INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

A Study on Boron Content in Tea Soil

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Abstract:
Attempt was made to delineate the distribution pattern of hot water soluble boron (HWB) in soil profiles supporting tea in few tea estates of south Bank. In each garden representative soil samples were collected from three tea fields supporting tea of different age groups viz., youngish mature (5-10 yrs), mature tea (20-25 yrs) and old tea (>40 yrs) and estimated for hot water soluble B using Azomethine H spectrophotometric method. Results showed that the average hot water soluble B, irrespective of age group, varied from 0.16 to 0.36 mg/kg. Results also indicated that with the increase in the age of tea, B content in soil was found to decrease irrespective of tea estates.

Keywords*: boron, soil texture, age*

1. Introduction

Micronutrients, though required in small quantities in soil, are essential for plant growth and development, the deficiency of which lead to several disorders, nutrient imbalances and ultimately crop loss (Vasuki, 2010). With the introduction of high yielding clones/varieties, the rate of nutrient uptake by tea bushes from the soil become faster resulting in the depletion of soil micronutrients within a short span of time and lead to its deficiencies, may be initially in the hidden hunger level. Boron (B) is known to play a major role in the metabolic activities of the plants and its applications were also reported to be useful for tea (Pathak *et al* 2005**;** Gohian *et al*., 2000). The possible roles of B include lignifications of tissues and xylem differentiation, sugar transport, cell wall synthesis, lignification, cell wall structure integrity, carbohydrate metabolism, ribose nucleic acid (RNA) metabolism, respiration, indole acetic acid (IAA) metabolism, phenol metabolism, and as part of the cell membranes (Monday et al., 1993; Welch, 1995; Ahmad *et al.*, 2009). Plants respond directly to the activity of B in soil solution and only indirectly to B adsorbed on soil constituents (Goldberg 1997, Matula, 2009). Boron exists in four major forms in soil: in rocks and minerals, adsorbed on clay surfaces and Fe and Al oxides, complexes with OM, and as boric acid (H_3BO_3) and B $(OH)^{4-}$ in the soil solution. (Shorrocks, 1997; Raza *et al.,* 2002). The availability of boron depends on several factors such as soil texture, nature of clay minerals, pH, liming, temperature, organic matter content, and environmental conditions like moderate to heavy rainfall, dry weather and high light intensity, soil fertility and microbial activity (Goldberg, 1997; Moraghan and Mascagni, 1991).

Deficiencies of B result in many anatomical, biochemical and physiological changes in plants (Saleem et al., 2011). Recently deficiency of B in some tea sections have also been reported (Advisory officers' visit reports) which was corrected by foliar application. Soil analysis from eleven districts of Assam (Gogoi et al., 1992) and four districts of west Bengal (Nandi et al., 1992) reported B deficiency in 17% and 64% of the samples respectively. Soil boron concentration range between plant deficiency and toxicity symptoms is very narrow but both deficiency and toxicity conditions can lead to marked decline in the yield of tea (Gupta, 1993). Furthermore, the range between toxic and deficient B levels for crop growth is quite narrow; therefore, indiscriminate use of this essential micronutrient is avoided. Further B is relatively immobile in plant and thus its availability is essential at all stages of tea growth. As monitoring of soil B status in tea soils is in infancy, therefore, proper soil assessment and effective planning is very important for correction of deficiency while avoiding over-application and possible toxicity. Therefore this study was carried out to monitor the distribution of boron in soil in few texturally different tea estates of south bank.

2. Materials and Method

A soil survey work was carried out in eleven numbers of tea estates of south bank (Table 1) and soil samples were collected from three different age groups viz., youngish mature (F_1:5-10 yrs), mature tea (F_2: 20-25 yrs) and old tea (F_3: >40 yrs). Three samples from the surface (0-15 cm), sub surface (15-30 cm) and bottom (30-45 cm) were collected from each section of the tea estates and each sample consisted of a composite of ten random borings. After proper processing, soil samples were estimated for soil pH and soil organic carbon (org C) following standard procedure (Jackson, 1973). Soil textural analysis was done by the standard international pipette method. Hot water soluble boron (HWB) in the soil samples was estimated spectrophotometrically by using Azomethine-H method (Baruah and Barthakur, 1997). A linear calibration was observed, followed by the calculation of the slope factor. The results are estimated in mg B/l. Regression equation was: $y = 0.4369\ x + 0.0161$. $R^2 = 0.9941$. Boron concentration was read directly from the standard curve (Fig 1). Acceptable ranges for hot water soluble B under different textural classes is shown in Table 2 (photo 1).

