FOLIAR FERTILIZATION OF SOYBEANS IN MISSOURI

DALE G. BLEVINS AND TIM M. REINBOTT
UNIVERSITY OF MISSOURI
COLUMBIA, MISSOURI

ABSTRACT

Soybeans may benefit from foliar fertilization during the reproductive phase of growth. Foliar fertilizers consisting of factorial combinations of boron, calcium, magnesium and phosphorus were applied to soybeans every other week for eight weeks beginning at flowering at three locations. The foliar fertilization treatment containing B+Mg (1.0 lb/acre B + 2.0 lb/acre Mg total) and split into four applications at Mt. Vernon and the Delta Center increased yields by 8 and 4 bu/acre, respectively. The same treatment, with only two sprays at Bradford yielded 4 bu/acre more than the control. This is roughly 480, 240 and 240 lbs/acre of increased soybean production at each location, respectively, with the application of only "trace" quantities of B and Mg. This treatment increased final yield by increasing total seeds/plant and seed size. The leaves probably remained photosynthetically active longer than leaves from control plots based on the nutrient and chlorophyll results. With more sucrose available from photosynthesis and more Mg in these leaves, more sucrose could be translocated to the developing seeds in pods on the main stem and on branches.

INTRODUCTION

Boron and calcium are required for pollen germination, pollen tube growth and the directional growth of pollen tubes. Pollen tubes grow toward increasing concentrations of calcium and boron, therefore these elements are especially important during reproductive growth of plants. Both calcium and boron are relatively phloem immobile so these elements reach the reproductive organs mainly via xylem. Calcium and boron sprayed on floral structures during reproductive growth may increase seed number in grain crops. The developing seeds on reproductive annual grain crops become powerful sinks for carbohydrates and nutrient elements. These sinks may become relatively more powerful than roots and root function may be limited by lack of carbohydrate. The nutrient

element with the highest harvest index is phosphorus, therefore reproductive sinks may drain leaves of phosphorus thus limiting photosynthesis, starch to sucrose conversions, and sucrose transport. Loss of magnesium from leaves also may damage photosynthesis and carbohydrate mobilization. Therefore both phosphorus and magnesium may be important as foliarly applied nutrients in reproductive plants. For the above reasons, a combination of boron, calcium, magnesium and phosphorus foliarly applied at flowering may increase soybean yields.

OBJECTIVE

To determine the effects of foliar boron, calcium, magnesium and phosphate on yield components, leaf nutrients and chlorophyll, and final seed yield of soybeans in Missouri.

MATERIALS AND METHODS

Studies on the foliar fertilization of soybeans were conducted at three locations in Missouri to reflect different soil types, different climates, and different cultivars (Table 1). A different cultivar was chosen for each location based on its performance in the 1989 variety trial at that location and its potential for branching. Locations, cultivars, planting dates, spraying dates and sampling dates are listed in Table 1. At Bradford farm in Columbia, foliar applications were either a combination of two sprayings early in the reproductive growth phase or four sprayings throughout reproductive growth. Spraying was begun at flowering and was conducted roughly every other week, weather permitting.

The chemicals used were: B as boric acid, Ca as calcium acetate, Mg as magnesium acetate and P as pentasodium tripolyphosphate. At each spraying a total of 0.25 lbs/acre of B, 0.5 lbs/acre of Ca, 0.5 lbs/acre of Mg and 1.0 lbs/acre of P was applied. We were limited to these quantities because higher rates of B caused tissue damage and higher rates of the other elements caused precipitation problems in mixtures.

Leaf samples were taken twice at each location for nutrient element analysis. At Bradford and Mt. Vernon, leaf samples were removed for chlorophyll analysis after we visually observed that plants in some treatments had retarded rates of senescence. After physiological maturity, plants at Bradford and Mt. Vernon were harvested for yield component determinations.

RESULTS AND DISCUSSION

Yield- The highest combine yields were 48.7. 46.8 and 42.7 bu/acre at the Delta Center, Bradford and Mt. Vernon, respectively (Table 2). These yields were approximately 4, 4 and 8 bu/acre above controls at each location, respectively. All three of these highest yields at each location were from the B+Mg treatment. Plots that received the B+Ca treatment had the second highest yields at both the Delta Center and Bradford (Table 2). Plots that received the P+Mg ranked third in yield at both Mt. Vernon and the Delta Center. At the Delta Center three of the top four yields (over 40 bu/acre) were from plots with B or a combination of B and Mg or Ca. In general, yields at Bradford with four sprayings were lower than those with two sprayings. At Bradford, in plots sprayed four times, we damaged plants in the center two rows of the four-row plots. The center two rows were the ones combined for total yield determinations. We obviously damaged many pod-bearing branches, while spraying, collecting leaf samples and taking photographs.

