The *Journal of Cotton Science* 4:171-177 (2000)
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ECONOMICS AND MARKETING

Soil- and Foliar-Applied Boron in Cotton Production: An Economic Analysis

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INTERPRETIVE SUMMARY

Boron deficiency in cotton may cause small, deformed bolls; poor fruit retention; and reduced lint yields. Boron is considered a micronutrient, which means only a low level of B is required by the plant. When recommended for improving yields, B may be applied either to the soil at or before planting or as a foliar application at or just prior to bloom. Use of an adjuvant with foliar-applied B may improve efficiency and increase lint yields.

Agronomic analyses exist that compare the effects on yields of soil- and foliar-applied B and of using an adjuvant with foliar-applied B, but a thorough economic analysis has not been performed. The objectives of this study were to determine: (i) the profitability of foliar-applied B compared with soil-applied B in cotton production; (ii) the economic benefit to cotton producers of foliar-applied B with an adjuvant; (iii) the influence of soil pH and the buffering properties of the adjuvant on the economic effectiveness of foliar-applied B.

Field experiments were conducted in 1993 through 1995 on a Collins silt loam soil at the West Tennessee Experiment Station in Jackson. Six treatments were evaluated: (i) a non-B check; (ii) soil-applied B at 0.50 lb acre^{-1}; (iii) four applications of foliar-applied B at 0.10 lb acre^{-1} per application (a total of 0.40 lb B acre^{-1}); (iv) four applications of foliar-applied B at 0.10 lb acre^{-1} per application on soils receiving 1000 lb acre^{-1} soil-applied ground agricultural limestone; (v) four applications of foliar-applied B at 0.20 lb acre^{-1} per application; (vi) four applications of foliar-applied B at 0.10 lb acre^{-1} plus the adjuvant Penetrator Plus (Helena Chemical Co. of Memphis, TN) added to the foliar solutions at 1.25% (v/v). The B source was Solubor DF (U.S. Borax, Valencia, CA).

The cultivar Deltapine 50 (DP50) was planted by mid-May each year. Plots were 30 ft long and four rows wide with cotton planted in 38-in rows.

Foliar-applying B four times at a rate of 0.10 lb acre^{-1} per application was clearly more profitable than foliar-applying B at double that rate. Foliar-applying B at 0.10 lb acre^{-1} per application and soil-applying B at the currently recommended rate of 0.50 lb acre^{-1} provided about the same net returns. Both application rates and methods were economically superior to not applying B.

Applying agricultural limestone did not reduce B availability to the crop. Foliar-applying B with an adjuvant was economically superior to both soil and foliar applications without the adjuvant. These results can help farmers make B application decisions. For example, although using an adjuvant with foliar-applied B may appear costly to cotton producers, the adjuvant may increase lint yields more than enough to offset its cost.

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ABSTRACT

Boron deficiency in cotton (*Gossypium hirsutum* L.) may be corrected with foliar or soil B applications, but a thorough economic analysis of soil- versus foliar-applied B has not been done. The objectives of this study were to determine: (i) the profitability of foliar-applied B compared with soil-applied B in cotton production; (ii) the economic benefit to cotton producers of foliar-applied B with an adjuvant; (iii) the influence of soil pH and the buffering properties of the adjuvant on the economic effectiveness of foliar-applied B. Field experiments were conducted in 1993 through 1995 evaluating soil and foliar applications of B to cotton produced on a Collins silt loam soil (coarse-silty, mixed, active, acid, thermic Aquic Udifluvents). Foliar-applying B four times at a rate of 0.11 kg ha^{-1} per application was clearly more profitable than foliar-applying B at

twice that rate. Foliar-applying B at the 0.11 kg ha^{-1} per application rate and soil-applying B at the currently recommended 0.56 kg ha^{-1} rate provided about the same net returns. Both methods were economically superior to not applying B. Applying agricultural limestone did not reduce B availability to the crop. Foliar-applying B with an adjuvant was economically superior to both soil and foliar applications without the adjuvant. These results can help farmers make B application decisions. For example, although using an adjuvant with foliar-applied B may appear costly to cotton producers, the adjuvant may increase lint yields more than enough to offset its cost.

