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Depth-wise Distribution of Boron in Relation to Soil Properties in South-west Punjab

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Abstract: The soils of Punjab are coarse textured and low in organic matter, therefore leaching of boron (B) beyond the root zone is more likely to occur in these soils. To study the depth-wise B availability in different soil types, samples were collected from 0-15, 15-30, 30-60 and 60-90 cm depth representing Ustic Torripsamments, Typic Ustipsamments and Ustochreptic Camborthids. The highest (3.94 mg kg^{-1} soil) of hot water soluble boron (HWS-B) was observed in Ustochreptic Camborthids followed by Typic Ustipsamments (2.40 mg kg^{-1} soil) and Ustic Torripsamments (2.03 mg kg^{-1} soil). In general, hot water soluble B decreased with depth to the tune of 41.8, 35.4 and 36.4 per cent in Ustic Torripsamments, 16.2, 15.0 and 31.2 per cent in Typic Ustipsamments and 17.2, 29.1 and 39.1 per cent in Ustochreptic Camborthids, respectively. Significant positive correlations of HWS-B were observed with pH, organic carbon of soil and negative with $CaCO_3$.

Keywords: *Soil types, soil depth, boron*

Introduction

The deficiency of B is expected to be high in coarse-textured soils having low organic matter, high $CaCO_3$ and high pH. Calcareous and coarse textured soils which are highly leached exhibited boron deficiency to a greater extent as compared to other soils (Takkar *et. al.* 1989).About 33 per cent of the cultivated area in India is B deficient (Borkakati and Takkar 2000). Total B content varied from 7 to 630 mg kg^{-1} (Das 2000), while available B content ranged from traces to 12.2 mg kg^{-1}. In Punjab, available B in soils has been reported to be 0.40 to 7.49 mg kg^{-1} (Katyal and Agarwala 1982). Bansal *et al. (*1991) and Singh and Nayyar (1999) also reported B deficiency in alluvial soils of arid and semi-arid regions of Punjab. However, B toxicity in saline soils of Punjab has also been reported (Sharma and Bajwa 1989; Arora and Chahal (2005) because the critical range between the deficiency and toxicity limit for B is very narrow as compared to other elements. As the soils of Punjab are coarse textured, low in organic matter and being extensively cultivated, the possibility of B to be leached down to the deeper layers is more likely in these soils. Saline soils and saline well water are found to be associated with high concentrations of B (Dhankhar and Dahiya 1980). Therefore, the present study was planned to study the relationship between the availability of B and soil depths in relation to soil properties.

Materials and Methods

The climate of the area is semi-arid sub-humid The annual rainfall ranges from 400-600mm of which more than 70 per cent occur during July to September. Soil samples were collected from 0-15 cm, 15-30 cm, 30-60 cm and 60-90 cm depth representing Ustic Torripsamments, Typic Ustipsamments and Ustochreptic Camborthids from Bathinda, Mansa and Muktsar districts during *kharif* 2015 under the cotton-wheat cropping system. The soil samples were air-dried, processed and analysed for hot water soluble boron (Berger and Truog 1939). The physical and chemical properties were determined by following standard procedures (Jackson 1967; Walkley and Black 1934; Puri1930).

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Results and Discussion

The relevant physico-chemical properties of the soils are given in table 1. The depth-wise distribution of HWS-B is given in table 2. The highest HWS-B was observed in Ustochreptic Camborthids followed by Typic Ustipsamments and Ustic Torripsamments. In Ustic Torripsamments, HWS-B ranged from 0.86-3.39, 0.49-2.21, 0.39-1.99 and 0.30-1.82 mg kg^{-1}. In Typic Ustipsamments, it ranged from 2.23-2.57, 1.99-2.03, 1.76-2.32 and 1.25-2.06 mg kg^{-1} of soil. The HWS-B at 0-15, 15-30, 30-60 and 60-90 in Ustochreptic Camborthids, if ranged from 1.45-5.83, 2.57-4.17, 2.23-3.29 and 2.08-2.80 mg kg^{-1} of soil.

