

## Fractions of Soil Boron

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### SUMMARY

Fractionation of boron 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. Total B (T-B) is quantified into five fractions: readily soluble (Rs-B), specifically adsorbed (Spa-B), oxide bound (Ox-B), organically bound (Org-B) and residual B (Res-B). Of these, Rs-B is the fraction present in soil solution and adsorbed weakly by soil particles, and is most readily available for plant uptake. It accounts for 1–2% of T-B. The second most plant available form is Spa-B; it may be adsorbed onto clay surfaces or associated with organic matter (OM) in soil. The remaining fractions, Ox-B, Org-B and Res-B, are unavailable for plant uptake. The major portion (generally 87.4–99.7%) of T-B is composed of Res-B. Overall, the relative proportion of B in various fractions is in the order of Res B > Org-B > Spa-B > Rs-B > Ox-B.

### INTRODUCTION

Boron is a nonmetallic element and the only non-metal of the group 13 of the periodic table and is an essential micronutrient for crops. More than 90 per cent of the B in plants is found in cell walls and its most important role is associated with cell wall formation. Boron is involved in the reproduction of plants and germination of pollen spikelet (Jegadeeswari and Muthumanickam, 2017). Boron exists in the soil in five fractions. Zerrari *et al.* (1999) reported that these fractions are readily soluble, specific adsorbed, oxide bound, organic matter bound and residual (these are in silicate minerals, and cannot be used by plants). It has also been specified that the amount of these different fractions depends on the soil properties and the availability levels of these fractions differ. Ellis and Knezek (1972) stated that B is more strongly adsorbed by soil when compared with other anions such as Cl and NO<sub>3</sub> and this adsorption is realized through inorganic substance such as Fe and Al oxides and hydroxides, clay minerals and especially mica type clay, Mg (OH)<sub>2</sub> and organic matter.

### Fractionation procedure and colorimetric estimation of boron

**Readily soluble boron:** Ten gram of soil in duplicate was weighed into 50 ml polyethylene centrifuge tubes to which 20 ml of 0.01 M CaCl<sub>2</sub> was added and shaken for 16 h (Hou *et al.*, 1994). After centrifuging at 10,000 rpm for 30 minutes the supernatant solution was filtered through Whatman no 42 filter paper. Boron was determined in clear extracts using azomethine-H reagent (Datta *et al.*, 2002).

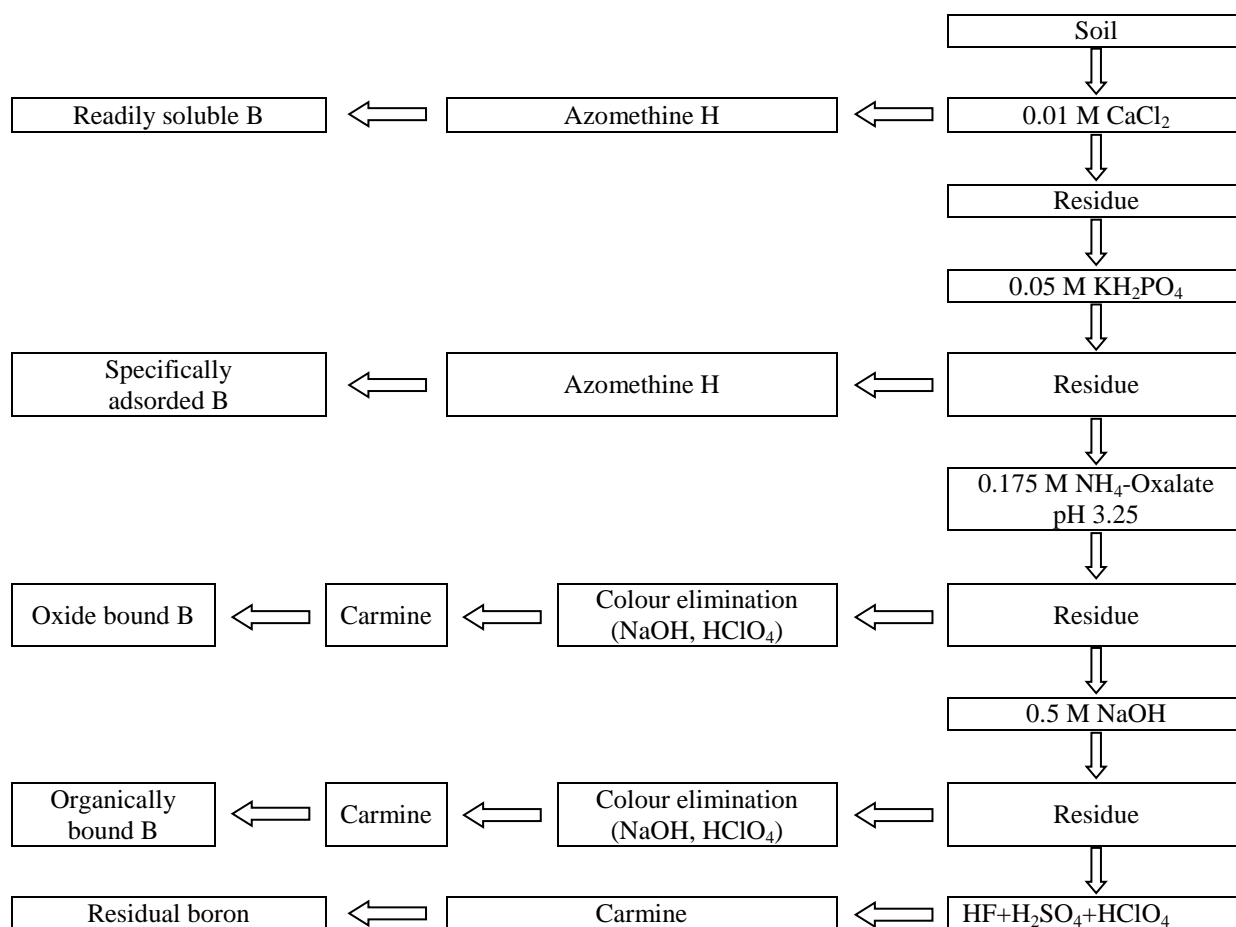
**Specifically adsorbed boron:** The residue from the above step was then extracted with 20 ml of 0.05 M KH<sub>2</sub>PO<sub>4</sub> by shaking for 1 h (Hou *et al.*, 1994). After centrifugation at 10,000 rpm for 30 minutes the supernatant solution was filtered through whatman no 42 filter paper. Boron was determined in clear extract using azomethine-H (Datta *et al.*, 2002).

