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SOILS

Buffering of Foliar Potassium and Boron Solutions for No-tillage Cotton Production

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INTERPRETIVE SUMMARY

Research was conducted to evaluate buffering of foliar B and/or K solutions for no-tillage cotton (*Gossypium hirsutum* L.) production. Previous research indicated that buffering foliar K solutions to pH 4 increased cotton leaf and petiole K uptake and increased yields. Additional research showed slightly higher yields for applications of unbuffered foliar B + K solutions than for foliar B alone. Additional information is needed for the evaluation of buffering of B and B + K solutions for no-till cotton production.

Field research on a Collins silt loam (coarse-silty, mixed, active, acid, thermic Aquic Udifluvents) was initiated in 1995 and continued through 1997 at the West Tennessee Experiment Station. A general soil test evaluation showed the research area has a pH of 6.6 and Mehlich-1 extractable K of 170 lb acre^{-1} (high level), calling for recommendations of 0.5 lb B acre^{-1} and 30 lb K_2O acre^{-1} for cotton production.

Foliar treatments included: (i) 0.1 lb B acre^{-1} foliar unbuffered; (ii) 0.1 lb B acre^{-1} buffered to (a) pH 6 and (b) pH 4; (iii) 4.4 lb K acre^{-1} unbuffered; (iv) 4.4 lb K acre^{-1} buffered to (a) pH 6 and (b) pH 4; (v) 0.1 lb B acre^{-1} plus 4.4 lb K acre^{-1} applied unbuffered; (vi) 0.1 lb B acre^{-1} plus 4.4 lb K acre^{-1} buffered to (a) pH 6 and (b) pH 4; (vii) untreated check. An experimental blend of surfactant and boric acid salts (HM 9751; Helena Chemical, Memphis, TN) also was applied at 0.1 lb B acre^{-1}. Plots were fertilized at 80 lb N acre^{-1}, 30 lb P_2O_5 acre^{-1}, and 30 lb K_2O acre^{-1}, using ammonium nitrate, concentrated superphosphate, and potassium chloride, respectively. The research plots were planted between 1 and 15 May, with Deltapine 50 in 1995 and 1996 and Deltapine 5409 in 1997. Foliar K was applied as KNO_3 in 1995, but K_2SO_4 was applied in 1996 and 1997 to eliminate possible confounding response to foliar N. Foliar B was applied as Solubor DF[1] ($Na_2O \cdot 5B_2O_3 \cdot 10H_2O$; U.S. Borax, Valencia, CA) [17.4% B]. Solution pH levels were adjusted immediately before application using the anionic Buffer Xtra Strength[1] (a proprietary blend of alkyl aryl polyethoxy ethanol phosphates and organic phosphatic acids; Setre Chemical, Memphis, TN). Each solution was reformulated before application and applied within 30 min of tank pressurization. Foliar treatments were applied through a four-nozzle boom with each nozzle centered over the row. Solutions were applied in 10 gal H_2O acre^{-1} with treatments applied at bloom and repeated on a 7-d interval for a total of four applications.

Three-year average lint yields were increased with the foliar treatments by 5 to 16% compared with the check. Some of the foliar treatments increased yields more than others. Generally, buffering the foliar B and/or K solutions to pH 4 increased lint yields when compared with unbuffered solutions. Foliar applications of the B + K solution buffered to pH 4 increased total lint yields 15.9%; foliar K solutions buffered to pH 4 increased yields 13.8%; foliar B solutions buffered to pH 4 increased yields 10.3%. The experimental boric acid compound HM 9751 increased yields more than the unbuffered B solutions.

ABSTRACT

Buffering foliar K solutions to pH 4 increased K uptake and lint yield of cotton (*Gossypium hirsutum*

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[1] The use of trade names in this publication is for accuracy and does not imply approval of the product named to the exclusion of others that may be of similar suitable composition, nor does it guarantee or warrant the standard of the product.

