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Response of *Kharif* maize (*Zea mays* L.) to micronutrients

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Abstract
A Field experiment was conducted on experimental farm of National Agricultural Research Project, Aurangabad during *kharif* season 2015. The field experiment was laid as in randomized block design with nine treatments and three replication. The grain yield ha^{-1} as influenced by different treatments revealed that highest grain yield was recorded by T_8-RDF + $ZnSO_4$ + $FeSO_4$ + Borax (4890 kg ha^{-1}) followed by T_9-RDF + Foliar application of Micronutrient (4791 kg ha^{-1}). Thus, for securing maximum grain yield maize crop should be sown by supplying recommended dose of NPK (150:75:75 kg ha^{-1}) along with $ZnSO_4$ 20 kg ha^{-1}, $FeSO_4$ 20 kg ha^{-1} and borax 5 kg ha^{-1}.

Keywords: Micronutrients, fertilizers and yield

Introduction
Maize (*Zea mays* L.) is an annual plant. It is cultivated globally being one of the most important cereal crop worldwide. It is a versatile crop grown over a range of agro climatic zones. It is called "Queen of Cereals" because of its high productive potential compared to any other cereal crop. It is a C_4 plant, it is capable to utilize solar radiation more efficiently even at higher radiation intensity.

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}. In Marathwada, it is cultivated over an area of 320900 hectares with an annual production of 256800 tonnes having an average productivity of more than 688 kg ha^{-1} (Annual Report of Research Work on Wheat and Maize, VNMKV, Parbhani, 2016) [2].

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) [1] 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 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.

Also the field experiment was conducted by Paramasivan *et al.* (2010) [7] at farmers' field with maize (COHM 5) as a test crop. The highest grain yield (7908 kg ha^{-1}) was recorded in the treatment with 250:70:150:9.6 kg of NPK and Zn ha^{-1}. Archana *et al.* (2012) [3] reported that among the iron treatments, 50 kg $FeSO_4$ + 0.5% $FeSO_4$ foliar spray showed the highest grain yield and it was comparable with 25 kg $FeSO_4$ + 0.5% $FeSO_4$ foliar spray.

Keeping these in view, the present field experiment was carried out to study the response of *kharif* maize (var. DKC-9133) at Experimental farm of National Agricultural Research Project, Aurangabad during *kharif* 2015-16.

Material and Method
The study was carried out on medium black soil at the experimental farm of National Agricultural Research Project, Aurangabad (Maharashtra). The chemical composition of experimental plots indicated that the soil was low in available nitrogen (121 kg ha^{-1}), high in available phosphorus (25.40 kg ha^{-1}), very high in available potassium (550.26 kg ha^{-1}) and

alkaline in reaction having pH 8.1. The concentration of zinc and iron in experimental plots was 0.3 ppm and 2.3 ppm, respectively.

The experiment was laid out in Randomized Block Design with three replications. It consisted of 9 treatments *viz*, T_1-RDF, T_2-RDF + $ZnSO_4$, T_3-RDF + $FeSO_4$, T_4-RDF + Borax, T_5-RDF + $ZnSO_4$ + $FeSO_4$, T_6-RDF + $ZnSO_4$ + Borax, T_7-RDF + $FeSO_4$ + Borax, T_8-RDF + $ZnSO_4$ + $FeSO_4$ + Borax, T_9-RDF + Foliar application of Micronutrient.

Maize seeds were sown at uniform row of 60 cm and plant to plant spacing of 30 cm. The sources used for applying N, P and K were urea, diammonium phosphate (adjusted for its N content) and muriate of potash, respectively. Zinc sulphate, ferrus sulphate and borax were used to supply Zn, Fe and B, respectively. The 100% NPK dose in kg ha^{-1} worked out was 100:75:75 for maize crop. The doses for zinc, iron and boron were framed by applying $ZnSO_4$ 20 kg ha^{-1}, $FeSO_4$ 20 kg ha^{-1} and borax 5 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 mixed with FYM and applied at sowing.

