Soybean Response to Soil and Foliar Boron Applications

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RESEARCH PROBLEM AND BACKGROUND INFORMATION

Boron deficiency of soybean [*Glycine max* (L.) Merr.] has been routinely observed in numerous soybean fields in northeast Arkansas since 2001. Boron deficiency of soybean has not previously been recognized as a common problem in Arkansas and research-based fertilization recommendations are not available. Slaton et al. (2002) noted that B deficiency frequently occurred during the vegetative growth stages of soybean, which lead to a provisional recommendation for growers to apply 1 lb B/acre near the time of seeding. These tentative B fertilization recommendations were made as a short-term remedy while research was initiated to collect replicated field data that would refine recommendations by defining the proper B rates and times of application.

In 2002, B deficiency was not observed or reported on fields that received preplant-B applications, but was again observed in numerous fields that did not receive B. This report describes the results of research trials initiated at the University of Arkansas Agricultural Experiment Stations during 2002. The overall objective of these studies was to evaluate soybean yield response to B fertilizer application rate and time (i.e., growth stage).

PROCEDURES

Foliar-B Application Study

A single study was established at the Pine Tree Branch Station (PTBS) located near Colt, AR, to evaluate the rate and growth stage of B application on soybean yield. The soil at the PTBS is an alkaline Calhoun silt loam, which is very similar to the soils where B deficiency has been documented. Selected soil chemical properties (4-inch sample depth) at the time of seeding are listed in Table 1. Rice (*Oryza sativa* L.) was grown on the test site in 2000 and 2001. 'Caviness' soybean was seeded in 15-inch rows on 30 May 2002. Phosphorus and K fertilizers (0-40-150) were applied to ensure P and K were not yield-limiting factors. Boron was applied at rates of 0, 0.25, 0.5, 1.0, and 2.0 lb B/acre at the V4 and R2 growth stages. The appropriate amount of Solubor (17.5% B), equal to each B rate, was mixed with water and applied to soybean foliage with a CO_2 backpack sprayer calibrated to deliver 10 gal/acre. The B treatments were arranged as a randomized complete block, 2 (growth stage) × 4 (B rate) factorial with an untreated check [0 lb B/acre (application rate) and none (application time)] and six replications.

Soil-Applied B Studies

Two studies were initiated to evaluate the effect of preplant soil B applications on soybean yield at the PTBS and at the Rice Research Experiment Station (RREC), near Stuttgart, AR. The residual effect of the B fertilizer rates applied in 2002 will be considered in tests on these same plots in 2003 and 2004. The soil at the PTBS is an alkaline Calhoun silt loam and was cropped to rice in 2000 and 2001. The soil at the RREC is a DeWitt silt loam and was fallow in 2001. Lime (8,000 lb/acre) was applied in March of 2002 at the RREC to increase soil pH (~5.5) and increase the likelihood of B deficiency. Boron-deficient soybean had not previously been observed at either location. Selected soil chemical properties (4-inch sample depth) for each site at the time of seeding are listed in Table 1.

At each location, 'Caviness' soybean was seeded in 15-inch rows on 30 May and 22 May at the PTBS

and the RREC, respectively. Boron rates of 0, 1, 2, 4, 6, and 8 lb B/acre were applied to the soil surface at each site after seeding but before soybean emergence. At the PTBS, B was applied as a solution using Solubor (17.5% B) as the B source. The 1 lb B/acre rate was mixed with water and sprayed with a CO_2 backpack sprayer calibrated to deliver 10 gal/acre. Plots receiving B rates > 1.0 lb B/acre were sprayed multiple times until the desired rate was applied. At the RREC, Granubor (15% B) was uniformly broadcast by hand to each plot. Phosphorus and K fertilizers (0-40-150) were applied to each location to ensure P and K were not yield-limiting factors. The experiment was arranged in a randomized complete block design with six replications.

All test sites were flood-irrigated as needed throughout the growing season. At maturity, soybeans from all three studies were harvested by combine. Soybean yields were adjusted to a uniform moisture content of 13% for statistical analysis. Analysis of variance procedures were conducted with the PROC GLM procedure in SAS. Mean separations were performed by Fisher's protected least significant difference (LSD) at a significance level of 0.05 or 0.10.

