

## DETERMINATION OF AVAILABLE BORON CONTENT OF THE SOILS OF JOS PLATEAU, NIGERIA

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The available boron content of sixteen soil samples from an agricultural area of Jos Plateau were critically investigated. The hot water extractable boron (available boron) contents were found to range from 6.0 ppm to 14.5 ppm. These values lie outside the range (0.5 - 5.0 ppm) required by most plants and may prove toxic if corrections are not applied. The boron content of the top soils were slightly higher in all cases than in the sub-soils. Relationship between the available boron and the pH of the soil samples followed the usual trend i.e. the boron content of the samples were found to increase as the soils pH increased.

**Key words:** Soils, Boron content. Nigeria.

### Introduction

Determination of soil specimens for their nutritive values from time to time is important for the proper management of soils. The recent decrease in agricultural yield in some parts of the country has drawn attention to the determination of the essential elements needed for plant productivity. One of these trace and essential elements is boron (B).

Basic understanding of the chemistry of boron (B) in soils, most importantly in arid and semi-arid regions, is essential for optimum productivity.

Boron (B) is one of the elements which may be present in phytotoxic quantities in wastes [1]. The element can be toxic for plants at relatively lower concentration in soils and the concentration range between plant deficiency and toxicity is narrow [2]. Boron concentration in cultivated land may be sufficient during initial crop growth but later may become insufficient due to extensive leaching during raining seasons or fixation during dry seasons.

For these reasons, routine testing is important for boron concentration in soils during the growing season and this can be used in conjunction with plant analysis results to determine appropriate corrective measures.

It has been discovered that boron applied to soils is being adsorbed to a variable extent and an equilibrium exists between B in solid and liquid phases [2-4].

The equilibrium between B in liquid and solid phases has been explained by either the Langmuir adsorption isotherm [5-7] or the Freundlich adsorption isotherm [8-10].

Boron content in soils is affected by a variety of soil properties such as the pH of the soil, the organic carbon, the clay content,  $\text{CaCO}_3$ , cation exchange capacity, sesquioxides, soil salinity etc. [2, 11-13].

Olson and Berger [14] found that fixation was closely related to the clay content and to the soil pH as changed by the

addition of sodium hydroxide, Calcium hydroxide and hydrochloric acid. They demonstrated that clays fixed the most boron, silts-fixed an intermediate amount, and sands fixed very little. The cations used had little influences on the boron fixation but the alkalinity they produce resulted in fixation.

Boron that is fixed by a rise in pH can be made available again by lowering the pH to its original value. This indicates that a rapid reversible chemical reaction is involved [15].

The ultimate objective of this work is to determine the boron content of some agricultural areas of importance in Jos Plateau, Nigeria to enable proper management of the soil for optimum productivity.

### Materials and Methods

Sixteen surface and sub-surface soil samples from agricultural areas in Jos Plateau, Nigeria were selected for study. Sampling and B analysis were done in triplicate over a period of six months and the average taken. Soil classification, pH of the samples determined in water and in 0.01 M  $\text{CaCl}_2$  respectively and B concentration are given in Table 1.

#### PREPARATION OF REAGENTS

**Carminic solution.** 0.5 g of carminic reagent (manufactured by BDH Chemical Limited, Poole, England) was accurately weighed into 1 litre standard flask. Highly concentrated sulphuric acid was then added and the mixture shaken vigorously until complete dissolution of the carminic reagent.

The mixture was then made up to 1 litre mark with concentrated sulphuric acid.

**Sample preparation.** For hot water extractable boron, 1 g of each soil sample was weighed into separate plastic bottle. 10 ml of boiling distilled water was added to each bottle and the contents were shaken for 25 min. (using orbital shaker) after which 0.5 g of  $\text{CaCl}_2$  was added and the contents shaken for

another 5 mins. After this time, the extraction should be completed.

The contents were centrifuged and 2 ml aliquot of the supernatant liquid was pipetted into a separate 25 ml conical flask. Two drops of concentrated HCl were added (to eliminate interference by some ions) followed by the addition of 10 ml of concentrated  $H_2SO_4$ . Each flask was swirled and the mixture then cooled.

After cooling, 2 ml of carmine reagent (0.5 g/l) was added to each flask, swirled and left for 45 mins for colour development. Each was put in a cuvette and their absorbance were read in the spectrophotometer (634 Varian model) at wavelength of 585 nm. The absorbance values were then translated to concentration using a calibration curve.

A blank solution of 2 ml of distilled water (to eliminate any contribution from distilled water used in the analyses) was carried through the entire analyses. The spectrophotometer was set at zero with concentrated  $H_2SO_4$  (to eliminate interference that could be caused by the strength of the acid) and the absorbance of the blank solution was subtracted from the individual absorbance reading of each sample to obtain the actual concentration value.

