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EFFECT OF DIFFERENT BORON SOURCES AND LEVELS ON MACRO AND MICRONUTRIENT UPTAKE AND POST-HARVEST AVAILABILITY IN SALINE SODIC SOIL

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ABSTRACT

The study was conducted to assess the effect of different boron sources and levels of macro and micronutrient uptake andpost-harvest availability in saline sodic soil. Four levels of B (0, 0.5, 1.0 and 1.5 mg kg-1) was supplied through three different sources, namely borax, sodium octaborate and magnesium boro humate complex. A total of twelve treatment combinations were laidin factorial CRD design with three replications. Cotton var. LRA5166 was chosen as the test crop. The results revealed that application of 1.5 mg B kg-1 as magnesium boro humaterecorded the highest NPK uptake of 3.05, 0.99 and 2.55 g pot-1, respectively and the highest mean Zn, Fe, Mn and Cu uptake of 8.78, 13.69, 5.93 and 1.84 mg pot-1, respectively.The available NPK and other micronutrient status in post-harvest soil were invariably not influenced by the source and levels of the boron sources.

Keywords: cotton, boron, magnesium boro humate, NPK uptake

INTRODUCTION

Cotton (*Gossypium hirsutum* L.), is an important fibre cropthat accounts for a major share in agro industry in the world. In recent years, productivity is in decline trend due to poor nutrient management such as micronutrient management with other parameters like salinity and low organic carbon content, etc. The low availability of micronutrients in soil has become a constraint on the growth and suitability of crops and sustainability of soil (Bell and Dell, 2008).Application of micronutrient free fertilizers, intense cultivation and high yielding variety are the main cause of micronutrient deficiencies of the soils (Mooro *et al.,* 2000). Boron deficiency is next to zinc which is economically significant for many agricultural crops (Shorrocks 1997).

Boron (B) plays a vital role in cell elongation, cell maturation, meristematic tissue development, and protein synthesis of crops (Oliveira *et al.,* 2006). In the earth crust, B is widely distributed as uncharged boric acid and/or borate and its availability depends on soil moisture, soil temperature, soil pH, salinity, organic matter and climatic conditions, including precipitation (Shorrocks, 1997). B supply actively supported the absorption of water and nutrients as well as dry matter production (Eggert and Wirén 2016).Boron (B) and salinity are two drastic individual abiotic stress conditions largely responsible for crop losses (Izadi *et al.,* 2014).

Boron deficiency drastically affects the morphology of the plants and some physiological functions.Increasing salinity increases Na^+ content in plant could lead to a nutritional imbalance that creates low plant growth and dry matter production (Abdelaziz *et al.,* 2019).Siddiqui *et al.,* (2009) concluded that the use of 1.5 kg ha^{-1} boron with recommended NPK and zinc resulted in maximum improvement in the nutrient status of the plant. As perhaps the most essential micronutrient for cotton production, boron has been widely acknowledged, and cotton is very susceptible to B deficiencies despite ofits high B requirement (Shorrocks 1992). The mean boron uptake by seed cotton was found to be increased significantly up to 1.0 mg B kg^{-1} soil-applied boron level and then remained non-significant with further higher levels of soil-applied boron (Sunil Kumar *et al.,* 2018). Ahmad *et al.,* (2016) reported that use of boron and zinc with NPK resulted in significantly higher uptake of nitrogen, phosphorus, potassium zinc and boron. Keeping the above points, this study aimed to investigate the uptake of NPK and micronutrient by cotton and the availability of NPK and micronutrient in post-harvest soil.

