BORON FERTILIZATION IN POTATO

B.G. Hopkins[1], V.D. Jolley[1], B.L. Webb[1], J.W. Ellsworth[2], and R.K. Callahan[1]
[1]Brigham Young University, Provo, UT
[2]Wilbur-Ellis, Pasco, WA

ABSTRACT

The high value of potato (*Solanum tuberosum* L.), its inefficient rooting system and the low organic matter content of sandy soils on which potatoes are cultivated result in widespread application of boron (B) and other micronutrients. However, in times of cost trimming, B may become an omitted input regardless of soil test values. Further, soil tests for B may need to be updated for higher yields, better management or improved soil test methods. Russet Burbank potato was grown at two locations in southeastern Idaho in 2004 and one location in 2005. Five replications of 0 and 2.2 kg B ha^{-1} soil applied before planting were used in 2004. One experiment was conducted in 2005 with six replications of four treatments of 0 and 3.3 applied at hilling, 3.3 at tuberization and 0.22 foliar applied at tuberization (kg B ha^{-1}). Original soil tests were near or below 0.5 mg kg^{-1} hot water extractable B in both years, and mid to late season soil samples from untreated areas were slightly above 0.5 mg kg^{-1}. Neither foliar nor soil B application impacted total or US No. 1 tuber yields in either year nor did the application of soil B at tuberization in 2005 improve yields. Soil test values for all four soil extraction techniques were effective in quantifying the early season B application but not the soil application at tuberization. That the soil test B would not increase with a low foliar application at tuberization as observed is not surprising. Consequently, pressurized hot water, DTPA-Sorbitol and Mehlich III were not eliminated as potential substitutes for the laborious hot water extraction, but studies with positive yield responses are still needed. Three field sites with six application methods including combinations of soil, fertigation and foliar B applications at different growth stages were completed in 2006, and data is currently being analyzed.

INTRODUCTION

Potato is a crop of major economic importance in the irrigated Western US. Much of the most productive, intensively cultivated regions in these states (e.g. Snake River Plain, Columbia Basin, San Luis Valley, San Joaquin Valley, etc.) are dominated by potato cropping systems. Only grain, bean, and cotton crops exceed potato in terms of row crop production value and acreage nationally. Potato growers pride themselves in proper fertilization and care of the high value potato crop, with input costs ranging from $1500 to $2500 per acre. Historically, potato growers apply micronutrient fertilizers including boron (B) to potato. The high value of the crop, the inefficient rooting system, and the commonly deficient low organic matter, sandy soils favorable to potato production have resulted in growers and agronomists applying B and other micronutrients to potato, often without regard to soil test values. Low potato prices result in growers trimming costs of production and B may be an omitted input. As a result, B soil test values are thought to be declining and the incidence of B deficiency increasing.

Although soil test calibration work for B on potato is available, the information is dated and based on relatively low yields or is questionable because of better extraction techniques that have

never been calibrated. Currently, hot water extraction is the most widely used soil B test to estimate plant available B (Berger and Truog, 1939; Mahler et al., 1984) but has various challenges that promote sporadic use among laboratories or lead to guessing or estimating B needs rather than assessment. Practitioners desire alternative extraction methods that are easier to use. Pressurized hot water, DTPA-sorbitol and Mehlich III are gaining interest because of simplicity, low costs, or the desire for a universal extractant (Mehlich, 1984; Miller et al., 2001; Shiffler et al., 2005a, 2005b; Webb et al., 2002). Further research to calibrate soil test B levels from various soil extracts with fertilizer response in high yielding potato is needed. Timing and method of application could also impact potato response to B and these ideas were included in the 2005 experiment. The objective of this research is to determine if application of B to potato at different times during the growing season and with different methods impact potato yields or is reflected in available B by four extractants

MATERIALS AND METHODS

Three B experiments were conducted in 2004-2005 in Southeastern Idaho (near Blackfoot or Fort Hall) on sandy or sandy loam soils using randomized complete block designs. In 2004, two were conducted with five replications of two treatments (kg B ha^{-1}): 0 and 2.2 soil applied before planting. In 2005, one was conducted with six replications of four treatments (kg B ha^{-1}): 0 and 3.3 applied at hilling, 3.3 at tuberization and 0.22 foliar applied at tuberization. Plots were four, 90-cm rows by 12 m long. Russet Burbank variety of potato was planted on 30-cm spacing in late April or early May in each year. The middle 6.1 m of the two middle rows (1.8 m) were harvested and weighed in mid to later September each year. Standard grower practices were followed, but no additional B was applied at any time. Soil samples were taken before planting and of every plot at harvest. Soils were air dried and ground to pass 2 mm screen. Analyses were performed at the Soil and Plant Analysis Laboratory, Brigham Young University, Provo, UT, using hot water, pressurized hot water, DTPA-Sorbitol and Mehlich III extractions as described below:

Hot Water: 20 g of soil mixed with 40 ml of distilled water and 0.5 ml of 10% BaCl2 in plastic pouches; mixture heated to boiling; boiled for 14 minutes; extract filtered through medium filter paper

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 and collected in a plastic cup

DTPA-Sorbitol: 12.5 g soil and 25 ml 0.2 M DTPA-Sorbitol solution are shaken for 2 hours, centrifuged and filtered through medium filter paper

