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Different fractions of boron in soils of Alfisol and Entisol of West Bengal

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Abstract
Boron (B) is an important micronutrient in plant nutrition supply from the soil solution which is highly governed by the pools of B and their equilibrium with the soil solution. The concentration of B and their forms are widely distributed in soil horizons under different depths. The physico-chemical properties of the soil have profound effect on these different forms of Boron. An experiment was conducted to assess the response of different soil attributes to the B dynamics influencing the pattern of distribution in soil. Samples collected from the identified series of two soil orders namely Alfisol and Entisol. Results revealed that the relative proportion of various fraction of boron in soils are in the following order i.e. readily soluble B< Specifically adsorbed B < Organically bound B < Oxide bound B < Residual B. The soil attributes like pH, organic carbon, texture, CEC, extractable-Al, exchangeable-Al, CBD-Fe, CBD-Al, amorphous-Fe and Al influence the fraction of boron to a various extent.

Keywords: Alfisol, Entisol, Boron fractions, Surface and Sub-surface layer, Soil attributes

1. Introduction

Boron (B) is called unique among the essential mineral plant nutrients because it is the only element normally present in soil solution as a non-ionized molecule over the pH range suitable for plant growth. The total concentration of B in the soils of India varies from 7-630 mg/kg. But generally less than 5% of the total B is available to plants (Berger and Truog, 1945) [1]. Irrespective of the native sources or added, B is quickly converted to relatively unavailable form and removed from the soil solution largely due to leaching in high rainfall areas or through its reaction with inorganic and organic constituents in soils. Maintaining B in the soil solution is important for plant nutrition and it is controlled by the pools of B in other soil fractions and their equilibrium with the soil solution. Following the fractionation procedures developed by Hou *et al.*, (1994) [4], the soil B is distributed in different forms which includes readily soluble B (Red.sol.B), specifically adsorbed B (Spc.B.), oxide bound B (Ox.B.), organically bound B (Org.B.) and residual B(Res.B). The Red.sol.B is the most labile fraction constituting solution plus non-specifically adsorbed B is present on the clay edges and other variable charge surfaces by displacement through anion exchange and mass reaction. Spc.B., is lightly bound at the mineral surface as well as B that has isomorphously replaced Al^{3+} or Fe^{3+}within the octahedral sheet of the minerals. Ox.B includes tightly bounded B at non-crystalline and some crystalline of Fe and Al. Org.B is totally associated with organic matter and the Res.B exists within primary and secondary mineral structures, such as tourmaline and clay mica. The assessment of these forms in soils helps in understanding its dynamics in soils. Among all these forms at any given point of time about 80-90% is present as unavailable form. However, the supply of B to Labile pool which is mainly constituted by Red.sol.B is being regulated by relatively less available forms of Spc.B., Ox.B and Org. B in the soils (Hou *et. al*., 1994) [4]. Distribution of these different forms of B in soil surface is always influenced by sub-surface soil and capability of these underlying B should also be taken into consideration while evaluating the reasons for variability of these forms. Soils of Lateritic and Terai region are acidic in reaction. The availability of B in plant available form is different in these soils irrespective of the zones. Moreover, the soils also belong to these different orders of soil Taxonomic classification. Inherently, due to these differences the soil physico-chemical properties will also vary and simultaneously influence the boron dynamics in these soils. Considering these facts in mind, an experiment was conducted to evaluate the effect of different fractions of boron on soil attributes influencing the pattern of distribution in soil

2. Materials and methods

Soils have been collected from two different agro-ecological regions–Lateritic and Terai zones from 8 identified series (NBSS & LUP) of two soil orders, viz., Entisol and Alfisol in Cooch

Behar, Jalpaiguri, and Purulia districts of West Bengal. Sampling depth was from surface (0-20 cm) and sub-surface (20-40 cm) layers in Entisol and for Alfisol, 0-15 and 15-30 cm for surface and sub-surface layers, respectively were chosen to maintain the depth wise parity in the number of soil samples. Collected samples were at first processed; starting from air drying and then passed through 2 mm and 0.5 mm nylon sieves, and the fractions were separately mixed. The pH, organic C, texture, and CEC of the soils were estimated by following the standard procedures. Exchangeable Al, Extractable Al, CBD and Amorphous Al and Fe were estimated by the methods of Black (1965) [3], Mehra and Jackson (1960) [8] and McKeague and Day (1966) [7], respectively. The iron and aluminium in the extract were determined colorimetrically by using o-phenanthroline (Jackson, 1973) and aluminon (Black, 1965) [3]. The fractions of boron were estimated by using different extractants as explained by Datta *et al* (2002) [5]. The Readily soluble B was extracted by 0.01M $CaCl_2$ solution (soil:extractant ratio of 1:2) and shaked for 16 hrs. Specifically adsorbed B is extracted with 0.05M KH_2PO_4 (1:2) and shaked for 1 hr. Oxide bound B was extracted by 0.175M NH_4-oxalate (1:4) and shaked for 4 hrs. Organically bound B was extracted by 0.5M NaOH (1:4) and heating at 85^0C.Residual B can be extracted with 1:5.5 ratios of HF, H_2SO_4, $HClO_4$ and heating at 135^0C. The boron from the above extract was determined by following Azomethine-H and carmine method (Bingham, 1982).Statistical Analysis were done by the help of a statistical software-Gen-res and a simple correlation study was undertaken in order to find out the relationships between extractable boron fraction and the soil physico-chemical properties of surface and sub-surface soil.

