VARIATIONS IN EXTRACTABLE BORON USING THREE EXTRACTION METHODS ON BORON-TREATED INCUBATED SOILS

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ABSTRACT
Pressurized hot water extraction compared favorably to the more difficult hot water extraction on 40 untreated western soils and predicted boron (B) uptake in three Rosaceae species collected from various soil sites in Utah. Under other conditions, DTPA-Sorbitol compared favorably to hot water extraction. No work has been reported comparing the three extraction methods on incubated soils treated with varied amounts of B. In this experiment all three soil tests were used to extract B from sandy and silt loam soils previously treated with 10 levels of B and incubated for 7 and 28 d. High correlations (R^2 of 0.95 to 0.99) were observed between extractable B and rate of B application with all three procedures. The soils incubated for 7 days produced lower extractions than those incubated for 28 days with DTPA-Sorbitol and pressurized hot water. The amount of B extracted increased as the rate of B application increased with all three soil extraction methods. Hot water generally extracted the least and pressurized hot water the most B regardless of soil type, rate of application or duration of incubation. Because of the ease and relatively rapid nature of extracting soil available B with pressurized hot water, we recommend it be used in lieu of hot water or DTPA-Sorbitol extraction.

INTRODUCTION

Total B in soils typically ranges from 20 – 200 mg kg^{-1}, the major determining factor being parent material. Although the plant available fraction is small, ranging from 0.4 to 5.0 mg B kg^{-1}, these quantities generally meet the needs of agronomic crops, 0.4 – 1.0 mg B kg^{-1}. Boron availability is modified by factors such as pH, soil texture, soil moisture, temperature, organic matter and clay mineralogy.

Soil B tests must determine nutrient status of the soil relative to plant needs under a wide range of conditions including estimation of deficient and toxic levels for different plant species. Currently, the standard plant available soil B test is a hot water extractable method (HW; Berger and Truog, 1939; Mahler, 1984). This procedure has various challenges that result in inconsistent or sporadic use by many laboratories. Clientele often see little need to incur extra costs associated with B testing. Practitioners desire alternative extraction methods that are easier to use. The use of a simple extraction that includes B would address these problems.

There are currently several extraction methods that are plausible alternatives for use in arid soils. Two of these are DTPA-Sorbitol (Miller et al., 2001) and pressurized hot water (Webb et al., 2002). Both methods have been correlated to extraction values obtained with the hot water method. Diethylenetriaminepentaacetic acid (DTPA) is broadly used to extract copper (Cu), iron (Fe), manganese (Mn) and zinc (Zn). Certain organic molecules, i.e. sorbitol, act as chelating agents for B and could be used for extraction. The DTPA-Sorbitol extraction method combines DTPA and sorbitol. It offers multi element extraction capability but requires monitoring of microbial contamination under routine analysis. Recently, the pressurized hot water method was proposed for extraction of plant available B. This method extracts B as it forces boiling, pressurized distilled water through soil. This procedure offers simplicity, no hazardous chemical use, speed and low cost. Studies of cultivated soils treated with levels of B comparing these three extraction methods have not been reported. Our objective was to compare three soil boron extraction methods in two soil types treated with 10 levels of B and incubated for 7 and 28 days.

METHODS

Two soils (Hayeston sand and Minidoka silt loam) were air dried (25 - 30°C), screened (5-mm) and mixed vigorously. Two hundred g samples were placed in 250 ml plastic bottles with screw on lids. Individual samples were mixed with 0, 0.125, 0.25, 0.5, 1.0, 2.0, 3.0, 4.0, 6.0 or 8.0 mg B kg^{-1} (4 replications), brought to field capacity and incubated for 7 and 28 days. The subsamples taken after 7 d incubation and the soil remaining after 28 d incubation were air dried (25°C), screened (2-mm) and analyzed for available B by the three extraction methods.

Analysis of soil and plant for B were accomplished as follows: (a) For hot water, 20 g of soil, 40 ml of distilled water and 0.5 ml of 10% $BaCl_2$ are heated to boiling and boiled for 14 minutes in plastic pouches. The extract is filtered through medium filter paper. (b) For pressurized hot water, boiling water (100 ml, 93˚ C) under 0.25 Mpa pressure produced by espresso machine is forced through 5.0 g of soil that is placed on medium filter paper. The extract is collected in a plastic cup. (c) For DTPA-Sorbitol, 12.5 g soil and 25 ml 0.2 M DTPA-Sorbitol solution are mixed, shaken for 2 hours, centrifuged and filtered through medium filter paper. (d) For B analysis, filtrate from each extraction method was analyzed using Inductively Coupled Plasma Spectrometer (ICP).

