Influence of Selected Soil Properties and Cropping System on Soil Boron Fractions in an Inceptisol of Assam, India

ABSTRACT

The current research aimed to investigate different boron fractions in diverse cropping systems and assess their relationship with various soil physico-chemical properties. Twenty-four geo-referenced surface soil samples (0-15 cm) were collected from four cropping systems: Rice-Rice, Rice-Fallow, Vegetable-Vegetable, and Plantation crops. The study found that the available boron (ranging from 0.56 to 1.69 mg kg-1) and five boron fractions, including Readily Soluble Boron (0.04-2.41 mg kg-1), Specifically Adsorbed Boron (0.15-1.92 mg kg-1), Oxide Bound Boron (5.18-17.41 mg kg-1), Organically Bound Boron (6.86-20.3 mg kg-1), and Residual Boron (17.73-36.57 mg kg-1), did not significantly differ among the cropping systems.The results revealed that the proportions of these boron fractions in soils followed this order: Readily Soluble B < Specifically Adsorbed B < Oxide Bound B < Organically Bound B < Residual B. Additionally, pH and CEC (Cation Exchange Capacity) did not exert a significant influence on soil boron fractions, while Soil Organic Carbon (SOC) significantly impacted Oxide Bound and Organically Bound Boron fractions. Despite the different cropping systems, there were no significant variations in the various boron fractions. Furthermore, the study identified positive correlations between soil organic carbon and Oxide Bound B, Organically Bound B, Specifically Adsorbed B, and Electrical Conductivity (E.C.). The cropping system did not have a significant effect on the diverse boron fractions investigated in this study.

Keywords: Boron; Boron fractions, cropping system; soil properties

Introduction

Boron (B) is a crucial element essential for the growth and productivity of crops (Gupta & Solanki, 2013). It plays critical roles in various aspects of plant biology, including cell-wall structure, reproductive growth and development, plant metabolism, and membrane structure and function (Brown et al., 2002). Additionally, B is known to enhance pollen grain germination, pollen tube elongation, fruit set, fruit yield, oil content, and oil quality (Desouky et al., 2009; Hegazi et al., 2015; Tsadilas et al., 1994).In natural soil environments, boron exists in the form of borosilicates and borates (Gross et al., 2008). When dissolved in water, it appears as either boric acid (H3BO3) or borate (BOH−) ions (Epstein & Bloom, 2005). Managing boron nutrition in crop production is a delicate task due to the close proximity of B deficiency and toxicity thresholds (Yau & Ryan, 2008). Unintentional over-fertilization practices aimed at preventing B deficiency can inadvertently lead to toxicity issues (Alloway, 2008). Furthermore, addressing B toxicity is more complex than managing B deficiency (Takano, Wiwa, and Fujiwara 2008). Achieving improved management of boron nutrition for plants necessitates a comprehensive understanding of B fractions, their interactions, soil mobility, and mechanisms governing their availability for plant uptake.

Recent studies (Barman et al., 2017; Colak, Korkmaz, and Horuz, 2013; Kumari et al., 2017; Padbuhushan & Kumar, 2017; Sarkar & Haldar, 2011; Sathya, Mahendran, and Arulmozuhiselvan 2013) have undertaken the task of characterizing and quantifying boron fractions in various soil samples. These studies typically classify boron in soils into distinct categories, including readily soluble, specifically adsorbed, oxide-bound (such as manganese oxide, amorphous and crystalline iron-aluminum compounds), organically bound, residual associated with soil silicates, and the total boron content. However, limited research has been conducted to explore how these boron fractions are influenced by specific physicochemical properties of the soil and the choice of cropping systems in the Lower Brahmaputra valley region of Assam. Therefore, the primary objectives of the current investigation were as follows: (1) To examine the impact of various soil physicochemical properties on the distribution of soil boron fractions. (2)To assess how specific cropping systems prevalent in the region affect the distribution of soil boron fractions.

Materials and methods

In this study, we selected four distinct cropping systems: Rice-Rice, Rice-Fallow, Vegetable-Vegetable, and Plantation, which were sampled from villages located in the Boko Block of Kamrup (Rural) district, Assam. The geographical coordinates for this region are 26°19'60.00" N-91°14'60.00" E (Figure 1). The district is situated in the hilly region of Assam and spans a total area of 1,043,396 hectares. The landscape of this region consists of both lower and higher-elevation landforms, featuring terraced cultivation areas and dense forests.

We collected a total of 24 surface soil samples from the four different cropping systems, with six samples taken from each cropping system. These soil samples were then prepared for subsequent analyses, following the procedures outlined by Chapman & Pratt (1961). The soil's pH was determined using a 1:2.5 soil-to-water ratio (Jackson, 1958). Electrical conductivity (E.C.) was measured in the saturation extract of the soils. Particle size analysis was conducted using the International Pipette method (Piper, 1966) and interpreted using the soil textural triangle. Soil organic carbon content was determined through the wet oxidation method of Walkley and Black (1934). Cation exchange capacity was assessed by leaching the soil with a neutral ammonium acetate solution (1N NH4OAc, pH 7.0) followed by distillation (Chapman, 1965). Exchangeable cations such as potassium were determined after extraction with 1 M ammonium acetate (NH4OAc) at pH 7.0 (Kacar, 2009), and the extracted potassium was analyzed using an Eppendorf Elex 6361 model flame photometer.