Results and Discussion

Effect on growth parameters

The effects of treatments were noticed on important growth parameters *viz.* plant height, number of functional leaves and leaf area. All the growth attributing characters *viz.*, plant height, number of functional leaves and leaf area per plant were higher in RDF+$ZnSO_4$+$FeSO_4$+Borax (T_8) treatment during entire crop growth period as compared to all other treatments and it was at par with RDF (T_1). Similar results were reported by Soomro *et al.* (2011) [11], Soleymani and Shahrajabian (2012) [10], Preetha and Stalin (2014) [9], Gillani *et al.* (2014) [4] and Gowthami and Rama (2014) [5].

Table 1: Effect of different treatments on different growth parameters

Treatments	Plant height	Number of leaves	Leaf area	Days required for 50 percent tasseling	Days required for 50 percent silking
T_1-RDF	143.09	11.92	68.32	55.67	60.33
T_2-RDF + $ZnSO_4$	154.36	12.60	77.12	55.33	60.67
T_3-RDF + $FeSO_4$	149.47	12.21	74.26	55.67	61.00
T_4-RDF + Borax	151.77	12.41	75.65	55.33	60.33
T_5-RDF + $ZnSO_4$ + $FeSO_4$	162.93	12.71	79.32	55.67	61.33
T_6-RDF + $ZnSO_4$ + Borax	172.38	12.98	82.14	55.67	61.33
T_7-RDF + $FeSO_4$ + Borax	168.65	12.86	80.97	55.67	60.33
T_8-RDF + $ZnSO_4$ + $FeSO_4$ + Borax	181.40	13.31	89.64	55.33	60.67
T_9-RDF + Foliar application of Micronutrient	177.60	13.17	85.33	56.00	61.67
SE ±	3.23	0.07	1.17	0.45	0.48
CD at 5%	9.24	0.19	3.33	NS	NS

Effect on yield of maize

Maximum grain yield, stover yield and biological yield were observed in RDF + $ZnSO_4$ + $FeSO_4$ + Borax (T_8) which was higher than all other treatments followed by RDF + Foliar application of Micronutrient (T_9). Similar results were reported by Parasuraman *et al.* (2008) [8], Paramasivan *et al.* (2010) [7], Soomro *et al.* (2011) [11] and Mohsin *et al.* (2014) [6]. The highest harvest index was observed in RDF + $FeSO_4$ (T_3) and lowest harvest index was observed in RDF + Borax (T_4) but, it was found to be non-significant. The similar result was reported by Mohsin *et al.* (2014) [6].

Table 2: Effect of different treatments on grain, stover and biological yield and harvest index

Treatments	Grain yield kg ha^{-1}	Stover yield kg ha^{-1}	Biological yield (kg ha^{-1})	Harvest index (%)
T_1-RDF	3862	4267	8129	47.51
T_2-RDF + $ZnSO_4$	4201	4672	8873	47.35
T_3-RDF + $FeSO_4$	4065	4470	8535	47.63
T_4-RDF + Borax	4103	4653	8756	46.86
T_5-RDF + $ZnSO_4$ + $FeSO_4$	4455	4951	9406	47.36
T_6-RDF + $ZnSO_4$ + Borax	4549	5037	9586	47.45
T_7-RDF + $FeSO_4$ + Borax	4497	5026	9523	47.22
T_8-RDF + $ZnSO_4$ + $FeSO_4$ + Borax	4890	5390	10280	47.57
T_9-RDF + Foliar application of Micronutrient	4791	5307	10098	47.45
SE ±	81.41	83.2	149.53	-
CD at 5%	231.07	260.1	504.3	-
General Mean	4379.22	4863.66	9242.88	47.37

Conclusion

The RDF + $ZnSO_4$ + $FeSO_4$ + Borax (T_8) was the best treatment including growth, yield attributing characters and yield of hybrid maize. The RDF + Foliar application of Micronutrient (T_9) was the second best treatment including growth, yield attributing characters and yield of hybrid maize.

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