3. Results and discussion

3.1. Readily soluble B

The soils collected from Entisol recorded greater amount of Red. B in sub-surface layers (0.19 mg kg^{-1}) in average and comparatively lower amount in surface layers(0.17 mg kg^{-1}).The mean content of 0.12 mg $kg^{-1}$and 0.17 mg $kg^{-1}$for surface and sub-surface layers, respectively were found in the soils of the Alfisol order. Red.B is positively and significantly correlated to the pH of soils of both surface and sub-surface layers. It can be ascribed to the fact that increasing the pH increases the negative surface charges of clays and other variable charge surfaces. Similar findings were reported by Datta *et al.* 2002 [5] and Choudhury and Shukla, 2003. This form in subsurface layer is also related to clay and CBD Fe. The relationship with clay is negative and significant. Naturally increase in clay content will decrease the content of readily soluble boron. As this form consist of non-specifically adsorbed B in clay edges and other variable charge surface by displacement through anion exchange an mass reaction (Hou *et al* 1994) [4], significant and positive (0.93****) relation with CBD Fe indicate increase in Red.B with increase in CBD Fe.

3.2. Specifically adsorbed B

The average content of Spc.B is comparatively higher in Entisol than the Alfisol. In soils of Entisol order, we observed this form to be present in 1.63 mg kg^{-1}in sub-surface layers than the surface (1.39 mg kg^{-1}) layers. No specific relationship is recorded with Spc.B and physico-chemical properties in both the horizons. Datta *et al.,* (2002) [5] failed to obtain any relationship between this form and soil attributes. This fraction probably originates from the weakly binding sites of both organic and inorganic constituents and none of these contributed exclusively towards this B fraction.

3.3. Oxide bound B

The Ox.B content of sub-surface layer (1.21 mg kg^{-1}) was more than surface layer (1.09 mg kg^{-1}) under the Alfisol following the similar trend of higher content in sub-surface layer. In the order Entisol, values varied from 1.52 to 1.55 mg kg^{-1}.Significant positive relationship (r=0.79*) of oxide bound B (Ox.B) with amorphous Fe in surface soil is observed. Similarly, a significant relationship of Ox.B with organic carbon, CBD Fe, Am-Fe and Exchange acidity were recorded in sub-surface layer. Ammonium and iron oxides play an important role in B adsorption behaviour in soils. The mechanism of B adsorption on aluminum and iron oxide minerals is considered to be ligand exchange with reactive surface hydroxyl group (Gold berg *et.al.*1993b). Ammonium oxalate can solubilize non crystalline and some crystalline oxyhydroxides of Fe and Al forms in soils. The relationship of oxide bound boron and ammonium oxalate Fe is logical as an adsorption of B, both as $B(OH)_3^0$ and $B(OH)_4^-$species take place on Fe_2O_3 was ligand exchange (Su and Suarez, 1995).

3.4. Organically bound Boron

In contrast to Alfisol, the range of Org.B was comparatively higher in sub-surface layers of soil series in Entisol (1.58mg kg^{-1}). With respect to other three forms of B, average Org.B content recorded relatively low in sub-surface layers than the surface layers under the order Alfisol (0.85mg kg^{-1}). The highest value of 2.19 mg kg^{-1}in sub-surface layers was also noticed in Entisol. Org.B increased with increase in organic carbon which is further corroborated by significant and positive correlation (r=0.77* and 0.75*) of Org.B with organic carbon in both the layers. In surface layer Org.B is also positively related to Amorphous (Am.) Al and Exchange acidity. A fraction of Al polymer is chelated by ligand group of organic matter, and NH_4^{--} oxalate is capable of extracting this form of aluminium to different degrees. While doing so, the breaking of complexes may result in release of other elements too. Naturally, the Org.B may be released and due to this reason the Am Al (NH_4- oxalate Al) is related to Org.B. Datta *et.al.* (2002) [5] reported similar findings which corroborate the above relationship. Similarly, in subsurface layers, extractable and exchangeable Al were found to have positive and significant (r=0.81*; 0.73*) relationship with Org.B. Extraction of Org.B may result in release of other elements and a concentration is directly influenced by extractable and exchangeable Aluminium.