MATERIALS AND METHODS

In order to study the response levels of cotton to boron fertilization as well as to identify efficient B sources in saline sodic soil, the pot experiment was conducted in factorial CRD. The surface soil collected at Karanampoondi village of Thiruvannamalai district, Tamil Nadu, India was filled in 20 kg capacity pots. The experimental soil was sandy loam in texture (Typichaplustalf) having pH 8.7 and EC1.23 dSm^{-1}. The fertility status of the soil was found low nitrogen (228 kg ha^{-1}) and phosphorus (9.12 kg ha-

Table 1. Effect of different sources and levels of B on NPK uptake of cotton in a saline sodic soil

Levels	Nitrogen (g pot-1)					Phosphorus (g pot-1)					Potassium (g pot-1)				
Source	L1	L2	L3	L4	Mean	L1	L2	L3	L4	Mean	L1	L2	L3	L4	Mean
S1	2.50	2.57	2.62	2.74	2.60	0.81	0.84	0.86	0.89	0.85	2.09	2.15	2.19	2.29	2.18
S2	2.50	2.71	2.79	2.86	2.71	0.81	0.88	0.91	0.93	0.89	2.09	2.27	2.34	2.40	2.27
S3	2.50	2.78	3.00	3.05	2.83	0.81	0.91	0.98	0.99	0.92	2.09	2.32	2.51	2.55	2.37
Mean	2.50	2.68	2.81	2.88		0.81	0.88	0.92	0.94		2.09	2.25	2.35	2.41	
	SED		CD(P= 0.05)			SED		CD(P= 0.05)			SED		CD(P= 0.05)		
L	0.03		0.07			0.009		0.02			0.02		0.06		
S	0.04		0.09			0.014		0.03			0.03		0.08		
LX S	0.06		0.13			0.019		0.04			0.04		0.10		

*S1 – borax , S2-Sodium octaborate, S3- magnesium boro humate, L1- 0 mg kg-1 of boron, L2- 0.5 mg kg-1 of boron, L3-1.0 mg kg-1 of B and L4- 1.5 mg kg-1 of boron

Table 3. Effect of different sources and levels of B on available NPK in post-harvest soil

Levels	Nitrogen (g pot-1)					Phosphorus (g pot-1)					Potassium (g pot-1)				
Source	L1	L2	L3	L4	Mean	L1	L2	L3	L4	Mean	L1	L2	L3	L4	Mean
S1	116.84	115.27	113.59	113.49	114.80	6.32	6.23	6.14	6.13	6.21	144.88	142.93	140.85	140.73	142.35
S2	116.84	113.70	112.63	111.50	113.67	6.32	6.15	6.09	6.03	6.14	144.88	140.99	139.66	138.26	140.95
S3	116.84	112.78	110.39	109.58	112.40	6.32	6.10	5.97	5.92	6.08	144.88	139.85	136.88	135.88	139.37
Mean	116.84	113.92	112.20	111.52		6.32	6.16	6.07	6.03		144.88	141.26	139.13	138.29	
	SED		CD(P= 0.05)			SED		CD(P= 0.05)			SED		CD(P= 0.05)		
L	1.02		NS			0.10		NS			2.10		NS		
S	1.25		NS			0.12		NS			4.46		NS		
LX S	1.80		NS			0.15		NS			5.11		NS		

*S1 – borax , S2-Sodium octaborate, S3- magnesium boro humate, L1- 0 mg kg-1 of boron, L2- 0.5 mg kg-1 of boron, L3-1.0 mg kg-1 of B and L4- 1.5 mg kg-1 of boron

^{1}) and medium in potassium (290 kg ha^{-1}). The hot water soluble B status of the soil was 0.34 mg kg^{-1} of soil.A total of 12 treatments formed with four levels of B (0, 0.5, 1.0 and 1.5 mg kg^{-1}) was supplied through three different sources, namely borax, sodium octaborate and magnesium boro humate complex. All the pots were supplied with soil test based recommended NPK dose of 40:20:20 mg kg^{-1} through Urea, SSP, Muriate of potash. The necessary plant protection measure was taken to control the pest and disease. Plant samples were collected separately in each pot, washed with distilled water; air dried then oven dried at 65ºC. After drying the plant samples were grounded in a clean wiley mill. The powdered plant samples were digested in diacid mixture (H_2SO_4: $HClO_4$ in 4:1 ratio) and analysed for total N (Microkjeldahl method by Humphries (1956), P (Vanadomolybdate method by Jackson (1973) and K (Flame photometer method by Chesnin and Yien (1951)as well as Zn, Mn, Fe, Cu(Atomic Absorption Spectrophotometer method by Yoshida *et al.,* (1972) and B (Azomethine-H method by Wolf (1974).Uptake of N, P, K, Zn, Mn and B by plants were calculated by multiplying nutrient content with dry matter production and dividing the product by hundred.

