BORON FRACTIONATION IN SOME SASKATCHEWAN SOILS

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INTRODUCTION

Boron (B) is the only nonmetal among the micronutrients. The total concentration of B in soils varies between 2 and 100 ppm and frequently ranges from 7 to 80 ppm (Tisdale et al, 1993). Less than 5 % of the total soil B is available to plants. Most soils have 10 ppm B (Karen and Bingham, 1985). It occurs in low concentrations in the earth's crust and in most igneous rocks (~10ppm). Among sedimentary rocks, shales have the highest B concentrations (up to 100 ppm), present mainly in the clay minerals. Boron exists in four major forms in soil: in rocks and minerals, adsorbed on clay surfaces and Fe and Al oxides, complexed with OM, and as boric acid ($H_3BO_3^0$) and $B(OH)_4^-$ in the soil solution.

Sequential extraction procedures are often used to separate element into different chemical fractions. Soil chemists use these schemes to investigate native forms of microelements in soils and fixation and mobility of micronutrients in soils. Gupta and Chen (1975) used a sequential extraction scheme to study partitioning of trace metals among the various geochemical phases of sediments. Landau and Hossner (1982) also employed this technique to study marsh substrate fractionation. Boron fractionation has not been study extensively. Hou et al (1994) differentiated boron into, readily soluble, specifically adsorbed, oxide bound, organically bound and residual pools. Increasing frequency of B deficiencies worldwide suggests that native soil B reserves may be incapable of supplying plant requirements under prolonged heavy cropping

Current soil testing criteria for identifying B deficiency in prairie soils need to be verified and improved. The contribution of various soil B fractions to plant available B over the long term is also not well understood.

OBJECTIVE:

The main objective of the study reported in this paper was;

I. To reveal the nature of soil B chemistry by investigating the distribution of B in Saskatchewan soils with diverse soil properties, and the relationship of soil properties to the observed distribution of soil B in different fractions.

MATERIALS AND METHODS

Eight composite soil samples (surface layer, 0-15 cm) from south and north east agricultural regions of Saskatchewan were collected in fall 1999 to provide contrast in soil climatic zone, texture, pH and organic matter content. One composite soil sample was brought from Pakistan. Physico-chemical properties such as pH, organic matter, texture; CEC, Fe and Al oxides and lime content were determined. (Table1)

Table 1 Selected physico-chemical properties of the soils used for B fractionation

Soil Association	pH	Org. C %	Sand %	Silt %	Clay %	Text-re	Lime %	Fe_2O_3 mg kg^{-1}
Chaplin (wheat stubble)	6.6	1.2	61.6	25.8	12.5	S. L	0.05	3.2
Peshawar (Pakistan)	7.6	0.5	28.4	30.2	30.2	C.L	4.17	4.7
Sylvania S.L	5.9	1.2	76.1	15.5	8.5	S.L	0.00	2.07
Saline Seep.(Haverhill)	7.4	1.8	43.4	28.0	28.5	S.C.L	0.13	2.8
Chaplin(dryland barley)	7.8	2.2	63.2	17.8	19.0	S.L	0.0.3	2.3
Chaplin. Alfalfa	7.5	2.0	63.5	21.1	15.4	S.L	0.05	2.5
Sylvania L	6.0	2.7	34.1	42.7	23.2	L	0.04	3.54
Sylvania LS	6.0	0.9	89.9	0.05	10.0	L.S	0.02	1.8
Humic.Gleysol (Slough)	5.8	2.9	29.4	28.5	42.1	C	0.05	2.8

S=Sandy, L=Loam, C=Clay

Boron was determined in the following five chemically extracted fractions;

Fraction 1: Measures soluble or plant available B.

Fraction 2: Specifically adsorbed B.

Fraction 3: Non-crystalline, and Fe and Al oxide associated B.

Fraction 4: Organically bound forms of B.

Fraction 5: After the first four fractions, B in the residual should mainly exist within primary and secondary mineral structures, such as tourmaline and clay mica.

