

## Chapter 6

# Recommended Soil Tests for Boron

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Responses to boron fertilization are limited to a few crops in the Northeast. As a result, routine analysis, interpretation, and recommendation for soil boron is generally limited to those crops known to be sensitive to boron deficiency. Many laboratories that test soils for B use some modification of the hot-water extraction procedure of Berger and Truog (1939). Those laboratories not using hot-water extraction for B may routinely use other common extractants, such as Mehlich 3 (DE) and  $\text{NH}_4\text{OAc}$ , pH 4.8 (ME, VT). This chapter provides alternative methods for hot-water extraction for B. Procedures for micronutrient extraction using the Mehlich 3, and acetate-based extractants are identical to those provided in Chapter Five of this bulletin ("Recommended Soil Tests for Macro and Micronutrients").

Hot-water extraction is often the method of choice for soil test B in most northeastern states, despite the limited field calibration data available for this test. Some laboratories use Mehlich 3 extraction for B because this method was shown by Shuman et al. (1992) to be well correlated with hot-water extractable B. In internal comparisons at the University of Maine, B extracted by modified Morgan was not significantly different from hot-water extractable B within the soil pH range of 6 – 7. However, modified Morgan extracted significantly less B from low pH (< 6) soils and significantly more B from high pH (> 7) soils than did the hot water method.

The hot-water extraction method recommended in this chapter actually uses a dilute calcium chloride solution and is similar to the method of Watson (1988) in *Recommended Chemical Soil Test Procedures for the North Central Region*. It is a rather time-consuming method and requires specialized glassware for the extraction phase. Another extraction method that uses boiling plastic bags offers promise as a means to decrease the time required for B extraction from soils (Mahler et al., 1984).

Once extracted, B can be determined either colorimetrically using azomethine-H or curcumin or by ICP. The azomethine-H method is described in this chapter and is recommended for laboratories without an ICP because it is rapid, reliable, and requires much less sample preparation and handling than the curcumin method.

Use of low-B (aged) glassware or plasticware is critical for accurate, reproducible B analyses. If glassware is used it is highly recommended that all samples be run in replicate, to isolate and eliminate random contamination that can occur from contact with any borosilicate glass, regardless of its age.

## Hot Water Extractable Boron

### Equipment:

1. Spectrophotometer that can measure absorbance at a wavelength of 420 nm.
2. Reflux condenser, water-cooled and boiling flasks of low-boron glass (from multiple uses).
3. Standard 10 g stainless steel scoop.
4. Centrifuge and plastic centrifuge tubes.

### Reagents:

1. **Extracting solution (10 mM CaCl<sub>2</sub>)**: Dissolve 1.5 g of CaCl<sub>2</sub>•2H<sub>2</sub>O in a 1 L volumetric flask containing ~ 600 mL of deionized water. Make to volume with deionized water and mix thoroughly.
2. **Buffer-masking solution**: Dissolve 250 g of ammonium acetate and 15 g of ethylenedinitrilo-tetracetic acid disodium salt (EDTA-Na<sub>2</sub>) in 400 mL of deionized water in a 1 L plastic beaker. Slowly add 125 mL of glacial acetic acid and mix thoroughly.
3. **Azomethine-H**: Dissolve 0.45 g of azomethine-H in exactly 100 mL of 1% L-ascorbic acid solution. This reagent should be prepared fresh each week and stored in a refrigerator when not in use.
4. **Boron Stock Solution (1000 mg/L)**: Weigh 5.716 g boric acid (H<sub>3</sub>BO<sub>3</sub>) into a 1 L volumetric flask and dilute to volume with deionized water.
5. **Boron Stock Solution (20 mg/L)**: Pipette 20 mL of the 1000 mg/L B stock solution into a 1 L volumetric flask. Make to volume with deionized water.
6. **Boron Working Standards**: Dilute either 0, 1, 2, 4 or 5 mL of the 20 mg/L B stock solution to volume in 100 mL volumetric flasks. This gives a series of working standards with B concentrations of 0, 0.2, 0.4, 0.8 and 1.6 mg B/L.

