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COMPARISON OF THREE METHODS FOR THE ESTIMATION OF SOIL AVAILABLE BORON FOR MAIZE

M.A. Kausar, M. Tahir and A. Hamid

Nuclear Institute for Agriculture and Biology, P.O. Box 128, Faisalabad, Pakistan

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A pot experiment was conducted employing eleven soils and using maize as an indicator crop to compare three methods for the estimation of soil available B. Boron concentrations extracted from the soils by the three extractants; hot water, HCl and mannitol were correlated (r> .9) with each other. The efficiency of various methods for the extraction of soil B varied in the order of hot water > HCl > mannitol. The soil B concentrations extracted by the above extractants were correlated with the plant B concentrations with r values of .89, .86 and .70 respectively. Boron concentrations of 0.5, 0.5 and 0.25 mg kg- appeared to be the critical levels in the soils extracted by the above mentioned extractants respectively where as about 11 ug g- B in the maize tissue was found to be the critical level.

Key words: Methods, Estimation, Soil boron, Maize.

Introduction

Among the micronutrients, B deficiency is next to Zn only to limit the crop yields in Pakistan [1-4]. Soil tests have played an important role in B fertilization of many crops in the world [5-8]. Hot water extraction of the soil has long been a reliable method to predict B availability in the soils [5].Keeping in view the tediousness of this method, research workers have been trying to replace it by some simple and efficient method. In this process .05 M HCl was found to be a good extractant to assess Zn, Cu and B in the soils [8]. Similarly, 0.05 M mannitol elsewhere, was found a comparable extractant with hot water to estimate the soil B [6]. Methods of dilute HCl and mannitol were selected for their simplicity, economy and efficiency. Particularly in case of HCl, the same extraction was supposed to be used for Zn and Cu estimation also. In Pakistan, little work have been conducted on this aspect [2]. Therefore, the objective of this work was to find out a simple and efficient method of B extraction suitable for soils of Pakistan.

Materials and Methods

Bulk soil samples of the eleven local soils were collected from 40 km radius of district Faisalabad. The area is situated in the western part of Rachna Doab, between longitudes 72° 0' and 73° 45' east and latitudes 30° 30' and 32° 0' north. It has a semi arid and arid subtropical continental climate. Mean annual rain fall is 35 cm mainly received in July and August. The hottest months are May and June with mean maximum temperature of 106° F with daily maximum rising to 115° F. January is the coldest month with a temperature of 41° F. Winters are generally frost free except for a short spell of 10-15 days in January. The soils have been formed in a river terrace (Sandal Bar) and in the alluvial deposits of rivers Chenab and Ravi. In the area, some loess (wind deposited silty material) may be mixed with the alluvium. The material ranges in age from Late Pleistoocene to Late Holocene and so have different degree of development. The soils are invariably calcareous with pH 8.2 except in case of alkali soils where it ranges to 9.6 organic matter 0.5% [10].

After crushing and seiving through 2 mm sieve, these soils were packed in the polythene lined plastic pots at the rate of 2.5 kg pot^{-1}. Properties of the soils used are given in Table 1. Boron was applied as boric acid at the rate of 1 mg kg^{-1} to each soil except the control. Nitrogen and P were applied as basal dose to all the pots. Three maize plants (Variety Akbar) wer grown for 6 weeks while soils were irrigated with deionized water according to their field capacities. Each treatment was replicated thrice. Plants were then harvested, washed thoroughly with deionized water, dried in a steel oven at 80° for 60 hr. After recording the dry matter yield, the plant material was ground to 60 mesh in a Wiley mill having a stain less steel cutting chamber. Plant material was dry ashed at

