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Effect of micronutrient on yield and nutrient uptake in sorghum

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Abstract
A field experiment was conducted during the rainy (*kharif)* seasons of 2010 and 2011 at Rajasthan College of Agriculture, Udaipur, to study the effect of micronutrients on yield and nutrient uptake in sorghum [*Sorghum bicolour* (L.) Moench]. The experiment consisted of 24 treatment combinations and replicated three times in split plot design. The results showed that methods of micronutrient application through combined soil+foliar spray significantly increased grain (14.15 and 12.13%), stover (10.75 and 8.60%) and biological yields (11.37 and 9.31%) over soil and foliar application, respectively. The results show that application of Fe+ Zn+ B along with RDF proved its superiority over rest of treatments, however, combined application of two micronutrients were also significantly higher over alone nutrient application. Combined application of micronutrient (Fe+ Zn+ B) was significantly increased grain (25.33 %), stover (15.44 %) and biological yield (17.42 %) over control. The combined applications of soil + foliar application significantly uptake of N, P & K by 14.12 & 11.75%, 13.98 & 10.86% and 12.33 & 9.57% over soil and foliar application, respectively. Improvement of N, P and K uptake with RDF+ Fe+ Zn+ B was noticed of 33.25, 33.14 & 18.51 per cent over control. Micronutrient significantly improvement of Zn, (47.90, 18.32 %) Fe (30.20, 16.11%) and B (25.60, 19.75%) uptake were also noticed with soil + foliar and (Fe+ Zn+ B) over control.

Keywords: Sorghum, Micronutrient, Yield, Nutrient uptake.

1. Introduction

In India, the area under sorghum is approximately 5.82 million ha with an annual production of about 5.39 million tonnes and an average productivity of 926 kg/ha (DAC, 2014). Since the possibility of horizontal expansion or put- ting more area under cultivation is difficult, future aug - mentation in yield should have to be harnessed vertically through increase in productivity by judicious management of all input especially nutrients. The balanced fertilization has shown positive effects on various aspects of growth, development and biological yield of the crop in comparison to nutrient use in single or in combination. Micronutrients are important for maintaining soil health and also for increasing productivity of crops. These are needed in very small amounts. The soil must supply micronutrients for desired growth and development of plants. Increased removal of micronutrients as a consequence of adoption of HYVs (high yielding variety's) and intensive cropping together with shift towards high analysis NPK fertilizers has caused decline in the level of micronutrients in the soil to below normal at which productivity of crops cannot be sustained. The role of zinc and iron in crop nutrition is well recognized as it is used for bio-synthesis of plant auxins, nitrogen metabolism, oxidation-reduction reactions, which are considered to be necessary for plant growth and development, chlorophyll formation, photosynthesis, important enzyme system and respiration in plants. Boron also plays a very important role in vital functions of the plant, including meristem, sugar and hydrocarbon metabolism and their transfer, RNA and cytokinin production and transfer, pollen building and seed formation, Murthy *et al*. (2006) [12]. Application of micronutrient fertilizers through soil application is the most efficient and economical method of getting these nutrients into the crops. The amount of nutrient required is much higher compared to foliar application. Foliar application is widely used to apply micronutrients for many crops. Soluble salts are generally effective in foliar sprays. Deficiency symptoms are usually corrected within the few days and there after the entire field could be sprayed with the appropriate micronutrients source (Mortvedt, 2000) [12]. Therefore, the present investigation was conducted to study the effect of micronutrient fertilization on yield and nutrient uptake in sorghum.

Materials and Methods

A field experiment was conducted during the rainy (*kharif)* seasons of 2010 and 2011 at Rajasthan College of Agriculture, Udaipur.