As the soil depth increased from 0-15, 15-30, 30-60 and 60-90 cm, the mean HWS-B decreased by 41.8, 35.4 and 36.4 per cent in Ustic Torripsamments, 16.2, 15.0 and 31.2 per cent in Typic Ustipsamments and 17.2, 29.1 and 39.1 per cent in Ustochreptic Camborthids, respectively over the surface layer (Table 2). The decrease in HWS-B content with increase in soil depth was mainly due to decrease in soil pH and organic carbon with increase in calcium carbonate content. This could also be due to the accumulation of B in the surface layers through addition of B by irrigation water (Fig.1). Similar results were also observed by Bhargava *et al.* (1974) and Arora and Chahal (2005). The lowest decrease in HWS-B was observed in Ustochreptic Camborthids which may be attributed to the higher clay content in deeper layers.

Significantly positive correlations of HWS-B (0-90 cm depth) with soil pH, SOC and negative correlation with $CaCO_3$ were observed in these soils (Table 3). These results are in conformity with Takkar *et al.* (1989) and Rashid *et al.* (1994). Padbhushan and

Table 1. Some physico-chemical properties of soil

Soil characteristic	Ustic Torripsamments				Typic Ustipsammments				Ustochreptic Camborthids			
	0-15*	15-30*	30 -60*	60-90*	0-15*	15-30*	30-60*	60-90*	0-15*	15-30*	30-60*	60-90*
pH (1:2)	8.4±0.40	8.26±0.23	8.1±0.10	8.1±0.10	8.1±0.21	8.2±0.24	8.3±0.18	8.13±0.12	8.03±0.06	8.08±0.10	7.93±0.25	7.72±0.46
SOC (%)	0.94±0.06	0.43-0.08	0.27±0.07	0.30±0.04	0.63±0.01	0.42±0.02	0.43±0.03	0.23±0.09	1.13±0.16	0.67±0.10	0.46±0.07	0.35±0.07
$CaCO_3$(%)	4.14+0.74	5.03±1.5	6.25±1.75	8.63±2.17	0.96±0.19	2.06±0.26	2.56±0.06	4.08±0.8	4.74±1.58	5.41±1.15	6.13±2.52	7.59±3.28
Available P (kg ha^{-1})	14.8±1.32	10.4±2.58	7.88±1.20	6.89±2.17	26.9±9.22	21.5±15.3	22.5±16.7	14.5±6.46	35.8±18.5	25.2±12.5	16.86±9.5	9.29±2.57
Available K (kg ha^{-1})	183±0.82	166±14.6	153±14.5	144±17.8	255±14.3	229±15.3	229±17.5	100±20	190±9.7	140±3.23	160±27.1	148±23.3
CEC (cmol (p+) kg^{-1} soil	6.04±0.17	4.96±0.26	5.3±0.36	5.86±0.61	4.92- 0.32	5.31±0.31	4.89±0.27	4.93±0.12	7.17±1.77	4.17±1.00	6.33±0.17	5.98±0.40
Sand (%)	64.0±0.08	60.8±2.01	61.63±4.3	19.9±2.37	5.31±0.31	76.5±2.51	69.5±1.86	68.9±0.70	45.3±7.31	43.9±7.85	39.57±3.8	35.2±3.67
Silt (%)	6.71±2.15	17.6±1.17	16.73±5.3	19.9±2.37	3.11±2.04	6.69±1.78	4.44±0.21	5.95±1.96	26.5±11.8	32.5±7.36	35.8±4.29	37.04±4.5
Clay (%)	29.3±3.53	21.7±0.84	21.25±0.9	21.3±0.94	20.37±0.4	23.78±0.1	25.7±0.91	24.89±0.7	28.23±4.5	23.8±2.63	24.6±2.63	27.8±2.50

* Soil depth (cm)