Table 1. Characteristics of 11 Soils Used in the Experiment

Soil No.	Clay %	pH	EC dS M^{-1}	O.M. %	CaCO %	DTPA-Zn mg kg^{-1}
1.	25.0	7.5	1.5	1.20	2.0	1.40
2.	11.5	8.0	1.9	0.51	3.5	0.70
3.	9.5	8.2	2.1	0.59	3.7	0.65
4.	6.0	8.0	2.3	0.62	3.1	0.56
5.	12.5	7.8	2.9	0.72	2.9	0.75
6.	15.8	8.2	4.4	0.68	4.3	1.00
7.	14.5	7.6	3.1	0.82	2.7	1.20
8.	16.8	8.0	4.5	0.61	4.5	0.95
9.	9.6	8.2	1.5	0.52	3.5	0.70
10.	13.8	8.1	2.2	0.67	3.9	0.65
11.	10.5	8.2	2.1	0.59	3.1	0.55

450° for 5 hr. dissolved in .1 M HCl, B was determined colorimetrically by using Azomethine-H and read at 420 nm [4]. The following methods were used to extract the soil B:

(a) Hot water extraction. Ten g soil sample was boiled in 20 ml of distilled deionized water for 5 min. in pyrex conical flasks (previously treated with conc. HCl for a week) and filtered immediately [5]. Colour was developed as described above.

(b) HCl Extraction. Ten g soil sample in a polypropylene tube was shaken with 20 ml of .05 M HCl for 5 min. and then filtered [8]. The colour was developed by Azomethine-H (4).

(c) Mannitol extraction. Ten g soil sample was shaken with 20 ml of 0.05 M mannitol + 0.01 $CaCl_2$ (pH 8.5) for 1 hr. and then filtered [6]. The colour was developed by Azomethine-H (4).

Results and Discussion

(a) Relationship of boron uptake by maize with soil boron extracted by three methods. The concentrations of plant and soil B are shown in Table 2. The hot water soluble (HWS) B ranged from 0.23 to 1.31, HCl extractable from .25 to 1.0 and mannitol extractable from .15 to 0.81 mg kg^{-1}. The efficiency of various methods for extracting B from soils varied in the order of HWS > HCl > Mannitol. Almost, similar order was found by other workers [2,6,8]. The B concentrations extracted by all the methods were correlated with each other (Table 3.). All the three methods appeared to successfully measure the available B for the maize plants. The HWS and HCl methods showed equally good correlation with the plant B (control treatment) with r values of .89 and .86 (P< .01) respectively. Mannitol extractable B was also correlated with the plant B with r value of .7 (P< .05). Investigators at IRRI, have found HCl to extract less B from the soils than HWS, but its correlation with the plant B was better than that of HWS [8]. Similarly, investigators have found elsewhere mannitol to extract less B from the soil than the HWS method yet it has equally good relationship with the plant B [6]. However, other workers found significant correlation of HWS B with the wheat tissue B and little relationship with HCl and mannitol extractable B [2].

TABLE 2. DRY MATTER YIELD (DMY) AND B CONCENTRATIONS IN MAIZE AND THEIR RELATION TO B EXTRACTED FROM 11 SOIL.