**Stock solution:** A stock solution of 1000 ppm of standard boron was prepared by dissolving 5.716 g of recrystallized boric acid (analytical grade) in distilled water in 1 litre standard flask and then diluted to the mark.

From the stock solution, working solution consisting of 5, 10, 15, 25, 30, 35, 40, 45 and 50 ppm were obtained through stepwise dilution method. Using these concentrations, a straight line calibration curve was obtained. Using the calibration curve, boron concentration in each soil extract was accurately deduced.

### Results and Discussion

The available boron concentration of the sixteen soil samples determined and the interpretation of boron data in soil analysis are represented in Tables 1 and 2 respectively.

The boron content of the samples was found to increase as the soils pH increased (Table 1). This is in accordance with the findings of Olson and Berger in their research work [14].

The hot water extractable boron (available boron) content in various layers of the mineral soils examined ranges from 6.0–14.5 ppm. Ahmed and Elseewi [16] reported a distribution range of 1–2.6 ppm of the available boron in certain soils in Egypt. In a similar work, the same researchers reported a concentration range from 1–3.4 ppm with an average of 1.3 ppm. In this work, the boron content of the samples examined were higher than those reported by Ahmed [16] in the arid region in Egypt. This variation could depend upon the parent material from which the soil was derived and the soil type which

reflects diverse geographical and climatic conditions. However, the data shown by Aubert and Pinta [17] in a similar environment pointed out that total boron in soils range from 1–270 ppm. The boron content in the top soils are slightly higher in all cases than in the sub-soils (Table 1). This is in accordance with Wolf's observation [18]. It is generally believed that boron content in the top soil is usually higher than in the sub soil, especially in the arid region like Jos Plateau. It was assumed that leaching from top to sub soil could have been reduced; that is both the total and water soluble boron in the mineral soils decreases with depth of soil. When statistically tested (F-test), there was no significant difference between the boron content of the top and sub soil at 95% confidence limit ( $v = 7$ ).

The available boron content of the most soils, according to the literature, ranges from 0.1 ppm to a few ppm with the assumption that 0.5 ppm water-soluble boron is the minimum needed for crops with low B requirement [19] and over 5.0 ppm water soluble B is generally toxic to most plants (Table 2). This table represents a standard guide to the application of boron to soil and water for plant development.

In these samples from Jos Plateau (Table 1) the boron content in the soils are significantly above toxic levels (compare Tables 1 and 2) and therefore, the water soluble boron content may be injurious to many plants. However, under proper soil and water management, the incidence of boron toxicity is unlikely. For example, Naftel [20] reported that application of lime in a calculative amount relative to boron content often results in a lower availability of soil boron. Also, boron deficiency can be corrected by the application of the

TABLE I.

Soil sample No.	Soil classification	Soil pH in $H_2O$	Soil pH in 0.01M $CaCl_2$	B Concentration in ppm
1*	Sandy clay soil	4.8	4.4	7.25
1**	" " "	4.8	4.4	6.75
2*	" " "	4.6	4.3	7.25
2**	" " "	5.5	4.4	6.75
3*	Loamy sand soil	3.8	4.4	7.25
3**	" " "	5.2	4.3	6.40
4*	" " "	4.4	3.8	6.40
4**	" " "	5.2	4.0	6.00
5*	" " "	5.4	4.0	11.00
5**	" " "	5.3	4.4	6.25
6*	Loamy clay soil	5.4	4.4	7.25
6**	" " "	5.0	4.1	6.50
7*	Loamy sand soil	5.8	5.1	14.50
7**	" " "	5.4	4.4	14.25
8*	" " "	5.1	4.1	10.25
8**	" " "	4.6	3.4	10.50

\* Top soil, \*\* Sub soil.

required amount of boron through irrigation water to the soils [16].

TABLE 2. INTERPRETATION OF BORON DATA IN SOIL ANALYSIS.

Soil Boron (ppm)	Rating	Evaluation
0.0 - 0.4	Poor	Boron contents in this range for extended periods will result in deficiencies for most plants.
0.5 - 0.9	Fair	Probably satisfactory for crops with a low B requirements although additional amounts of B may be applied.
1.0 - 2.4	Good	Satisfactory for most plants but for high requirement plants, maintenance amount of B may be applied.
2.4 - 4.9	High	High although toxicity symptoms not always be apparent. B additions should be stopped.
5.0 and above	Toxic	Such B levels maintained for an appreciable time will develop toxicity symptoms.

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