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Availability of boron under different cropping systems in soils of Morigaon district of Assam

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Abstract
Boron is an essential micronutrient element for growth and development of plants. The boron availability of soil is low, the range between deficient and toxic concentrations of boron in plants and soils are very narrow. The Morigaon district is situated in the central Brahmaputra valley zone of Assam between longitude (92° and 95.5°E), latitude (26.15° and 26.5°N) and five blocks *viz.*, Bhurbandha, Mayong, Lahorighat, Kapili, and Mairabari. Hundred numbers (100) of surface (0-15 cm) soil samples from different cropping systems were collected with an auger from Morigaon district representing twenty five (25) soil samples from each dominant cropping systems. Soil samples were analyzed to determine the availability of boron under different cropping systems in Inceptisols soils of Morigaon district and its relation to soil properties. The experimental findings revealed that the soils were sandy loam to silty clay loam in texture and strongly acidic to near neutral (4.17 to 6.94) in reaction with organic carbon content ranging from medium to high (0.51 to 1.14 per cent). EC of the soils were very low ranging from 0.01 to 0.06 dS m^{-1}. The CEC of the soils were low and varied from 5.50 to 7.70 [cmol (p^{+}) kg^{-1}]. The available nitrogen and phosphorus content of the soil ranged from low to medium (219.52 to 533.12 kg/ha), (21.54 to 57.96 kg/ha) and available potassium status were low to high (104.36 to 419.46 kg/ha). The available boron content was found to be lowest in *rice-rice* followed by *rice-rapeseed, rice-vegetable* and *vegetable-vegetable* cropping system and values ranged from 0.29 to 0.98, 0.52 to 1.00, 0.74 to 1.14 and 1.10 to 1.38 mg kg^{-1}, respectively. The available boron showed a positive and significant correlation ship with pH and organic carbon in all the cropping systems.

Keywords: boron, cropping, Morigaon, Assam, soils

Introduction
Boron is the only non-metallic element in Group 13 of the Mendeleev Periodic Table and shares a chemical resemblance with carbon. The importance of boron as an essential plant nutrient was first established in 1923 by Warrington and now it is reported as the most deficient plant nutrient worldwide (Shorrocks, 1997) [19]. Though plants vary in boron need, there exists a narrow range between toxicity and deficiency and plant can develop symptoms both deficiency and toxicity in the same growing period (Reisenauer *et al*., 1995) [14]. Boron deficiency causes reduction in cell enlargement in growing tissues due to its structural role and responsible for creating male sterility and inducing floral abnormalities (Sharma, 2006) [17]. Boron deficiency is much more common in crops that are grown in soil that have higher amount of free carbonates, low organic matter, and high pH (Rashid *et al*., 2004) [13].
Availability of boron is influenced by their distribution and physico-chemical properties of the soil (Sharma and Chaudhary, 2007) [18]. Several soil factors influence the availability of boron content to the plants. These factors are pH, soil texture, organic matter, clay minerals, microbiological activity, soil drainage, oxidation-reduction conditions, seasonal variation in climatic conditions and interrelations of micronutrients.
Analysis of more than 3 lakhs soil samples carried out under the aegis of All India Coordinated Project on Micro and Secondary Nutrients and Pollutant Elements in Soils and Plants of the ICAR showed that about 33 per cent soil is deficient in boron. Coarse texture, high pH, calcareousness, declining organic carbon and leaching aggravate micronutrient deficiency. Irrespective of these soil properties, irrigated crops whose productivity is two-three times higher than rainfed crops, suffered more often from micronutrient deficiency. Boron deficiencies that appear to be localized today may expand geographically in the near future posing threat to the production system. As such it is important to estimate and monitor the boron status/deficiencies in various agro ecological regions to forecast potential boron prospect and problems in order to develop models for different soil crop situation (Nayar, 1999) [10].