RESULTS AND DISCUSSION

Foliar-B Application Study

Although excellent soybean yields were produced, yields did not respond to B fertilizer rate, time of application, or the interaction between the two main effects. Soybean yields for each B treatment are given in Table 2. Analysis of soybean tissue and harvested seed for B concentration has not been completed and will be reported in the 2003 report. The soil pH (7.9) and Mehlich 3-extractable B (0.9 mg B/kg soil) were typical of silt loam soils used for rice and soybean production in eastern Arkansas. However, Mehlich 3-extractable B, which is approximately 2× the B concentrations extracted by the hot water method (unpublished data from North American Proficiency Testing Samples), was slightly higher than the soil B (0.10 to 0.45 mg B/kg soil) reported in deficient fields during the growing season by Slaton et al. (2002).

Soil-Applied B Studies

Visual symptoms of B deficiency or toxicity were not observed in either study. Soybean yields were not significantly affected by preemergence soil-B applications at the RREC (Table 2). Excessive rainfall following seeding resulted in stand reduction and poor growth of some plots and is reflected by a high C.V. (18.4%) at this location. At the PTBS, preemergence B application rate significantly affected soybean yields (Table 3), however the unfertilized control yield was statistically similar to yields of all B application rates. The yield data suggest a trend for soybean yield reduction when B application rates exceeded 4 lb B/acre. Analysis of the soybean leaf tissues, which are not yet completed, collected at the R2 growth stage should indicate whether this trend is real or merely variation within the test area.

PRACTICAL APPLICATIONS

The single year of data collected in 2002 indicated B was not a yield-limiting factor at the test sites and indicates that a better understanding of the soil properties associated with B deficiency of soybean is needed. Research efforts located in grower fields, close attention to soil and environmental characteristics in B-deficient fields, and results from a statewide nutrient-concentration survey of soybean tissues obtained from commercial fields should provide further insight concerning the need for B fertilization of soybean in Arkansas. Until several years and locations of research data can be obtained, growers in the areas where widespread B deficiency has occurred should likely continue to consider preplant-B applications of 1.0 lb B/acre, especially on fields with high pH (> 7.0) and low Mehlich 3-extractable B (< 1.0 lb Mehlich 3 B/acre or 0.5 mg B/kg soil).

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LITERATURE CITED

Slaton, N.A., L. Ashlock, J. McGee, E. Terhune, R. Wimberly, R. DeLong, and N. Wolf. 2002. Boron deficiency of soybean in Arkansas. *In*: N.A. Slaton (ed.). Wayne E. Sabbe Arkansas Soil Fertility Studies 2001. University of Arkansas Agricultural Experiment Station Research Series 490:37-41. Fayetteville.

Table 1. Selected soil chemical properties (samples taken to a depth of 4 inches) for three B fertilization of soybean studies conducted at the Pine Tree Branch Experiment Station and the Rice Research Extension Center during 2002.

		Mehlich 3-extractable soil nutrients							
Location	pH	P	K	Ca	Mg	Fe	Mn	Zn	B
		(mg/kg[z])							
PTBS[y]	7.9	23	104	2048	327	322	120	1.9	0.9
PTBS[x]	6.5	20	96	1629	289	318	107	1.5	0.8
RREC[x]	7.8	10	102	942	183	224	138	0.7	0.7

[z] Values are the mean of 6 composite samples from the 0- to 4-inch soil depth collected from each unfertilized control of each study. Samples were extracted with Mehlich 3 solution at a soil:solution ratio of 1:10.
[y] Boron rate and growth stage of application study.
[x] Preemergence, soil-applied B rate studies.

Table 2. Soybean (Caviness) yield response to B application time and rate at the Pine Tree Branch Experiment Station during 2002.

	Time of foliar B application	
B application rate	V4 stage	R2 stage
(lb B/acre)	[soybean yield, bu/acre (adjusted to 13% moisture)]	
0	72.4	
0.25	76.8	72.5
0.5	66.0	73.0
1.0	76.2	70.3
2.0	69.3	69.2
Time mean	72.1	71.2
LSD (0.10)	NS[z]	

[z] NS = not statistically significant.

Table 3. Soybean yield response to B application rate at the Pine Tree Branch Experiment Station (PTBS) and the Rice Research Extension Center (RREC) during 2002.

	Soybean yield	
B application rate	PTBS	RREC
(lb B/acre)	[bu/acre (adjusted to 13% moisture)]	
0	70.6	50.5
1	71.4	51.8
2	69.4	50.4
4	76.0	48.2
6	66.6	45.4
8	65.6	43.7
P-value	0.0892	0.6431
LSD (0.10)	6.1	NS[z]

[z] NS = not statistically significant.