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Boron Contents of Light and Medium Textured Soils and Cotton Plants

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ABSTRACT

Light and medium textured soils from 13 different sites were sampled from the Punjab Province during 1997-2000. Boron contents of soils and cotton plants were analyzed by colorimeter using azomethine-H as color developing reagent and 0.05 M HCl as extractant. Out of 13 soils, 12 were found boron deficient (less than 0.5 µg g^{-1}). Cotton plants were sampled at flowering stage and after harvest. Younger leaves were analyzed for their boron content. Boron concentration in leaves ranged from 7.9 to 23.8 µg g^{-1} with an average of 11.4 µg g^{-1} and come under critical level which is 15 µg g^{-1}. Only one sample out of 13, contained adequate concentration of boron which clearly indicated that 90% samples were deficient in boron. Light textured soils (sandy loam and loamy sands) were also deficient in boron contents because they were well drained and had good leaching.

Key Words: Boron; Light; Medium texture; Cotton

INTRODUCTION

The FAO global study on micronutrients observed that out of 177 soil samples from 20 districts of the Punjab, 49% were boron (B) deficient (Sillanpae, 1982; Rashid, 1995; 1996; Rashid *et al.,* 1997). Several soil factors including soil organic matter, soil texture, cultivation, drought, microbial activity, soil pH and liming can affect the availability of B to plants. Dregne and Powers (1942) concluded that the availability of B in soils is influenced by soil reaction, soil moisture, active calcium and organic matter. The amount of B left available in soil after fixation takes place has been determined in some cases by plant growth (Ghaibeh & Abdelgawad, 1997; Blevins *et al.,* 1998). This method is probably not reliable when the amount of calcium in the soil varies because the calcium-boron ratio is changed.

Boron is one of the 16 elements essential for plant growth (Joham, 1986) and is directly and indirectly involved with many plant functions (Blevins & Lukaszewski, 1998). One is the growth of cells in new root and shoot tips. Others involve in flowers and seed development and the transport of sugar within the plant (Eaton, 1955). Cotton is very responsive to B. Boron application has been reported to increase cotton yield (Murphy & Lancaster, 1971; Karev, 1988; Malik *et al.,* 1992; Rashid, 1995; 1996).

Several soil conditions and farming practices in Pakistan are perceived as being likely to induce micronutrient deficiencies, including high soil pH, calcareousness of soils, low soil organic matter and use of fertilizers poor in micronutrients (Eguchi & Yamada, 1997; Rashid *et al.,* 1997). Much is now known about the B deficiency problem in the cotton belt of Punjab and Sindh provinces where about three million hectares of cotton are grown every year. About 50% of the cotton is thought to be suffering from boron deficiency. Experiments throughout the Punjab cotton belt have shown substantial increases in seed cotton yield to boron application (Borax, 1996). Present study was conducted to asses the B deficiency in light and medium textured soils of Faisalabad, Jhang and Toba Tek Singh districts and also in cotton crop.

MATERIALS AND METHODS

This research was conducted at laboratories of Soil Chemistry Section, AARI, Faisalabad during 1997-2000. Various sites in Faisalabad, Jhang and Toba Tek Singh districts were visited to collect soil and plant samples from light and medium textured soils.

Soil analyses. Composite soil samples were collected from farmers fields, located on farm area of Soil Chemistry Section and Agronomy area of Ayub Agricultural Research Institute, Faisalabad, Chak No. 80 J.B; Chak No. 71 J.B. Thekrewala; Chak No. 2 J. B Ramdewali; Chak No. 5 J.B. Kamalpur; Chak No. 450 J.B. Jhang; Chak No. 445 J.B., Gojra Mor, Jhang; Chak Dasooha; Chak Jehangir; Rasala No. 15 Faisalabad; Nawan Lahore and Dharam Kot, Gojra. Soil samples were collected from 0-15 cm soil depths and analyzed for ECe (Rhoades, 1982), pHs (Mclean, 1982), organic matter (Nelson & Sommers, 1982), total N (Tecator, 1981), particle size analysis (Gee & Bauder, 1986) and available B (Bingham, 1982). Boron was extracted by 0.05M HCl (Annonymous, 1981) and color was developed by azomethine-H by using Genesis-5 spectronic spectrophotometer at 420 nm wavelength (Mills & Jones, 1996).

Plant analyses. Plant leaves were ground to 2 mm mesh size and 1 g plant sample passed into porcelain crucible and kept them into muffle furnace at 450-500°C for 4-5 h to get dry ashing (Reuter & Robinson, 1986; Mills & Jones, 1996). After extraction by 0.36 N H_2SO_4, filtered the samples through Whattman # 1. Color was developed by Azomethine-H reagent and read absorbance at 420 nm on spectrophotometer (Malekani & Cresser, 1998).

RESULTS AND DISCUSSION

Soil analyses. This study was conducted on light and medium texture soils and out of 13 sites 5 were medium textured (clay loam), the texture of two sites were silty clay loam and one was loam textured. Six sites were light textured and contained sandy loam or loamy sand texture. Low organic matter and low total N content was clear picture of sampling sites which also induces B deficiency in the soil. The results in Table I revealed that high soil pH and $CaCO_3$ content induce B deficiency in the surveyed area. Similar results were found by Borax (1996) and Rashid *et al.* (1997). The results of soil and plant analysis were discussed by keeping in view the critical level of B in soil and plants. Critical level is the concentration where a reduction in plant growth and expression of foliar deficiency symptoms occur (Heathcote & Smithson, 1974). In soil, the B concentration of <0.65 μg g^{-1} and >3.5 μg g^{-1} are deficient and toxic levels for cotton crop, respectively (Annonymous, 1985), while in cotton plants the range for these deficient and toxic levels are 10-28 μg g^{-1} and >1000 μg g^{-1}, respectively (Cassman, 1993).