Post-harvest soil samples were collected pot wise. The soil samples were air dried, powdered, processed and analysed for available nitrogen, phosphorus, potassium, DTPA extractable Fe, Mn, Zn, Cu and hot water soluble B by adopting the procedure given in Table 2.

RESULTS AND DISCUSSION

NPK uptake: The uptake of NPK by cotton was significantly influenced by the application of boron through different sources in a saline sodic soil (table 1). Among the different levels of boron, the application of 1.5 mg B kg^{-1} (L_4) significantly registered the highest mean NPK uptake of 2.88, 0.94 and 2.41 g pot^{-1}, respectively. Addition of 1.0 mg B kg^{-1} (L_3) recorded the NPK uptake of 2.81, 0.92 and 2.35 g pot^{-1}, respectively. However, this was found to be onpar with application of 1.5 mg B kg^{-1}(L_4). The L_1 registered the lowest mean NPK uptake of 2.50, 0.81and 2.09 g pot^{-1}, respectively. Among the three sources of boron tried, application of magnesium boron humate (S_3) excelled the other two sources in increasing the NPK uptake to 2.83, 0.92 and 2.37 g pot^{-1}, respectively. This was followed by sodium octaborate (S_2) which recorded the NPK uptake of 2.71, 0.89 and 2.27 g pot^{-1} respectively. The lowest NPK of 2.60, 0.85 and 2.18 g pot^{-1}, respectively was recorded with application of borax (S_1).The interaction effect between levels and sources of boron favourably improved the NPK uptake by cotton. Application of 1.5 mg B kg^{-1} as magnesium boro humate (S_3L_4) recorded the highest NPK uptake of 3.05, 0.99 and2.55 g pot^{-1}, respectively. This was also found to be on par with application of 1.0 mg

Table 2. Effect of different sources and levels of B on Zn, Fe, Mnand Cu uptake of cotton in a saline sodic soil

Levels	Zinc uptake (mg pot-1)					Iron uptake (mg pot-1)					Manganese uptake (mg pot-1)					Copper (Cu)uptake (mg pot-1)				
Source	L1	L2	L3	L4	Mean	L1	L2	L3	L4	Mean	L1	L2	L3	L4	Mean	L1	L2	L3	L4	Mean
S1	7.08	7.83	8.00	8.33	7.81	10.62	12.19	12.46	13.00	12.07	3.72	5.28	5.39	5.63	5.00	1.59	1.64	1.67	1.75	1.66
S2	7.08	8.26	8.51	8.72	8.14	10.62	12.86	13.27	13.60	12.59	3.72	5.57	5.74	5.89	5.23	1.59	1.73	1.78	1.83	1.73
S3	7.08	8.47	9.16	9.28	8.50	10.62	13.20	14.27	14.47	13.14	3.72	5.71	6.18	6.26	5.47	1.59	1.77	1.92	1.94	1.81
Mean	7.08	8.18	8.56	8.78		10.62	12.75	13.33	13.69		3.72	5.52	5.77	5.93		1.59	1.71	1.79	1.84	
	SED		CD(P= 0.05)			SED		CD(P= 0.05)			SED		CD(P= 0.05)			SED		CD(P= 0.05)		
L	0.06		0.13			0.11		0.23			0.05		0.11			0.02		0.05		
S	0.10		0.22			0.17		0.37			0.09		0.19			0.02		0.06		
LX S	0.12		0.26			0.23		0.48			0.12		0.26			0.05		NS		