Note : Values denotes mean ± SE

Table 2. Distribution of HWS-B in soils

Soil classification		HWS-B (mg kg^{-1} soil) Depth (cm)			
		0-15	15-30	30-60	60-90
Ustic Torripsamments	Range	0.86-3.39	0.49-2.21	0.39-1.99	0.30-1.82
	Mean±SE	2.03±0.74	1.18±0.52	1.31±0.48	1.29±0.50
Typic Ustipsammments	Range	2.23-2.57	1.99-2.03	1.76-2.32	1.25-2.06
	Mean±SE	2.40±0.17	2.01±0.02	2.04±0.28	1.65±0.40
Ustochreptic Camborthids	Range	1.45-5.83	2.57-4.17	2.23-3.29	2.08-2.80
	Mean±SE	3.94±1.30	3.26±0.47	2.79±0.30	2.40±0.21

Table 3. Linear coefficients of correlation of HWS-B (0-90 cm) with soil properties

Soil properties	'r' value		
	UsticTorripsamments	TypicUstipsammments	UstochrepticCamborthids
pH	0.950*	0.962*	0.805*
SOC	0.983*	0.995**	0.985**
$CaCO_3$	-0.803*	-0.976*	-0.950*
CEC	0.872*	-0.055	0.239
ESP	0.981*	-0.600	-0.754
Available P	0.995**	0.829	0.933*
Available K	0.971*	0.969*	0.710
Sand	0.829	0.853	-0.123
Clay	0.934*	-0.772	0.156

**significant at 1% level, *significant at 5% level

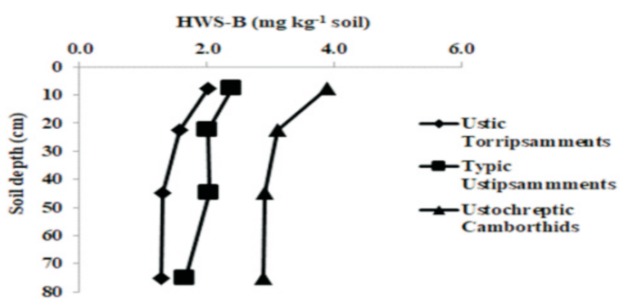

Fig. 1. Depth-wise distribution of HWS-B (mg kg^{-1} soil) in soils

Kumar (2015) reported a negative correlation between the HWS-B and calcium carbonate. It may be due to the bonding of B with $CaCO_3$ which resulted into precipitation of Ca-borate or substitution of carbon by B in $CaCO_3$ or simple surface adsorption of B on $CaCO_3$.

The HWS-B per unit of soil organic carbon was highly correlated in Typic Ustipsamments followed by Ustic Ustipsamments and Ustochreptic Camborthids (Fig. 2) but the HWS-B per unit of calcium carbonate was highly correlated with Ustochreptic Camborthids followed by Typic Ustipsamments and Ustic Ustipsamments (Fig. 3).

Conclusions

The HWS-B in soils indicate a decreasing trend with soil depth. The decrease was mainly due to the decrease in soil pH and soil organic carbon and increase in calcium carbonate content. The distribution of HWS-B was positively affected by pH and soil organic carbon and negatively by calcium carbonate.