The available phosphorus content in the soil samples was extracted using the Bray and Kurtz No. 1 method (0.03 N NH4F + 0.025 N HCl), and its concentration was measured colorimetrically after the development of a blue color with ascorbic acid, following the procedure described by Black et al. (1965). Available boron was extracted by boiling a soil-water suspension (1:2) for five minutes, and the filtered boron content was determined using the Azomethine-H colorimetric method (Wolf, 1974). The table in the manuscript provides additional information on some physical and chemical characteristics of the orchards (Table 1).Fractional methods used in this study are described by Hou, Evans, and Spiers (1994) and Jin, Martens, and Zelazny (1987) and these methods are given in Table 2.

We assessed various boron fractions, including the readily soluble fraction, specifically adsorbed B, oxidatively bound, organically bound, residual, and total boron, utilizing a non-sequential extraction method outlined in Table 2. The quantity of boron extracted from the soil via these methods was quantified using inductively coupled plasma-optical emission spectrometry (ICP-OES) conducted on a Perkin Elmer ICP-OES Optima 2100 DV instrument. All analyses were performed in duplicate, and the results underwent analysis of variance using statistical tools. In cases where the p-value was less than 0.05, Duncan Multiple Range Tests were employed to identify the least significant difference among the means. We also conducted simple correlation analyses to explore relationships between the soil boron fractions and the measured physico-chemical properties of the soil (Anonymous, 2005).

Results and discussion

Cropping systems' effect on boron fractions

The results, displayed in Table 2, provide insights into boron fractions within four predominant cropping systems, obtained through various extraction techniques. Among these fractions, "readily soluble boron" (RS-B) represents the portion of boron readily adsorbed by soil particles and available for plants. Notably, in Table 3, RS-B was found to exhibit a range of values, spanning from 0.08 to 0.74 mg kg-1, with an average of 0.34 mg kg-1. In comparison, the "specifically adsorbed boron" (SA-B) fraction displayed a wider range, varying between 0.25 and 1.92 mg kg-1, and possessing an average value of 0.94 mg kg-1.

Moving on to the "oxide-bound boron" (Ox-B) fraction, this component in the soil samples showed variability, with values ranging from 5.97 to 17.41 mg kg-1 and a mean value of 9.41 mg kg-1. Meanwhile, the "organically bound boron" (Org-B) fraction exhibited a broader range, fluctuating from 6.86 to 20.33 mg kg-1, with an average value of 12.11 mg kg-1. Lastly, the soil's "residual boron" (Res-B) content demonstrated a mean value of 24.88 mg kg-1, with a range spanning from 18.78 to 33.64 mg kg-1.

In the context of the rice-rice cropping system, the magnitude of the different boron fractions followed the order RS-B < SA-B < Ox-B < Org-B < Res-B.Hou, Evans, and Spiers (1994) reported that ORG-B formed 6.32% of total B. After the residual boron, the most significant part of total B is Oxides bound B (OX-B).

In the context of the rice-fallow cropping system, the distribution of boron fractions exhibited specific characteristics. The RS-B fraction ranged from 0.15 to 2.81 mg kg-1, with an average value of 0.94 mg kg-1, while the SA-B fraction displayed variability, spanning from 0.44 to 1.63 mg kg-1, with an average of 1.08 mg kg-1. Regarding the Ox-B fraction, its content varied between 7.15 and 15.54 mg kg-1, with a mean value of 10.43 mg kg-1. Similarly, the Org-B fraction of the soil exhibited a range from 9.62 to 18.09 mg kg-1, with an average value of 11.93 mg kg-1. Lastly, the Res-B content in the soil samples fluctuated from 17.73 to 30.29 mg kg-1, with an average of 23.42 mg kg-1. Notably, the magnitude of boron fractions in the rice-fallow system closely mirrored that observed in the rice-rice cropping system, maintaining the same order.Hou, Evans, and Spiers (1994) also reported that among the B fractions most abundant after residual boron are the AMOX-B and CROX-B fractions, expressed isomorphically in Al or Fe in the octahedral layers of minerals and B bound tightly to the mineral surface.