*S1 – borax , S2-Sodium octaborate, S3- magnesium boro humate, L1- 0 mg kg-1 of boron, L2- 0.5 mg kg-1 of boron, L3-1.0 mg kg-1 of B and L4- 1.5 mg kg-1 of boron

Table 4. Effect of different sources and levels of B on available Zn, Fe, Mn and Cu (DTPA extractable) in post-harvest soil

Levels	Zinc uptake (mg pot-1)					Iron uptake (mg pot-1)					Manganese uptake (mg pot-1)					Copper (Cu)uptake (mg pot-1)				
Source	L1	L2	L3	L4	Mean	L1	L2	L3	L4	Mean	L1	L2	L3	L4	Mean	L1	L2	L3	L4	Mean
S1	0.53	0.54	0.54	0.55	0.54	10.82	10.25	10.28	10.15	10.38	1.85	1.53	1.46	1.35	1.55	0.61	0.56	0.56	0.54	0.57
S2	0.53	0.55	0.55	0.55	0.55	10.68	10.56	10.21	10.16	10.40	1.78	1.43	1.44	1.31	1.49	0.6	0.58	0.52	0.53	0.56
S3	0.53	0.52	0.52	0.52	0.52	10.87	10.2	10.06	10.18	10.33	1.82	1.30	1.39	1.37	1.47	0.6	0.51	0.52	0.52	0.54
Mean	0.54	0.550	0.55	0.56		10.79	10.34	10.18	10.16		1.82	1.42	1.43	1.34		0.60	0.50	0.51	0.52	
	SED		CD(P= 0.05)			SED		CD(P= 0.05)			SED		CD(P= 0.05)			SED		CD(P= 0.05)		
L	0.05		NS			0.29		NS			0.03		NS			0.01		NS		
S	0.06		NS			0.24		NS			0.04		NS			0.01		NS		
LX S	0.14		NS			0.58		NS			0.07		NS			0.02		NS		

*S1 – borax , S2-Sodium octaborate, S3- magnesium boro humate, L1- 0 mg kg-1 of boron, L2- 0.5 mg kg-1 of boron, L3-1.0 mg kg-1 of B and L4- 1.5 mg kg-1 of boron

B kg^{-1} through magnesium boro humate (S_3L_3) which recorded the NPK uptake of 3.00, 0.98 and 2.51 g pot^{-1}, respectively.

The treatment S_3L_3 was also found to be on par with application of 1.5 mg B kg^{-1} through sodium octaborate (S_2L_4) which recorded the NPK uptake of 2.86, 0.93 and 2.40 g pot^{-1}, respectively. This was followed by the application of 1.0 mg B kg^{-1} through sodium octaborate (S_2L_3) which recorded the NPK uptake of 2.79, 0.91 and 2.34 g pot^{-1}, respectively. This was also found to be on par with application of 1.0 mg B kg^{-1} through magnesium boro humate (S_3L_3). Lopez-Lefebre *et al.,* (2002) reported that positive effects of B on N metabolism could be due to a positive influence of B on protein synthesis, enzymes activity and promotion of the entrance of substrate through plasma membrane into the interior of the cells. Assimilation of P was appreciably enhanced with B supply. There was a positive correlation between B and P in leaves, burs, seed, and lint, which indicated that B fertilizer improved P use efficiency in cotton.

Zn, Fe, Mn and Cu uptake: The uptake of Zn, Fe, Mn and Cu by cotton was significantly influenced by the application of B through different and sources to cotton in a saline sodic soil(table 2).Among the different levels of boron, the application of 1.5 mg B kg^{-1} (L_4) significantly registered the highest mean Zn, Fe, Mn and Cu uptake of 8.78, 13.69, 5.93 and 1.84 mg $pot^{-1,}$ respectively. Addition of 1.0 mg B kg^{-1} (L_3) of soil recorded the mean Zn, Fe, and Mn and Cu uptake of 8.56, 13.33, 5.77

