-effective approaches for diminishing malnutrition.

MATERIALS AND METHODS

A. Field location and materials

The experiment was directed during both the years at the Instructional Farm, Rajasthan College of Agriculture, MPUAT, Udaipur, which is situated at 24°35'N latitude, 72°42'E longitude and an altitude of 579.5 m above mean sea level. It falls under agro-climatic zone IVa (Sub-Humid Southern Plain and Aravalli Hills) of Rajasthan. 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 and iron on physical and chemical properties of soil after harvest of maize.

Treatments	pH	EC (dSm^{-1})	Organic carbon (%)	CEC (Cmol (P^+) kg^{-1})	Bulk density (Mg m^{-3})	Particle density (Mg m^{-3})	Porosity (%)	WHC (%)
Soil application								
S_0	8.18	0.82	0.73	16.52	1.45	2.43	40.00	38.63
S_1	8.19	0.83	0.74	16.68	1.44	2.44	41.14	38.97
S_2	8.20	0.84	0.75	16.77	1.44	2.45	41.23	39.15
S_3	8.18	0.83	0.77	16.75	1.45	2.45	41.10	39.13
S_4	8.19	0.83	0.77	16.84	1.43	2.45	41.59	39.70
S_5	8.20	0.84	0.77	17.01	1.43	2.47	42.09	40.00
S_6 =	8.22	0.85	0.78	17.24	1.43	2.47	42.00	40.95
S.Em.±	0.07	0.01	0.01	0.18	0.02	0.03	0.77	0.82
C.D. (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Foliar application								
F_0	8.18	0.82	0.75	16.80	1.45	2.43	40.17	38.69
F_1	8.20	0.84	0.76	16.82	1.43	2.46	41.64	39.78
F_2	8.18	0.83	0.76	16.83	1.44	2.45	41.22	39.56
F_3	8.22	0.85	0.78	16.87	1.43	2.47	42.20	39.98
S.Em.±	0.03	0.01	0.01	0.09	0.01	0.01	0.65	0.35
C.D. (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS

B. Experimental detail

The experiment was laid out under a split plot design with three replications. In the main plot, zinc and iron were applied as a soil application, and in sub plot, zinc and iron were applied as a foliar application. Soil application include S_0- control; S_1- 12.5 kg $ZnSO_4$ ha^{-1}; S_2-25 kg $ZnSO_4$ ha^{-1}; S_3-12.5 kg $FeSO_4$ ha^{-1}; S_4- 25 kg $FeSO_4$ ha^{-1}; S_5- 12.5 kg $ZnSO_4$ ha^{-1} + 12.5 kg $FeSO_4$ ha^{-1} and S_6-25 kg $ZnSO_4$ ha^{-1} + 25 kg $FeSO_4$ ha^{-1}. Foliar application include four treatments F_0-control; F_1- 0.5% $ZnSO_4$ ha^{-1}; F_2- 0.5% $FeSO_4$ ha^{-1} and F_3-0.5% $ZnSO_4$ ha^{-1} + 0.5% $FeSO_4$ ha^{-1}. 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 % tasselling stage as top dressing at the time of first irrigation through urea.

Table 2: Effect of soil and foliar application of zinc and iron on nutrient content in soil after harvest of maize.

Treatments	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})	Zinc (ppm)	Iron (ppm)	Manganese (ppm)	Copper (ppm)
Soil application							
S_0	260.86	17.78	466.72	2.02	2.64	9.82	1.70
S_1	281.11	16.24	502.63	2.30	2.78	9.94	1.71
S_2	300.73	14.85	522.74	2.41	2.88	10.03	1.73
S_3	277.11	19.40	492.65	2.16	3.15	9.91	1.74
S_4	299.05	20.01	514.68	2.19	3.37	9.81	1.72
S_5	309.18	18.37	531.81	2.32	3.25	10.10	1.75
S_6 =	347.80	17.27	559.02	2.48	3.41	10.29	1.76
S.Em.±	3.67	0.15	4.26	0.02	0.04	0.13	0.03
C.D. (P = 0.05)	10.70	0.44	12.44	0.07	0.11	NS	NS
Foliar application							
F_0	262.26	17.81	462.93	2.02	2.66	9.89	1.70
F_1	288.12	16.51	517.33	2.34	2.96	9.90	1.75
F_2	285.08	18.97	511.95	2.26	3.24	10.07	1.73
F_3	350.74	17.52	559.36	2.45	3.41	10.08	1.74
S.Em.±	1.81	0.06	2.07	0.01	0.02	0.08	0.02
C.D. (P = 0.05)	5.10	0.16	5.82	0.03	0.04	NS	NS

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 and iron and zinc applied through $FeSO_4.7H_2O$ and $ZnSO_4.7H_2O$ respectively, before sowing. Foliar application of zinc and iron was done at 30 and 50 DAS.

C. 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), and the cation exchange capacity of the soil was determined by using neutral normal ammonium acetate (Metson, 1956). 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 gravimetric method of Veihmeyer and Hendrickson (1931) was used to determine the water holding capacity. 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, CEC, bulk density, particle density, porosity and water holding capacity of soil after crop harvest were not significantly affected by soil application of $ZnSO_4$ and $FeSO_4$. The soil application of zinc sulphate @ 25 kg ha^{-1} significantly reduced available P content in soil and increased DTPA-Zn in the soil after crop harvest. The highest nitrogen, potassium, zinc and iron content were found with soil application of 25 kg $ZnSO_4$ ha^{-1} + 25 kg $FeSO_4$ ha^{-1}. In contrast, available manganese and copper were found non-significant with zinc and ferrous sulphate application. The trial soil being low in accessible zinc and press may have expanded accessible zinc and iron with the increment in the degree of zinc and iron sulfate application. The increase in the accessible status of Zn and Fe may likewise be because of higher sum consumption of Zn and Fe 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}. The decrease in the available phosphorus due to the increasing level of zinc and iron 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 micronutrients Zn and Fe significantly increased nitrogen in the soil after harvest of the crop control. The increase in soil's available nitrogen and potassium status with an application of 25 kg $ZnSO_4$ ha^{-1} + 25 kg $FeSO_4$ ha^{-1} was 33.32 and 19.78 per cent over control. A higher amount of available N and P 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). The application of iron significantly increased the available N content in soil due to its synergistic effect on soil nitrogen content. 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).

Soil application of RDF with different concentrations of foliar spray of $ZnSO_4$ and $FeSO_4$ could not significantly affect physic-chemical properties (pH, EC, organic carbon, CEC, bulk density, particle density, porosity and water holding capacity) and nutrient concentration (manganese and copper). In contrast, foliar application of zinc and ferrous sulphate significantly increase the nitrogen, phosphorus, potassium, zinc and iron concentration after harvest of maize. An increase in available zinc in the soil might be due to the synergistic effect between nitrogen and zinc. The zinc enriched treatments showed increased Zn content of the soil, which was attributed to the different levels of fertilizer zinc, which might have supplied additional Zn to the soil pool. Increased iron availability was due to foliar application of iron in the form of iron sulphate. A similar result was observed with Fulpagare *et al.* (2018); Jain *et al.* (2018); karrimi *et al.* (2018), and Daphade *et al.* (2019).

CONCLUSION

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

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Conflict of Interests. None.

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