Journal of Applied and Natural Science 9 (4): 2400 - 2403 (2017)

JANS

Boron availability in relation to some important soil chemical properties in acid soils of Cooch Behar district, West Bengal

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Received: February 25, 2016; Revised received: July 1, 2017; Accepted: November 1, 2017

Abstract: In the present study, we investigated the distribution of soil available boron and its relationship with some soil properties in the samples collected from different locations in acidic alluvial soils of Cooch Behar district in West Bengal during 2013-2014. For the study about two hundred fifty (250) georeferenced surface soil samples covering 11 blocks of the districts were collected with the help of a global positioning system (GPS). The soil results revealed that pH of the analyzed samples varied from 4.91-7.28 (mean value 5.68) which indicated that soils of the district were in the acidic to slightly acidic in reaction. Organic carbon content of the soils varied from 0.42 to 1.62 % with a mean value of 0.96 % and about 93.7 % of the samples were high whereas about 5.2 and 1.2 % of the samples analyzed were in medium and low category, respectively. Results also indicated that the available B content in the soils of the districts ranged from 0.04 to 3.87 mg kg^{-1} with a mean value of 0.51 mg kg^{-1} and about 38.26 % soil samples were classified under low, whereas, 3.58 and o.35 % samples were categorized as medium and high in available B content. It was further indicated that the content of available B in soil was positively correlated with organic carbon (r = 0.170**) and negatively correlated with pH (r = -0.021).Organic carbon status was also found to be positively and non significantly correlated with soil pH (r = 0.062). The results of the study would be immensely helpful for the extension workers to recommended B application considering pH and organic carbon status in acidic soils of the district for a profitable crop production.

Keywords: Acid soil, Available B, Correlation, Organic carbon, West Bengal

INTRODUCTION

The physico-chemical characteristics such as soil pH and organic carbon are important as these affect the availability of nutrients in soil and thereby on crop growth and production. The soil must supply the nutrients that are essential for plant growth and the supply of nutrients from soil can be maintained by proper monitoring and management of these properties to meet the present need of food for ever-growing population in the country (Sakal and Singh, 1997).

The availability of utilization of boron is determined to a considerable extent by pH. Boron is most soluble under acid conditions. This occurs in acid soils in part as Boric acid ($H_3 BO_3$)which is readily available to plants. The possible roles of B in crops include 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 (Srivastava and Gupta 1996; Gupta *et al*., 2011).Boron is essential micronutrients and is present in soil solution as a non-ionized specially over the pH range suitable for plant growth (Arora and Chahal, 2001). Its deficiency is wide spread in highly leached coarse texture soils containing low organic matter leading to low crops yields. Boron is also phytotoxic if present in excess amounts in growth medium (Rajaie *et al*., 2009). Boron (B) deficiency has been reported from many mustard growing areas in India. Boron deficiency is more commonly observed in light textured acidic Entisols and Inceptisols receiving high precipitation (Mandal and De, 1993). Under acidic environment, soil solution B remains as non-ionised H_3BO_3 species having little propensity to be adsorbed onto negatively charged soil colloids. With precipitation B leaches out of the surface layer of the light-textured soils resulting in its deficiency. Only small quantities of boron are needed for optimum production. On sandy soils 0.5-1.0 kg/ha boron is sufficient. Foliar application of boron as low as 0.1 ppm also increased the yield (Datta *et al*., 1998).

MATERIALS AND METHODS

Two hundred fifty (250) geo-referenced surface soil samples (0-15 cm) were collected for this study using global positioning system (GARMIN GPS Version etrex) from eleven (11) blocks of the Cooch Behar