and 1.79 mg pot^{-1}, respectively. This was statistically on par with application of 1.5 mg B kg^{-1}. The control (L_1) registered the lowest mean Zn, Fe, Mn and Cu uptake of 7.08, 10.62, 3.72 and 1.59 mg pot^{-1}, respectively. Among the three sources of boron tried, application of B as magnesium boron humate recorded highest Zn, Fe, Mn, and Cu uptake of 8.50, 13.14, 5.47 and 1.81 mg pot^{-1},respectively. This was followed by sodium octaborate which recorded the mean Zn, Fe, Mn and Cu uptake of 8.14, 12.59, 5.23 and 1.73 mg pot^{-1}, respectively and lowest mean Zn, Fe, Mn and Cu uptake was recorded with application of borax (7.81, 12.07, 5.00 and 1.66 mg pot^{-1}, respectively). The interaction effect between levels and sources of boron favourably improved Zn, Fe, Mn and Cu by uptake by cotton. Application of 1.5 mg B kg^{-1} as magnesium boro humate (S_3L_4) recorded the highest Zn, Fe, Mn and Cu uptake of 9.28, 14.47, 6.26 and 1.94 mg pot^{-1}, respectively. This was followed by application of 1.0 mg B kg^{-1} through magnesium boro humate (S_3L_3) which recorded the Zn, Fe, Mn and Cu uptake of 9.16, 14.27, 6.18 and 1.92 mg pot^{-1}, respectively. The treatment S_3L_4 andS_3L_3 were found to be on par with each other. Application of B through magnesium boro humate significantly increase the availability of B and showed a positive influence on DMP of cotton which led to increased uptake of B, Zn, Fe, Mn and Cu by cotton in salt affected soil. Similar observation was made by El-Gharably and Bussler (1985), Shaaban *et al.,* (2004) and Tariq and Mott, (2007). Alvarez-Tinaut(1990) found a positive correlation between B and Fe and Cu contents of sunflower, suggested that B could indirectly affect catalase activity via Fe and Cu. However, Ohki (1976) reported that concentration of Cu remained unaffected in blades of cotton at lower and higher levels of B. Golakiyaand Patel (1986) reported that uptake of Fe was increased with B application in groundnut. Under B deficient conditions decreased Fe content was noticed in tomato leaves (Carpena-Artes and Carpena- Ruiz, 1987).

Available NPK content : The available NPK status of post-harvest soil was slightly decreased due to application of boron through different sources in a saline sodic soil(table 3). Addition of graded levels of boron from 0 to 1.5 mg kg^{-1} consistently decreased the available N ($KMnO_4$-N), P (Olsen-P) and K (CH_3COONH_4 extractable) in post-harvest soil. However, the decrease was not statistically significant. Similarly, addition of B through different sources also did not influence the NPK availability in post-harvest soil. The interaction effect between levels and sources of B on the available NPK status of post-harvest soil was non-significant.The decrease in available content may be due to increase uptake of NPK by cotton.

Available DTPA extractable Zn, Fe, Mn, and Cu content

The available Zn, Fe, Mn, and Cu content of post-harvest soil was not favorably influenced by the application of different levels and sources of boron to cotton in a saline sodic soil (Table 4). Application of increasing level of B decreased the DTPA extractable Mn, Fe, Cu and Zn. However, the decrease was not significant. All the three sources of B showed a decreasing trend on the availability of Fe, Cu, Zn and Mn in post-harvest soil. Addition of B through magnesium boro humate recorded the lower mean DTPA extractable Zn, Fe, Mn, and Cu of 0.52, 10.33, 1.47 and 0.54 mg kg^{-1}, respectively. The interaction effect due to level and sources of B on DTPA extractable Fe, Cu and Zn was non-significant. All the three sources of B showed a decreasing trend on the availability of Fe, Cu, Zn and Mn in post-harvest soil. It proves that B did not affect the availability of other micronutrients in soil.

CONCLUSION

Based on the result, it can be concluded that the higher NPKand micronutrientuptake wasrecorded by application of 1.5 mg B kg^{-1} as magnesium boron humate. But the available NPK and micronutrient status on post-harvest soil were not influenced by the source and levels of the boron sources.

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