The analysis of boron fractions within the vegetable-vegetable cropping system, as outlined in Table 3, yielded several findings. Firstly, the available boron content of the soil exhibited a range from 0.11 to 0.91 mg kg-1, with an average value of 0.49 mg kg-1. Within this system, the RS-B fraction ranged from 0.04 to 0.94 mg kg-1, with an average of 0.44 mg kg-1. In contrast, the specifically adsorbed boron (SA-B) fraction displayed variability, spanning from 0.54 to 1.33 mg kg-1, with an average of 0.87 mg kg-1. Additionally, the Ox-B and Org-B fractions were observed to fluctuate within ranges of 7.84 to 11.99 mg kg-1 and 7.05 to 17.12 mg kg-1, respectively, with mean values of 10.24 mg kg-1 and 10.18 mg kg-1. Lastly, the Res-B fraction in the soil samples showed a range from 19.21 to 32.75 mg kg-1, with a mean value of 25.07 mg kg-1.It's noteworthy that the order of boron fraction content in the vegetable-vegetable cropping system mirrored that of the rice-rice cropping system, following the sequence RS-B < SA-B < Ox-B < Org-B < Res-B.

The study's findings align with the observations of numerous researchers (Barman et al., 2017; Datta et al., 2002; Hou, Evans, and Spiers, 1994; Jin, Martens, and Zelazny, 1987; Kumari et al., 2017; Raza et al., 2002; Tsadilas et al., 1994; Xu et al., 2001) who have reported that the predominant proportion of total boron exists in the residual form.Diana (2006) reported that the concentration of total B is to be in the range of 20 to 200 mg B kg−1, and its available concentrations also vary significantly from soil to soil. In the regions with the expected rain, the soil's boron content changes between 4 and 88 mg kg−1. In arid regions soils, boron content is more than 200 mg kg−1 (Silanpaa, 1990).

The assessment of boron fractions within the plantation system yielded specific findings. The available boron content in the soil was observed to range from 0.19 to 0.69 mg kg-1, with an average value of 0.38 mg kg-1. Furthermore, the RS-B and SA-B fractions spanned from 0.15 to 0.64 mg kg-1 and 0.15 to 0.94 mg kg-1, respectively, with mean values of 0.38 mg kg-1 and 0.66 mg kg-1. The Ox-B fraction displayed variation, ranging from 5.18 to 12.78 mg kg-1, with an average value of 8.57 mg kg-1. Meanwhile, the Org-B fraction of the soil exhibited a range from 6.86 to 16.92 mg kg-1, with an average value of 9.98 mg kg-1. The Res-B fraction in the soil samples was the highest, fluctuating between 22.89 and 36.57 mg kg-1, with an average of 27.79 mg kg-1.

Upon examining the relationships between the different boron fractions in the soil samples, statistically significant associations were identified, particularly between the Oxide-bound boron fraction and hot water-soluble boron, as detailed in Table 4. Notably, the connections between ORG-B and Res-B were found to be significant at a 5% level. These findings align with those reported by Tsadilas et al. (1994).

Table 5 presents the influence of different cropping systems on available boron and various boron fractions. Mean values for available boron were recorded as 0.43 mg kg-1 for Rice-Rice, 0.54 mg kg-1 for Rice-Fallow, 0.49 mg kg-1 for Vegetable-Vegetable, and 0.38 mg kg-1 for Plantation, and these values did not exhibit significant differences. Similarly, there was no substantial variance among the cropping systems concerning the RS-B fraction, with values of 0.34 mg kg-1 for Rice-Rice, 0.94 mg kg-1 for Rice-Fallow, 0.44 mg kg-1 for Vegetable-Vegetable, and 0.38 mg kg-1 for Plantation.

Moving on to the SA-B fraction, mean values were recorded as 0.94 mg kg-1 for Rice-Rice, 1.08 mg kg-1 for Rice-Fallow, 0.87 mg kg-1 for Vegetable-Vegetable, and 0.66 mg kg-1 for Plantation. Regarding the Ox-B fraction, the mean values were as follows: 9.41 mg kg-1 for Rice-Rice, 10.43 mg kg-1 for Rice-Fallow, 10.24 mg kg-1 for Vegetable-Vegetable, and 8.66 mg kg-1 for Plantation. For the Org-B fraction, mean values were 12.11 mg kg-1 for Rice-Rice, 11.93 mg kg-1 for Rice-Fallow, 10.18 mg kg-1 for Vegetable-Vegetable, and 9.98 mg kg-1 for Plantation. Lastly, the Res-B fraction exhibited mean values of 24.88 mg kg-1 for Rice-Rice, 23.42 mg kg-1 for Rice-Fallow, 25.07 mg kg-1 for Vegetable-Vegetable, and 27.79 mg kg-1 for Plantation.

Notably, the LSD ($\alpha=0.05$) values presented in Table 5 revealed no significant impact of the cropping systems, including Rice-Rice, Rice-Fallow, Vegetable-Vegetable, and Plantation, on soil boron fractions and boron availability. This lack of significance can be attributed to the similarity in cultural management practices across the systems, with minimal input management. It's important to note that residual boron, belonging to the non-labile pool, is influenced by the dynamic equilibrium between soil and soil solution. Nevertheless, this reservoir of boron can serve as a long-term source for cropping systems, particularly those with higher boron requirements, such as vegetable crops, as highlighted by Jena et al. (2017).

