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

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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 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 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 ZnSO₄ @ 25 kg ha⁻¹, FeSO₄ @ 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 NaHCO\(_3\). 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 tasseling stage 191.57 kg ha\(^{-1}\), cob initiation stage 165.03 kg ha\(^{-1}\) and harvesting stage 156.51 kg ha\(^{-1}\) was found in T\(_8\) which was at par with T\(_5\), T\(_6\), T\(_7\) and T\(_9\). 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 P\(_2\)O\(_5\)**

The data furnished in Table 1 revealed that significantly highest Availability of P at tasseling 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 T\(_8\) which was at par with T\(_9\). 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 K\(_2\)O**

The data furnished in Table 1 revealed that significantly highest availability of K at tasseling 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 T\(_8\) which was at par with treatment T\(_5\), T\(_6\), T\(_7\) and T\(_9\). 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 ZnSO\(_4\) 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 tasseling stage 1.55 mg kg\(^{-1}\), 1.29 mg kg\(^{-1}\) and harvesting stage 1.38 mg kg\(^{-1}\) found in T\(_8\) which was at par with treatment T\(_9\). 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, P\textsubscript{2}O\textsubscript{5} and K\textsubscript{2}O in soil at critical growth stages of maze

| Treatments                                      | Availability of N (Kg/ha) | Availability of P\textsubscript{2}O\textsubscript{5} (Kg/ha) | Availability of K\textsubscript{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\textsubscript{1} - RDF                          | 134.32        | 116.43            | 98.51         | 26.20        | 19.51            | 17.23        | 529          | 503.23            | 487          |
| T\textsubscript{2} - RDF+ZnSO\textsubscript{4}   | 138.37        | 149.66            | 132           | 36.53        | 28.38            | 25.06        | 549.64       | 521.57            | 513.70       |
| T\textsubscript{3} - RDF+FeSO\textsubscript{4}   | 165.23        | 144.10            | 128.52        | 35.38        | 26.41            | 23.07        | 543.5        | 526.13            | 518.12       |
| T\textsubscript{4} - RDF+Borax                  | 168.56        | 146.3             | 134.25        | 37.01        | 29.28            | 24.40        | 569.12       | 547.25            | 538.10       |
| T\textsubscript{5} - RDF+ZnSO\textsubscript{4}+FeSO\textsubscript{4} | 179.35        | 157.06            | 142.51        | 40.16        | 34.25            | 29.92        | 558.98       | 539.45            | 526          |
| T\textsubscript{6} - RDF+ZnSO\textsubscript{4}+Borax | 187.61        | 165.40            | 150.21        | 44.51        | 36.41            | 31           | 578.23       | 557.34            | 542          |
| T\textsubscript{7} - RDF+FeSO\textsubscript{4}+Borax | 181.13        | 159.36            | 137.81        | 41.73        | 35.48            | 29           | 573.10       | 551.32            | 540          |
| T\textsubscript{8} - RDF+ZnSO\textsubscript{4}+FeSO\textsubscript{4}+Borax | 191.57        | 168               | 156.51        | 49.84        | 44.41            | 37.87        | 601          | 582.62            | 567.20       |
| T\textsubscript{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 maze

| 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 |
| T1- RDF                            | 0.73            | 0.64           | 0.57          | 0.43       | 0.35           | 0.26          | 2.98         | 2.81           | 2.70          |
| T2- RDF+ZnSO₄                      | 1.32            | 1.26           | 1.15          | 0.49       | 0.42           | 0.31          | 3.37         | 3.16           | 3.01          |
| T3- RDF+FeSO₄                      | 0.87            | 0.78           | 0.70          | 0.47       | 0.39           | 0.29          | 3.58         | 3.27           | 3.17          |
| T4- RDF+Borax                     | 0.89            | 0.78           | 0.71          | 1.04       | 0.93           | 0.82          | 3.41         | 3.23           | 3.08          |
| T5- RDF+ZnSO₄+FeSO₄               | 1.35            | 1.24           | 1.19          | 0.57       | 0.46           | 0.34          | 3.63         | 3.38           | 3.19          |
| T6- RDF+ZnSO₄+Borax             | 1.39            | 1.27           | 1.23          | 1.09       | 0.98           | 0.85          | 3.69         | 3.42           | 3.20          |
| T7- RDF+FeSO₄+Borax              | 1.38            | 1.26           | 1.21          | 1.08       | 0.96           | 0.84          | 3.59         | 3.51           | 3.17          |
| T8- RDF+ZnSO₄+FeSO₄+Borax       | 1.55            | 1.29           | 1.38          | 1.20       | 1.12           | 0.98          | 3.90         | 3.63           | 3.24          |
| T9- 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 T₁.

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. Renukadavi (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 T₈ which was at par with treatment T₅, T₆, T₇ and T₉ whereas lowest availability of Fe was found in treatment T₁. The lowest availability of Fe (2.70 mg kg⁻¹) was found in treatment T₁. 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 + ZnSO₄ + FeSO₄+ Borax.

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