Short Communication

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Extraction of boron using different extractants in soils of two agro-ecological sub-regions, West Bengal – A comparative study

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Boron is one of the essential micronutrients required for the growth of plants and has a marked effect on plants from the standpoint of both nutrition and toxicity (Keren 1996). Boron in soil exists in its various chemical pools *viz.* soil solution boron (readily available B), adsorbed B (labile pool of B), organically bound boron as well as in minerals, each form being in dynamic equilibrium with the other. In soil solution, boron is present mainly as a non-ionized molecule *viz.* H_3BO_3 over the entire pH range suitable for plant growth and is, therefore, susceptible to rapid leaching loss from the soil, particularly under high rainfall conditions (Yan *et al.* 2006).

Of late, deficiency of B has emerged in Indian soils and crops, next to zinc primarily due to intensive cropping of high yielding crop varieties that warrants for precise estimation of the B in soils. Distribution of available boron in the surface and sub-surface soil samples of alluvial zones of West Bengal has been reported by Debnath and Ghosh (2009). Ghoshal and Debnath (2008) also reported the available B status in Entisol and Alfisol of West Bengal while studying the effect of liming on retention and availability of the B. However, it is worth mentioning that the complexity of boron, both in soil and plant system, makes it challenging to develop a soil-B extraction method which can determine the nutrient status matching with plant requirement under a wide range of soil conditions for different plant species (Shiffler *et al.* 2005).

The objective of the present investigation is to determine the available boron status in soils under two Agro-ecological Sub-regions (AESRs) of West Bengal using two extractants *viz.* Hot Calcium Chloride and Mannitol Calcium Chloride.

Based upon the methodology for grid-wise composite surface (0-25 cm) soil sampling (Govt. of West Bengal and NBSS & LUP, 2009, 2011), 80 composite surface soil samples were collected from cultivated / fallow field of 8 selected blocks (10 representative samples from each block), spread over 6 districts *viz.* Birbhum, Bankura, Puruliya, Paschim Medinipur, Hugli and Nadia. Agricultural crops in the sampling sites comprised rice, maize, pulses and groundnuts under AESR 12,3 while rice, jute, maize, mustard, potato and other vegetables were the crops grown under AESR 15.1.

The soil samples, after thorough processing, were analysed for selected physico-chemical properties *viz.* pH, organic carbon, cation exchange capacity and mechanical composition following standard procedures described by Jackson (1973). The soil samples were analysed for Hot $CaCl_2$ (HCC) extractable boron (Parker and Gardner 1981) and Mannitol Calcium Chloride (MCC) extractable boron (Cartwright *et al.* 1983) using Inductively Coupled Plasma-Atomic Emmision Spectroscopy (ICP Model No.1600 SP2, Leeman Labs Prodigy).

The physico-chemical characteristics of the soils and their taxonomy have been presented in table 1. The pH of the soils in AESR 12.3 varied from 5.1 to 5.6 whereas the pH of the soils in AESR 15.1 varied from 6.4 to 7.2. The overall mean CEC and clay content of the soils in AESR 12.3 and 15.1 were found to be 11.0 and 17.5 [cmol$(p^+)kg^{-1}$] and 23% and 33.6%,