Boron deficiency in cotton may cause small, deformed bolls; poor fruit retention; and reduced lint yields. Relatively small amounts of B are required to support the processes of growth and development of cotton fibers in the boll (Stewart, 1986). Deficiency can be a problem on soils containing insufficient B, or when B availability to the plant is reduced as B changes form with higher soil pH. Application is recommended for soils having a pH of 6.1 or higher or when lime is recommended on soils having a pH of 6.0 or lower (Extension Plant and Soil Science, 2000; Shelby, 1996). Soil-applied B increased cotton yields even when B deficiency was not evident in the plants (Anderson and Boswell, 1968).

Foliar-applied B supplements soil-supplied B and can correct low B concentrations in cotton (Heitholt, 1994). Because small amounts of B are required, foliar application of B may be more efficient than soil application, especially when deficient conditions are suspected (Howard et al., 1998). A thorough economic analysis of foliar- versus soil-applied B has not been performed.

The use of adjuvants may promote absorption of foliar-applied nutrients into leaves compared with solutions without adjuvants (Howard, 1993), reducing nutrient loss and enhancing yield. Increased uptake from adding an adjuvant may be related to solution pH being adjusted to an acid pH level (Howard et al., 1998).

Agronomic analyses exist that compare the effects on yields of using adjuvants to enhance B absorption by cotton leaves (Heitholt, 1994; Ohki, 1975), but the economic implications of using an adjuvant with foliar B have not been thoroughly analyzed. The objectives of this study were to determine: (i) if foliar-applied B is more profitable than soil-applied B in the production of cotton, (ii) if applying an adjuvant with foliar-applied B is economically beneficial to cotton producers, and (iii) if soil pH and the buffering properties of the adjuvant influence the economic effectiveness of foliar-applied B.

MATERIALS AND METHODS

Field experiments were conducted in 1993 through 1995 evaluating soil and foliar B applications to cotton produced on a Collins silt loam soil at the West Tennessee Experiment Station in Jackson. This loess-derived soil was naturally low in B, with low anion-exchange capacity due to low organic matter content, making it suitable for B experiments. Furthermore, B applications were recommended for these plots because pH levels were above 6.1 (Extension Plant and Soil Science, 2000).

The design of the experiment was a randomized complete block, with five replications, established to evaluate six treatments, including: (i) a non-B check; (ii) soil-applied B at 0.56 kg ha^{-1}; (iii) four foliar applications of B at 0.11 kg ha^{-1} per application; (iv) four foliar applications of B at 0.11 kg ha^{-1} per application plus 1129 kg ha^{-1} soil-applied ground agricultural limestone; (v) four foliar applications of B at 0.22 kg ha^{-1} per application; (vi) four foliar applications of B at 0.11 kg ha^{-1} per application plus the adjuvant Penetrator Plus (light to mid-range paraffin oil, polyol fatty acid esters, polyethoxylated esters of polyol fatty acids, and ethoxylated alkyl aryl phosphate ester, buffering crop oil concentrate) manufactured by Helena Chemical Co. of Memphis, TN. The adjuvant was added to the foliar solutions at 1.25% (v/v).

The four foliar applications were applied in 94 L H_2O ha^{-1} starting at flowering to 14 d after flowering on a 9 to 14-d interval.

Lime was broadcast by hand prior to planting. This treatment was included because B is recommended for soils having a pH of 6.1 or higher, or when lime is recommended for soils having a pH of 6.0 or lower (Extension Plant and Soil Science, 2000; Shelby, 1996). Even though these soils had a pH level above 6.1, the treatment was included to induce lower B availability.

Soil B was broadcast immediately before or immediately after planting. Farmers typically soil-apply B about 10 d before planting. The soil B treatment was applied at planting to allow less time for chemical reactions that could reduce B availability to the cotton plant. To ensure uniformity of application, soil B was applied using a boom with B dissolved in 94 L H_2O ha^{-1}. The soil-applied rate was recommended by the University of Tennessee Soil Test Lab (Extension Plant and Soil Science, 2000), while the lower foliar rate was suggested by Dr. J.R. Woodruff of the U.S. Borox Corp. (personal communication, 1993). Because the optimal foliar B rate is not known, double the foliar rate suggested by Woodruff was also applied to see if the higher rate would increase or decrease yield and net revenue compared with the lower rate. The B source for both soil and foliar applications was Solubor DF (Na_2O •$5B_2O_3$ •$10H_2O$) (17.4% B) manufactured by U.S. Borax, Valencia, CA.