Effect of soil properties on boron fractions

Table 1 provides an overview of some key physical and chemical properties of the soils. In the context of the rice-rice cropping system, the soil textures ranged from clay loam to sandy and silty clay loam. The soil's pH exhibited a range from very strongly acidic to strongly acidic, specifically between 4.9 and 5.5, with a mean pH value of 5.18.

It's important to note that soil pH plays a pivotal role in influencing the availability of boron in soils, as highlighted in previous research (Keren & Bingham, 1985; Sandobe & Mohammed, 2011; Waqar et al., 2012). Additionally, studies by Goldberg & Glaubig (1986) and Shafiq et al. (2008) have emphasized that the adsorption of boron by soils is significantly influenced by the pH of the soil solution.

The soil's organic carbon content exhibited a range from low to high, spanning from 0.6% to 1.6%, with an average value of 1.02%. In terms of cation exchange capacity (CEC), the soil displayed variability, ranging from 4.50 to 7.20 [cmol (p+) kg-1], with an average CEC value of 6.42 [cmol (p+) kg-1]. The soil's electrical conductivity (E.C.) remained very low, registering values between 0.01 and 0.03 dSm-1, with an average E.C. of 0.02 dSm-1.

Regarding nutrient content, the available nitrogen content in the soil ranged from low to medium, with values ranging from 200.8 to 313.6 kg ha-1 and an average of 263.9 kg ha-1. The phosphorus (P_2O_5) content ranged from 8.11 to 33.07 kg ha-1, averaging 15.9 kg ha-1, while the potassium (K_2O) content ranged from 180.7 to 237.9 kg ha-1, with an average value of 201.77 kg ha-1.

The soil textures across the samples ranged from sandy clay loam to clay loam. Specifically, the sand, silt, and clay fractions displayed variability, with percentages ranging from 18.1% to 49.2%, 27.2% to 48.4%, and 23.6% to 33.5%, respectively. In terms of soil characteristics, the soils were very strongly acidic to strongly acidic, with pH values falling within the range of 4.9 to 5.5. Additionally, the soils were non-saline, as indicated by an electrical conductivity (E.C.) value of 0.02 dSm-1. The availability of nitrogen (N), phosphorus (P), and potassium (K) exhibited a range from low to medium.

When examining the relationships between various physical and chemical properties of the soil samples and the different boron fractions, as presented in Tables 5 and Figure 3, no significant correlations were observed between soil pH (as shown in Figure 3) and any of the studied soil boron fractions, except for specifically adsorbed boron (SA-B). This finding is noteworthy since soil pH is typically considered one of the most influential factors affecting boron availability in soils, as reported in previous studies (Keren & Bingham, 1985; Sandobe & Mohammed, 2011; Waqar et al., 2012). However, the present study did not identify any significant correlations between soil pH and boron fractions.

The lack of a significant influence of pH on soil boron levels in our study could be attributed to the relatively narrow range of soil pH values, falling within the categories of 4.7-5.0 and 5.1-5.6 (as indicated in Table 5). We observed a statistically negative relationship between the sand fraction and the content of specifically adsorbed boron (SA-B), as depicted in Figure 3.

In terms of soil organic carbon content, we categorized the soils into two groups: those with organic carbon content ranging from 0.6% to 1.0% and those with content from 1.1% to 1.6%. Interestingly, the fractions Oxide bound boron (Ox-B), Organically bound boron (Org-B), and Residual boron (Res-B) exhibited significant differences, with higher values observed in soils with a greater percentage of organic carbon. Additionally, we found statistically positive correlations between soil organic carbon and the various soil boron fractions, as illustrated in Figure 3. This observation aligns with the understanding that organic matter serves as one of the primary surfaces for boron adsorption in soils, as documented in previous studies (Goldberg, 1997).

The adsorption complex plays a critical role in regulating the concentration of boron in the soil solution, as noted in previous studies (Goldberg et al., 2005). In our findings, we observed a negative correlation between sand content and specifically adsorbed boron (SA-B) (-0.47). Conversely, finer fractions such as silt (0.42) and clay (0.49) exhibited significant and positive correlations with SA-B, as depicted in Figure 3.

It is well-documented that coarse-textured soils typically have lower available boron levels compared to fine-textured soils due to their limited adsorption capacity (Malhi et al., 2003; Niaz et al., 2002; Raza et al., 2002). Among the various boron fractions (Figure 2), Organically bound boron (Org-B) displayed a positive and significant correlation with both SA-B (0.414) and Oxide bound boron (Ox-B) (0.513). In acidic soils, Fe-Al minerals play a crucial role as surfaces for boron adsorption (Serhat et al., 2019), and boron adsorption tends to be more pronounced in soils rich in short-order amorphous clay minerals.

Conclusion:

In this study, the analysis revealed that the total boron concentration in soils across different cropping systems ranged from 36.26 to 74.11 mg B kg-1, with an average concentration of 47.87

mg B kg-1 in the 0-15 cm soil depth. Residual boron was found to be the most abundant form in the soil, followed by readily soluble boron (RS-B), specifically adsorbed boron (SA-B), oxide bound boron (Ox-B), and organically bound boron (Org-B), in descending order of abundance. The RS-B fraction had the lowest proportion of boron.

