

Original Research Article

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Influence of Zn, Fe and B Applications on Nutrient Availability in Soil at Critical Growth Stages of Maize (*Zea mays*) in Vertisol of Marathwada Region of Maharashtra, India

S.T. Daphade, G.R. Hanwate and P.H. Gourkhede*

Department of Soil Science and Agriculture Chemistry, Vasanttrao Naik Marathwada Krishi Vidyapeeth, Parbhani-431402 (M.S.), India

*Corresponding author

ABSTRACT

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The experiment was conducted during *Kharif* 2017-18 to study the “Influence of Zn, Fe and B applications on nutrient availability in soil at critical growth stages of maize crop in Vertisol of Marathwada Region of Maharashtra” at the research farm, Department of Soil Science and Agricultural Chemistry, College of Agriculture Badnapur. The experiment was planned in randomized block design with nine treatments with three replications in randomized block design. The treatment consists of T₁ RDF (150:75:75 NPK kg ha⁻¹), T₂ (RDF + ZnSO₄), T₃ (RDF + FeSO₄), T₄ (RDF + Borax), T₅ (RDF + ZnSO₄ + FeSO₄), T₆(RDF + ZnSO₄ + Borax), T₇ (RDF + FeSO₄+ Borax), T₈ (RDF + ZnSO₄ + FeSO₄ + Borax), T₉ (RDF + Foliar application of grade II micronutrient application at 45 DAS). The results emerged out clearly indicated that nutrient availability in soil was increased due to application of micronutrients. It was inferred from the results that application of RDF + ZnSO₄ @ 20 kg ha⁻¹ + FeSO₄ @ 20 kg ha⁻¹ + Borax @ 10 kg ha⁻¹ found superior over only N P and K application i.e. RDF (150:75:75 N, P₂O₅ and K₂O kg ha⁻¹).

Introduction

Maize is an important cereal crop of the world as well as of India. Maize crop is grown next to wheat and rice in the world. In India, it is cultivated over an area of 92.32 lakh hectares with an annual production of 236.73 lakh tonnes having an average productivity of more than 2564 kg ha⁻¹. In Maharashtra it occupies an area of 10.59 lakh hectares with total production of 22.03 lakh tonnes having an average productivity of more than 2080 kg ha⁻¹

Micronutrients are essential for crop production in the present situation of soil fertility and their deficiency drastically affects the growth, metabolism and reproductive phase of crop plants, animal and human beings. Micronutrient deficiencies in crop plants are widespread because of increased micronutrient demand from intensive cropping practices and adaptation of high-yielding crop cultivars, enhanced crop production on marginal soils that contain low levels of essential micronutrients, increased use of high analysis fertilizers with low amounts of

micronutrients, decreased use of animal manures, composts and crop residues, use of soils low in micronutrient reserves, use of liming in acid soils, involvement of natural and anthropogenic factors that limit adequate supplies and create elemental imbalance in soil Fageria *et al.*, (2002). Shukla and Behera (2011) reported that as much as 48, 12, 5, 4, 33, 13 and 41 per cent soils in India are affected with deficiency of Zn, Fe, Mn, Cu, B, Mo and S respectively. In India, the trends of micronutrient deficiencies are now changing. Instead of single nutrient deficiency, cluster of micronutrient deficiencies are emerging fast in vast areas. This suggests that increasing multi-micronutrients deficiencies in soil and crops not only affect the crop productivity, but also create malnutrition and health problems. In experiments with rice-wheat, sesame-wheat, pigeon pea-wheat, maize-wheat, groundnut-wheat and sorghum (Fodder)wheat cropping systems, the addition of S + Zn + B in balanced fertilization schedule increased N,P and K utilization efficiency which highlights the role of micronutrients in enhancing macronutrient use efficiency. Based on the results of large number of field trials (4144), Katyal (1985) concluded that at least in two out of three experiments, treatment with Zn fertilizer was necessary to derive optimum benefit from NPK fertilizers.

Micronutrients are trace elements which are needed by the maize crop in small amounts and play an active role in the plant metabolic functions in shortage of which show deficiency symptoms and crop yields are reduced, they are therefore to be added into the soil before crop planting or applied directly to the crop to increase maize productivity. Adhikari *et al.*, (2010) revealed in order to evaluate the effects of micronutrients (B, Zn, Mo, S and Mn) on the grain production of maize (var. Rampur Composite), series of field experiments were conducted during the winter season of three consecutive years (2007 to 2009) in the acidic

soil condition (5.1 pH) at National Maize Research Programme (NMRP), Rampur. The highest grain yield (5.99 t ha^{-1}) was recorded with the crop which was supplied with all micronutrients (B, Zn, S, Mn and Mo applied in combination with NPK fertilizers at $120:60:40 \text{ kg ha}^{-1}$ which produced almost 171 % higher grain yield than those with control plot (2.21 t ha^{-1}) and 3.78 t ha^{-1} of additional grains over NPK treated crop.