The cultivar DP 50 was planted by mid-May each year. Plots were 9.1 m long and four rows wide with cotton planted in 0.97-m rows. Soil fertilizer applications were 90 kg N ha^{-1} as NH_4NO_3, 15 kg P ha^{-1} as triple superphosphate, and 28 kg K ha $^{-1}$ as KCl. Plots were disked several times before planting. Recommended cotton production practices were used (Shelby, 1996).

Partial budgeting was used to estimate net-revenue differences in dollars per hectare among the six treatments because it provided a method for calculating the expected change in net revenue by considering only those revenue and cost items that changed from treatment to treatment (Boehlje and Eidman, 1984).

Expected gross revenue differences were calculated by multiplying the average Tennessee cotton lint price received by farmers for 1995 through 1999 of \$1.38 kg^{-1} (USDA, 1999) by the treatment differences in 3-yr yield means. Differences in seed revenue were assumed to cover differences in ginning costs. Material costs were calculated by multiplying the quantities of soil B, foliar B, lime, and the adjuvant by their respective prices. According to J. Duke, Tennessee Farmers Co-op. (personal communication, 1999), the price of agricultural limestone (material and application) was \$0.01925 kg^{-1} , and the price of Solubor DF was \$1.36 kg^{-1} . The price of the adjuvant, Penetrator Plus, was \$3.69 L^{-1} , according to M. Powell, Helena Chemical Co. (personal communication, 1999).

Additional machinery costs for the soil and foliar B treatments included the variable costs of fuel, oil, filter, and repair; and the fixed costs of depreciation, interest, insurance, and storage. These were calculated by multiplying the cost per hour of operation by the fraction of an hour required per hectare for soil or foliar application.

Soil and foliar B applications were assumed to be performed using a self-propelled sprayer with an 18-m boom, a purchase price of \$63 000, a 14-yr useful life, and the ability to cover a hectare in 4.4 min.A wage rate of \$6.75 h^{-1} was assumed in calculating labor costs and labor hours were assumed to be 1.25 times machine hours or 5.5 min ha^{-1}. This method of allocating machinery costs implicitly assumed the sprayer was fully employed on the farm, but not necessarily in cotton production (Gerloff and Maxey, 1999).

Sensitivity analysis was performed on cotton lint yield differences and on cotton lint prices. Given a cotton lint price of \$1.38 kg^{-1}, break-even yield differences between treatments were found that made gross revenue differences equal to cost differences (that is, no difference in net revenue between treatments). These break-even yield differences were calculated by solving the formula $PY = C$, which stands for "price times yield equals cost." First we solved it for Y, where P was the 1995 through 1999 mean cotton lint price (\$1.38 kg^{-1}), Y was the break-even yield difference between two treatments (kg ha^{-1}), and C was the budgeted cost difference between the treatments (\$ ha^{-1}).

Similarly, using the yields obtained from the experiment, cotton lint prices were calculated that made gross revenue differences between treatments equal to cost differences. These break-even lint prices were calculated by solving $PY = C$ for P, where P was the break-even cotton lint price (\$ kg^{-1}), Y was the experimental mean yield difference between two treatments (kg ha^{-1}), and C was the same as defined above. These break-even prices were compared with the standard deviation in lint prices received by farmers for 1995 through 1999 of \$0.25 kg^{-1}. Break-even lint prices that were estimated to be more than two standard deviations from the mean lint price, or outside the range of \$0.88 and \$1.88 kg^{-1}, were considered unlikely to occur in the near future.

The statistical analyses of lint yields and net revenues were conducted using the mixed model procedure of the Statistical Analysis System (SAS Institute, 1997). The mixed model procedure provides Type III *F* statistical values but does not provide mean square values or the error terms for normal mean separation. Therefore, mean separation was evaluated at a probability level of $\alpha = 0.10$ through a series of protected pair-wise contrasts among all treatments (Saxton, 1998).

RESULTS AND DISCUSSION

Table 1 presents the budgeted material and application costs and the total cost of material and application for each treatment. Those were the cost differences for the various treatments compared with the check. Budgeted material costs for the soil B treatment and the lower foliar B treatment were \$0.76 and \$0.60 ha^{-1}, respectively, and for the adjuvant the cost was \$17.34 ha^{-1}. The cost of lime and its application was estimated at \$21.56 ha^{-1}. The budgeted cost of application for four foliar B applications at the lower or higher rate was \$22.95 ha^{-1}, which was the sum of machinery variable (\$5.64 ha^{-1}) and fixed (\$14.95 ha^{-1}) costs and the cost of labor (\$2.36 ha^{-1}) (Gerloff and Maxey, 1999, p.2). The application cost of one soil B application was budgeted at one-fourth the cost of four foliar B applications (\$5.74 ha^{-1} = \$1.41 + \$3.74 + \$0.59 ha^{-1}) (Gerloff and Maxey, 1999, p.2).