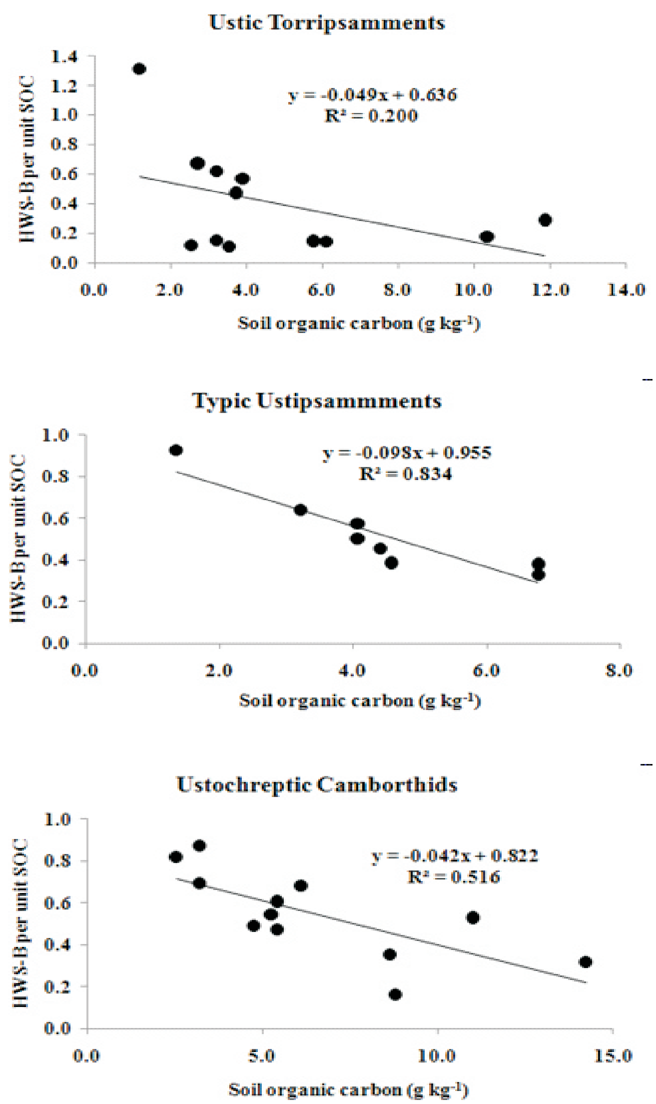

Fig. 2. Relationship of HWS-B (mg kg^{-1} soil) per unit soil organic carbon with soil organic carbon in soils

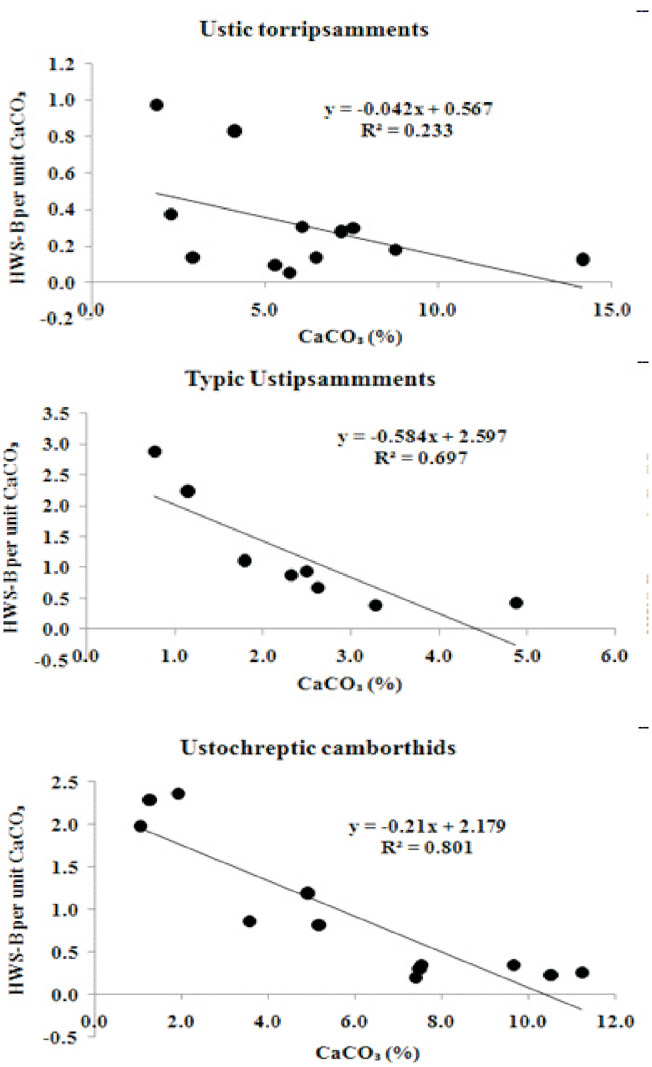

Fig. 3 : Relationship of HWS-B (mg kg^{-1} soil) per unit calcium carbonate with calcium carbonate in soils

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