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Jaison M
Department of Soil Science and Agricultural Chemistry, College of Agriculture, UAS, GKVK, Bengaluru, Karnataka, India

Kiran Pilli
Department of Soil Science and Agricultural Chemistry, College of Agriculture, OUAT, Bhubaneswar, Odisha, India

Harish SG
Department of Soil Science and Agricultural Chemistry, College of Agriculture, UAS, GKVK, Bengaluru, Karnataka, India

Chikkaramappa T
Department of Soil Science and Agricultural Chemistry, College of Agriculture, UAS, GKVK, Bengaluru, Karnataka, India

Correspondence
Jaison M
Department of Soil Science and Agricultural Chemistry, College of Agriculture, UAS, GKVK, Bengaluru, Karnataka, India

Response of foxtail millet to application of zinc and boron in *Alfisols* of Karnataka

Jaison M, Kiran Pilli, Harish SG and Chikkaramappa T

Abstract
A field experiment was conducted in KVK at Bidaregudikaval village, Tiptur taluk, Tumkur district of Karnataka in soil which was deficient in DTPA extractable zinc and hot water soluble boron, to study the effect of zinc and boron on growth and yield of foxtail millet. The experiment was laid out in RCBD design comprising 18 treatments replicated thrice. The results revealed that significantly higher grain and straw yield (17.19 and 25.91 q ha^{-1}) of foxtail millet was recorded in treatment which received fertilizers application of 40 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1}, 30 kg K_2O ha^{-1}, $ZnSO_4$ @ 12.5 kg ha^{-1} and Borax @ 5 kg ha^{-1} combined with application of farm yard manure at 6.5 t ha^{-1} as compared to RDF (40: 40:30 N: P_2O_5: K_2O kg ha^{-1}). The results of the present study evidently concluded that the application of 40: 40: 30 kg N: P_2O_5: K_2O ha^{-1}, $ZnSO_4$ @ 12.5 kg ha^{-1} and Borax @ 5 kg ha^{-1} along with FYM at 6.5 t ha^{-1} under rainfed condition is beneficial for getting higher yield of foxtail millet as compared to the RDF (40: 40: 30 kg N: P_2O_5: K_2O ha^{-1}) in zinc and boron deficient soils of Tumkur district of Karnataka.

Keywords: foxtail millet, boron, *Alfisols*, Karnataka

Introduction
Foxtail millet (*Setaria italica* L.) is one of the oldest cultivated millet grain and the most important species of the *Setaria* genus economically. Foxtail millet is grown mainly in dryland. Foxtail millet is getting popular and its importance is realized nowadays, because of its low requirement of inputs, wider adaptability and nutritional superiority over cereals. Soil fertility is one of the main limiting factors that influences production in intensive cultivation of crops. Introduction of high yielding hybrids and varieties in many crops, increased use of high analysis chemical fertilizers without adequate application of organics and micronutrients have resulted in the wide spread deficiency of micronutrients and nutrient imbalance which adversely affected the yield of many crops. Zinc is an essential trace element for the growth and development of plants, humans and animals. Zinc deficiency is one of the most important reasons affecting human health. The growth and immune system of humans can be impaired by Zn deficiency. Zinc deficiency in soils may reduce yield and quality of the crop. Agronomic and genetic bio fortification has been suggested as strategies to increase the dietary Zn through edible crops (Bouis and Welch, 2010) [1]. Boron is an essential micronutrient for plant growth, seed development and crop yield. Although cereals and millets generally less sensitive to B deficiency than pulses, it still affects cereals by a deficiency in several parts of the world. In Karnataka, millets are one of the main components of cropping system. Boron and zinc are deficient in soils of many parts of Karnataka. Millets grains can accumulate more amount of zinc and boron compared to cereals. Hence the study is conducted to find the response of foxtail millet to different levels of zinc and boron application.

Material and Methods
The field experiment was carried out in a soil with low boron and zinc content at Krishi Vigyan Kendra, Tumkur during *kharif* 2017. Geographically it is located in the eastern part of the state, between 12º45’ and 14º20’ North latitude and 76º20’ to 77º31’ East longitude. The experimental plot size was 4.2 m X 4 m and laid out in Randomized Complete Block Design with 18 treatments and three replications

