

Different Forms of Boron in Relation to the Properties of Some Soils of North Bengal

S. DHAR, A. K. SINHA AND P. MUKHOPADHYAY

*Department of Soil Science & Agricultural Chemistry, Uttar Banga Krishi Viswavidyalaya
Pundibari 736165, India*

Abstract

Results of the experiment conducted in soils of northern plains (terai agro-ecological region) in the state of West Bengal to study the influence of relative proportion of boron fractions on its availability revealed that the readily soluble fraction, being the most labile form and constituted of solution plus adsorbed B exhibited the least (5.8%) out of the total amount, while the oxide bound form accounted for the maximum (44.2%). The readily soluble soil B was found to be negatively and significantly correlated with CBD Al, specifically adsorbed B was positively and significantly correlated with pH, oxide bound B showed positive correlation with soil organic carbon content and CBD Fe and organically bound was also positively and significantly related to organic carbon content of the soil.

Key words : Readily soluble B, Adsorbed B, Oxide bound B, Organically bound B.

Boron is one of the most essential micronutrient elements and its deficiency in the soil adversely affects the plant growth. Plant available B derived from the soil sediments and plant deposits may transform into various other forms into soils and may remain soluble or insoluble depending on soil characteristics, environment and crop production management systems. The pH, organic matter, clay minerals, Fe and Al oxides, carbonates and tillage management are amongst the soil factors which are reported to influence the soil solution boron and its transportation. Since B is present in soil solution in a minute quantity at a given point of time, supply of native soil B to supplement the crop demand based on the crop requirement must necessitate its gradual transformation into a soil solution form and other soil fractions which remain in equilibrium with each other in soil environment. So dynamics of different forms of boron must have definite role in governing its availability in soil system. The present study was made to determine different forms of boron in some selected soils and to find out the relationship of boron fractions with salient characteristics.

Methods

Fifteen composite soil (0—15 cm) samples were collected from different locations of Cooch Behar

district of West Bengal. Samples collected were processed, passed through 2 mm and 0.5 mm nylon sieve and were maintained separately for analysis. Four fractions of boron namely readily soluble B, specifically adsorbed B, oxide bound B and organically bound B were determined. Boron extractions for these fractions were made by the procedure given by Hou et al. (1). After the extraction, the sample preparations and the color development of the extract were done by the method given by Datta et al. (2). Along with these fractions, the available boron content of the soil was determined by 0.01 M CaCl₂ (3) separately. Among the physico-chemical characteristics pH (4), organic carbon (5), clay (6), CEC (7), CBD Al, amorphous Al, CBD Fe, amorphous Fe (8) were estimated to evaluate the relationship of different forms B with these soil characters (Table 1).

Results and Discussion

The available boron (hot 0.01 M CaCl₂) content of 15 surface soils varied from 0.15 to 0.34 mg/kg with a mean value of 0.23 mg/kg (Table 2). Highest available B was reported in Dewanhat-II soil having pH 8.0 and lowest available B was found in Natabari with its pH value of 5.0. Grewal et al. (9) observed an increase in available B content with successive rise in pH of soil ranging from 5.3 to 9.4. Correlation

Table 1. Physico-chemical properties of soils.

Soil	pH	Org. carbon (g/kg)	Clay (%)	CEC cmol (p+)/kg	CBD Fe (g/kg)	CBD AI (g/kg)	Am. Fe (g/kg)	Am. AI (g/kg)
Pholimari	4	4.3	16	6.7	5.65	1.31	2.77	2.12
Patchara	4.3	10.4	20	8.8	5.59	1.2	2.41	1.57
Chilkirhat	4.5	11.5	20	9.5	7.87	2.81	3.24	1.74
Chanhamari	4.7	5.7	15	5.7	5.6	0.74	1.72	1.7
Dholpol	4.8	9.6	18	9.6	6.7	1.7	2.32	1.21
Natabari	5	7.8	16	7.2	7.61	2.52	2.45	2.73
Dhandinguri	5.4	7.3	15	5.6	6.94	1.25	2.18	1.72
Patlakhawa	5.6	5.5	19	7.2	6.93	2.8	2.59	1.23
Gopalpur I	5.8	6.4	18	9.9	5.96	1.87	2.43	1.44
Dewanhat I	5.5	8.4	17	7.9	7.79	2.56	1.65	1.44
Gopalpur II	6.1	5.6	14	6.2	9.02	2.85	1.58	1.97
Pholimari	6.4	4.3	14	5.8	9.53	1.98	3.27	1.59
Purbagopalpur	6.7	9.3	19	10	6.04	2.31	2.94	2.59
Lotafela	6.9	5.8	20	15.2	8.51	2.57	2.59	1.53
Dewanhat II	8	16.2	18	12.5	10.29	2.34	2.58	3.11

studies between available B content and soil pH (Table 3) indicated that pH did not have significant influence on the availability of B in these soils. Similar insignificant relationship was also reported by Bhattacharya et al. (10).

The oxides and hydroxides of iron and aluminium compounds present in soils also showed marked affinity for B which may be explained due to the rea-

son that these adsorption sites might have acted as pool from where the B was supplied to the solution, or acted as the sink of B and exerted its influence, depending on the change in the solution boron concentration in the soil (11). Among the four fractions of aluminium studied only CBD AI was found to influence the availability of boron in these soils. Correlation studies presented in Table 3 postulated that available B content decreases with the concomitant increase in CBD AI. Similar findings were reported by Alleoni et al. (12).