In a study on Assam soils reported that 44 and 34 per cent of the alluvial and lateritic soils were deficient in boron, respectively (Borkakati and Takkar, 2000) [2]. On the other hand, importance of boron in crops and cropping systems are increasing, more particularly under intensive agricultural situations in Morigaon district of the state. Considering the above fact and need maiden research investigation was proposed to identify the availability of boron in Inceptisols of Morigaon district of Assam under different cropping systems to determine the availability of boron under different cropping system and its relation to soil properties.

The Morigaon district is situated in the central Brahmaputra valley zone of Assam between longitude (92° and 95.5°E) and latitude (26.15° and 26.5°N). Morigaon district is divided into five blocks *viz.*, Bhurbandha, Mayong, Lahorighat, Kapili, and Mairabari. Total gaon panchayats and Revenue villages are 97 and 790, respectively. Total geographical area of the district is 1550 sq km. Rice is the main crop followed by rapeseed, jute, wheat, vegetable and pulses. Rice is also growing as a monocrop. The soil of the district is alluvial and fertile. According to taxonomic classification soil orders are 3 and 10 great groups. The dominant cropping systems are: 1. *rice – rice,* 2. *rice – rapeseed,* 3. *rice – vegetable* and 4. v*egetable - vegetable.* The climate of the district is sub-tropical humid, characterized by high rainfall. It receives an average annual rainfall of 1291.1 mm of which about 90 per cent falls between April to October and 10 per cent of total annual rainfall is received in between November to March. The maximum temperature goes up to 36°C in June/July whereas the minimum temperature falls to 8°C in December/January with an annual average temperature of 22°C.

Materials and Methods

Representative soil samples from different cropping systems were collected from Inceptisols of Morigaon district. Hundred numbers (100) of surface (0-15 cm) soil samples were collected with an auger from Morigaon district representing twenty five (25) soil samples from each dominant cropping systems as mentioned above. The samples collected were air-dried, ground and passed through a 2 mm sieve and stored in labeled polythene bags for further analysis.

The soil properties and available boron contents were determined using the facilities available in the Department of Soil Science, Assam Agricultural University, Jorhat. Standard laboratory procedures adopted during the analysis are presented in Table 1.

Simple correlation was computed using Pearson's equation to reveal the magnitudes and directions of relationships between selected soil physico-chemical properties and availability of boron. Statistical analysis of the experimental data was done by CoStat Professional, Version 6.311, Copyright© 1998-2005, CoHort Software, CoHort Software, 798 Lighthouse Ave, PMB 320, Monterey, CA 93940, USA.

Table 1: Methods adopted for physico-chemical analysis

Sl. No.	Parameters	Methods	References
1.	Soil reaction (1:2.5)	Glass electrode pH meter	Jackson (1973)
2.	Electrical conductivity (1:2.5)	Electrical conductivity meter	Jackson (1973)
3.	Organic carbon	Walkley and Black's method	Jackson (1973)
4.	Cation exchange capacity	Distillation method	Jackson (1973)
5.	Mechanical analysis	International Pipette Method	Piper (1966)
6.	Available nitrogen	Alkaline $KMnO_4$ method	Subbiah and Asija (1956)
7.	Available phosphorus	Extracted with 0.03N NH_4F in 0.025 N HCl (Bray's-I method).	Bray and Kurtz (1945)
8.	Available potassium	Flame photometric method	Jackson (1973)
9.	Available boron	Azomethine-H colorimetric method	Wolf (1974)

Findings and Discussion

Results on physico-chemical properties of soils under *rice-rice* cropping systems, the texture of the soils were varied from sandy loam to clayey. Sand, silt and clay fractions of the soils varied from 28.20 to 66.16, 15.00 to 33.00 and 15.84 to 49.40 per cent, respectively. The pH of the soil was strongly acidic to near neutral (4.17 to 6.94) in reaction with a mean value of 4.75. The organic carbon content of the soil ranged from medium to high (0.51 to 0.95 per cent) with a mean value of 0.72 per cent, while CEC of the soil varied from 5.50 to 7.60 [cmol (p^+) kg^{-1}] with an average value of 6.61 [cmol (p^+) kg^{-1}] of the soil. The EC of the soil was very low. It ranged between 0.01 and 0.05 dS m^{-1} with an average value of 0.02 dS m^{-1}. The available nitrogen, phosphorus, potassium and boron content of the soil ranged from low to medium 219.52 to 533.12 kg/ha with a mean value of 381.32 kg/ha; from 21.54 to 57.96 kg/ha with a mean value of 33.54 kg/ha; from 105.36 to 229.95 kg/ha with a mean value of 167.36 kg/ha and from 0.29 to 0.98 mg kg^{-1} with a mean value of 0.57 mg kg^{-1} of soil, respectively.