T_1	Absolute control
T_2	FYM
T_3	RDF + FYM
T_4	T_3 + $ZnSO_4$ @ 10 kg ha^{-1}
T_5	T_3 + $ZnSO_4$ @ 12.5 kg ha^{-1}
T_6	T_3 + $ZnSO_4$ @ 15 kg ha^{-1}
T_7	T_3 + Borax @ 2.5 kg ha^{-1}
T_8	T_3 + Borax @ 5 kg ha^{-1}
T_9	T_3 + Borax @ 7.5 kg ha^{-1}
T_{10}	T_3 + $ZnSO_4$ @ 10 kg ha^{-1} + Borax @ 2.5 kg ha^{-1}
T_{11}	T_3 + $ZnSO_4$ @ 10 kg ha^{-1} + Borax @ 5 kg ha^{-1}
T_{12}	T_3 + $ZnSO_4$ @ 10 kg ha^{-1} + Borax @ 7.5 kg ha^{-1}
T_{13}	T_3 + $ZnSO_4$ @ 12.5 kg ha^{-1} + Borax @ 2.5 kg ha^{-1}
T_{14}	T_3 + $ZnSO_4$ @ 12.5 kg ha^{-1} + Borax @ 5 kg ha^{-1}
T_{15}	T_3 + $ZnSO_4$ @ 12.5 kg ha^{-1} + Borax @ 7.5 kg ha^{-1}
T_{16}	T_3 + $ZnSO_4$ @ 15 kg ha^{-1} + Borax @ 2. 5 kg ha^{-1}
T_{17}	T_3 + $ZnSO_4$ @ 15 kg ha^{-1} + Borax @ 5 kg ha^{-1}
T_{18}	T_3 + $ZnSO_4$ @ 15 kg ha^{-1} + Borax @ 7.5 kg ha^{-1}

The DHF11073 variety of foxtail millet which is having duration of 90 days was cultivated in the *alfisol* which was sandy loam in texture and acidic soil reaction (pH: 5.57). Electrical conductivity was 0.04 $dSm^{-1}$and organic carbon content was 0.54 per cent. Available N, P_2O_5 and K_2O contents of the soil were 257, 23.51 and 274.32 kg ha^{-1} respectively and available Zn and B contents were 0.54 and 0.40 mg kg^{-1} respectively. Plant height was measured at 30 and 60 days after sowing and at harvest stage, from the ground level up to the base of the node on which the first fully opened leaf from the top and expressed in centimetre. The length of ear head was measured from a sample of five randomly labelled plants selected from each plot. It was measured from the neck to the tip of the ear heads and the average was computed. Grains from the harvested Ear heads of each plot of five labelled plants are separated by threshing and weight was measured. The average weight of grains per Ear heads is computed. The test weight of randomly sampled foxtail millet grains were recorded by counting the 1000 filled grains using seed counter and were weighed to compute test weight of foxtail millet grains. The net plots (leaving two borders on each side of the plot, 0.5 meters from each side of the plot) were harvested and sun dried for 3 days in the field and then the total biomass yield was recorded. After threshing, cleaning and drying grain yield was recorded and reported at 12 per cent moisture content. The straw yield was obtained by subtracting grain yield with total biomass yield. The yield was expressed in q ha^{-1}.

Results and Discussion

Effect of zinc and boron application on plant height of foxtail millet at different growth stages:

The data in Table 1 indicates the effect of zinc and boron on plant height of foxtail millet at 30 DAS, 60 DAS and harvest. There was a significant increase in plant height of foxtail millet observed at different intervals of crop growth due to the application of different levels of zinc and boron along with recommended dose of fertilizers. At 30 and 60 DAS significantly higher plant height was recorded in T_{14} and was on par with treatment T_1, T_{12}, T_{13}, T_{15}, T_{16}, T_{17}, T_{18}. However, the lowest plant height was recorded in T_1 (absolute control). After harvesting also the treatment T_{14} recorded significantly highest plant height it was also found to be on par with treatments T_{15} and T_{16}. Lowest was recorded in treatment T_1 (absolute control) with plant height.

There was a significant increase in plant height at 30 DAS and 60 DAS due to boron and zinc application to the soil. Between the two mineral nutrients, zinc had a greater positive influence on plant height than boron application. Similar results were observed even at harvest stage of the crop. It is a well-known fact that boron is essential in enhancing carbohydrate metabolism, sugar transport, cell wall formation, protein metabolism, root growth and stimulating other physiological processes of the plant (Ashour and Reda, 1972) [8]. These results of the present study were in accordance with that of Balachandar *et al*. (2003) [9] and Sathya *et al*. (2010) [10] reported that an increase in plant height of crop was observed due to the application of boron and zinc. Highest plant height was recorded in combined application of zinc and boron due to the synergistic effect of zinc and boron on plant height which was in accordance to result obtained by Chandrakumar (2013) [6].