Readily soluble boron fraction which is the most

Table 2. Forms of boron (mg/kg) in experimental soils. Values are in mg/kg.

Soil	Red sol B		Spe Ad B	Ox-ide bo-und B	Org. B	Avail. B
	Pholimari	0.45	0.61	2.9	0.86	0.23
Patchara	0.58	0.88	3.2	4.1	0.25	
Chilkirhat	0.32	0.09	4.71	2.2	0.17	
Chandamari	0.6	0.52	1.2	2.97	0.31	
Dholpol	0.65	0.82	3.98	4.4	0.28	
Natabari	0.36	0.93	5.03	2.97	0.15	
Dhandinguri	0.54	0.71	4.07	3.92	0.23	
Patlakhawa	0.29	2.3	2.96	2.3	0.17	
Gopalpur I	0.61	0.91	2.42	2.02	0.3	
Dewanhat I	0.18	0.54	4.1	4.92	0.18	
Gopalpur II	0.26	1.5	3.34	2.67	0.24	
Pholimari	0.69	0.89	4.9	2.05	0.22	
Purbagopalpur	0.58	1.356	3.77	4.25	0.23	
Lotafela	0.4	1.29	3.07	1.55	0.34	
Dewanhat II	0.74	1.1	5.22	5.8	0.34	
Mean	0.48	1.02	3.66	3.13	0.23	

Table 3. Correlation (*r* values) of different forms of B with physico-chemical properties of soils. *Significant at 5% level; **Significant at 1% level.

Soil properties	Avail-able B	Rea-dily avail-able B	Spe-cifi-cally adso-rbed B	Ox-ide bo-und B	Organi-cally bound B
pH	0.26	0.25	0.61*	0.32	0.31
Organic carbon	0.29	0.28	0.17	0.52*	0.74**
Clay	0.001	-0.04	0.16	0.01	0.11
CEC	0.27	0.15	0.47	0.13	0.14
CBD Fe	-0.06	-0.05	0.43	0.66**	0.17
CBD AI	-0.59*	-0.580*	0.53*	0.47	-0.03
Am. Fe	0.05	0.35	0.13	0.42	-0.31
Am. AI	0.08	0.20	0.38	0.44	0.31

labile fraction and constituted of solution plus non-specifically adsorbed B registered a wide variation for its content and ranged from 0.18 mg/kg in Dewanhat-I and 0.74 mg/kg in Dewanhat-II with an average value of 0.48 mg/kg. Being the most active phase which is subject to leaching from the soils, readily soluble B was found to be negatively and significantly ($r = -0.58^*$) related to CBD AI indicating that increase in CBD AI resulted in increase B adsorption from the solution phase. Similar influence of this form of AI on readily adsorbed B was also reported by Hou et al. (1).

The content of specifically adsorbed boron (Spa. B) was reported to be 0.52 mg/kg in Chandamari and 2.3 mg/kg in Patlakhawa with a mean of 1.02 mg/kg (Table 2). Among the soil characteristics pH ($r = 0.61^*$) and CBD AI ($r = 0.53^*$) were significantly and positively correlated with Spa. B. Hou et al. (1) postulated that this fraction include desorbed B from inorganic constituent such as hydrous oxide through ligand exchange reactions and they established positive and significant relationship of specifically adsorbed B with pH of the soil, but a negative and significant relationship with free Al_2O_3 .

Oxide bound fraction of boron that included tightly bound boron at the non-crystalline and some crystalline oxy-hydroxides of iron and aluminium and that isomorphously replaced Al^{3+} and Fe^{3+} within the octahedral sheets of the minerals showed varied distribution in terms of their values between the range of 1.2 mg/kg in Chandamari and to 5.22 mg/kg in Dewanhat II with a means of 3.66 mg/kg (Table 2). This form of B had positive and significant correlation with CBD Fe ($r = 0.58^*$) and organic carbon content ($r = 0.55^*$) of the soil. The higher amount of CBD extractable Fe in these soils suggested that B is closely associated with Fe oxide or oxy-hydroxides and it was corroborated with the findings of Hou et al. (1). A significant positive relation ($r = 0.55^*$) between organic carbon and oxide bound B observed in this study suggested that ammonium oxalate as an extractant that could dissolve organic fractions of the soils to some extent (8).

The mean organic boron (Org B) content of soils was found to be 3.13 mg/kg with its highest value of 5.8 mg/kg recorded in Dewanhat II and the lowest value of 0.86 mg/kg was registered in Pholimari soil. The organic carbon content of soils in this investiga-

tion generally varied from medium to high range (Table 1). Positive significant relationship ($r = 0.71^{**}$) was found between Org B and organic carbon content of the soils. Hou et al. (1) also elucidated that the Org. B was significantly correlated with the clay and organic carbon contents in soils of Canada.

A comparison of relative proportion of individual boron fraction indicated that of cumulated average of four fractions, readily soluble B, specifically adsorbed boron, organically bound boron and oxide bound boron accounted for 5.8, 12.3, 37.7 and 44.2% respectively.

Conclusion

The maximum proportion of B under consideration remains in the form unavailable to the plant. The available boron (hot 0.01 M $CaCl_2$) content of the soils was found to be low. The relative proportion of various fraction of the B in the soil are of the order : Readily soluble B < Specifically adsorbed B < Organically bound B < Oxide bound B. The pH, organic carbon content, aluminum oxide (CBD AI), iron oxide (CBD Fe) contents of the soils significantly influenced the available form of B, readily soluble B, specifically adsorbed B, organically bound boron and oxide bound boron.

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