### Procedure:

#### Extraction

1. Scoop 10 cm<sup>3</sup> or weigh 10 g of air-dried, sieved soil into a low-B boiling flask capable of use with a water-reflux condensing apparatus. See Chapter 2 for details on soil sample preparation and scooping technique.

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2. Add 20 mL of B extracting solution to the flask, attach to the condenser.
- 2a. *Alternatively, if refluxing apparatus is not available, follow the method of Jeffrey & McCallum (1988): use small plastic funnels as condensers, weigh the flask with soil and extracting solution (without funnel) to 0.01 g and record the weight on the flask. Place the funnel on the flask before heating.*
3. Heat the flasks until initiation of boiling, and then reflux the suspension for 5 - 15 minutes. Allow to cool slightly (2-3 minutes) before removal from condenser. For funnel-flask extractions, remove the funnel and immediately place the flask with soil and extracting solution on a balance and add hot deionized water to attain original recorded weight. Swirl to mix.
4. Immediately transfer the solution to a plastic centrifuge tube and centrifuge for 15 minutes at 2700 g. Decant an aliquot from the supernatant of the centrifuge tube for analysis. It may be necessary to filter the supernatant solution to remove particulate matter.
- 4a. *Alternatively, filter the suspension, while still warm, through Whatman No. 42 filter paper, catching the filtrate in plastic sample bottles.*
5. Inspect supernatant solution or filtrate for clarity and refilter if necessary. For colorimetric B analysis: if the filtrate is yellow in color, refilter with < 1/8 teaspoon of activated charcoal in the filter paper cone (McGeehan et. al., 1989).

### **Analysis:**

1. Pipette a 1 mL aliquot of soil extract into a plastic tube or small plastic beaker.
2. Add 2 mL of the Buffer-masking solution and mix thoroughly by swirling.
3. Add 2 mL of Azomethine-H solution and mix contents thoroughly.
4. Allow mixture to stand 30 minutes, then measure absorbance at a wavelength of 420 nm.
5. Prepare a standard curve by adding 1 mL of each of the working standards to a plastic tube or beaker; add Buffer-masking solution and Azomethine-H in an identical manner as with soil extracts. Determine absorbance of standards and compare results of samples with those from a standard curve.
- 5a. *Alternatively, extracts can be analyzed by ICP against calibration standards made up in extracting solution.*

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6. Soil B = extract-B(mg/L) X 2. Report results in mg/dm<sup>3</sup> (for scooped samples) or mg/kg (for weighed samples). If replicate analysis was performed, discard any replicates >10 % high as probable contamination. Otherwise, report average results.

**References**

1. Berger, K. C. and E. Truog. 1939. Boron determination in soils and plants. *Ind. Eng. Chem. Anal. Ed.* 11:540-545.
2. Jeffrey, A.J. and L.E. McCallum. 1988. Investigation of a hot 0.01M CaCl<sub>2</sub> soil boron extraction procedure followed by ICP-AES analysis. *Commun. Soil Sci. Plant Analysis.* 19: 663 – 673.
3. Mahler, R. L., D. V. Naylor, and M. K. Fredrickson. 1984. Hot water extraction of boron from soils using sealed plastic pouches. *Comm. Soil Sci. Plant Anaysis* 15:479- 492.
4. McGeehan, S.L., K. Topper, and D.V. Naylor. 1989. Sources of variation in hot water extraction and colorimetric determination of soil boron. *Commun. Soil Sci. Plant Analysis* 20: 1777-1786.
5. Shuman, L. M., V. A. Bandel, S. J. Donahue, R. A. Isaac, R. M. Lippert, J.T. Sims, and M. R. Tucker. 1992. Comparison of Mehlich 1 and Mehlich 3 extractable soil boron with hot-water extractable boron. *Commun. Soil Sci. Plant Analysis* 23:1-4.
6. Watson, M. E. 1988. Recommended soil boron test. p. 23-25. *In* W. C. Dahnke (ed.) *Recommended Chemical Soil Test Procedures for the North Central Region.* North Dakota Agric. Expt. Stn. Bull. No. 499.

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