Results on physico-chemical properties of soils under *rice-rapeseed* cropping systems, the results showed that the texture of the soils varied from sandy loam to clay loam. Sand fraction varied from 35.20 to 67.16, silt from 13.00 to 34.28 and clay from 17.84 to 34.12 per cent. The soils were acidic in reaction with pH values ranging from 4.32 to 5.71 with a mean value of 5.01, while the organic carbon content of the soil ranged from medium to high. It ranged from 0.61 to 0.88 per cent with a mean value of 0.70 per cent. The CEC of the soils were found to vary from 5.70 to 7.50 [cmol (p^+) kg^{-1}] with an average value of 6.55 [cmol (p^+) kg^{-1}], while the EC of the soil was found to be very low ranging from 0.01-0.06 dS m^{-1} with an average value of 0.03 dS m^{-1}. The available nitrogen, phosphorus content of the soil ranged from low to medium 282.24 to 533.12 kg/ha with a mean value of 363.76 kg/ha and 21.54 to 53.86 kg/ha with a mean value of 31.54 kg/ha, respectively. The available potassium and boron distributed between low to high from 104.16 to 419.46 kg/ha with a mean value of 170.52 kg/ha and ranged from 0.52 to 1.00 mg kg^{-1} with a mean value of 0.89 mg kg^{-1}.

Results on physico-chemical properties of soils under *rice-vegetable* cropping system, the results were showed that the texture of the soil varied from sandy loam to silty clay loam. Sand, silt and clay fraction varied from 19.16 to 66.88, 10.48 to 54.00 and 17.84 to 44.60 per cent, respectively. The soils were found to be strongly acidic to medium acidic in reaction with pH values ranging from 4.28 to 5.94 with a mean value of 4.90. Organic carbon content of the soil varied from low to high with values ranging from 0.49 to 1.05 per cent with a mean value of 0.71 per cent. The CEC of the soil was found to range from 5.70 to 7.60 [cmol (p^+) kg^{-1}] with an average value of 6.59 [cmol (p^+) kg^{-1}], while the EC of the soil was found to be very low which ranged from 0.01 to 0.06 dS m^{-1} with an average value of 0.03 dS m^{-1}. The available nitrogen, phosphorus, potassium and boron content of the soil varied from low to medium 219.52 to 533.12 kg/ha with a mean value of 365.00 kg/ha; low to medium from 21.54 to 57.96 kg/ha with a mean value of 32.91 kg/ha; low to high from 107.11 to 462.47 kg/ha with a mean value of 173.90 kg/ha and ranged from 0.74-1.14 mg kg^{-1} with a mean value of 0.95 mg kg^{-1} of soil.

Results on physico-chemical properties of soils under *vegetable-vegetable* cropping system are presented in Table 4.7. The results showed that the texture of the soil varied from sandy loam to clay soil. Sand, silt and clay fraction varied from 19.16 to 63.56, 15.00 to 52.00 and 16.00 to 50.00 per cent, respectively. The soils were found to be strongly acidic to medium acidic in reaction with pH values ranging from 4.40 to 6.95 with a mean value of 5.09. Organic carbon content of the soil varied from medium to high with values ranging from 0.58 to 1.14 per cent with a mean value of 0.77 per cent. The CEC of the soil was found to range from 5.70 to 7.70 [cmol (p^+) kg^{-1}] with an average value of 6.60 [cmol (p^+) kg^{-1}], while the EC of the soil was found to be very low which ranged from 0.01 to 0.06 dS m^{-1} with an average value of 0.03 dS m^{-1}. The available nitrogen, phosphorus, potassium and boron content of the soil varied from medium to high 282.24 to 533.12 kg/ha with a mean value of 387.60 kg/ha; medium to high from 23.33 to 57.96 kg/ha with a mean value of 37.06 kg/ha and low to high 117.46 to 425.37 kg/ha with a mean value of 196.74 kg/ha and from 1.10-1.51 mg kg^{-1} with a mean value of 1.38 mg kg^{-1} of soil.