Interestingly, the various soil boron fractions, including available boron, did not exhibit any significant differences among the different cropping systems, which included rice-rice, rice-fallow, vegetable-vegetable, and plantation. Therefore, it can be concluded that the choice of cropping system did not play a significant role in influencing the variation in soil boron fractions and, consequently, its availability.

Furthermore, the study found that soil pH within the range of 4.7-5.6 did not have a significant impact on soil boron fractions. Similarly, soil cation exchange capacity, which ranged from 2.8 to 9.6 meq per 100 g-1 of soil, did not show a significant influence on these boron fractions. However, the presence of organic carbon had a positive and significant effect on soil boron fractions, particularly on oxide-bound boron and organically bound boron. Therefore, it can be inferred that soil physico-chemical properties, particularly the organic carbon content, predominantly influenced soil boron fractions in the Inceptisols of the study area, whereas the dominant cropping system did not play a significant role in this regard.

Table 1: Selected soil characteristics under four dominant cropping systems

Croppingsystem	SoilpH	SOC (%)	AvailableN(kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})	CEC (Cmol(p+)kg^{-1}	E.C. (dsm^{-1})
Rice-Rice	5.5	0.6	267.8	15.70	215.0	6.5	0.02
Rice-Rice	5.3	0.7	311.5	9.55	201.6	4.5	0.01
Rice-Rice	5.1	0.7	238.8	33.07	180.7	6.9	0.01
Rice-Rice	5.0	1.4	250.9	19.68	237.9	7.2	0.03
Rice-Rice	4.9	1.1	200.8	8.11	189.8	6.3	0.02
Rice-Rice	5.3	1.6	313.6	9.55	185.6	7.1	0.03
Rice-Fallow	5.0	1.0	225.8	11.72	169.3	4.3	0.03
Rice-Fallow	5.2	1.1	200.7	8.11	225.6	7.2	0.02
Rice-Fallow	5.1	1.4	238.3	24.75	208.3	4.5	0.03
Rice-Fallow	5.2	1.1	261.8	37.05	247.7	6.5	0.02
Rice-Fallow	4.7	1.2	276.3	5.93	198.2	4.9	0.01
Rice-Fallow	4.9	1.1	238.3	18.60	146.3	6.7	0.02
Veg-Veg	4.7	0.9	213.3	52.61	274.6	9.6	0.02
Veg-Veg	5.6	0.9	238.3	11.00	196.6	7.6	0.02
Veg-Veg	4.9	0.9	215.2	17.51	246.7	8.3	0.02
Veg-Veg	4.7	0.9	186.9	11.36	276.2	5.1	0.03
Veg-Veg	5.1	1.2	301.1	57.68	213.0	5.3	0.02
Veg-Veg	4.8	1.0	225.6	26.20	136.9	3.2	0.02
Plantation	5.4	0.9	225.8	17.51	250.7	2.8	0.01
Plantation	5.6	1.2	225.8	14.62	130.8	8.2	0.02
Plantation	4.7	1.2	326.4	16.79	205.6	6.8	0.02
Plantation	5.3	0.9	248.7	29.09	188.2	3.3	0.02
Plantation	5.0	0.8	175.6	32.71	137.7	5.2	0.02
Plantation	5.1	0.7	248.8	11.72	157.5	3.5	0.02
Mean	5.09	1.02	244.00	20.86	200.85	5.90	0.02
Range	4.7-5.6	0.6-1.6	175.6-326.4	5.93-57.68	130.8-276.2	2.8-9.6	0.01-0.03

S.E. (±)	0.28	0.24	40.65	13.83	41.63	1.76	0.24
Kurtosis	-0.610	0.125	-0.06	1.83	-0.54	-0.571	0.014

Table 2: Extraction processes of different boron fractions in soil samples.

SlNo.	Parameters	Methodology
1.	ReadilySolubleBoron (RS-B)	0.50-gram soil was weighed into 50 mlpolyethene centrifuge tubes to which 10 ml of 0.01 M $CaCl_2$ and the mixture was shaken for 24 h in a benmari type orbital shaker at 100°C (±1°C). The suspension was filtered through Whatman No. 42 filter paper.
2.	Specifically adsorbed B (SA-B)	A 5 g soil sample was shaken with 20 ml 0.05 M KH_2PO_4 solution for one h and then extracted.
3.	Oxides bound B Amorphous Fe and Al oxides bound (OX-B)	1 g soil sample was shaken with 40 ml, 0.175 M ammoniumoxalate (pH:3.5) solution for three h at 85°C temperature in the dark
4.	Organically bound (Org-B)	1 g soil sample extracted with 20 ml, 0.02 M HNO_3 and % 30 H_2O_2 solution.
5.	ResidualBoron (Res-B)	It is calculated by subtracting the total number of boron sums from the other fractions.
6.	Available Boron (Av-B)	Hot water extractable B using Azomethine H reagent determined by spectrophotometer reading at 430 nm.

