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# Correlation between the different fractions of boron with soil physico-chemical properties

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**Abstract**
Knowledge of different fractions and availability of boron (B) is essential while studying the response of crops to B. Fractionation provides information about the chemistry of B and quantifies its bioavailability. Such information is potentially valuable for predicting bioavailability, B leaching, dynamics, transformation between chemical forms in soils and environmental impacts. A total of thirty number of soil sample from thirty different village of Imphal-West District were collected and analyzed in the laboratory to study the correlation between various fractions of boron with various soil physico-chemical properties. From the correlation studies, it can be seen that boron had a positive and significant relationship with soil pH, soil organic matter, soil cation exchange capacity (CEC), silt and clay content of the soil. Whereas, soil electrical conductivity (EC) and the sand content of the soil showed a negative relationship with different fractions of boron. Positive and significant relationships were found between the different fractions of boron except oxide bound boron which showed negative correlation with residual boron however non-significant. This proved that all the fractions of boron are interrelated and exist in an equilibrium state within the soil.

**Keywords:** B fraction, physico-chemical, correlation, soil, Imphal West District

## 1. Introduction

Boron is a chemical element which is represented by the symbol B and atomic number 5. Boron is among one of the essential plant nutrient and compounds of boron such as boric acid and borax are used in agriculture as fertilizers. Boron is required by the plants in petty quantities, with excess being toxic. Boron is non-metal micronutrients which is the only non-metal of the group 13 of the periodic table and has transitional properties between non-metals and metals (Marschner, 1995) [18]. Boron was reported as an essential plant nutrient as early as 1923 by Warrington (Tandon, 1995) [31] and is neither an enzyme constituent nor does it affect enzyme activities directly (Prasad, 2007) [34]. B in plants is relatively immobile and generally its content increases from lower to upper parts in plants (Cripps, 1956) [5].

Availability of soil B to plants is often related to the total B content as well as other properties such as pH, organic matter and $CaCO_3$ contents, interaction of nutrients, type of plant or variety and environmental factors, which strongly influence the emergence of B toxicity or deficiency in plants (Sakal *et al.*, 1996; Saha and Singh, 1997) [26, 24]. Deficiencies of B in Indian soils varried from 2% in alluvial soils of Gujarat, to 68% in red soils in Bihar, with a mean of 33% for the whole country (Singh, 2001; Singh 2012) [29, 30]. The highest deficiency of B occurred at 54–86% was recorded in Alfisol soils of West Bengal and Assam, the reason due to increased in rainfall which led to the decrease of water soluble B (Sakal and Singh, 1995) [25].

Boron that are available to plant exists in soil mostly as a neutral boric acid molecule and decomposing organic matter serves as the main source of this boron. Boron is usually present as an un-dissociated boric acid in the soil solution which is taken up by the plants. The major form of boron in soils usually exists as Boric acid where it present dominant above pH 9.2. The mechanism by which boron reaches to plant roots is usually through mass flow and its spread in different parts of the plant is influence by the transpiration stream through the xylem. About 3-4% of Boron is obtained through Tourmaline which serves as the main source of Boron. The total concentration of boron in soil ranges from 20-200 mg $kg^{-1}$. Boron accessibility is highly influenced by the characteristics of soil such as pH, electrical conductivity, texture, cation exchange capacity, organic matter and calcium carbonate of soil

(Evans and Sparks, 1983) [9]. Knowledge of different fractions of boron is necessary to understand the chemistry of B in soils as it enables to know about plant availability, its binding forms, dynamics, and possible impacts of B on environmental. The knowledge of the effect of different amendments and chemical fertilizers on native soil boron and the distribution of boron in different fractions are also essential for the proper management of soils. In soil, Boron is found in five different fractions *viz*. readily soluble, specifically adsorbed, oxide bound, organically bound, occluded or residual B. The relative concentration of these fractions in a soil at a given time depends on properties of soil like pH, amount and nature of clay, lime content, organic matter, soil moisture and plant factors.