Tea Estates	Letter Designated	Textural Class
Rongagora	G_1	Heavy textured
Borbam	G_2	Heavy textured
Deha	G_3	Light textured
Numaligarh	G_4	Light textured
Ligripookhuri	G_5	Light textured
Borshillah	G_6	Heavy textured
New Sunuwall	G_7	Light textured
Ghilladhary	G_8	Heavy textured
Lattakoojan	G_9	Heavy textured
Mokrung	G_{10}	Heavy textured
Methony	G_{11}	Light textured

Table 1: Tea estates of South Bank

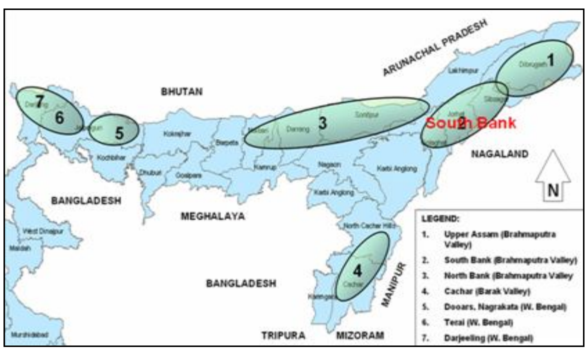

Photo 1: Map of sampling site (South Bank)

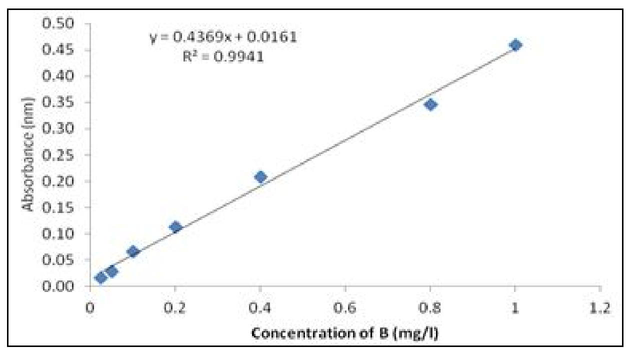

Figure 1: Calibration graph of boron

Soil texture	Very low	Low	Optimum	High	Excessive
Sands, Loamy sands	<0.20	0.30-0.40	0.50-1.00	1.10-1.25	>2.50
Sandy loam, loam, silt loam, silty clay loam	<0.30	0.40-0.80	0.90-1.50	1.60-3.00	>3.00

Table 2: Interpretation of boron content in soil
Source: Kelling, K. A., Soil and Applied Boron (A2522), University of Wisconsin System Board of Reagents And university of Wisconsin Extension, Cooperative Extension, US Deptt. Agri

3. Results and Discussion

Results showed that HWB content in different tea estates varied from 0.12 to 0.45 mg/kg Table 3a). Ligripookhuri tea estate maintained lowest content and Rongagora tea estate showed the highest level. These data suggest that available boron content of tea soils is rather low remaining well below 0.5 mg/kg, known to be critical level for other crops (Sakal, 1985; Das and Saha, 1999; Malewar, et al., 1999; Thiagalingam, 2000; Katyal and Rattan, 2003) below which response of applied boron is expected,. This indicates that all the soils below this critical value markedly responded to B fertilizer application. Therefore, in such soils, boron deficiency can be manifested specially in high yielding tea areas and application of .B may give positive response to yield of tea (Diana and Beni, 2006). Ma. *et al.*, (2003) reported that critical limit of available boron was 0.50 mg/kg from the analysis of tea growing soils of China.

Tea estates	F_1	F_2	F_3	Mean
G_1	0.45	0.37	0.28	0.36
G_2	0.37	0.32	0.23	0.31
G_3	0.25	0.23	0.15	0.21
G_4	0.28	0.18	0.14	0.20
G_5	0.19	0.17	0.12	0.16
G_6	0.30	0.29	0.16	0.25
G_7	0.26	0.17	0.18	0.19
G_8	0.36	0.30	0.20	0.29
G_9	0.34	0.30	0.27	0.31
G_{10}	0.34	0.23	0.19	0.25
MT	0.36	0.26	0.21	0.28
Mean	0.30	0.26	0.19	
CD (<0.05)	Comparing means Tea estates:0.04; Age: 0.02; Tea estate x age: 0.06			

Table 3a: Distribution of HWB in tea estates with respect to age of tea (0-15 cm depth)

Results also indicated that the average HWB, irrespective of age group, varied from 0.16 to 0.36 mg/kg (Fig 2a). With the increase in the age of tea, B content in soil was found to decrease irrespective of tea estates (Fig 2b). Gardens having heavy textured soils (RN, BM, BS, GH, LK and MK) were associated with higher B content (Fig 2c) as compared to light textured soil (Light texture: 0.16 to 0.23 mg/kg; Heavy texture: 0.22 to 0.36 mg/kg). Fine textured soils usually contain more available B than coarse textured soils because of their greater content of clay mineral (Raza et al, 2002;Malhi et al., 2003). B deficiency often occurs in plants growing in sandy soils (Gupta, 1968; Fleming, 1980). Low HWB in light textured soil may be due to higher leaching of boron during monsoon rains from surface soils beyond the root zone (Shorrocks, 1997). Kalita and Dey (1983) studied the distribution pattern of boron (B) in tea soil in north-east India and observed that the available boron content of tea soils was low <0.5 mg/kg).The review of the works done in micronutrients suggests that the soils of Assam are deficient in B as per both soil analysis and field experiments (Barthakur, 1992). Bhupen et al (2011) revealed that surface soil of some tea garden of Golaghat district of Assam HWB content below detection limit. HWB decreased with depth, top soil layer (0-15 cm depth) containing relatively higher quantities of HWB as compared to sub soil (Table 3b). However, this difference is more prominent in heavy textured soil. In heavy textured soil HWB varied from 0.25 to 0.36 mg/kg and 0.09 to 0.11 in 0-15 cm and 30-45 cm depth respectively. In light textured soil, it indicated narrow variation from 0.16 to 0.28 mg/kg and 0.16 to 0.25 mg/kg in 0-15 cm and 30-45 cm depth respectively.