Table 3: Soil boron fractions under four different dominant cropping systems

CroppingSystem	RS-B (mgkg^{-1})	Av. Boron-1 (mgkg^{-1})	SA-B (mg kg^{-1})	Ox-B (mg kg^{-1})	Org-B (mg kg^{-1})	Res-B (mg kg^{-1})
Rice-Rice	0.25	0.46	0.64	8.24	6.86	21.76
Rice-Fallow	0.15	0.12	0.44	7.15	9.72	25.48
Veg-Veg	0.94	0.91	0.74	7.84	9.62	32.75
Plantation	0.54	0.32	0.74	8.53	7.84	22.89
Rice-Rice	0.44	0.61	0.84	5.97	9.62	18.78
Rice-Fallow	0.25	0.34	0.64	15.54	12.58	27.65
Veg-Veg	0.74	0.68	0.54	11.99	7.05	19.21
Plantation	0.24	0.69	0.44	12.78	12.2	27.31
Rice-Rice	0.17	0.23	0.25	7.94	6.86	25.78
Rice-Fallow	2.81	0.84	1.43	8.04	11.19	17.73
Veg-Veg	0.14	0.29	0.74	11.20	8.63	26.55
Plantation	0.64	0.40	0.74	7.15	16.92	36.57
Rice-Rice	0.35	0.41	1.92	9.13	18.79	25.89
Rice-Fallow	0.54	0.64	1.23	8.93	10.41	18.23
Veg-Veg	0.74	0.41	1.33	7.94	9.32	20.13
Plantation	0.35	0.45	0.15	10.31	8.83	27.81
Rice-Rice	0.08	0.64	7.74	10.21	23.45	0.18
Rice-Fallow	1.23	1.13	13.17	18.09	21.11	0.74
Veg-Veg	0.05	0.74	11.49	17.12	24.57	0.56
Plantation	0.35	0.94	5.18	7.25	28.58	0.19
Rice-Rice	0.74	1.33	17.41	20.3	33.64	0.69
Rice-Fallow	0.64	1.63	9.72	9.62	30.29	0.56
Veg-Veg	0.04	1.13	11.00	9.32	27.21	0.11
Plantation	0.15	0.94	7.45	6.86	23.56	0.23
Mean	0.52	0.89	9.66	11.05	25.29	0.46
Minimum	0.04	0.15	5.18	6.86	17.73	0.91
Maximum	2.81	1.92	17.41	20.3	36.57	0.11
SD	0.58	0.42	2.98	4.11	4.86	0.23
CV	388.11	47.77	40.04	59.85	19.20	48.95
kurtosis	11.441	0.229	1.051	0.147	-0.032	-0.843

SD- Standard deviation, CV- Coefficient of Variation

Table 4: Effectofcroppingsystem onavailableboronandboronfractions

CroppingSystem	Av.B (mgkg^{-1})	Rs-B (mgkg^{-1})	SA-B (mgkg^{-1})	Ox-B (mgkg^{-1})	Org-B (mgkg^{-1})	Res-B (mgkg^{-1})
Rice-Rice	0.43^{A}	0.34^{A}	0.94^{A}	9.41^{A}	12.11^{A}	24.88^{A}
Rice-Fallow	0.54^{A}	0.94^{A}	1.08^{A}	10.43^{A}	11.93^{A}	23.42^{A}
Vegetable-Vegetable	0.49^{A}	0.44^{A}	0.87^{A}	0.24^{A}	10.18^{A}	25.07^{A}
Plantation	0.38^{A}	0.38^{A}	0.66^{A}	8.66^{A}	9.98^{A}	27.79^{A}
LSD(α=0.05)	NS	NS	NS	NS	NS	NS
SE(m±)	0.06	0.24	0.1607	1.261	1.88	2.14

Means followed by the same letter within a column are not significantly different (Duncan Multiple Range Test, $P < 0.05$). SE(m±), Standard Error of Mean

Table 5: Effect of pH, soil organic carbon and cation exchange capacity on soil boron fractions

pH	RS-B	SA-B	Ox-B	Org-B	Res-B
4.7-5.0	0.481	1.035	8.838	11.590	27.092
5.1-5.6	0.623	0.838	10.354	10.787	23.257
C.D.(0.05)	N.S	N.S	N.S	N.S	N.S
SOC (%)	RS-B	SA-B	Ox-B	Org-B	Res-B
0.6-1.0	0.437	0.714	8.417	8.067	24.346
1.1-1.6	0.644	0.971	10.775	14.321	25.603
C.D(0.05)	N. S	N. S	1.791	1.791	N. S
CEC (meq 100 g^{-1})	RS-B	SA-B	Ox-B	Org-B	Res-B
2.8-5.8	0.623	0.891	8.748	10.469	23.440
5.9-9.6	0.464	0.874	10.812	11.766	27.946
C.D.(0.05)	N. S	N. S	N. S	N. S	N. S

Figure 1: Sampling site in the Boko block of Kamrup (Rural) district of Assam.