Discussion

Data revealed that soils of Morigaon district were sandy loam to silty clay loam in texture, strongly acidic to near neutral in reaction and organic carbon content ranged from medium to high. The EC content of the soils were low. The available nitrogen and phosphorus content of the soils ranged from low to medium, but potassium content of the soils ranged from low to high.

Most of the soils of the study area were sandy loam and silty clay loam in texture. Coarse textured (sandy) soils often adsorbed less available boron than fine textured soils, thus boron deficiency frequently arises in areas located in sandy soils (Fleming, 1980) [6]. In a soil higher percentage of sand indicates lower percentage of silt and clay content and vice-versa. Thus, increase in sand content reduces the reactive surface area of a soil. So, a negative correlationship was observed between available boron and sand content. The finding of the present investigation was in conformity with the findings of Wilson *et al.* (1951) [23] and Oyinlola *et al.* (2010) [12], who reported that higher sand content facilitated leaching of boron from the surface soil. Thus, negative relationship between available boron and sand content could be justified. Finding of the present investigation was in conformity with the findings of Chabbra *et al.* (1996) and Nazif *et al*. (2006) [11].

Results of the correlation studies under *rice-rice* cropping systems, it was observed that available boron of the soil was significantly correlated with pH (r=0.424*) and organic carbon (r=0.440*) content of the soil.

Correlation coefficient rates of different parameters under *rice-rapeseed* cropping systems, data revealed that available boron was found to be positive correlationship with pH (r=0.455*) and organic carbon (r=0.422*) content of the soil.

Data revealed that available boron of the soil had a positive correlationship with pH (r=0.452*), organic carbon (r=0.478*), available phosphorus (r=0.939**) and negative correlation with sand (r=-0.483*) content of the soil.

Results in the correlation studies of the soils under *vegetable-vegetable* cropping systems are presented in Table 4.15. Data revealed that available boron was positively correlated with pH (r=0.427*) and organic carbon (r=0.460*) content of the soil.

Available boron content of the soil was found to be least under *rice-rice* cropping system followed by *rice-rapeseed, rice-vegetable* and *vegetable-vegetable* cropping system. It was reported that rice removes relatively higher amount of boron (120 g/ha) as compared to vegetable (7 g/ha) and rapeseed (5 g/ha) (Vasuki, 2010) [21]; so, boron availability was found to be lower under that system. In case of other cropping systems, it was experienced that farmers used to apply boron fertilizer for vegetable crops and to a smaller extent in rapeseed. Probably because of that reason boron availability was higher in *vegetable-vegetable* cropping system followed by *vegetable- rapeseed* cropping systems. The status of available in *rice-rice* cropping system were low to just at the critical limit while in other cropping systems availability status was above critical limit i.e. in sufficiency zone.

Available boron showed a positive and significant correlation with pH, organic carbon and clay content of the soil. Berger and Truog (1945) [1] reported that boron availability in acid soil increases with increasing pH and observed a positively correlation with pH for acid soil (pH < 7). Available boron was also reported to be positively and significantly correlated with pH in arid soils of Western Rajasthan and in Bikaner district (Chaudhary and Shukla, 2003 and Mathur *et al.*, 2011) [4, 8]. Colloidal material like organic carbon and clay content might have influenced boron availability owing to its adsorption on positively charged surfaces. A positive relation between available boron and phosphorus might be due to their positive relationship with organic carbon.

In all the cropping system available boron showed a positive and significant correlation with pH and organic carbon. Similarly, increased in available boron content with organic carbon was also reported by Murthy and Srinivas (2005) [9], Nazif *et al.* (2006) [11] and Sarwar *et al.* (2007) [16].