Effect of zinc and boron application on yield attributes of foxtail millet

Table 2 gives the data of yield attributes of foxtail millet as influenced by the application of zinc and boron.

Highest grain yield 17.19 q ha^{-1} was recorded in T_{14} treatment which received $ZnSO_4$ @ 12.5 kg ha^{-1} + Borax @ 5 kg ha^{-1}which was also on par with treatments T_{15} (T_3 + $ZnSO_4$ @ 12.5 kg ha^{-1} + Borax @ 7.5 kg ha^{-1}) having grain yield 17.16 q ha^{-1} and T_{16} (T_3 + $ZnSO_4$ @ 15 kg ha^{-1} + Borax @ 2.5 kg ha^{-1}) recording 17.06 q ha^{-1}.

Table 1: Effect of zinc and boron application on plant height of foxtail millet at different growth stages

Treatments		Plant height (cm)		
		30 DAS	60 DAS	At harvest
T_1	Absolute control	17.00	68.83	106.83
T_2	FYM	18.07	77.50	117.17
T_3	RDF + FYM	19.13	81.50	118.67
T_4	T_3 + $ZnSO_4$ @ 10 kg ha^{-1}	19.12	84.83	121.50
T_5	T_3 + $ZnSO_4$ @ 12.5 kg ha^{-1}	19.11	85.00	123.33
T_6	T_3 + $ZnSO_4$ @ 15 kg ha^{-1}	19.19	85.00	123.50
T_7	T_3 + Borax @ 2.5 kg ha^{-1}	19.17	83.00	121.17
T_8	T_3 + Borax @ 5 kg ha^{-1}	19.27	83.33	122.17
T_9	T_3 + Borax @ 7.5 kg ha^{-1}	19.13	84.50	123.50
T_{10}	T_3 + $ZnSO_4$ @ 10 kg ha^{-1} + Borax @ 2.5 kg ha^{-1}	19.67	85.67	125.67
T_{11}	T_3 + $ZnSO_4$ @ 10 kg ha^{-1} + Borax @ 5 kg ha^{-1}	20.00	86.00	127.33
T_{12}	T_3 + $ZnSO_4$ @ 10 kg ha^{-1} + Borax @ 7.5 kg ha^{-1}	20.07	89.50	126.83
T_{13}	T_3 + $ZnSO_4$ @ 12.5 kg ha^{-1} + Borax @ 2.5 kg ha^{-1}	20.13	91.83	129.33
T_{14}	T_3 + $ZnSO_4$ @ 12.5 kg ha^{-1} + Borax @ 5 kg ha^{-1}	20.23	92.17	131.93
T_{15}	T_3 + $ZnSO_4$ @ 12.5 kg ha^{-1} + Borax @ 7.5 kg ha^{-1}	20.20	91.93	131.53
T_{16}	T_3 + $ZnSO_4$ @ 15 kg ha^{-1} + Borax @ 2. 5 kg ha^{-1}	20.10	90.50	131.33

T_{17}	T_3 + $ZnSO_4$ @ 15 kg ha^{-1} + Borax @ 5 kg ha^{-1}	20.07	89.83	128.17
T_{18}	T_3 + $ZnSO_4$ @ 15 kg ha^{-1} + Borax @ 7.5 kg ha^{-1}	20.03	89.03	127.83
S.Em. ±		0.52	0.83	0.96
CD @ 5%		1.57	2.50	2.88

RDF (Recommended Dose of Fertilizers): 40 kg N, 40 kg P2O5 and 30 kg K2O ha-1, FYM (Farm Yard Manure): 6.5 t ha-1

The least was observed in T_1 (absolute control) with straw yield of 20.58 q ha^{-1}which was followed by treatment T_2 (FYM) with straw yield of 21.04 q ha^{-1}. Significantly highest grain weight per ear head 23.07 (g) was observed in T_{14} treatment which was superior to all other treatments and followed by T_{15} treatment. The significantly lowest number of grains per earhead of 14.70 (g) was recorded in T_1 treatment (absolute control) compared to other treatments and it was followed by treatment T_2 (FYM).

The highest significant weight of ear head (34.61 g) was recorded in treatment T_{14} which received $ZnSO_4$ @ 12.5 kg ha^{-1} + Borax @ 5 kg ha^{-1} and significantly lowest was recorded in T_1 which was absolute control.