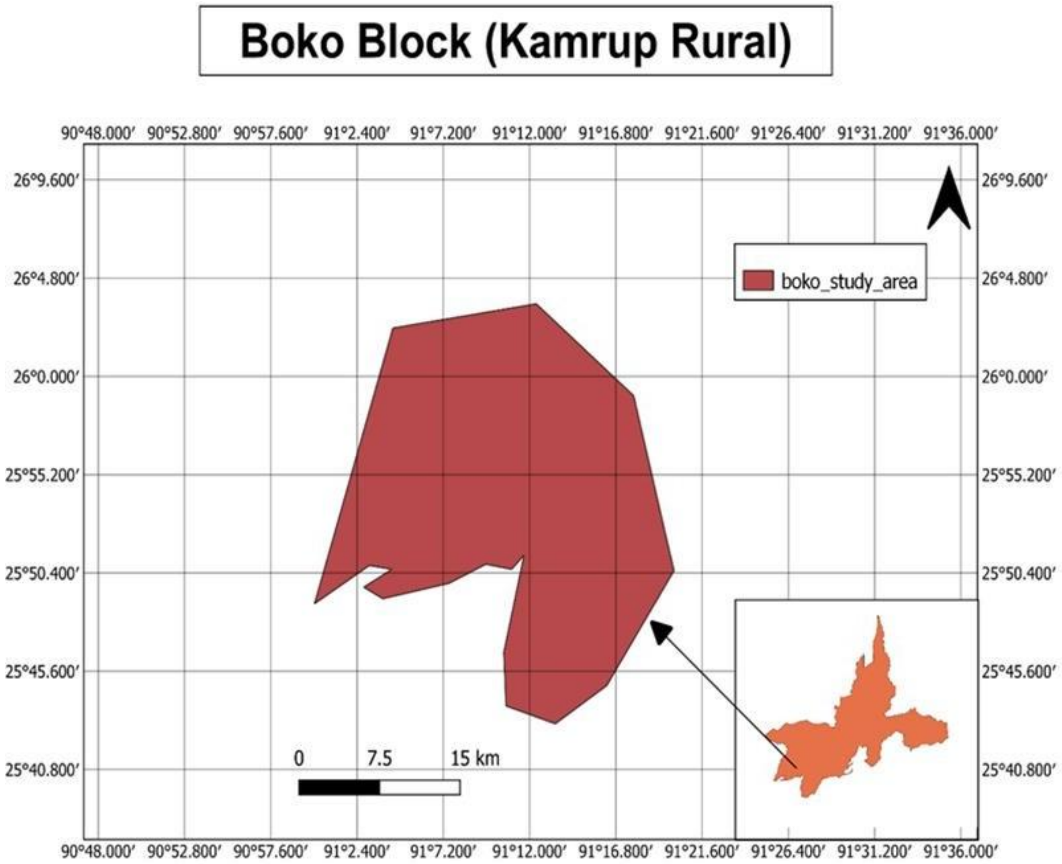


Figure 2: The correlation coefficients among boron fractions with hot water-soluble boron (available boron)