Physicochemical characteristics of soils have been presented in Table I, while Table II indicates the texture, organic matter and 0.05 M HCl extractable B of the sampling sites. Results clearly revealed B deficiency at all the locations, except Dharamkot, Gojra site where soil B content was 0.96 μg g^{-1} and it was slightly saline soil. Soil available B ranged from 0.19-0.96 μg g^{-1} with an average of 0.34 (μg g^{-1}) and found almost all soil samples less than, the critical level of B in soil (0.5 μg g^{-1}). B in soil solution exists principally as boric acid, some of which could be complexed through cis-diol linkages to small soluble organic molecules,

Table I. Physico-chemical characteristics of surveyed soil

Sites/locations	pHs	ECe	Av. P	K	Total N	$CaCO_3$
		dSm^{-1}	ppm		%	
Farm area Chemistry Section Faisalabad	8.10	1.17	12.60	121.0	0.031	4.33
Agronomy area, AARI, Faisalabad	7.45	1.20	8.96	179.0	0.038	4.27
Chak No 80 JB, Thekrewala Faisalabad	8.25	1.35	6.50	122.0	0.032	3.45
Chak No. 71 JB, Thekrewala Faisalabad	8.20	1.10	8.14	138.0	0.038	4.10
Chak No.2 JB Ramdewali Faisalabad	8.15	1.72	12.5	160.0	0.038	3.81
Chak No.5 JB Kamalpur Faisalabad	7.68	0.70	8.10	165.0	0.035	3.76
Chak Dsooha Faisalabad	8.00	2.01	4.56	120.6	0.032	4.19
Chak Jahangir Faisalabad	8.10	2.30	5.76	221.0	0.030	4.43
Chak 445 JB Gojra Mor Jhang	7.45	1.20	5.20	135.0	0.028	3.21
Chak 450 JB Jhang	7.90	1.10	5.39	173.0	0.031	3.89
Nawan Lahore, Faisalabad	7.65	0.96	7.80	157.0	0.040	4.00
Rasala No. 15, Faisalabad	7.90	0.53	6.60	67.0	0.028	4.33
Dharamkot, Gojra	8.50	3.01	2.89	136.0	0.036	4.21
Mean	7.95	1.41	7.30	146.0	0.034	4.00
S. D.	0.32	0.69	2.80	37.00	0.004	0.36

Table II. Texture, organic matter and 0.05M HCl Extractable B of 13 sites

Sites	O.M (%)	Available Boron (μg g^{-1})	Texture
Farm area Chemistry Section Faisalabad	0.81	0.23	Clay loam
Agronomy area, AARI, Faisalabad	0.83	0.37	Clay loam
Chak No 80 JB, Thekrewala Faisalabad	0.76	0.41	Clay loam
Chak No. 71 JB, Thekrewala Faisalabad	0.88	0.43	Sandy loam
Chak No.2 JB Ramdewali Faisalabad	0.89	0.25	Clay loam
Chak No.5 Kamalpur Faisalabad	0.69	0.32	Sandy loam
Chak Dasooha Faisalabad	0.66	0.33	Silty clay loam
Chak Jahangir Faisalabad	0.60	0.28	Silty clay loam
Chak 445 JB Gojra Mor Jhang	0.51	0.22	Sandy loam
Chak 450 JB, Jhang	0.58	0.19	Loamy sand
Nawan Lahore Faisalabad	0.89	0.27	Loam
Rasala No. 15, Faisalabad	0.46	0.20	Loam sand
Dharamkot Gojra	0.83	0.96	Clay loam
Mean	0.72	0.34	-
S.D.	0.15	0.20	-

Table III. Leaf boron concentration of cotton plants

Sites/Locations	B concentration ($\mu g\ g^{-1}$)
Farm area Chemistry Section AARI, Faisalabad	13.3
Agronomy area, AARI, Faisalabad	12.1
Chak No 80 JB, Thekrewala Faisalabad	8.9
Chak No. 71 JB, Thekrewala Faisalabad	10.3
Chak No.2 JB Ramdewali Faisalabad	13.9
Chak No.5 JB Kamalpur Faisalabad	11.0
Chak Dasooha Faisalabad	8.9
Chak Jahangir Faisalabad	10.0
Chak 445 JB Gojra Mor Jhang	11.6
Chak 450 JB, Jhang	7.9
Nawan Lahore Faisalabad	8.4
Rasala No. 15, Faisalabad	8.0
Dharamkot Gojra	23.8
Mean	11.4
S.D.	4.0

and the borate anion BOH_4, some of which may be complexed to cations. The amount of B is present as borate anion and its relevance to plant nutrition is likely to be minimal, although it is known that plants can limit B absorption (Nable *et al.,* 1990).

Plant analyses. Results showed that concentration of all the samples was less than 15 $\mu g\ g^{-1}$ except one sample from Dharamkot site having 23.8 $\mu g\ g^{-1}$ B. The B in cotton plant leaves ranged from 7.9 to 23.8 $\mu g\ g^{-1}$ (Table III). These results clearly showed that 90% plant samples were deficient in boron. The average B content was 11.4 $\mu g\ g^{-1}$. These results are in accordance with Reuter and Robinson (1986) and Shorrocks (1979).

CONCLUSION

The surveyed area is found to be B deficient both in soil samples and in plant samples. Boron contents of soils and plants from light and medium textured soils were less than the critical levels. High soil pH, calcareousness and low organic matter in such soils might be rendering the B less available to the plants.

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