Boron Fixation as Influenced by pH, Organic Matter Content, and other Factors

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Published results regarding the effects of available calcium, soil reaction, organic matter, and texture on boron fixation in soils are somewhat controversial. Eaton and Wilcox (4) report increasing boron fixation with increasing pH values, while Parks (6) states that lime decreases fixation, and Drake, et al. (3) failed to note fixation of boron at pH levels (pH 4.1 to pH 11.6) in soil colloids. Midgley and Dunklee (5) found increasing boron fixation with increasing lime applications up to or slightly beyond neutrality. They believe organic matter to be responsible for at least part of the fixation in soils, while Eaton and Wilcox and Drake, et al., found that humus extracts did not absorb boron. Berger and Truog (1) found a high positive correlation between available boron and the organic matter content of acid soils, and that pH had a much greater influence in decreasing the availability of boron in alkaline soils than did organic matter in maintaining availability.

The amount of boron left available in soils after fixation takes place has been determined in some cases by plant growth. This method is probably not reliable when the amount of calcium in the soil is varied, because the calcium-boron ratio is changed. It has been shown by Drake, et al., that as the amount of calcium in the culture medium is increased the boron requirement of the plant is also increased. Consequently, a chemical method was used for the determination of boron fixation in the present laboratory investigation which was undertaken for the purpose of obtaining further information regarding the influence of pH, cation saturation, and organic matter content. Extent of fixation by the different soil separates was also investigated.

MATERIALS AND METHODS

The soils used for most of this investigation were taken from the plow layer of Carrington and Spencer silt loams. Carrington silt loam is a prairie soil formed on calcareous glacial drift modified somewhat by loess. The surface layer is acid and contains about 3% organic matter. The Spencer silt loam was formed under forest cover on acidic pre-Wisconsin glacial drift, with loess contributing slightly to the surface material. The surface soil is strongly acid and contains about 1½% organic matter.

For the determination of available boron, the quinalizarin method (2) was used with the following modification; 25 mg of quinalizarin per liter of 98% sulfuric acid were used rather than 5 mg. All determinations were made with the pho-

cetic polarimeter, and it was found that the higher concentration of quinalizarin gave a greater color range than the lower concentration. Eaton and Wilcox (4) failed to note fixation of boron at pH levels (pH 4.1 to pH 11.6) in soil colloids. Midgley and Dunklee (5) found increasing boron fixation with increasing lime applications up to or slightly beyond neutrality. They believe organic matter to be responsible for at least part of the fixation in soils, while Eaton and Wilcox and Drake, et al., found that humus extracts did not absorb boron. Berger and Truog (1) found a high positive correlation between available boron and the organic matter content of acid soils, and that pH had a much greater influence in decreasing the availability of boron in alkaline soils than did organic matter in maintaining availability.

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In the experiments dealing with boron fixation, 20 ppm of boric acid to a soil suspension so that the resulting suspension consisted of 10 grams of soil in 40 ml of solution was then shaken and allowed to stand for 16 hours after which it was refluxed for 5 minutes. The residue from the extraction was determined. Sufficient dilute hydrochloric acid was then added to the soils to lower their pH to that of the extract. Calcium hydroxide, boron was added, and the available boron content of the extract determined. It was found necessary to add more than the usual amount of calcium hydroxide in order to determine the available boron content. Organic matter was destroyed by successive additions of hydrogen peroxide solution to the soil. After the hydrogen peroxide, the sides of the beaker were washed down with water and the soil was then dried over a hot plate at 70° C. The soil was transferred to extraction flasks, boron was added, and the available boron in the extract determined. The residue was then added to the soils to lower their pH to that of the extract and the available boron determined.

Soils were fractionated into sand, silt, and clay in order to determine the available boron content and their ability to fix boron. Organic matter, iron and aluminum oxides were removed from the silt fractions after they were again separated to assure complete removal of the clay.

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RESULTS

It is apparent from the results shown in Fig. 1 that fixation increased rapidly as the pH approached 7, while below this point there was little or no correlation between pH and boron fixation. Similar curves were obtained with the Carrington silt loam. The authors are indebted to Professor E. Truog for many helpful suggestions. Figures in parenthesis refer to "Literature Cited", p. 219.