RESULTS AND DISCUSSION

The amount of B extracted increased as the rate of B application increased with all three soil extraction methods (Figure 1). Regression coefficients associated with regression of extractable B and rate of B application were high with all three procedures. R^2 values ranged from 0.955 to 0.998 for HW, from 0.988 to 0.997 for pressurized hot water and from 0.991 to 0.998 for DTPA-Sorbitol. Thus, all three procedures predicted extraction of soil applied B. Webb et. al (2002) compared hot water and pressurized hot water extractions on 40 untreated arid soils and observed less predictable linear relationships (R^2 = 0.68). In general, hot water extracted the least B and pressurized hot water the most regardless of soil type, rate of B application or duration of incubation. The most B extracted was 5.6 mg kg^{-1} with HW, 8.6 mg kg^{-1} with DTPA-Sorbitol and 12.5 mg kg^{-1} with pressurized hot water. DTPA-Sorbitol and pressurized hot water acted similarly in that they extracted more B after incubation while hot water extracted more before than after incubation (Figure 1). With 40 untreated soils, pressurized hot water always extracted more B than hot water. This was reflected in the regression equation developed (Webb et al, 2002).

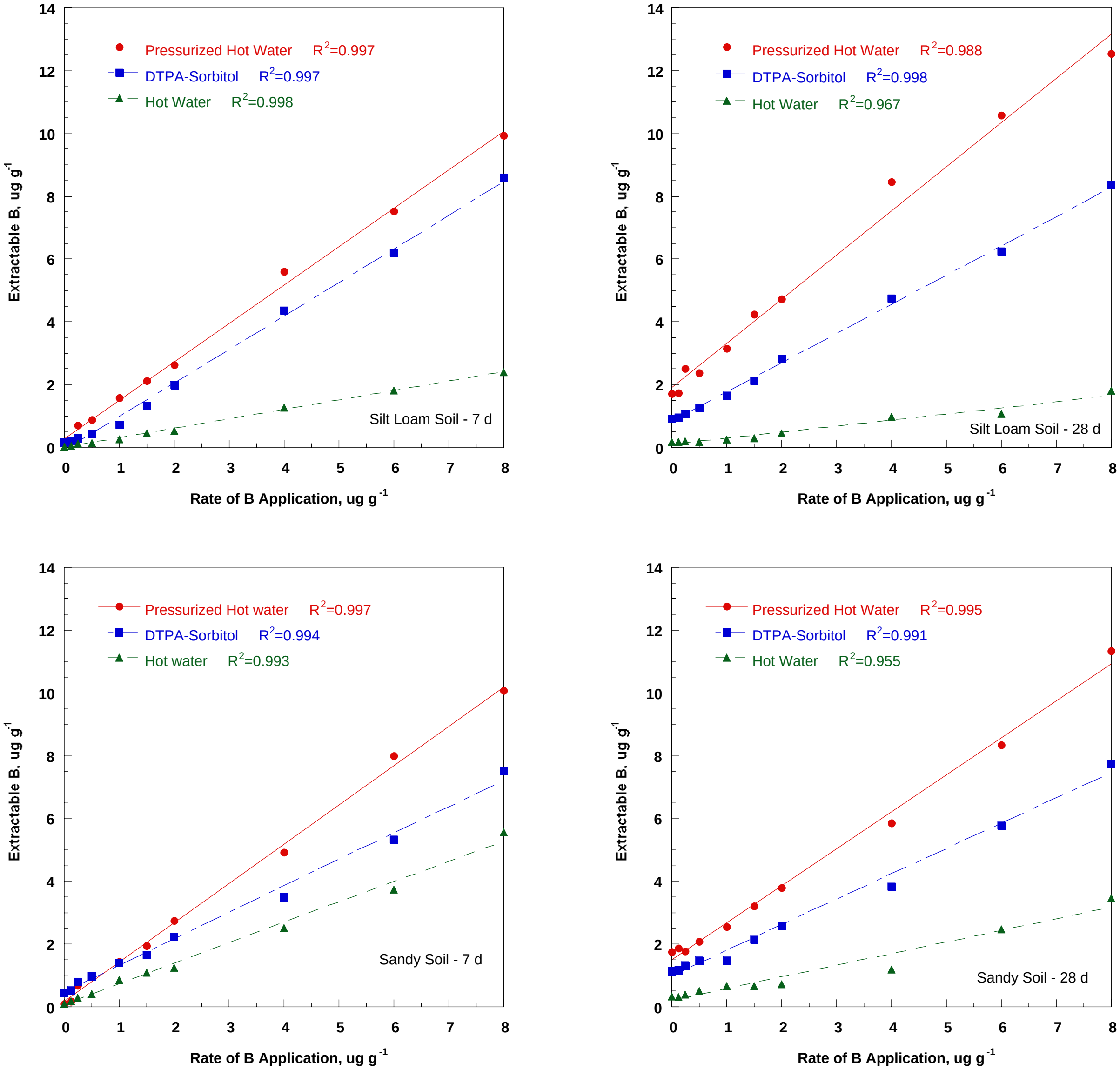

Figure 1. Relationships between B application and extractable B in two soils incubated for 7 and 28 d using three extraction methods.

CONCLUSION

R^2 values associated with regression of extractable B and rate of B application for pressurized hot water (0.988 to 0.997) were comparable to those obtained from hot water extraction (0.955 to 0.998) and DTPA-Sorbitol (0.991 to 0.998). Due to the similar correlations and the ease and relatively rapid nature of extracting soil available B with pressurized hot water, we recommend it be used in lieu of hot water or DTPA-Sorbitol extractions.

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