**Oxide bound boron:** The residue from the previous step was extracted with 40 ml of 0.175 M NH<sub>4</sub>- oxalate, pH 3.25 (Hou *et al.*, 1994) by shaking for 4 hr) most of these extracts had a yellow to slight reddish colour due to slight dissolution of organic matter. To remove the colour, a 14 ml portion of the extract was taken into 50 ml Teflon beaker and the weight of the beaker plus aliquot was noted. The content was then warmed on a hot plate and 2 ml of 5 N NaOH solution was added to completely precipitate the dissolved Fe as Fe (OH)<sub>3</sub>. The beaker with the aliquot was weighed again and the loss in weight was made up by adding distilled water. While doing so, the weight of the 2 ml 5 N NaOH was also taken into account. The suspension was filtered through Whatman No. 42 filter paper and thus Fe was separated. Nine ml aliquot of the filtrate was taken into a 50 ml Teflon beaker and 4 ml concentrated H<sub>2</sub>SO<sub>4</sub> and 1 ml of HClO<sub>4</sub> (60 %) were added and heated on hot plate at 135±5 °C to destroy the organic matter. When the volume was reduced to about 6 ml, HClO<sub>4</sub> was added in an increment of 0.5 ml until

the solution became colourless and the volume reduced to 4 to 5 ml. The content was then transferred to a 15 ml graduated polyethylene tube and the final volume was made up to 6 ml. After centrifuging at 10,000 rpm for 15 min, boron in the clear extracts was determined by using carmine reagent (Datta *et al.*, 2002).

**Organically bound boron:** The residue from the NH<sub>4</sub>-oxalate extraction was treated with 40 ml of 0.5 M NaOH by shaking for 24 hrs followed by filtration through whatman No. 42 filter paper. The extracts of all samples except sandy soils were dark in colour due to the dissolution of organic matter. Therefore 14 ml of aliquot was taken in a Teflon beaker to destroy the organic matter a 9 ml aliquot of the filtrate was taken into a 50 ml Teflon beaker and 4 ml of concentrated H<sub>2</sub>SO<sub>4</sub> and 1ml HClO<sub>4</sub> (60 %) were added and heated on hot plate at 135±5 °C to destroy the organic matter. When the volume was reduced to about 6 ml, HClO<sub>4</sub> was added in an increment of 0.5 ml until the solution became colourless and the volume reduced to 4 to 5 ml. The content was then transferred to a 15 ml graduated polyethylene tube and the final volume was made up to 7 ml. After centrifuging at 10,000 rpm for 15 min, boron in the clear extracts was determined by using carmine reagent (Datta *et al.*, 2002).

**Residual fraction:** The residue from the previous step was dried and ground. A 1 gm subsample was taken into a 50 ml Teflon beaker and few drops of concentrated H<sub>2</sub>SO<sub>4</sub>, 5 ml of HF (40 %), and 0.5 ml HClO<sub>4</sub> (60 %) were added (Lim and Jackson, 1982). The beaker was placed on a hot plate at 135±5 °C and the volume was reduced to about 3 ml. Then, 5 ml of concentrated H<sub>2</sub>SO<sub>4</sub> and 5 ml of HF (40%) were added and heating continued. Further HF was added in increment to complete digestion of the soil. After digestion, 3 to 5 ml of HClO<sub>4</sub> (60 %) was added depending upon the intensity of colour in the extract to get a clear extract. Finally, the volume was reduced to 3 to 4 ml by heating to drive off HF and HClO<sub>4</sub> completely. The content was then transferred to a polyethylene centrifuge tube and the volume was made up to 25 ml. After centrifuging at 10,000 rpm, boron in the clear supernatant was determined spectrometrically with carmine reagent.



Flow diagram for fractionation of boron in soils (Datta *et al.*, 2002)

**CONCLUSION**

Fractionation of soil Boron provides insights for qualitative and quantitative significance of B fractions. In general, Residual Boron forms the major fraction of Total Boron followed by Organically Boron, Specifically adsorbed Boron, readily soluble Boron and oxide bound Boron, respectively. Among all fractions, readily soluble Boron is the most available form for plant uptake. Transformation of readily soluble Boron to different fractions of B takes place at maturity of crop.

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