The critical limit of boron in Assam soils is considered to be 0.5 mg/kg, so based on the mean values of available boron in all the cropping systems, soils could be put under "sufficient" zone. However, *rice-rice* cropping system available boron content in some soils (20 per cent) were found to be in deficient zone or just at the critical level. In the present study available boron content of the soils ranged between 0.32 to 0.98 mg kg^{-1}. Working on acid soils of Assam, Borkakati and Takkar (1996) [3] reported that available boron varied from 0.41 to 0.60 mg kg^{-1}. Sakal and Singh (1995) [15] reported that available boron content in acidic soil ranged from 0.17 to 0.91 mg kg^{-1} with a mean value of 0.53 mg kg^{-1}. In another study, Debnath *et al.* (2010) [5] reported critical limit of available boron to be 0.32 mg kg^{-1} in rice growing soils of Terai zone of West Bengal.

Table 2: Simple correlation between physico-chemical properties and available boron in soils under different cropping systems

	pH	EC	OC	CEC	SAND	SILT	CLAY	Av. N	Av.P_2O_5	Av. K_2O	Av. Boron
pH	-	0.000	0.235*	0.092	0.152	-0.125	-0.109	0.094	0.130	0.092	0.205*
EC		-	-0.114	0.000	-0.070	0.098	-0.005	-0.046	-0.081	-0.109	0.151
OC			-	0.198*	0.093	-0.125	0.005	0.794**	0.904**	0.202*	0.223*
CEC				-	-0.022	-0.014	0.061	0.119	0.167	0.110	-0.009
SAND					-	-0.842**	-0.681**	0.008	0.063	-0.165	-0.266**
SILT						-	0.180	-0.057	-0.100	0.048	0.073
CLAY							-	0.065	0.026	0.233*	0.390**
Av. N								-	0.772**	0.075	0.139
Av.P_2O_5									-	0.100	0.219*
Av. K_2O										-	0.197*
Av. Boron											-

* Significant at 5% level
** Significant at 1% level

Summary and Conclusion

An investigation on the "Availability of boron under different cropping systems in soils of Morigaon district of Assam" representing Inceptisols of the district was carried out at Assam Agricultural University, Jorhat during 2011-2013. Four dominant cropping systems of Morigaon district were selected and studied for determine the availability of boron in soils of Morigaon district and its relation to soil properties under different cropping systems. Simple correlation was carried out between soil physico-chemical properties and availability of boron. The results of the study are summarized below:

- The soil texture varied from sandy loam to silty clay loam in texture and soils were strongly acidic to near neutral (4.17 to 6.94) in reaction with organic carbon content ranged from medium to high (0.51 to 1.14 per cent). The soils were low in CEC with magnitude ranged from 5.50 to 7.70 [cmol (p^+) kg^{-1}] and EC ranged from 0.01to 0.06 dS m^{-1} which were very low indicating non saline nature of the soils.
- The available nitrogen and phosphorus content of the soil ranged from low to medium (219.52 to 533.12 kg/ha), (21.54 to 57.96 kg/ha) and available potassium status were low to high (104.36 to 419.46 kg/ha).
- The available boron content was found to be the lowest in *rice-rice* cropping system followed by *rice-rapeseed*, *rice-vegetable* and *vegetable-vegetable* cropping systems which ranged from 0.29 to 0.98, 0.52 to 1.00, 0.74 to 1.14 and 1.10 to 1.51 mg kg^{-1}, respectively.
- Available boron showed a positive and significant correlation with pH, organic carbon, available phosphorus and potassium content of the soil.

From this study it can be concluded that availability of boron in soil was controlled by soil factors, such as organic carbon and pH. In all the cropping systems, available boron was found to be in the "sufficient" zone except, where in *rice-rice* cropping system, where 20 per cent of the soils were just below at critical limit. In near future, deficiency of boron might not pose a challenge, but in the long run regular monitoring of its availability would be pertinent for site specific management planes.