Soil application was the least costly method of applying B, only \$6.50 ha^{-1} more than the untreated check. The cost of the lower foliar B treatment was estimated at \$23.55 ha^{-1}, or \$17.05 ha^{-1} more than the cost of the soil treatment. The cost budgeted for the lower foliar B plus lime treatment (\$45.11 ha^{-1}) was more than the cost of the lower foliar B treatment by the cost of lime and its application (\$21.56 ha^{-1}), while the cost of the lower foliar B plus adjuvant treatment (\$40.89 ha^{-1}) was greater than the cost of the lower foliar B treatment by the cost of the adjuvant (\$17.34 ha^{-1}). Finally, the cost of the higher foliar B treatment (\$24.15 ha^{-1}) was higher than the cost of the lower foliar B treatment by the cost of the extra B applied (\$0.60 ha^{-1}).

The lower foliar B rate plus the adjuvant consistently produced the highest yield mean in each year, although the mean of this treatment was not significantly different from all other treatment means in any of the three years (Table 2). The ranking of the other treatments was not consistent across years. For example, the check had the lowest yield means, except in 1995 when the higher foliar B treatment had the lowest mean. The soil B, lower foliar B, and lower foliar B plus lime treatments produced similar means that were not significantly different from one another, except in 1995.

Table 1. Budgeted costs of materials, machinery, and labor used to develop treatment cost differences for various methods of applying B to cotton.

Cost item	Cost
Material costs:	**\$ ha^{-1}**
Soil B (\$1.36 kg^{-1} × 0.56 kg ha^{-1})	0.76
Lower foliar B (\$1.36 kg^{-1} × 0.11 kg ha^{-1} × 4 applications)	0.60
Lime (\$0.019 kg^{-1} × 1129 kg ha^{-1})	21.56†
Adjuvant (\$3.69 L^{-1} × 94 L ha^{-1} × 0.0125 × 4 applications)	17.34
Foliar B application costs:	
Variable machinery (\$20.13 h^{-1} × 0.07 h ha^{-1} × 4 applications)	5.64
Fixed machinery (\$53.41 h^{-1} × 0.07 h ha^{-1} × 4 applications)	14.95
Labor (\$6.75 h^{-1} × 0.07 h ha^{-1} x 1.25 × 4 applications)	2.36
Soil B application costs:	
Variable machinery (\$20.13 h^{-1} × 0.07 h ha^{-1})	1.41
Fixed machinery (\$53.41 h^{-1} × 0.07 h ha^{-1})	3.74
Labor (\$6.75 h^{-1} × 0.07 h ha^{-1} × 1.25)	0.59
Material plus application costs by treatment:	
Soil B	6.50
Lower foliar B	23.55
Lower foliar B + lime	45.11
Higher foliar B	24.15
Lower foliar B + adjuvant	40.89

† The cost of lime application is included with the material cost.

Much of the variation in rankings across years was caused by annual differences in uncontrolled variables, such as rainfall and temperature, as indicated by a significant treatment-by-year interaction (not reported). These uncontrolled variables cannot be predicted easily by farmers in advance of critical growing periods. The best estimates of a farmer's expected yields for these treatments would be the 3-yr yield means, which were used in the economic analysis.

Three-year yield means and pair-wise differences in those means are presented in Table 2. A positive (negative) yield difference indicates that the treatment in the column produced a higher (lower) yield than the treatment in the row. Compared with the check, foliar applications of B plus the adjuvant increased yields 14%, foliar B applications at the

Table 2. Yield means, yield differences, and break-even yield differences for various methods of applying B to cotton.