The site is situated at 24º.35' N latitude, 74º.42' E longitude and an altitude of 579.5m above mean sea level. The region falls under agro-climatic zone IVA of Rajasthan. The soil was clay loam, medium in organic carbon (8.6 g kg^{-1}), medium in available nitrogen (266.80 kg ha^{-1}), phosphorus (22.50 kg ha^{-1}) and high in available potassium (318. kg ha^{-1}) as well as micronutrient *i.e.* iron (4.45 mg ha^{-1}), zinc (0.80 mg ha^{-1}) and boron (0.310 mg ha^{-1}) with pH 8.1. The experiment consisted of 24 treatment combinations and replicated three times. These treatments were evaluated in split plot design with three method of micronutrient application (soil application, foliar spray and soil + foliar application) and eight micronutrient treatments (Control), (Fe), (Zn), (B), (Fe + Zn), (Fe + B), (Zn + B) and (Fe + Zn + B). Sorghum variety CSV-23 was sown on 13 July 2010 and 9 July 2011 in furrows at 45 cm row spacing using a seed rate of 10 kg ha^{-1}. The crop was harvested after 100-105 days. Iron, zinc and boron were applied as $FeSO_4$, $ZnSO_4$ and borax at rate the 25, 25 and 20 kg ha^{-1} as soil application, respectively. The (0.5, 0.2 and 0.2 % of Zn, Fe and B were sprayed at 15 and 30 days after sowing. All the plots were fertilized with recommended dose of NPK (80, 40 and 40 kg ha^{-1}) as basal at the time of sowing and remaining half dose of N at 30 days after sowing. Total amount of rainfall during the crop growth period was 580 and 630 mm in 2010 and 2011 respectively. Nutrient content in plant sample were analyzed for nitrogen (Nessler's reagent, spectrophotometrically by Snell and Snell 1959) [17], phosphorus (Vanadomolybdate phosphoric acid yellow colour method by Jackson, 1973) [6], potash estimated by Flame photometer Jackson, 1973) [6], iron & zinc (AAS by Lindsay and Norvell 1978) [10] and boron (Curcumin- oxalic acid method by Jackson, 1973) [6]. The results were analyzed using standard statistical procedure given by Panse and Sukhatme (2000) [14].

Results and Discussion

Yields

Significantly effect of micronutrients application through combined method *i.e.* Soil + foliar application obtained significantly higher grain, stover and biological yield. The results showed that (Table 1) methods of micronutrient application through combined soil+foliar spray significantly increased grain (14.15 and 12.13%), stover (10.75 and 8.60%) and biological yields (11.37 and 9.31%) over soil and foliar application, respectively. Micronutrient elements are needed in relatively very small quantities for adequate plant growth and production. Their deficiency may cause great disturbance in the physiological and metabolic processes involved in the plant. The application of micronutrient fertilizers in the cultivation zone may not be meeting the crop requirement for root growth and nutrient use. The alternative approach is to apply these micronutrients as foliar spray which results in the absorption of nutrients through foliage and supply nutrients at vegetative and flowering stages of crop growth (Welch *et al.* 1995 and Havlin *et al*. 2003) [4]. The results show that application of Fe+ Zn+ B along with control (RDF) proved its superiority over rest of treatments, however, combined application of two micronutrients were also significantly higher over alone nutrient application. Combined application of micronutrient (Fe+ Zn+ B) was significantly increased grain (25.33 %), stover (15.44 %) and biological yield (17.42 %) over control. Foliar application of iron, zinc and boron at reproductive growth stage increased grain and stover yield. Combined application of control (RDF) with micronutrients resulted in higher grain, stover and biological yields as compared to control. The existence of favourable nutritional environmental below ground and above ground under the influence of zinc had a positive influence on both the phases of crop, which ultimately led to realization of higher yields. Iron is a structural component of porphyrin molecules, Cytochroms, hemes, hematian, ferrichrome and leghemogloben. These substances are involved in oxidation-reduction reactions in respiration and photosynthesis. The increase in yields attributed to the fact that because of favourable nutritional environment in rhizosphere and higher absorption of nutrients by plant leading to the increased photosynthetic efficiency and production of assimilates. Similar results were also reported by Khan *et al*. (2010) [7], Issa Piri (2012) [5], Bhunwal *et al*. (2015) [1] and Choudhary *et al.* (2015) [2].

Nutrient uptake

The micronutrients applied through combined method *i.e.* soil + foliar application obtained significantly higher uptake of N, P, K and Zn, Fe and B (Table 2). The combined applications of soil + foliar application significantly uptake of N, P & K by 14.12 & 11.75%, 13.98 & 10.86% and 12.33 & 9.57% over soil and foliar application, respectively. Improvement of N, P and K uptake with Fe+ Zn+ B was noticed of 33.25, 33.14 & 18.51 per cent over control. These micronutrients help in formation of nucleic acid, protein synthesis and play an active role in several enzymatic activities of photosynthesis as well as in respiration. The application of micronutrient with NPK fertilizers provides a double benefit: increasing grain yield and improving the nutritional quality of the grains, since micronutrient with NPK fertilizers also increase the concentration of nutrients in grain as well as stover and thereby increased the uptake of nutrients. These results are in agreement with those recorded by Kotangale *et al*. (2009) [9], Shivay, (2010) [15] and Khalifa *et al.* (2011) [8].