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. Borkakati K, Takkar PN. Forms of boron in acid alluvial and lateritic soils in relation to ecosystem and rainfall distribution. In International Conference on Managing Resources for Sustainable Agricultural Production in the 21st century. Crops Prog. Fmg. 2000; 21:13-22.
3. Borkakati K, Takkar PN. Forms of Boron in major soil orders of Assam under different land use. J Agric. Sci. Soc. 1996; 9(1):28-33.
4. Chaudhary DR, Shukla LM. Profile distribution of Boron forms in relation to soil characteristics in arid soils of Western Rajasthan. Am. Agric. Res. New Series. 2003; 24(2):314-321.
5. Debnath P, Chandra G, Ghosh SK. Critical limit of available boron for rice in red and laterite soils of West Bengal. Agropedology. 2010; 20(2):175-181.
6. Fleming GA. Essential micronutrients. I: Boron, molybdenum. *In*: Applied Soil Trace Elements. Ed. B E Davies. John Wiley and Sons, New York. 1980, 155-195.
7. Jackson ML. In soil chemical analysis. Prentice Hall of India. Pvt. Ltd., New Delhi, 1973.
8. Mathur R, Sudan P. Relationship and distribution of various forms of boron with different physico-chemical properties of soil in bikaner district. J Chem. Pharm. Res. 2011; 3(3):290-294.
9. Murthy KR, Srinivas MCA. Distribution of some available micronutrients in black and red soils of Karnataka. Mysore J Agric. Sci. 2005; 39(1):57-63.
10. Nayar VK. Micronutrient management for sustainable intensive agriculture. J Ind. Soc. Soil Sci. 1999; 47(4):666-680.
11. Nazif W, Perveen S, Saleem I. Status of micronutrients in soils of district bhimber (Azad Jammu and Kashmir). J. Agric Bio. Sci. 2006; 1(2):1990-6145.
12. Oyinlolaa EY, Chude VO. Status of available micronutrients of the basement complex rock – derived alfisols in Northern Nigeria. Savanna Trop. Subtrop. Agroecosys. 2010; 12:229-237.
13. Rashid A, Yasin M, Ashraf M, Mann RA. Boron deficiency in calcareous soils reduces rice yield and impairs grain quality. Intern. Rice Res. 2004; 29:58-60.
14. Reisenauer HM, Walsh LM, Hoeft RF, Testing soils for sulfer, boron, molybdenum and chlorine. In 'soil testing and plant analysis' (Eds L.M. Walsh, J.D. Beaton) Soil Sci. Soc. Amer. J. 1995, 173-200.
15. Sakal R, Singh AP. In Micronutrient Research and Crop Production (H.L.S. Tandon, Eds.), FDCO, New Delhi, I, 1995.
16. Sarwar S, Parveen S. Shoaib M, Ahmad F, Khan J. To study the correlation of micronutrients with physico-chemical properties of soils of district Palandri (Azad Kashmir). Sarhad J Agric. (Pak.) 2007; 23(3):655-665.

17. Sharma CP. Plant Micronutrients. Science Publishers, Enfield, USA, 2006.
18. Sharma JC, Chaudhary SK. Vertical distribution of micronutrient cations in relation to soil characteristics in lower Shiwaliks of Solan district in North-West Himalayas. J Indian Soc. Soil Sci. 2007; 55(1):40-44.
19. Shorrocks VM. The occurrence and correction of boron deficiency. Plant Soil. 1997; 193:121-148.
20. Subbaiah BV, Asija GC, A Rapid Procedure for Determination of Available Nitrogen in Soils. Curr. Sci. 1956; 25:259-260.
21. Vasuki N. Micronutrient management for enhancing crop production- future strategy and requirement. J Ind. Soil. Sci. Soc. 2010; 58(1):32-36.
22. Walkey A, Black IA. An examination of Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Sci. 1934; 37:29-38.
23. Wilson CM, Lovvorn RL, Woodhouse WW. Movement and accumulation of water soluble boron within the soil profile. Agron. J. 1951; 43:363-367.
24. Wolf B. Improvements in the Azomethine-H method for determination of boron. Commun. Soil Sci. Plant Anal. 1974; 5:39-44.