There was no significant difference observed in test weight of foxtail millet due to the application of Zinc and boron. Increase in grain and straw yield was noticed among treatments due to the application of zinc and boron. A significant increase in grain and straw yield of foxtail millet was noticed due to the application of different levels of $ZnSO_4$ and borax over RDF+FYM. The highest yield was recorded in T_{12} treatment which received RDF + $ZnSO_4$ @ 20 kg ha^{-1} + Borax @ 4 kg ha^{-1} was found significantly superior over all other treatments. The lowest grain yield was recorded in T_1 (RDF+FYM) treatment. Application of Zn and B, when used alone as well as when applied in combination, resulted in significantly higher grain and straw yields than the control. The beneficial effect of B on the enhancement of crop yield had been reported by Raghuveer *et al*. (2013) [2]. Similarly, the favourable effect of Zn on the yield of different crops had also been well documented (Bagewadi *et al.,* 2003) [3]. In this experiment, the crop yield increased to a greater extent due to the combined use of Zn and B than their use alone. These results were in accordance with Quddus *et al.* (2011) [5], Muhammad *et al*. (2012) [4], Chandrakumar (2013) [13] and Kumar (2014) [7]

Table 2: Effect of zinc and boron application on grain yield, straw yield and yield attributes of foxtail millet

Treatments		Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Grain weight per earhead (g)	Earhead weight (g)	Test weight (g)
T_1	Absolute control	13.63	20.58	14.70	22.05	4.42
T_2	FYM	13.94	21.04	15.02	22.54	4.47
T_3	RDF + FYM	14.12	21.32	15.38	23.07	4.54
T_4	T_3 + $ZnSO_4$ @ 10 kg ha^{-1}	14.40	21.74	18.43	27.64	4.24
T_5	T_3 + $ZnSO_4$ @ 12.5 kg ha^{-1}	15.14	22.86	20.32	30.49	4.25
T_6	T_3 + $ZnSO_4$ @ 15 kg ha^{-1}	15.83	23.91	17.35	26.03	4.49
T_7	T_3 + Borax @ 2.5 kg ha^{-1}	14.34	21.66	15.61	23.42	4.44
T_8	T_3 + Borax @ 5 kg ha^{-1}	15.07	22.75	18.48	27.72	4.09
T_9	T_3 + Borax @ 7.5 kg ha^{-1}	15.67	23.66	17.48	26.22	4.09
T_{10}	T_3 + $ZnSO_4$ @ 10 kg ha^{-1} + Borax @ 2.5 kg ha^{-1}	15.87	23.97	20.53	30.79	4.13
T_{11}	T_3 + $ZnSO_4$ @ 10 kg ha^{-1} + Borax @ 5 kg ha^{-1}	16.13	24.36	21.64	32.47	4.16
T_{12}	T_3 + $ZnSO_4$ @ 10 kg ha^{-1} + Borax @ 7.5 kg ha^{-1}	16.22	24.50	20.74	31.11	4.29
T_{13}	T_3 + $ZnSO_4$ @ 12.5 kg ha^{-1} + Borax @ 2.5 kg ha^{-1}	16.91	25.53	20.60	30.91	4.30
T_{14}	T_3 + $ZnSO_4$ @ 12.5 kg ha^{-1} + Borax @ 5 kg ha^{-1}	17.19	25.96	23.07	34.61	4.60
T_{15}	T_3 + $ZnSO_4$ @ 12.5 kg ha-1 + Borax @ 7.5 kg ha^{-1}	17.16	25.91	22.54	33.80	4.48
T_{16}	T_3 + $ZnSO_4$ @ 15 kg ha^{-1} + Borax @ 2. 5 kg ha^{-1}	17.06	25.76	21.46	32.19	4.37
T_{17}	T_3 + $ZnSO_4$ @ 15 kg ha^{-1} + Borax @ 5 kg ha^{-1}	16.89	25.51	19.32	28.97	4.37
T_{18}	T_3 + $ZnSO_4$ @ 15 kg ha^{-1} + Borax @ 7.5 kg ha^{-1}	16.88	25.48	18.96	28.44	4.21
S.Em. ±		0.07	0.06	0.08	0.13	0.10
CD @ 5 %		0.21	0.18	0.24	0.35	NS

Conclusion

It was concluded that plant height and Grain and straw yield was significantly higher in T_{14} (RDF + FYM + $ZnSO_4$ @ 12.5 kg ha^{-1} + Borax @ 5 kg ha^{-1}) which was on par with T_{15} (RDF + FYM + $ZnSO_4$ @ 12.5 kg ha^{-1} + Borax @ 7.5 kg ha^{-1}) and T_{16} (RDF + FYM + $ZnSO_4$ @ 15 kg ha^{-1} + Borax @ 2.5 kg ha^{-1}). However, lowest was recorded in T_1 (absolute control).

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