Soil	DMY		Plant B		Extractants		
No.	-B*	+B**	-B	+B	Hot	HCl	Mannitol
	g pot^{-1}		µg g		mg kg^{-1}		
1.	8.9	8./8	14.2	64.2	0.64	0.55	0.39
	(±.30	(±.36)	(±.45)	(±3.25)	(±.010)	(±.011)	(±.006)
2.	10.7	11.5	12.4	41.0	0.50	0.51	0.20
	(±.35)	(±.49)	(±.40)	(±2.25)	(±.008)	(±.009)	(±.004)
3.	8.1	9.0	10.6	45.3	0.23	0.25	0.15
	(±.31)	(±.35)	(±.35)	(±2.52)	(±.004)	(±.006)	(±.002)
4.	8.6	9.3	10.4	40.6	0.32	0.25	0.15
	(±.27)	(±.40)	(± .33)	(±2.05)	(±.005)	(±.005)	(±.002)
5.	7.1	7.9	10.1	45.3	0.23	0.31	0.16
	(±.25)	(±.32)	(±.33)	(±2.90)	(±.002)	(±.006)	(±.003)
6.	6.7	3.9	17.8	82.5	1.31	1.00	0.81
	(±.21)	(±.18)	(±.52)	(±4.30)	(±.031)	(±.015)	(±.010)
7.	5.9	7.8	13.6	42.0	0.73	0.61	0.44
	(±.20)	(±.33)	(±.44)	(±2.25)	(±.012)	(±.012)	(±.009)
8.	6.1	3.4	15.8	85.7	0.64	0.56	0.36
	(±.21)	(±.16)	(±.51)	(±4.45)	(±.011)	(±.010)	(±.006)
9.	13.4	13.3	11.0	31.7	0.56	0.60	0.63
	(±.41)	(±.52)	(±.39)	(±1.95)	(±.011)	(±.012)	(±.010)
10.	15.5	15.4	13.8	34.3	0.56	0.55	0.49
	(±.47)	(±.51)	(±.49)	(±1.85)	(±.009)	(±.011)	(±.007)
11.	17.1	18.0	9.8	25.6	0.35	0.28	0.24
	(±.56)	(±.75)	(±.32)	(±1.47)	(±.005)	(±.004)	(±.004)

Figures in parentheses are standard deviations of means.
* = No B addition, ** = B addition at the rate of 1 mg kg^{-1}

TABLE 3. CORRELATION BETWEEN B CONCENTRATION IN MAIZE AND METHODS OF B EXTRACTION FROM THE SOIL

Comparison	Correlation coefficient
Hot water - B vs HCl - B	0.97**
Hot water - B vs Mannitol - B	0.87**
HCl - B vs Mannitol - B	0.91**
Hot water - B vs Plant B	0.89**
HCl B vs Plant B	0.86**
Mannitol - B vs Plant B	0.70*

** Significant at 1% level, * Significant at 5% level.

(b) Critical level of extractable soil boron for maize. A successful soil test should distinguish between deficient and non deficient soils. Various B extraction methods were put to this test. When extractable B was plotted against plant response (95% of the relative yield) to the added B, all the methods clearly separated B deficient from non deficient soils (Figs. 1-3). About .5 mg kg^{-1} HWS and HCl and .25 mg kg^{-1} mannitol extractable B appeared to be the critical levels of B in soil. Other workers have reported similar results with respect to HWS and mannitol extractable B [6-7]. However, some others have reported little extraction of soil B with mannitol [2]. Low organic matter in our soils was supposed to be the cause for extremely low B extraction while present studies have shown the low pH (around 5) of the extractant instead of low organic matter in the soils, as the cause of low B extraction from the soils. In case of HCl extractable B, a little work has so far been reported. In IRRI this method has shown better relationship with the rice B than that of HWS but this was used to distinguish the soils containing toxic and

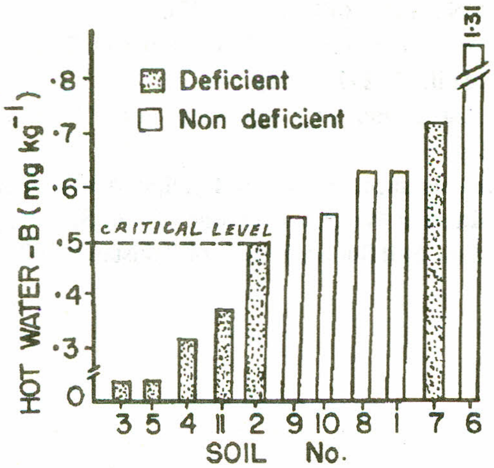

Fig. 1. Response of maiz to B in relation to hot water extractable B.