Yield mean and treatment (row)	Treatment (column)					
	Check	Soil B	Lower foliar B	Lower foliar B + lime	Higher foliar B	Lower foliar B + Adjuv.
	kg ha^{-1}					
Yield means						
1993 yield mean	791f †	969cd	968cd	1008bcd	921e	1049abc
1994 yield mean	1342c	1386abc	1359bc	1445ab	1342c	1460a
1995 yield mean	1147ab	1136ab	1201a	1100bc	1068bc	1223a
Three-year yield mean	1094c	1164b	1176b	1185b	1110c	1244a
Check						
Yield difference‡	---------	70	82	91	17	150
Break-even yield difference§	---------	5	17	33	18	30
Soil B						
Yield difference‡		---------	12	21	-53	80
Break-even yield difference§		---------	12	28	13	25
Lower foliar B						
Yield difference‡			---------	9	-65	68
Break-even yield difference§			---------	16	0	13
Lower foliar B + lime						
Yield difference‡				---------	-74	59
Break-even yield difference§				---------	-15	-3
Higher foliar B						
Yield difference‡					----------	133
Break-even yield difference§					----------	12

† Yield means followed by same letter are not significantly different at $\alpha = 0.10$.

‡ Three-year yield mean of treatment in column minus treatment in row.

§ Increased lint yield required for treatment in column to break even with treatment in row.

lower rate increased yields 7%, applied limestone plus the lower rate of foliar B increased yields 8%, and soil B applications increased yields 6%.

The higher foliar B treatment did not significantly increase lint yields relative to the check. The higher foliar B treatment reduced lint yields 6% compared with the lower foliar B treatment, indicating that the lower level of foliar B was closer to achieving optimal lint yield than the higher level.

Four foliar applications of 0.11 kg B ha^{-1} resulted in lint yields that were not significantly different from soil-applying B at the currently recommended rate of 0.56 kg ha^{-1}. Applying limestone with the lower foliar B rate did not change yields significantly from those achieved with the lower foliar B rate alone. This finding suggests that lime did not reduce B availability to the crop.Applying the adjuvant with the lower rate of foliar B increased yields 7% and 6% compared with the lower rate of foliar B without the adjuvant and soil B applications, respectively.

Table 2 also presents break-even yield differences between treatments based on 3-yr means. When the yield difference between two treatments was greater than the break-even yield difference, the increased yield provided more than enough additional revenue to cover the cost difference in Table 1, implying that the treatment in the column would be economically preferred by a profit-maximizing farmer to the treatment in the row; otherwise, the treatment in the row would be economically preferred to the treatment in the column. All treatment comparisons in Table 2 that had significantly different 3-yr mean yields also had substantially higher or lower mean yield differences than their break-even yield differences. Thus, not only were the mean yields significantly different, but those yield differences were more than sufficient to cover the differences in costs between treatments.

These results suggest that (i) the lower foliar B plus adjuvant treatment would be preferred to all other treatments; (ii) the soil B, lower foliar B, and the lower foliar B plus lime treatments would be economically preferred to the higher foliar B treatment and the check; (iii) a farmer would not prefer the higher foliar B treatment and the check. In addition, yield differences were similar to the break-even yield differences for comparisons between the soil B, the lower foliar B, and the lower foliar B plus lime treatments, suggesting no clear economic advantage for one treatment over another.

Annual and 3-yr net-revenue means are presented in Table 3. Again, the lower foliar B plus adjuvant treatment consistently produced the highest net-revenue mean in each year, although its mean was not significantly different from all other

Table 3. Net-revenue means, net-revenue differences, and break-even cotton lint prices when applying B by various methods to cotton.

	Treatment (column)					
Yield mean and treatment (row)	Check	Soil B	Lower foliar B	Lower foliar B + lime	Higher foliar B	Lower foliar B + Adjuv.
	$ ha^{-1} or $ kg ha^{-1}					
1993 net-revenue mean	1092e †	1331bcd	1312cd	1346abcd	1247d	1407abc
1994 net-revenue mean	1853ab	1906ab	1851b	1949ab	1828b	1973a
1995 net-revenue mean	1583ab	1561abc	1634a	1473bcd	1450cde	1647a
Three-year net-revenue mean	1509c	1599b	1599b	1590b	1508c	1676a
Check						
Net-revenue difference‡	---------	90	90	80	-2	165
Break-even lint price§	---------	0.09	0.28	0.50	1.51	0.27
Soil B						
Net-revenue difference‡		---------	-0	-9	-92	75
Break-even lint price§		---------	1.42	1.82	-0.33	0.44
Lower foliar B						
Net-revenue difference‡			----------	-9	-92	75
Break-even lint price§			----------	2.40	-0.01	0.26
Lower foliar B + lime						
Net-revenue difference‡				----------	-83	84
Break-even lint price§				----------	0.28	-0.07
Higher foliar B						
Net-revenue difference‡					----------	167
Break-even lint price§					----------	0.13

† Net revenue means followed by same letter are not significantly different at α = 0.10.