The sequential extraction procedures used for B extraction are shown in Table 2;

Table 2 Sequential extraction method for the determination of different fractions of B in soils

Step	Fraction conditions	Extractant	Soil:Soln (g:ml)	
1	Readily Sol.	Hot water	2:1	Boil 5 min
2	Specif. Adso.	0.05M KH_2PO_4	1:5	Shake 1 hr
3.	Oxide Bound	0.2 M NH_4-Oxalate	1:5	Shake 4 hrs
4	Organic. Bound	0.02M HNO_3, 30% H_2O_2, and 3.2M NH_4 Acetate	1:5	Heat at 85 ^oC and shake 30 min

RESULTS AND DISCUSSIONS

The content of B fractions and the percentage of the total soil B represented by each fraction for the 9 soils was described statistically in terms of the minimum, maximum,

and mean values, together with standard deviations (Table3). In all soils, the readily soluble B represented only a small proportion of the total B content. Less than 1% of the total soil B was extracted by hot water present in solution which is believed to be the most available for plant uptake. The mean contents of extractable B were 1.06% in the readily available form, 0.69% in the specifically adsorbed form, 0.40% was oxide bound and 0.86% was organically bound B. The major portion of soil B existed as residual or occluded form which accounted for 61.3 to 96.9% of the total soil B with a mean of 93.9%.

Table3 Descriptive statistics for B fractions as determined in nine soils using sequential extraction with hot water as readily soluble extractant.

	Minimum		Maximum		Mean	Stdev
B Fractions	content	%	content	%	content	
	mg B/kg	of total B	mg/kg	of total B		
ReadilySoluble	0.21	0.22	3.75	1.06	1.02	1.07
Specif.Adsorbd	0.04	0.04	1.59	0.72	0.69	0.57
Oxide Bound	0.26	0.27	0.995	0.41	0.40	0.23
Organic. Bound	0.292	0.30	2.496	0.89	0.86	0.73
Residual	61.28	63.23	138.06	96.91	93.92	22.62

The highest Hws B content of 3.75 mg kg^{-1} soil was found in saline seep soil. It also has the highest total B content of 138 mg kg^{-1} soil (Table 4). The lowest Hws (B 0.21 mg kg^{-1}) soil was found in Sylvania L.S. It's a sandy Gray luvisol of low organic matter content. Its total B content was 78.5 mg kg^{-1} soil. In addition Hws B and specifically adsorbed B were higher in soils of high organic matter such as humic gleysol. The mean content of organic bound B (0.86 mg kg-1 soil) is greater than mean contents of oxide and specifically adsorbed B (Table 3), indicating that B associated with organic matter may be relatively more important than mineral B as a slowly available B pool. The higher percentage of organically bound B suggests that organic substances are potential pools of the plant available B. Thus, it may be important to take it into consideration when assessing plant available B.

Table4 Boron concentration in different fractions of the nine selected soils.

	----------mg B kg^{-1} soil----------						
Soil	Hot water soluble B	Specif. adsorb, B	Oxide bound B	Org. bound B	Residual B	Total B	% Resi of total B
Chaplin S.L.	0.74	0.38	0.26	0.41	106.2	108.0	98.3
Pesh (Pakistan)	0.39	0.14	0.33	0.56	59.9	61.3	97.7
Sylvania S.L.	0.47	0.71	0.33	0.29	79.6	81.4	97.8
Saline S. Hesvestil	3.7	3.1	1.00	2.5	127.7	138.1	92.5
Chap.L.S.(dryland)	0.84	0.19	0.46	1.7	75.2	78.4	96.0
Chap. L.S. Alfalfa	0.93	0.22	0.31	0.53	116.6	118.6	98.3
Sylvania S.L	0.71	0.31	0.29	0.44	92.0	93.7	98.1
Sylvania L.S	0.21	0.09	0.27	0.72	77.2	78.5	98.4
Humic – .Gleysol (Slough)	1.4	1.1	0.33	0.63	111.0	114.3	97.0

CONCLUSIONS:

- Except for the saline seep soil less than 1% of the total soil B was in soluble form.
- The major portion of soil B exists as residual or occluded form, which accounted for 61.3 to 96.9% of the total soil B.
- The Saline seep and Humic gleysolic soils had the highest total and soluble B, while the sandy Grey luvisol soils and the soil from Pakistan had the lowest soluble and total B.
- Clay and organic C content appear to be dominant factors controlling total and soluble B, with higher B associated with soils of higher clay and organic matter content.

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