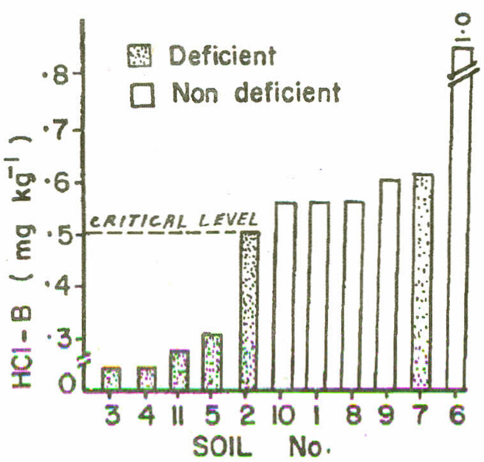

Fig. 2. Response of maize to B in relation to HCl extractable B.

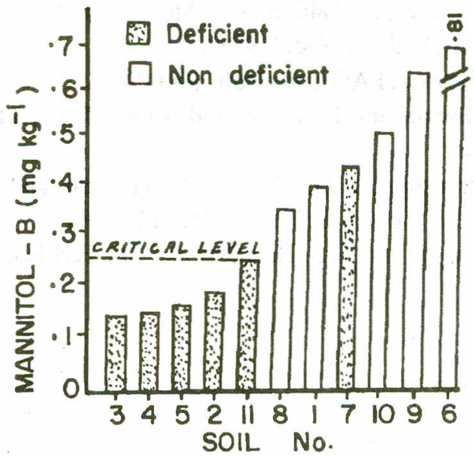

Fig. 3. Response of maize to B in relation to mannitol extractable B.

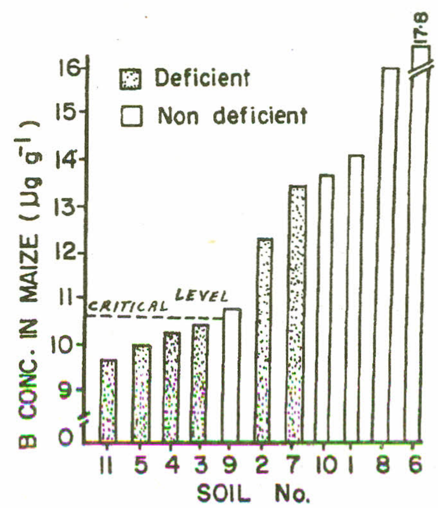

Fig. 4. B concentration in maize in relation to B response of maize on II soils

adequate concentrations of B [8]. The present study has indicated its validity also for the soils having low concentrations of B.

(c) Critical level of boron in the maize tissue. The dry matter yield of maize increased due to addition of 1 mg kg^{-1} B on soils 2,3,4,5,7 and 11 while it decreased on soil 6 and 8. On rest of the soils it had little effect. Boron concentration ranged in the untreated plants from 9.8 to 17.8 ug g^{-1} while in the treated plants from 25.6 to 85.7 ug g^{-1}. Positive response to the added B could be attributed to the lower native B in the soils which resulted in lower B concentration in the plants while negative response could be attributed to the adequate native B in the soils which resulted in normal plant B concentration. On addition of B to the soils 6 and 8 having enough B, plants accumulated > 80 ug g^{-1} B which proved toxic [7]. The reason for positive response on soil 7 despite its enough B, could not be ascertained as there could be many factors involved. The plant response was plotted against the plant B concentration (control treatment)to find the critical level of B in the maize tissue. There was no clear demarcation found, but about 11 µg g^{-1} B could be safely considered for the critical level (Fig.4). This is a bit higher than reported by other workers [9]. That could be attributed to the genotypic, soil and climatic differences.

Conclusion

The newly evaluated methods of HCl and mannitol are extremely simple and more efficient than the previous method of hot water extraction. These methods would hopefully go a long way in assessing the B status of our soils. In the past, tedious methods have been prohibiting the progress in this area of research. However, these methods need further testing on more number of varied soils and involving various plant species.

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