district in West Bengal (Table1) by grid sampling at an approximate interval of 3.7 km (Fig. 1).The soil samples were dried in shade, crushed with a wooden roller and passed through a 2 mm sieve. Processed soil samples were stored in polythene bags until pot filling. Soil samples were analyzed for extractable B by the hot $CaCl_2$ method. The concentration of B in soil extracts was estimated by a spectrophotometric method in which the intensity of yellow colour produced by the Azomethine-H reagent was estimated at 420 nm on a visible range spectrophotometer (Wolf 1974).
The pH of the soils were determined by using soil-water suspension (1:2.5) following the method of Jackson, 1973; Oxidizable organic carbon were determined by the rapid titration of Walkley and Black (1934) as outlined by Jackson (1967). Finally, the data were analyzed by using the soft-ware SPSS 13.0 for windows.
To categorize the soils of the individual blocks the nutrient index value (NIV) of B was obtained by mathematical expression as follows:
NIV = (% sample in high category x 3) + (% in medium category x 2) + (% in low category x 1)/ T
Nutrient index value (NIV) was calculated following the calculation method given by (Ramamoorthy and Bajaj, 1969). They found the NI value by multiplying the percentage of soil samples in low group by 1, in the medium group by 2, in the high group by 3. The products are then added and divided by total number of soil samples to obtain the Nutrient value.
Where, T=Total number of samples

RESULTS AND DISCUSSION

pH: The pH of the soils widely varied from 4.91-7.28 with a mean value of 5.63 (Table 1). Considering the soil having 42.02 per cent as acidic, 57.59 per cent slightly acidic and 0.39 per cent as slightly alkaline in nature.Cooch Behar districts are slightly to strongly acidic in reaction. The pH of the Cooch Behar district strongly acidic in reaction may be due to higher amount of organic matter and excessive leaching basic cations due to heavy rain fall. A similar type of result was also observed by (Paramanik *et al*., 2012). They have collected 24 surface soil samples from Cooch Behar district having high rainfall with low pH area for determination of available boron. They have also found available boron content was low in respect to the critical limit of boron.

Organic carbon: Data presented in Table 1 revealed that most of the soils are having medium to high status of organic carbon. It ranged from 0.42-1.62 per cent with a mean value of 0.96 per cent in acidic alluvial soil of Cooch Behar district. Nearly 5.15 per cent soil sample of different blocks of Cooch Behar district was medium in organic carbon content. Considering the soil having 1.19 per cent as low, 5.15 per cent medium and 93.66 per cent as high in organic carbon status. The high percentage of organic carbon in Cooch Behar district may be due to high amount of leaf fall from forest plants and the lower value in Nadia which may be due very poor source of organic matter and hot climate causing oxidation of organic matter. Organic carbon was significantly negatively correlated with pH of the soil (Walkley and Black, 1934).

Table 1. Number of soil samples collected from different blocks of Cooch behar district.

S.N.	Blocks Name	Number of samples collected
1.	Dinhata-II	25
2.	Tufanganj-II	32
3.	Coochbehar-I	30
4.	Coochbehar-II	27
5.	Tufanganj-I	31
6.	Dinhata-I	20
7.	Mekhliganj	19
8.	Sitai	4
9.	Sitalkuchi	14
10.	Mathabhanga-I	27
11.	Mathabhanga-II	22

Table 2. Correlation coefficient between soil characteristics and available boron (kg/ha).

	pH	OC	B
pH	1		
OC	0.062	1	
B	-0.021	0.170^{**}	1

**. Correlation is significant at the 0.01 level (2-tailed).

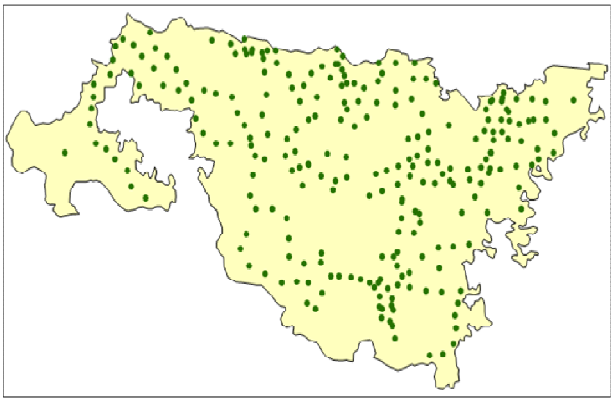

Fig. 1. *Map showing sampling sites in Coochbehar district.*

Relationship between soil characteristics and available B in Cooch Behar district: Available boron resulted significantly and negative correlated with pH as presented in (Fig.1). The result indicates that available boron increased with decreased in pH value. (Table 2) illustrates the negative relationship between soil B and pH of soil, which clearly exhibited that as the pH of soil increased, availability of B decreased, up-take by plants at water soluble B content was greater at lower soil solution pH (Wear and Patterson, 1962). Boron adsorption by soils increased as a function of solution pH in the range of pH 3 to 9 and decreased in the range of pH 10 to 11.5. Positive and significant correlation ($r = 0.170^{**}$) was observed be-