The results revealed that micronutrient application through soil + foliar spray significantly increased the Zn, Fe and B uptake in sorghum over individual micronutrient application. Micronutrient significantly improvement of Zn, (19.75,15. 82%) Fe (16.11,12.49%) and B (18.30,14.35%) uptake were also noticed with soil + foliar over soil and foliar application. Result show that of Zn, (47.90%) Fe (30.20%) and B (25.60%) uptake were also noticed with (Fe+ Zn+ B) over control. The improvement in nutrient status with basal as well as foliar application of micronutrients seems to be on account of higher dry matter accumulation as well as nutrient status. Application of micronutrients in the soil deficient in micronutrient content increased the availability of zinc in rhizosphere. The beneficial role of micronutrient in increasing the cation exchange capacity of root helped in the increased absorption of nutrients from the soil. Further, the beneficial role of micronutrient in chlorophyll formation, regulating the auxin concentration and its simulatory effect on most of physiological and metabolic processes of the plant might have helped the plants in absorption of greater amount of nutrients from soil. Our results are in concurrence with the findings of Mohammad *et al.* (2009) [11] and Singh and Kumar (2011) [16].

It may be concluded that an increasing response to micronutrient fertilization along with recommended doses of N, P and K in terms of increased yield and nutrient uptake by sorghum crop. Improvement of N, P, K, Zn, Fe and B uptake were also noticed with soil + foliar and (Fe+ Zn+ B) over control. The balanced fertilization has shown positive effects on various aspects of growth, development biological yield, and nutrients of the crop in comparison to nutrient use in single or in combination. Micronutrient fertilization includes combined use of all essential plant nutrients in optimum quantities, proportion and their application at appropriate time through suitable source and methods under specific cropping system.

Table 1: Effect of micronutrients and methods of application on yields and harvest index of sorghum (Mean data of 2 years).

Treatments	Yield (tonnes/ha)			Harvest index (%)
	Grain	Stover	Biological	
Methods (Main plot)				
Soil application	3.32	13.12	16.45	20.29
Foliar application	3.38	13.38	16.76	20.13
Soil+Foliar application	3.79	14.53	18.32	20.64
SEm $\pm$	0.05	0.19	0.20	0.31
CD (P = 0.05)	0.15	0.63	0.64	NS
Nutrients (Sub plot)				
Control	3.04	12.63	15.67	19.50
Fe	3.38	13.60	16.99	19.95
Zn	3.40	13.69	17.08	19.90
B	3.36	13.62	16.99	19.82
Fe + Zn	3.68	13.78	17.45	21.08
Fe + B	3.61	13.75	17.37	20.82
Zn + B	3.68	13.74	17.43	21.08
Fe + Zn + B	3.81	14.58	18.40	20.66
SEm $\pm$	.048	0.155	0.17	0.26
CD (P = 0.05)	0.14	0.44	0.47	0.74

Table 2: Effect of micronutrients on total uptake of NPK by sorghum (Mean data of 2 years).

Treatments	Total Uptake					
	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Zn (g ha^{-1})	Fe (g ha^{-1})	B (g ha^{-1})
Methods (Main plot)						
Soil application	126.5	36.2	230.1	383.7	2036.7	886
Foliar application	129.2	37.2	235.9	397.0	2102.4	916
Soil +Foliar application	144.3	41.3	258.5	454.0	2365.0	1061
SEm $\pm$	1.53	0.39	3.13	0.39	2.32	0.80
CD (P = 0.05)	5.01	1.27	10.21	1.27	7.58	2.70
Nutrients (Sub plot)						
Control	113.6	32.5	219.8	335.3	1877.0	810
Fe	130.0	37.5	238.4	386.1	2183.0	914
Zn	131.0	37.7	239.5	410.1	2116.7	922
B	129.5	37.6	238.4	383.6	2103.9	955
Fe + Zn	137.6	39.1	246.1	441.3	2239.2	955
Fe + B	136.1	39.0	244.4	407.6	2226.7	988
Zn + B	137.5	39.2	245.0	432.2	2152.6	997
Fe + Zn + B	151.3	43.4	260.5	496.2	2445.4	1094
SEm $\pm$	1.75	0.54	3.19	0.48	2.74	0.11
CD (P = 0.05)	4.93	1.52	8.97	1.35	7.72	31

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