Keeping the above points in view, the investigation was conducted to study the relationship between the different fractions of boron with soil physio-chemical properties

## 2. Materials and Methods

An experiment was conducted to study the relationship between various fractions of boron with various soil physico-chemical properties. A total of thirty soil samples (0-20 cm depth) were collected from different paddy growing soils of three sub-division of Imphal-west districts namely Wangoi, Lamsang and Patsoi. The soils were dried in shade, grounded and passed through 2 mm nylon sieve. The processed samples were stored in separate polyethylene bags and used for various physical and chemical analyses.

### 2.1 Methods adopted for determination of different soil parameters

**Table 1:** Physico-chemical properties:

| Sl. No | Parameters | Methods | References |
|---|---|---|---|
| 1 | Texture (%) | Hydrometer method | Bouyoucos,1962 [3] |
| 2 | pH | 1:2.5 soil:water suspension | Jackson,1973 [15] |
| 3 | EC (dS $m^{-1}$) | 1:2.5 soil:water suspension | Jackson,1973 [15] |
| 4 | Organic Carbon (%) | Walkley and Black rapid titration | Walkley and Black, 1934 [32] |
| 5 | CEC (cmol ($p^+$) $kg^{-1}$ | 1N Neutral Ammonium Acetate | Jackson, 1973 [15] |

**Table 2:** Boron Fractionation:

| Sl. No | Forms of Boron | Extractant | References |
|---|---|---|---|
| 1 | Readily soluble B | 0.01 M $CaCl_2$ | Hou *et al*. (1994, 1996) [13, 14]; Datta *et al*. 2002 [6] |
| 2 | Specifically adsorbed B | 0.05 M $KH_2PO_4$ | |
| 3 | Oxide bound B | 0.175 M $NH_4$-oxalate | |
| 4 | Organically bound B | 0.5 M NaOH | |
| 5 | Residual B | $HF+H_2SO_4+HClO_4$ | |

## 3. Results and Discussion

### 3.1 Correlation between the different fractions of boron with soil parameters

#### 3.1.1 Soil pH

Soil pH showed significantly positive correlation with all boron fractions. Similar result have also been reported by Kumari *et al. (*2017) [17] in the case of oxide bound boron. It can be ascribed to the fact that increasing the pH increases the negative surface charges of clays and other variable charge surfaces. Similar findings were reported by Datta *et al*. 2002 [6] and Choudhury and Shukla, 2004 [4].

#### 3.1.2 Soil EC

Soil EC had a negative but non-significant relation with all fractions of boron *viz*., readily soluble(r=-0.17), specifically adsorbed(r=-0.15), oxide bound (r=-0.11) organically bound(r=-0.27) and with residual boron(r=-0.32). EC was found towards decreasing trend on application of increasing boron doses over initial status. Rathiya *et al.* (2018) [22] also reported that there is no any significant effect on EC by the application of boron.

#### 3.1.3 Soil OC

Organic matter plays an important role in adsorption and desorption of B. Soil organic matter adsorbs more B than mineral soil constituents (Yermiyahu *et al*. 1988; Gu and Lowe 1990) [33, 11]. A possible mechanism for B sorption by organic matter is ligand exchange (Yermiyahu *et al*. 1988) [33]. Soil organic Carbon showed significantly positive correlation with all boron fractions with residual boron having the highest significant (r = 0.58**). This positive relationship may be explained as that organic carbon is source of boron due to which there is not much transformation from the residual to other pools, resulting higher residual boron in the soils having higher organic matter. Significant correlation of these fractions with organic carbon indicated that soil organic matter is an important parameter contributing towards availability of B in soils (Mathur and Sudan, 2011) [19]. The present observation is in agreement of Dey *et al*. (2014) [8] and Kumari *et al*. (2017) [17].