3.5. Residual B

The average Res.B content in surface and sub-surface soils under the Alfisol order were 18.14 and 16.68 mg kg^{-1}, respectively. This form of B recorded highest of 24.12 mg kg^{-1}in sub-surface layers of Entisol. Residual Boron has a positive relation (r=0.79* and 0.81*) with CBD Fe in both surface and sub-surface layers of soil. Data *et al.* (2002) reported that residual B was significantly correlated with clay, Al, Fe and Al+Fe. They confirmed that the residual B is the structural constituent of clay and sesquioxides.

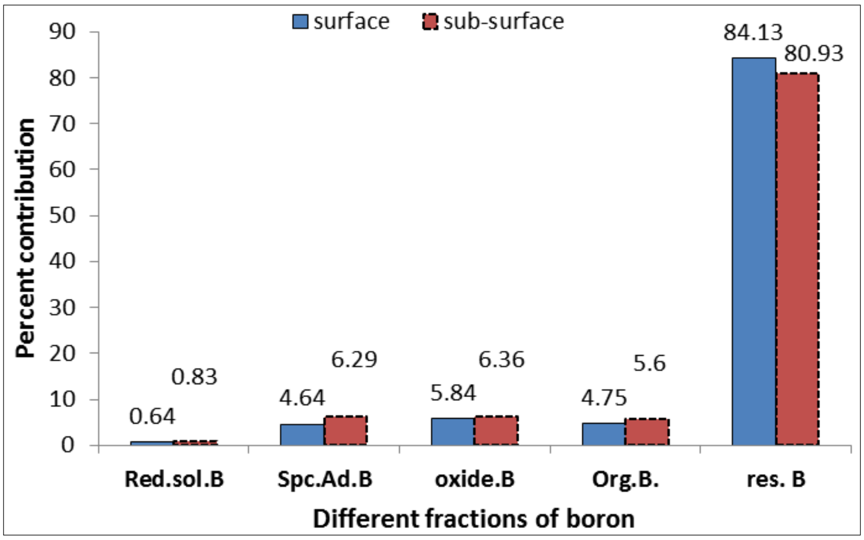

Fig 1: Cumulative average contribution of B forms in both surface and sub-surface layers ofAlfisol and Entisol expressed in percentage.

Table 1: Forms of Boron (mg/Kg) of four identified soil series under Alfisols.

Soil series	Depth (cm)	Red.sol.	Spc.Ad.	Oxide.B	Org.B.	Residual
Shyampur	0-15	0.15	0.67	0.79	0.77	16.44
	15-30	0.10	0.9	0.61	0.61	13.40
Patapahari	0-15	0.14	0.73	1.48	0.97	19.40
	15-30	0.15	0.84	0.87	0.88	16.60
DakhsinBahal	0-15	0.15	1.1	1.53	1.07	19.00
	15-30	0.10	1.14	1.66	1.48	14.52
SukniBasa	0-15	0.21	1.02	1.53	1.12	16.28
	15-30	0.32	1.55	1.70	0.44	22.20
Mean (Surface)		0.12	0.74	1.09	0.91	18.14
Mean (sub-surface)		0.17	1.11	1.21	0.85	16.68

Table 2: Forms of Boron (mg/Kg) of four identified soil series under Entisols.

Soil series	Depth (cm)	Red.sol.	Spc.Ad.	Oxide.B	Org.B.	Residual
Binnaguri	0-20	0.15	1.1	1.53	1.07	19.00
	20-40	0.11	1.91	2.45	2.19	20.92
Notefella	0-20	0.26	2.1	1.27	1.22	22.84
	20-40	0.38	2.2	1.40	1.53	24.12
Balarampur	0-20	0.21	1.02	1.53	1.12	16.28
	20-40	0.18	0.9	1.26	0.92	15.16
Berubari	0-20	0.08	1.32	1.74	1.33	19.40
	20-40	0.1	1.49	1.10	1.69	13.80
Mean (Surface)		0.17	1.39	1.52	1.19	19.38
Mean (sub-surface)		0.19	1.63	1.55	1.58	18.50

Table 3: Correlation (r values) of different forms of Boron with physico-chemical properties of surface soils.