‡ Three-year net-revenue mean for treatment in column minus treatment in row.

§ Cotton lint price required for treatment in row to break even with treatment in column.

treatment means in any of the three years. The ranking of the other treatments was not consistent across years. For example, the higher foliar B treatment had the lowest net-revenue mean in 1994 and 1995, but the check had the lowest mean in 1993.

The 3-yr net-revenue means followed the same pattern as the 3-yr yield means in Table 2; namely, the lower foliar B plus adjuvant treatment produced significantly higher net-revenue than all other treatments, while the check and the higher foliar B treatments provided significantly lower net revenues than all other treatments.

Table 3 also presents estimated differences in net revenues and break-even cotton lint prices between pairs of treatments, based on 3-yr net revenue means. A positive (negative) net-revenue difference indicates that the treatment in the column produced higher (lower) net revenue than the treatment in the row at a cotton lint price of \$1.38 kg^{-1}.

The lower foliar B plus adjuvant treatment produced a net revenue that was greater than all other treatments, with the highest net-revenue difference compared with the check (\$165 ha^{-1}) and the lowest compared with the soil B treatment (\$75 ha^{-1}). Furthermore, the low break-even lint prices (more than two standard deviations from the mean) suggest that the lower foliar B plus adjuvant treatment likely would earn higher net revenue than the other treatments would for lint prices that would reasonably be expected to prevail in the near future.

Net revenues for all treatments, except the higher foliar B treatment, were substantially higher than the check, ranging from \$80 ha^{-1} for the lower foliar B plus lime treatment to \$165 ha^{-1} for the lower foliar B plus adjuvant treatment, and their low break-even prices suggest that positive differences in net revenues likely would occur under expected future price conditions.

Net revenue for the higher foliar B treatment was lower than the net revenues for all other treatments, ranging from \$2 ha^{-1} lower than the check to \$167 ha^{-1} lower than the lower foliar B plus adjuvant treatment, and the break-even prices were low and even negative in some cases. Net-revenue differences for comparisons involving the soil B, the lower foliar B, and the lower foliar B plus lime treatments were small. The small and nonsignificant net-revenue difference between the lower foliar B and the lower foliar B plus lime treatments (−\$9 ha^{-1}) suggests that the relatively high break-even price of \$2.40 kg^{-1} may not be an important consideration.

Borax is normally used instead of Solubor by farmers for soil applications, which may lower the cost of soil-applied B relative to the other treatments. Using Borax would reduce the material cost of soil application because it is less costly than Solubor. Furthermore, the application cost of the soil B treatment would essentially be zero because Borax is typically applied in a bulk blend with N, P, and K. The lower cost of applying Borax may prove beneficial to farmers in the long run as the costs of Solubor and its application fluctuate relative to Borax.

The above statements should be mollified by three caveats. First, soil B applications in this experiment did not produce significantly different yields than the lower rate of foliar B. Second, bulk-blending and bulk-spreading may reduce the farmer's ability to uniformly distribute small amounts of B across the soil surface. Third, the cost of applying foliar B may be reduced if it is co-applied with other foliar inputs such as insecticides, growth regulators, or other foliar fertilizers.

This experiment evaluated four foliar B applications at two rates starting at bloom. Further research is needed to determine the optimal rate and timing of foliar applications. If optimal applications of foliar B are not restricted to the bloom period, costs can be reduced by distributing applications throughout the growing season to take advantage of co-application with other foliar inputs. Although the higher rate of foliar B proved to be excessive in this experiment, the optimal rate of foliar B and the number of foliar applications needed for optimal economic performance still need to be determined.

CONCLUSIONS

The results suggest several conclusions that may help farmers in their B application decisions. First, foliar-applying B four times at a rate of 0.11 kg ha^{-1} per application is clearly more profitable than foliar-applying B at twice that rate.

Second, foliar-applying B at the aforementioned rate and soil-applying B at the currently recommended rate of 0.56 kg ha^{-1} provide about the same net returns, though both foliar and soil application are economically superior to not applying B.

Finally, although using an adjuvant with foliar B appears costly to the typical cotton producer, the adjuvant increases lint yields more than enough to offset its higher cost when compared with soil-applying B or foliar-applying B without the adjuvant.

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