#### 3.1.4 Soil CEC

Cation exchange capacity also followed the same pattern as that of soil pH and OC and possessed significantly positive correlation with all the boron fractions. These results were in line with the findings of Kaundal *et al*. (2014) [16] and Dey *et al*. (2015) [7]. The organically bound boron pool is pivotal in governing transformation and distribution of boron in different fractions, organic carbon and CEC favored by high organic matter content has positive correlation with different boron fractions (Arora and Chahal, 2014). [2]

#### 3.1.5 Soil texture

The correlation of different boron fractions with mechanical separates (i.e. sand, silt and clay) have been presented in the table no. 3 and it can be seen from the table that sand content had significant and negative relationship with all the boron fractions. Coarse textured soils of humid regions may have B deficiency due to loss of B through leaching (Shuman, 1975) [28]. Generally coarse textured soils possess less adsorption sites and also favor good leaching of plant available nutrients. The present investigations were in line with the findings of Raza *et al*. (2002) [23] who opinioned that fine texture soils contain more available boron than coarse textured soils. The silt content had a positive correlation with all the fractions of boron but was found to be non-significant for all the fractions. Clay content showed significantly positive correlation with all boron fractions *viz*. readily soluble (r = 0.40*), specifically adsorbed (r = 0.37*), oxide bound (r = 0.39*), organically bound (r = 0.54*), and residual (r = 0.41*). It is clearly evident from the data that boron content increased in soil with an increase in clay content. Fine-textured soils retain B for longer periods than do coarse-textured soils due to the higher adsorption affinity of the former (Gupta, 1968; Goldberg and Glaubig, 1986; Nicholaichuk*et al*., 1988) [12, 10, 21].

**Table 3:** Correlation between the different fractions of boron with soil parameters

| Boron fractions | | Readily soluble B | Specifically adsorbed B | Oxide bound B | Organically bound B | Residual B |
|---|---|---|---|---|---|---|
| Soil parameters | pH | 0.46* | 0.49* | 0.43* | 0.62** | 0.39* |
| | EC | -0.17 | -0.15 | -0.11 | -0.27 | -0.32 |
| | OC | 0.56** | 0.53** | 0.35* | 0.40* | 0.58** |
| | CEC | 0.50** | 0.48* | 0.41* | 0.43* | 0.36* |
| | Sand | -0.57** | -0.54** | -0.46* | -0.53** | -0.56** |
| | Silt | 0.30 | 0.29 | 0.20 | 0.15 | 0.29 |
| | Clay | 0.40* | 0.37* | 0.39* | 0.54** | 0.41* |

*r significant @ 5% level and **r significant @ 1% level

### 3.2 Correlation between the different fractions of boron

The correlation for different fractions of boron has been presented in table no. 4. Positive and significant relationships were found between the different fractions of boron except oxide bound boron which showed negative correlation with residual boron however non-significant. This proved that all the fractions of boron are interrelated and exist in an equilibrium state within the soil. The highest significant correlation was observed between readily soluble and specifically adsorbed boron(r= 0.992**). These results were in line with the findings of Kumari *et al*, 2017 [17]. Similar findings have also been reported by various other researchers (Datta *et al*., 2002, Sarkar *et al*., 2008, Anitha *et al*., 2013 and Nath *et al*., 2018) [6, 27, 1, 20].

**Table 4:** Correlation between the different fractions of boron

| Boron fractions | Readily soluble B | Specifically adsorbed B | Oxide bound B | Organically bound B | residual B |
|---|---|---|---|---|---|
| Readily soluble B | 1.000 | 0.992** | 0.276 | 0.437* | 0.328 |
| Specifically adsorbed B | | 1.000 | 0.317 | 0.444* | 0.278 |
| Oxide bound B | | | 1.000 | 0.538** | -0.038 |
| Organically bound B | | | | 1.000 | 0.388* |
| residual B | | | | | 1.000 |

## 4. Conclusion

From the correlation studies, it can be seen that boron had a positive and significant relationship with soil pH, therefore increasing the pH of soils (not more than than 7) in Imphal-west through liming (not more than 15% calcium carbonate content) or other management practices should be practiced to increase the retention and availability of boron in soil. The presence of high cation exchange capacity and high amount of clay in the soil contributes to higher level of different fractions of B in soil. Also, from the correlation studies it can be seen organic matter plays an important role in maintaining the level of boron in soil. Positive and significant relationships were found between the different fractions of boron except oxide bound boron which showed negative correlation with residual boron however non-significant. This proved that all the fractions of boron are interrelated and exist in an equilibrium state within the soil.

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