Forms of Boron	pH	Org. C (g/kg)	Sand (%)	Silt (%)	Clay (%)	CEC (cmol (p+)/kg)	Extr. Al Cmol(p+) Kg^{-1}	Exch. Al Cmol(p+) Kg^{-1}	CBD Fe. (g kg^{-1})	CBD Al. (g kg^{-1})	Am Fe. (g kg^{-1})	Am.Al. (g kg^{-1})
Red.B	0.79*	-0.35	-0.60	0.63	-0.22	-0.14	-0.31	-0.40	0.34	-0.30	-0.25	-0.24
Spa.B	0.47	0.42	-0.73*	0.63	0.04	0.20	-0.10	0.16	0.60	0.30	0.22	0.56
Oxide B	-0.33	0.75*	-0.51	0.30	0.33	0.60	0.35	0.57	0.30	0.77*	0.91***	0.65
Org. B	-0.02	0.77*	-0.66	-0.51	0.38	0.58	0.12	0.44	0.33	0.66	0.61	0.75*
Res. B	0.22	0.32	-0.43	0.39	-0.20	-0.03	-0.03	0.18	0.81*	0.20	0.40	0.35

*Significant at 5% level; ** Significant at 1% level;***Significant at 0.5%;****Significant at 0.1%

Table 4: Correlation (r values) 0f different forms of Boron with physico-chemical properties of sub-surface soils.

Forms of Boron	pH	Org C (g/kg)	Sand (%)	Silt (%)	Clay (%)	CEC (cmol (p+)/kg)	Extr. Al Cmol(p+)Kg^{-1}	Exch. Al Cmol(p+)K g^{-1}	CBD Fe. (g kg^{-1})	CBD Al. (g kg^{-1})	Am Fe. (g kg^{-1})	Am.Al. (g kg^{-1})
Red.B	0.75*	-0.35	-0.16	0.53	-0.86**	-0.45	-0.54	-0.49	0.93****	-0.48	-0.15	-0.31
Spa.B	-0.01	0.40	-0.11	0.40	-0.60	-0.34	0.34	0.32	0.46	0.10	0.33	0.30
Oxide B	-0.38	0.30	-0.12	0.17	-0.17	0.10	0.60	0.35	0.15	0.22	0.79*	0.10
Org. B	-0.49	0.75*	-0.26	0.20	-0.01	-0.11	0.81*	0.73*	-0.30	0.44	0.39	0.55
Res. B	0.31	-0.13	-0.11	0.40	-0.62	-0.15	-0.04	-0.18	0.79*	-0.25	0.31	-0.20

*Significant at 5% level; ** Significant at 1% level;***Significant at 0.5%;****Significant at 0.1%

4. Conclusion

The result of the present study reveals that proportionately the boron content in different fraction was higher in Entisol than the Alfisol. Major portion of B in soil remain as unavailable form. Soil attributes like pH, organic carbon, extractable-Al, exchangeable-Al, CBD-Fe, CBD-Al, and amorphous-Fe and Al influence the different fractions of B to different extent. Among all the forms, the major portion of B in soils existed as residual or occluded forms which accounted for 84.06% and 80.93% in surface and sub-surface, respectively. It indicated that out of the cumulated average of five fractions, red.sol.B, spc.Ad.B, oxide.B, org.B and res.B accounted for 0.64, 4.74, 5.84, 4.69 and 84.06% in surface soils and 0.83%, 6.29%, 6.36%, 5.60% and 80.93%, respectively in sub-surface soils. The sequence of the content of different fractions of boron in both the orders was red.sol.B<spc.Ad.B<org.B <oxide.B< res.B, respectively.

References

1. Berger KC, Truog E. Boron availability in relation to soil reaction and organic matter content. Soil Sci. Soc. Am. Proc. 1945; 10:113-116.
2. Bingham FI, Page AL, Coleman NT, Flach K. Boron adsorption characteristics of selected soil from Mexocos. Hawaii. Soil Sci. Soc. Am. j. 1971; 35:546-550.
3. Black CA. Methods of soil Analysis. Part II, Agron.Ser. No.9. *Am.soc.Agron*., Inc. Madison, Wisconsin, U.S.A, 1965.
4. Chaudhary DR, Sukla LM. Profile distribution of Boron forms in relation to soil characterstics in Aridsoils of Western Rajasthan. Ann. Agric. Aer. New. Series. 2003; 24:314-321.
5. Datta SP, Rattan RK, Kandregula S, Datta SC. Fractionation and colorimetric determination of boron in soils. J. Plant Nutr. Soil Sci. 2002; 165:179-184.
6. Hou J, Evans LJ, Spires GA. On boron fractionation of soil, 1994, Commun. Soil Sci. Plant Anal, 1994; 25(9-10):1841-1853.
7. Mckeague JA, Day Jh. Dithionate and osalate extractable Fe and Al as aids in differentiating various classes of soils. Can. J. Soil. Sci. 1966; 46:13-22.
8. Mehra OP, Jackson ML. Iron oxide removal from soils and clays by a dithionite-citrate system buffered with sodium bicarbonate. 7th Natl. Conf. on clays and clay mineral. 1960, 317-327.