Materials and Methods

The experiment was conducted during *Kharif* 2017-18 at the research farm, Department of Soil Science and Agricultural Chemistry, College of Agriculture Badnapur. The experiment was conducted to study the effect of Zn, Fe and B on nutrients availability at critical growth stage of maize crop planned in randomized block design with nine treatments with three replications. The chemical composition of experimental plots indicated that the soil was low in available nitrogen (126 kg ha^{-1}), high in available phosphorus (26.40 kg ha^{-1}), very high in available potassium ($540.26 \text{ kg ha}^{-1}$) and alkaline having pH 8.1. The concentration of zinc, iron and B in experimental plots was 0.3 ppm, 2.3 ppm and 0.7 ppm respectively. The dose of the NPK along with Zn, Fe and B for maize was worked out according to the present recommendation of maize hybrids in Marathwada region. The 100% NPK dose in kg ha^{-1} worked out was 100:75:75 NPK kg/ha for maize crop. The doses for zinc, iron and boron were framed by applying ZnSO_4 @ 25 kg ha^{-1} , FeSO_4 @ 25 kg ha^{-1} and borax @ 10 kg ha^{-1} , respectively. Fertilizer application was made as per the treatments. Full dose of phosphorus, potash and half dose of nitrogen were applied at sowing as basal application. The remaining dose of nitrogen was top dressed at 30 DAS depending upon the occurrence of rains. Full dose of zinc, iron and boron were applied at sowing.

Maize variety Markiv-6202(Hybrid) was sown at the seed rate of 15 kg ha⁻¹ at spacing of 60 cm × 20 cm. Shallow furrows were opened and seeds were sown manually by using dibbling method at the depth of 5 cm. The sample from each plot was collected from a depth of 0-30 cm at the time of sowing and at harvest. The sample was air dried in shade. The remaining soil sample was ground using wooden pestle and mortar and passed through 2 mm sieve, and then cleaned sample was preserved in polythene bags for further analysis. Available nitrogen in soil was estimated by alkaline permanganate oxidation methods, available phosphorus was estimated by using 0.5 M NaHCO₃. The potassium content in the extract was determined by flame photometer, Available zinc and iron content in soil was extracted with DTPA (Diethylene Triamine Penta acetic Acid) reagent and Available boron in the soil was extracted by the procedure of Berger and Truog.

Results and Discussion

Available N

The data furnished in Table 1 revealed that significantly highest availability of N at tasselling stage 191.57 kg ha⁻¹, cob initiation 165.03 kg ha⁻¹ and harvesting stage 156.51 kg ha⁻¹ was found in T₈ which was at par with treatment T₅, T₆, T₇ and T₉. The decline in the available N status of the soil might be attributed to the utilization of N for growth of maize (Brar *et al.*, 2006). Elayaraja *et al.*, (2014) reported that application of Zinc sulphate at 30 kg/ha + RDF to groundnut increased nitrogen availability in soil.

Available P₂O₅

The data furnished in Table 1 revealed that significantly highest Availability of P at tasselling stage 48.84 kg ha⁻¹, cob initiation stage 44.41 kg ha⁻¹ and at harvesting stage

37.87 kg ha⁻¹ was found in T₈ which was at par with T₉. Rao and Shukla (1996) reported that application of micronutrients increased the P availability in sandy clay loam soil. The increased rates of it decreased the P availability (Nayak and Gupta, 2002).

Available K₂O

The data furnished in Table 1 revealed that significantly highest availability of K at tasselling stage 601 kg ha⁻¹, cob initiation stage 582.62 kg ha⁻¹ and harvesting stage 567.20 kg ha⁻¹ was found in treatment T₈ which was at par with treatment T₅, T₆, T₇ and T₉. Latha (2001) observed that the availability of K in the soil was significantly increased by zinc nutrition, highlighting the positive interactive effect between Zn and K.

Application of 25 kg ZnSO₄ ha⁻¹ registered the highest values for available K in the soil at maize harvest. Dhakshinamoorthy (1977) reported that available K increased with increased levels of Zn up to 10 mg kg⁻¹, beyond that level, there was a decrease of available K content in soil.

Available Zn

The data furnished in Table 2 revealed that significantly highest availability of Zn at tasselling stage 1.55 mg kg⁻¹, 1.29 mg kg⁻¹ and harvesting stage 1.38 mg kg⁻¹ found in T₈ which was at par with treatment T₉. Khurana *et al.*, (2002) observed a spectacular response of maize to Zn and Fe application. Dangarwala *et al.*, (1983) reported that the combined application of 1 kg B along 5 kg Zn ha⁻¹ exhibited higher available Zn (0.87 to 2.93 mg kg⁻¹). According to Gayatri and Mathur (2007) the application of 100 % NPK + Zn increased the Zn content of soil by 4.94 per cent over 100 % NPK alone at the harvest of maize.