Table 1. Relevant physico-chemical characteristics of surface soils

Block/District	$pH_{(aq.)}$	Organic carbon (gkg^{-1})	Cation exchange capacity [$cmol(p+)kg^{-1}$]	Clay (%)
AESR 12.3: Chhotanagpur plateau and Garhjat Hills : Hot, dry and moist, sub-humid transitional region				
Suri-I, Birbhum	5.3 (5.1-5.5)*	3.8 (3.6-4.5)	10.8 (9.8-11.0)	16.2 (15.8-19.6)
Sonamukhi, Bankura	5.1 (5.0-5.4)	4.2 (4.1-4.6)	11.2 (10.6-12.1)	20.6 (19.4-21.2)
Manbazar, Puruliya	5.2 (4.8-5.5)	3.6 (3.4-3.8)	11.5 (9.7-12.3)	25.2 18.8-26.1)
Jhargram, Paschim Medinipur	5.6 (5.2-5.9)	5.4 (4.7-5.6)	10.4 (9.4-11.2)	30.1 (25.2-31.8)
Overall mean		4.3	11.0	23.0
AESR 15.1: Bengal Basin : Hot, moist sub-humid ecoregion				
Gayeshpur, Nadia	6.5 (6.0-6.7)	5.2 (4.9-5.6)	14.2 (13.8-14.6)	26.6 (24.6-27.1)
Khanakul, Hugli	7.2 (7.0-7.4)	7.8 (6.6-8.0)	21.2 (18.6-22.4)	30.2 (28.4-31.5)
Chinsurah, Hugli	7.0 (6.8-7.2)	3.4 (3.1-3.6)	28.1 (24.4-29.2)	59.8 (38.6-60.2)
Nalhati, Birbhum	6.4 (6.0-6.9)	4.5 (4.2-4.6)	11.6 (9.9-12.2)	17.8 (16.7-20.4)
Overall mean		5.2	17.5	33.6

**Figures within the parenthesis indicates the range values*

Table 2. Available boron content (HCC and MCC extractable) in surface soils

Block/District	Hot $CaCl_2$ (HCC)extractable B ($mgkg^{-1}$)	Mannitol $CaCl_2$(MCC) extractable B ($mgkg^{-1}$)
AESR 12.3: Chhotanagpur plateau and Garhjat Hills, Hot, dry and moist, subhumid transitional region		
Suri-I, Birbhum	0.184	0.132
Sonamukhi, Bankura	0.156	0.068
Manbazar, Puruliya	0.176	0.075
Jhargram, Paschim Medinipur	0.240	0.108
Overall mean	0.189	0.096
AESR 15.1: Bengal Basin, Hot, moist subhumid ecoregion		
Gayeshpur, Nadia	0.286	0.194
Khanakul, Hugli	0.303	0.146
Chinsurah, Hugli	0.226	0.108
Nalhati, Birbhum	0.188	0.112
Overall mean	0.251	0.140

to be 11.0 and 17.5 [cmol(p^{-})kg^{-1}] and 23% and 33.6%, respectively. The HCC extractable boron varied from 0.156 to 0.240 mgkg^{-1} (Table 2) in soils of AESR 12.3 and from 0.188 to 0.303 mgkg^{-1} in soils of AESR 15.1. On the other hand, the MCC extractable boron varied from 0.068 to 0.132 mgkg^{-1} in soils of AESR 12.3 and from 0.108 to 0.194 mgkg^{-1} in soils of AESR 15.1.

The results indicated that HCC extracted higher boron (49% and 44% more) in both the AESRs than that extracted by MCC in AESRs 12.3 and 15.1, respectively. The B extraction in soils under AESR 15.1 was more than that in the AESR 12.3 which may probably be due to the higher organic matter content of the soil resulting in greater release of B from diol type of complexes upon extraction with HCC extractant (Das 2007). Significant and positive correlation was also obtained between HCC extractable B and soil pH ((r = 0.995**, 0.493**) and organic carbon (r = 0.816**, 0.750**) using both the extractants under AESR 12.3 and 15.1, respectively. Such significant positive correlations between soil pH and available boron contents in soils were also reported by Debnath and Ghosh (2009).

Irrespective of the AESRs and soil properties, all the soils were found to be B-deficient based upon critical limit of B as 0.36 mgkg^{-1} B (Govt. of West Bengal 2005) as the optimum threshold. The B-deficiency in the AESR 12.3 (Red and Lateritic zone) falling in districts of Bankura, Puruliya, East and West Medinipur was also reported by several workers (Mani and Halder 1996; Bose and Das 2005; Das 2007).

The results indicate that there is need for optimum B fertilization in both the AESRs depending upon soil test values.

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