Yield Components -Yield components were determined from plants harvested at both Mt. Vernon (Table 3) and Bradford (data not shown). At Mt. Vernon, soybeans that received foliar B had significantly more branches than controls and were second highest in number of branch pods/plant (Table 3). These results confirm our observation over the last four years that foliar B increases final branch number and the number of pods on branches. Several of the treatments at Mt. Vernon increased seed weight, in fact, the B+Mg treatment increased the weight of branch seeds from 108 mg to 132 mg. This treatment increased the weight of branch seeds to that of main stem seeds. This is important since branch seeds tend to be smaller than main stem seeds. At Mt. Vernon, plants from the P+Mg treatment had the highest number of branch seeds/plant and these seeds were significantly larger than controls. Main stem seeds from the B+Ca+P treatment at Mt. Vernon were heaviest at 142 mg. This large seed size is explained by the fact that plants from that treatment had the lowest number of main stem seeds/plant (Table 3). Conditions or treatments that cause less seed set commonly result in larger seed size.

Leaf nutrient and chlorophyll concentrations-Mt. Vernon- Leaves from plants treated with P+Mg had the highest Mg and Ca concentrations at the R-6 growth stage (data not shown). Leaves treated with B+P had the highest K and P concentrations at R-6 and those treated with Mg+B had one of the highest Mg concentrations.

Leaves from the P+Mg, B+P and Mg+B treatments had among the highest total chlorophyll (a+b) concentrations (Table 4). When we began our work on B several years ago, one of our hypotheses, based on the literature, was that B might delay leaf senescence. In the past we have noticed that plants in some plots treated with foliar B have stayed green longer than controls, but we have never documented this observation. In 1990, as plants approached senescence we noticed visual differences in leaf color with treatment. Leaves that retained the highest chlorophyll concentrations late in the season were generally from plots that had received treatments containing B (Table 4).

Table 1. Locations, cultivars, planting dates, spraying dates, sampling dates and harvest dates for the foliar fertilization study on soybeans in 1990.

Location	Planting Date	Cultivar	Harvest Date
Bradford	May 30	Pioneer 9391	September 27
Mt. Vernon	June 8	Asgrow 4595	October 30
Delta Center	June 1	Pioneer 9581	November 6

Location	Spraying date	Growth Stage	Leaf Sampling date
Bradford	July 16	R-2	Aug. 9
	July 30	R-3	Sept. 7
	Aug. 13	R-4	
	Aug. 27	R-5	
Mt. Vernon	July 18	R-2	Aug. 16
	Aug. 1	R-3	Sept. 13
	Aug. 16	R-4	
	Aug. 30	R-5	
Delta Center	July 26	R-1	Aug. 22
	Aug. 9	R-3	Sept. 6
	Aug. 22	R-4	
	Sept. 6	R-5	

Table 2. Combine yields of soybeans from the foliar fertilization study at Mt. Vernon, Bradford Farm (Columbia, two and four sprayings) and the Delta Center.

Treatment	Mt. Vernon	Bradford		Delta Center
		2	4	
		bushels/acre		
Control	34.4	43.2	41.8	44.6
B	34.1	42.3	44.3	48.1***
Ca	39.9	44.7	41.2	46.8
P	39.2	44.3	41.3	46.0
Mg	35.4	43.6	42.4	44.7
B+Ca	33.5	45.1	43.3	48.7**
B+P	31.9	45.0	41.8	45.6
B+Mg	42.7*	46.8*	42.9	48.9*
Ca+P	36.1	43.4	41.9	46.7
Ca+Mg	36.6	44.0	43.1	46.4
P+Mg	39.3	43.8	44.0	48.6**
B+Ca+P	34.9	39.9**	41.9	46.0
B+P+Mg	38.0	42.5	41.5	44.3
B+Ca+Mg	38.4	44.6	41.9	45.4
Ca+P+Mg	31.9	41.9	44.1	47.9
B+Ca+P+Mg	34.4	41.6	43.1	46.1

*= significantly different from control at the 0.05 level
**=significantly different from control at the 0.10 level
***=significantly different from control at the 0.15 level

Table 3. Yield components of soybeans from the foliar fertilization study at Mt. Vernon in 1990.

treatment	br/pl	brpd/pl	mspd/pl	mswt/sd	bwt/sd	mssd/pd	bsd/pd
control	1.3	5.2	26.9	.115	.108	2.19	2.18
B	2.1***	9.4	30.8	.128	.127**	2.30	1.96
Ca	1.7	6.1	31.4	.131	.124**	2.30	2.06
P	1.5	7.3	32.3***	.134**	.116	2.31	2.21
Mg	1.7	6.4	25.8	.127	.122***	2.23	2.12
B+Ca	1.6	6.6	27.0	.119	.113	2.12	1.99
B+P	1.9	8.7	29.6	.118	.107	2.08	1.91
B+Mg	1.8	8.4	32.0***	.136**	.132*	2.29	2.05
Ca+P	1.4	5.7	32.3***	.132***	.125**	2.32	2.02
Ca+Mg	2.0	8.9	32.9**	.131***	.128*	2.24	2.03
P+Mg	1.8	10.0**	30.5	.131***	.128*	2.24	1.96
B+Ca+P	1.8	6.3	25.3	.142*	.116	2.09	1.81
B+P+Mg	1.6	7.2	32.9*	.130	.125**	2.13	1.90
B+Ca+Mg	1.6	6.6	30.7	.138	.114	2.19	2.43
Ca+P+Mg	1.2	4.9	26.8	.120	.113	2.07	2.45
B+Ca+P+Mg	1.8	7.2	28.5	.118	.111	2.23	1.75

br/pl=branches/plant brpd/pl=branch pods/plant mspd/pl=mainstem pods/plant
mswt/sd=mainstem weight/seed bwt/sd=branch weight/seed
mssd/pd=mainstem seed/pod bsd/pd=branch seed/pod