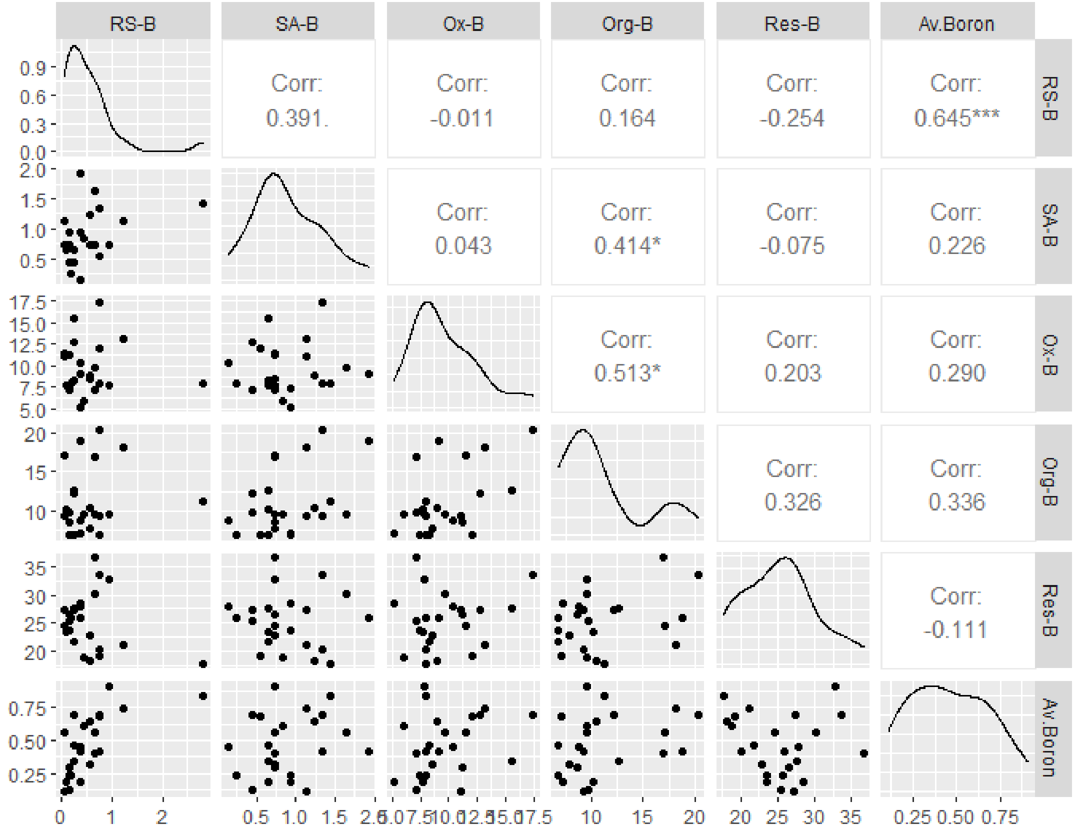
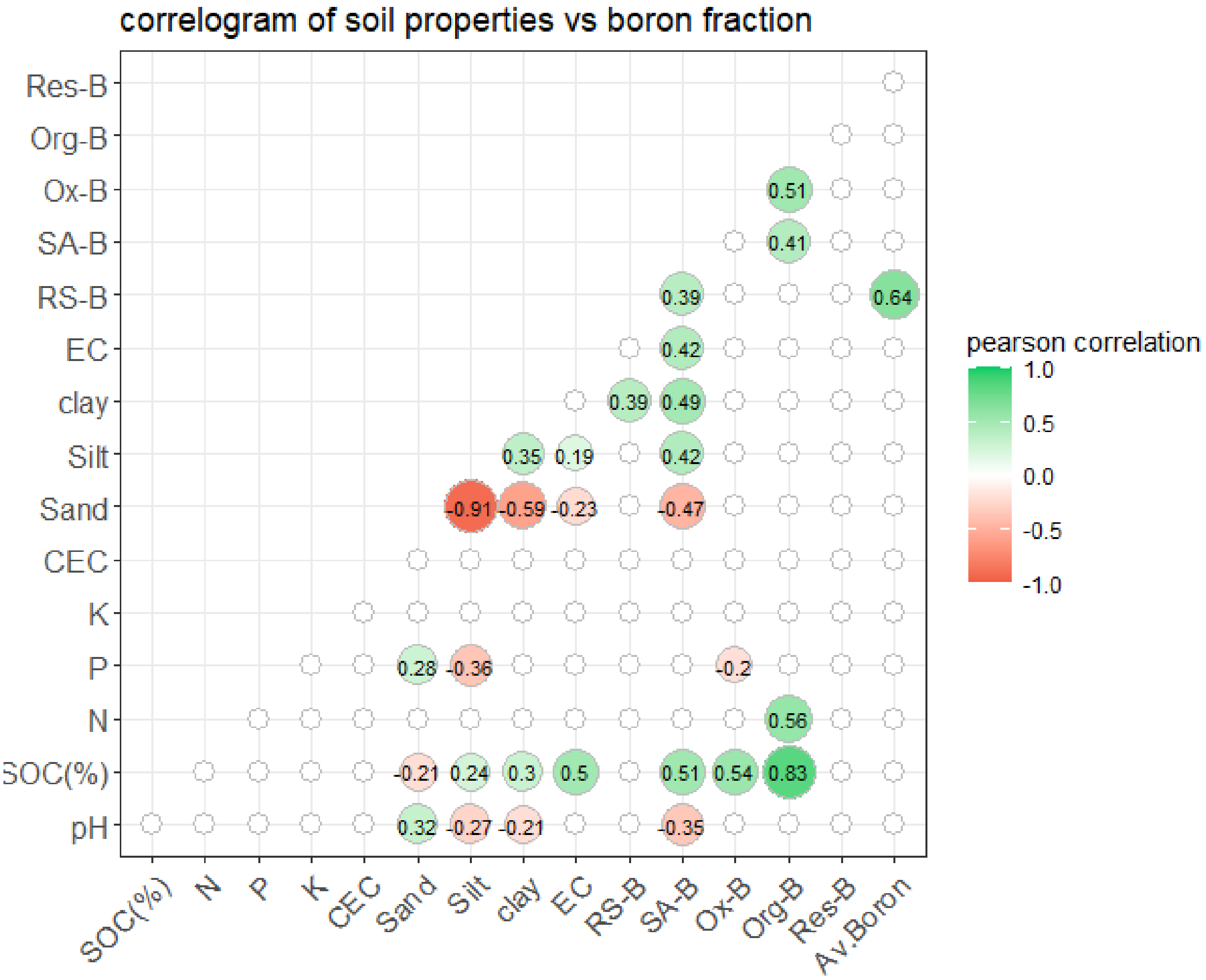


Figure 3: Correlationofsoilphysicochemicalpropertiesandboronfractions.



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