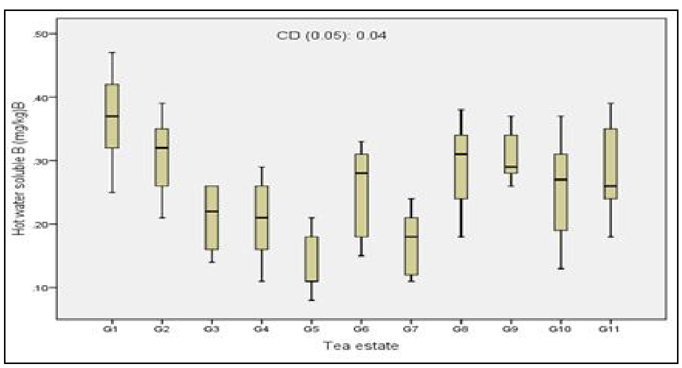

Figure 2a: Distribution of B in soil in tea estates (Mean value irrespective of age)

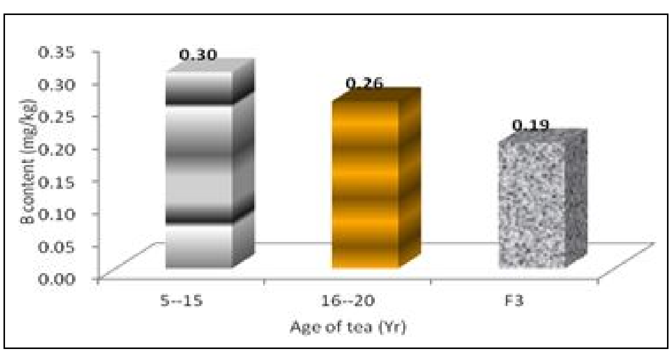

Figure 2b: Variation of B with age of tea

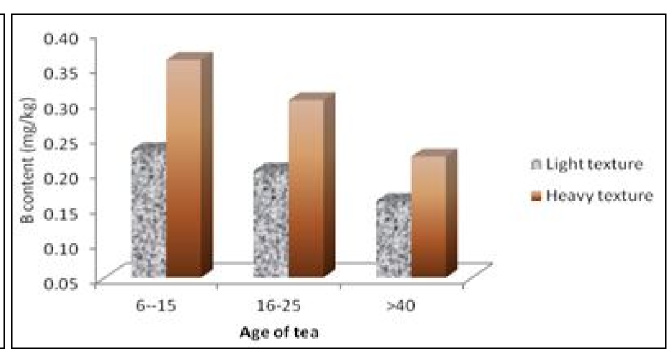

Figure 2c: Variation of B with soil texture

The negative non-significant correlation (r= -0.25) was observed between pH and HWB (Table 3c). This result was supported by Khattak *et al*.(1997) and Abid *et al.* (2002) but disagreement with Phukan and Bhattacharyya (2001) and Nath (2013) who reported positive correlation. The HWB was positively correlated with organic matter content (r=0.78). These findings were in agreement with Khattak et al (1997 and Goldberg *et al.* (2002) also reported positive correlation between HWB and organic matter content. Significant correlation was observed between HWB and silt plus clay content with r-value 0.88 respectively. These findings are in agreement with Khattak *et al*.(1997) and Goldberg *et al*. (2002) but was in disagreement with Nath (2013) who reported negative correlation between HWB and clay content.

Tea estates	**0-15 cm**	**15-30 cm**	**30-45 cm**
G_1	0.36	0.16	0.11
G_2	0.31	0.11	0.09
G_3	0.21	0.17	0.18
G_4	0.20	0.18	0.15
G_5	0.16	0.15	0.18
G_6	0.25	0.15	0.12
G_7	0.19	0.16	0.17
G_8	0.29	0.16	0.09
G_9	0.31	0.14	0.09
G_{10}	0.25	0.18	0.10
MT	0.28	0.20	0.25
CD (<0.05)	0.04	0.02	0.08

Table 3b: Distribution of boron with depth (Mean value irrespective of age group)

	HWB	**pH**	**Silt + Clay**	**Org C**
HWB	1			
pH	-0.52*	1		
Silt + clay	0.66*	0.18	1	
Org C	0.62*	0.24	0.66*	1

Table 3c: Correlation of boron with other parameters
**Significant at 5% level of significance*

4. Conclusion

Tea soils of south bank showed wide variation in different tea estates (mean value: 0.16 to 0.36 mg/kg) and was found to be low especially in light textured soil. HWB indicated a significant positive correlation with total organic C and silt plus clay content. It is expected to get positive response from B application particularly in light textured low organic C soil.

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