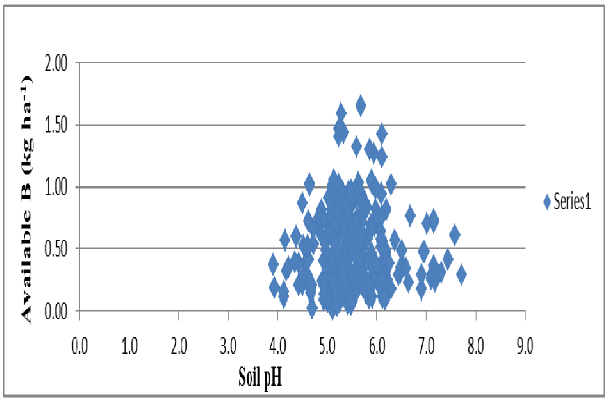

Fig. 2. *Graphical representation of soil available B (kg ha^{-1}) vs. soil pH in soils of Cooch behar district.*

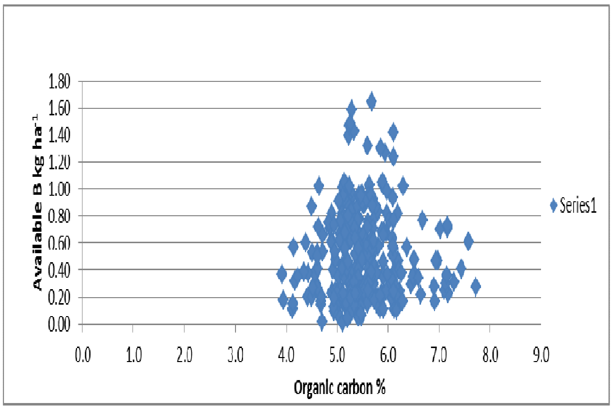

Fig. 2. *Graphical representation of available B (kg ha^{-1}) vs. soil organic carbon (%) in soils of Cooch Behar district.*

tween available boron content and organic carbon status. Organic carbon status was found to be positively and non significantly correlated with soil pH (r = 0.062).This suggests that organic matter is one of the major sources of available B. Similar results have also been reported by Mathur and Sudan, 2011.They have investigated the distribution of soil boron and its relationship with some soil properties in the soil collected from different locations in Bikaner, They found significant co-relation among available B content and EC, pH and organic carbon. Organic matter is an important constituent affecting the availability of B. Correlation (Fig. 2) showed that soil B has positive correlation with OM and with increase in OM content of soil, B concentration augmented as well as and this boost might be due to the decomposition of organic matter (by producing of certain acids like tartaric, oxalic, citric, acetic, formic and humic acid) that solubilized the unavailable fixed B in clay or $CaCO_3$. Moreover, some of B is complexed or chealeted with OM content and on decomposition, this B is released into soil solution. The results are confirmatory with the results obtained by (Shorrocks, 1997). They have revealed that more B was observed in clay textured soils. However, available B may be quite low because of the strength by which B is strongly held on clay surfaces or $CaCO_3$.

Conclusion

The soils of Cooch Behar district are slightly to strongly acidic in reaction, medium to high status in organic carbon content. In case of B soils were deficient in available boron content. We know Boron is very important micronutrient in the soil because it has many important roles in the metabolism, growth and development of crops. Boron in soil is considered not adequate. Thus, it can be concluded that the chemical properties like pH and organic carbon content alone or in combination controls the availability of boron in the soils. An integrated soil fertility management approach with special emphasis on Boron application should be considered for the soils of the area.

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