Table 3 continued.

treatment	pd/br	sd/br	tot sd	tot. pd/pl	mssd/pl	brsd/pl
control	4.1	8.8	70.5	32.1	59.1	11.4
B	4.6	9.1	89.7***	40.3***	71.8	17.9
Ca	3.4	7.1	85.9	37.4	73.2***	12.8
P	4.8	10.9	90.6***	39.7***	74.8***	15.8
Mg	3.7	7.6	70.4	32.1	57.1	13.3
B+Ca	4.1	8.1	70.2	33.5	57.3	12.9
B+P	4.2	8.2	78.4	38.3	61.7	16.7
B+Mg	4.5	9.3	92.1***	40.3***	74.1***	18.0
Ca+P	3.8	7.8	87.2	38.1	75.1***	12.1
Ca+Mg	4.7	9.6	91.5***	41.8**	73.8***	17.7
P+Mg	5.4***	10.5	88.3	40.4	68.7	19.5
B+Ca+P	3.7	6.6	63.6	31.6	52.2	11.4
B+P+Mg	4.5	8.5	83.3	40.1***	69.7	13.6
B+Ca+Mg	4.1	9.9	85.4	37.3	67.9	17.5
Ca+P+Mg	4.0	9.1	65.7	31.7	55.2	10.5
B+Ca+P+Mg	4.0	7.0	76.7	35.7	63.8	12.9

pd/br=pods/branch sd/br=seed/branch
tot.sd=total seed totpd/pl=total pods/plant mssd/pl=mainstem seed/plant
brsd/pl=branch seed/plant

Table 3 continued.

Treatment	mswt/pl	bwt/pl
control	6.8	1.2
B	9.2**	2.2***
Ca	9.7*	1.7
P	10.0*	1.9
Mg	7.3	1.6
B+Ca	6.9	1.5
B+P	7.3	1.9
B+Mg	10.0*	2.4***
Ca+P	9.9*	1.5
Ca+Mg	9.6**	2.3***
P+Mg	8.9***	2.5**
B+Ca+P	7.2	1.3
B+P+Mg	9.0***	1.7
B+Ca+Mg	9.6**	1.7
Ca+P+Mg	6.7	1.2
B+Ca+P+Mg	7.6	1.4

mswt/pl=mainstem weight/plant bwt/pl=branch weight/plant

*=significantly different from control at the 0.05 level
**=significantly different from control at the 0.10 level
***=significantly different from control at the 0.15 level

Table 4. Chlorophyll a and b analysis of soybean leaves at growth stage R-7 from the foliar fertilization study at Bradford Farm, Columbia, and Mt. Vernon in 1990.

Treatment	Bradford Chlorophyll A	Bradford Chlorophyll B	Mt. Vernon Chlorophyll A	Mt. Vernon Chlorophyll B
		ug/mg		
Control	2.25	7.58	5.70	5.14
B	4.21**	11.11*	5.18	6.19
Ca	2.53	6.96	5.65	5.93
P	4.63*	9.19	6.47	6.68
Mg	2.73	8.40	6.75	6.34
B+Ca	4.44**	10.94**	5.03	6.32
B+P	6.19*	13.47*	7.58*	6.88
B+Mg	3.88***	10.15***	6.34	7.16**
Ca+P	2.99	9.81	6.91	5.97
Ca+Mg	3.24	8.20	6.44	7.11***
P+Mg	4.15**	10.90**	6.82	7.46**
B+Ca+P	5.06*	10.95**	4.57	5.27
B+P+Mg	5.27*	10.64**	6.99***	7.04***
B+Ca+Mg	5.10*	11.87*	6.42	6.34
Ca+P+Mg	4.20**	9.68	5.89	6.57
B+Ca+P+Mg	4.68*	9.86	6.55	8.30*

*=significantly different from control at the 0.05 level
**=significantly different from control at the 0.10 level
***=significantly different from control at the 0.15 level

PROCEEDINGS OF THE TWENTY-FIRST

NORTH CENTRAL EXTENSION - INDUSTRY SOIL FERTILITY CONFERENCE

November 13-14, 1991, Holiday Inn St. Louis Airport

Bridgeton, Missouri

Volume 7

Program Chairman:

Randy Killorn

Department of Agronomy
Department of Agronomy
Iowa State University
Ames, IA 50011