Mehlich III: 2.5 g soil and 25 ml Mehlich III extraction solution are shaken for five minutes, filtered through medium filter paper and collected in plastic bottle

B Analysis: Filtrate from all extraction methods was analyzed for B using Inductively Coupled Plasma Spectrometer (ICP)

RESULTS

Yield of Russet Burbank potato were not affected by B application in either 2004 or 2005 (Table 1 and Table 2). Boron application at tuberization with soil (3.3 kg ha^{-1}) or foliar (0.22 kg ha^{-1}) applications did not promote increased yields in 2005 (Table 2). Initial soil tests were consistently near or below 0.5 mg kg^{-1} hot water extractable B (data not shown). Note that the mid to late season hot water extractable B levels were slightly above 0.5 mg kg^{-1} hot water

extractable B where little or no B had been applied (Table 3 and 4). In both years, soil test B after all treatments had been imposed reflected the initial soil B application rates and all four soil extractants reflected the differences. Average extractable soil B (mg B kg^{-1}) for the 0 and 2.2 kg ha^{-1} B applications were 0.51 and 0.78 for hot water, 1.02 and 1.50 for pressurized hot water, 0.73 and 0.97 for DTPA-Sorbitol, and 1.50 and 1.80 for Mehlich III extraction. (Table 3). The 3.3 kg ha^{-1} B application at hilling was consistently higher than other B treatments with all four extractants (Table 4). Thus, soil tests generally reflect B applications made, but do not predict yield responses.

CONCLUSIONS

- Potato yield response to B was not observed in either year despite the original soil test level suggesting potential response.
- Applying B at tuberization to the soil or the foliage did not improve yield response.
- Boron levels in soil extracts using hot water, pressurized hot water, DTPA-sorbitol and Mehlich III extractions were generally consistent with amount of B applied.

Table 1. Yield of Russet Burbank potato at two rates of B at two locations in Southeastern Idaho in 2004.

	B Rate, kg ha^{-1}		
Location- Grade	0	2.2 Soil Applied	Significance $p<0.05$
	Yield, t ha^{-1}		
Blackfoot - US No.1	50.7	52.9	NS
Blackfoot - Total	63.8	65.2	NS
Fort Hall- US No. 1	41.9	44.4	NS
Fort Hall - Total	56.0	58.9	NS

Table 2. Yield of Russet Burbank potato with different B treatments in 2005.

	Yield, t ha	
B Treatment, kg ha^{-1}	US No.1	Total
0	25.0	46.1
3.3 at hilling	23.6	46.6
3.3 at tuberization	23.8	45.9
0.22 foliar at tuberization	27.1	46.7
Statistical Significance	NS	NS

Table 3. Extractable B (mg kg^{-1}) at 0 and 2.2 kg ha^{-1} B application as extracted by four methods.

	Boron Treatment, kg ha^{-1}		
Soil Test	0	2.2 Soil Applied	Significance P < 0.05
Hot Water	0.51	0.78	*
Pressurized Hot Water	1.02	1.50	*
DTPA – Sorbitol	0.73	0.97	*
Mehlich III	1.50	1.80	*

Table 4. Boron soil tests with four B treatments measured with four soil extractants

	Soil Extractant, mg B kg^{-1}			
B Treatment, kg ha^{-1}	Hot water	Pressurized Hot Water	DTPA- Sorbitol	Mehlich III
0	0.57	2.03	0.28	1.49
3.3 at hilling	0.93	2.90	0.86	2.28
3.3 at tuberization	0.66	2.30	0.46	1.77
0.22 foliar at tuberization	0.52	2.02	0.32	1.48
LSD	0.13	0.27	0.23	0.29

REFERENCES

Berger, K.C., and E. Truog. 1939. Boron determination in soils and plants. Ind. Eng. Chem., Anal. Ed. 11:540-545.

Mahler, R.L., D.V. Naylor, D.V. and M.K. Fredrichson. 1984. Hot water extraction of boron from soils using sealed plastic pouches. Commun. Soil Sci. Plant Anal. 15:479-492.

Mehlich, A. 1984. Mehlich III soil test extractant: A modification of Mehlich II extractant. Comm. Soil Sci. Plant Anal. 15:1409-1416.

Miller, R.O., B. Vaughan, and J. Kotuby-Amacher. 2001. Extraction of soil boron with DTPA-sorbitol. The Soil – Plant Analyst. Spring:4-5, 10.

Shiffler, A.K., V.D. Jolley, D.C. Farrer, J.E. Christopherson, B.L. Webb, and.V.A. Haby. 2005a. Pressurized hot water and DTPA-Sorbitol, viable alternatives for soil boron extraction. I. Boron-treated soil incubation and efficiency of extraction. Comm. Soil Sci. Plant Anal. 36:2179-2187.

Shiffler, A.K., V.D. Jolley, J.E. Christopherson, V.A. Haby and. B.L. Webb. 2005b. Pressurized hot water and DTPA-Sorbitol, viable alternatives for soil boron extraction. II. Correlation of soil extraction to responses of boron-fertilized alfalfa. Commun. Soil Sci. Plant Anal. 36:2189-2207.

Webb, B.L., D.H. Hanks and V.D. Jolley. 2002. A pressurized hot water extraction method for boron. Commun. Soil Sci. Plant Anal. 33:31-39.