Table.1 Effect of Zn, B and Fe on Availability of N P₂O₅ and K₂O in soil at critical growth stages of maize

Treatments	Availability of N (Kg/ha)			Availability of P ₂ O ₅ (Kg/ha)			Availability of K ₂ O (Kg/ha)		
	At Tasseling	At Cob initiation	At harvesting	At Tasseling	At Cob initiation	At harvesting	At Tasseling	At Cob initiation	At harvesting
T ₁ - RDF	134.32	116.43	98.51	26.20	19.51	17.23	529	503.23	487
T ₂ - RDF+ZnSO ₄	138.37	149.66	132	36.53	28.38	25.06	549.64	521.57	513.70
T ₃ - RDF+FeSO ₄	165.23	144.10	128.52	35.38	26.41	23.07	543.5	526.13	518.12
T ₄ - RDF+Borax	168.56	146.3	134.25	37.01	29.28	24.40	569.12	547.25	538.10
T ₅ - RDF+ZnSO ₄ +FeSO ₄	179.35	157.06	142.51	40.16	34.25	29.92	558.98	539.45	526
T ₆ - RDF+ZnSO ₄ +Borax	187.61	165.40	150.21	44.51	36.41	31	578.23	557.34	542
T ₇ - RDF+FeSO ₄ +Borax	181.13	159.36	137.81	41.73	35.48	29	573.10	551.32	540
T ₈ - RDF+ZnSO ₄ +FeSO ₄ +Borax	191.57	168	156.51	49.84	44.41	37.87	601	582.62	567.20
T ₉ - RDF+Foliar application of Micronutrients	188.03	165.03	153.62	48.41	42.25	34.22	594.19	578.16	561.80
SE ±	5.56	4.67	4.10	4.36	4.17	3.67	14.3	16.03	15.38
CD at 5%	16.74	14.06	12.34	13.13	12.58	11.07	43.06	48.26	46.32

Table.2 Effect of Zn, B and Fe on Availability of Zn, B and Fe in soil at critical growth stages of maize

Treatments	Availability of Zn (Mg/kg)			Availability of B (Mg/kg)			Availability of Fe (Mg/kg)		
	At Tasseling	At Cob initiation	At harvesting	At Tasseling	At Cob initiation	At harvesting	At Tasseling	At Cob initiation	At harvesting
T ₁ - RDF	0.73	0.64	0.57	0.43	0.35	0.26	2.98	2.81	2.70
T ₂ - RDF+ZnSO ₄	1.32	1.26	1.15	0.49	0.42	0.31	3.37	3.16	3.01
T ₃ - RDF+FeSO ₄	0.87	0.78	0.70	0.47	0.39	0.29	3.58	3.27	3.17
T ₄ - RDF+Borax	0.89	0.78	0.71	1.04	0.93	0.82	3.41	3.23	3.08
T ₅ - RDF+ZnSO ₄ +FeSO ₄	1.35	1.24	1.19	0.57	0.46	0.34	3.63	3.38	3.19
T ₆ - RDF+ZnSO ₄ +Borax	1.39	1.27	1.23	1.09	0.98	0.85	3.69	3.42	3.20
T ₇ - RDF+FeSO ₄ +Borax	1.38	1.26	1.21	1.08	0.96	0.84	3.59	3.51	3.17
T ₈ - RDF+ZnSO ₄ +FeSO ₄ +Borax	1.55	1.29	1.38	1.20	1.12	0.98	3.90	3.63	3.24
T ₉ - RDF+Foliar application of Micronutrients	1.51	1.27	1.33	1.14	1.06	0.93	3.87	3.56	3.21
SE ±	0.03	0.03	0.03	0.02	0.02	0.02	0.10	0.09	0.09
CD at 5%	0.09	0.09	0.09	0.06	0.06	0.06	0.31	0.27	0.29

Available B

The data furnished in Table 2 revealed that the significantly highest availability of B at tasselling stage 1.20 mg kg^{-1} , cob initiation stage 1.12 mg kg^{-1} and at harvesting stage 0.98 mg kg^{-1} whereas lowest availability of B was found in treatment T_1 .

Similar result found by Chaudhary and Shukla (2004) in arid soils of western Rajasthan. Das (2000) reported that the amount of DTPA extractable Fe and Mn was found to decrease with B application while that of Cu and Zn increased with B application. Renukadevi (2000) reported that the application of 1 kg B along 5 kg Zn ha^{-1} increased the B availability from 0.31 to 0.54 mg kg^{-1} . Nirmale (1991) reported that the available boron ranged from 0.18 to 0.37 mg kg^{-1} in soil. There was steady decrease with depth showing relatively more accumulation of available boron at surface layers.

Available Fe

The data furnished in Table 2 revealed that significantly highest availability of Fe at tasselling stage 3.90 mg kg^{-1} , cob initiation stage and at harvesting stage 3.24 mg kg^{-1} was found in treatment T_8 which was at par with treatment T_5 , T_6 , T_7 and T_9 whereas lowest availability of Fe was found in treatment T_1 . The lowest availability of Fe (2.70 mg kg^{-1}) was found in treatment T_1 . Similar results were found by Reddy *et al.*, (2007) on pigeon pea. Gupta (1994) reported that addition of NPK along Zn increased the available Zn, Fe, Mn and Cu as compared to control.

In conclusion influence of Zn, Fe and B application on nutrient availability in soil at critical growth stages of maize concluded that nutrient availability of nitrogen, phosphorous, potassium and micronutrients in soil increased with the application of RDF + ZnSo_4 +

FeSo_4 + Borax.

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