L.). Research was conducted (1995-1997) on a Collins silt loam (coarse-silty, mixed, active, acid, thermic Aquic Udifluvents) to evaluate buffering of foliar B and/or K solutions for no-till cotton production. Foliar treatments included 0.11 kg B ha^{-1} and 4.1 kg K ha^{-1} applied separately and/or in combination as unbuffered or buffered to pH 6 or 4. Additional treatments included 0.11 kg B ha^{-1} of an experimental blend of surfactant and boric acid salts (HM 9751; Helena Chemical, Memphis, TN) and an untreated check. A general soil sample showed the research area had a 6.6 pH and 190 kg ha^{-1} (high level) Mehlich-1 extractable K, which called for recommendations of 0.56 kg B ha^{-1} and 28 kg K ha^{-1}. Plots were fertilized at 90-15-28 kg N-P-K ha^{-1}, respectively. Foliar K was applied as KNO_3 in 1995, but K_2SO_4 was applied in 1996 and 1997. Foliar B was applied as Solubor DF ($Na_2O\cdot5B_2O_3\cdot10H_2O$; U.S. Borax, Valencia, CA) [17.4% B]. Foliar treatments were applied in 93.3 L H_2O ha^{-1} at bloom and repeated on a 7-d interval for four applications. Solutions were buffered with Buffer Xtra Strength (alkyl aryl polyethoxy ethanol phosphates and organic phosphatic acids; Setre Chemical, Memphis, TN). Foliar K and/or B solutions buffered to pH 4 increased first-harvest and total lint yields more than unbuffered or solutions buffered to pH 6 did. Foliar B + K solutions buffered to pH 4 increased total yields by 15.9%, while foliar K solutions buffered to pH 4 increased yields by 13.8%, and foliar B solutions buffered to pH 4 increased yields 10.3% above the check yields.

Foliar K applications have been used as a means of supplementing soil-applied nutrients for occurrences of inadequate fertilization of cotton. Research conducted throughout the Cotton Belt has indicated that foliar K applications increased yields, although the effectiveness of the foliar treatments was not consistent with time and was not predictable (Oosterhuis et al., 1994). This research was conducted over a wide range of soil and climatic conditions. Bednarz et al. (1999) reported foliar fertilizer applications did not increase cotton yields when used as a supplement to the recommended fertility program.

Foliar K has supplemented soil K applications for maximum cotton yields on a soil initially having 95 kg ha^{-1} (low) of Mehlich-1 extractable K (Howard et al., 1998a). This research showed that foliar K increased yields on soils having Mehlich-1 extractable K of 177 kg ha^{-1} or less. This response to four foliar K applications of 4.1 kg K ha^{-1} continued through two years, during which 112 kg K ha^{-1} was surface-applied annually.

The production tillage system (conventional or no-till) may also contribute to the response of cotton to foliar K fertilization. Howard et al. (1997) reported that no-tillage cotton yields were increased by applying foliar K to cotton produced on a soil having 225 kg Mehlich-1 extractable K ha^{-1} but that conventional-till yields were not increased by applying K to cotton on a soil having 193 kg extractable K ha^{-1}.

Modifying foliar K solution chemistry has improved the K uptake of cotton (Heitholt, 1994; Howard and Gwathmey, 1995; Chang and Oosterhuis, 1995). Shafer and Reed (1986) suggested that leaf absorption of K from foliar applications can be enhanced by modifying solution pH values. Howard and Gwathmey (1995) reported higher leaf blade and petiole K concentrations up to 7 d following foliar application of KNO_3 with the adjuvant Penetrator Plus[1] (Helena Chemical), compared with foliar KNO_3 applied without an adjuvant or the non-foliar check. Foliar K increased second-harvest and total lint yields of cotton produced on soils having Mehlich-1 extractable K ranging from 168 to 202 kg ha^{-1} (high). Second-harvest lint yield increases from foliar K application indicated that soil K availability to the plant was marginal or deficient for boll production in the upper part of the plant. Adding Penetrator Plus buffered the foliar KNO_3 solutions to pH 5.5, compared with a pH of 9.4 for the unbuffered solution (Howard et al., 1998b). These researchers also reported increased yields and higher petiole K concentrations from foliar K applications buffered to pH 4, compared with unbuffered K solutions.

Boron is recommended as an annual application for cotton production in some areas (Baird and Guthrie, 1992). In Tennessee, B is recommended for cotton production on soils of pH 6.1 or higher or when ground agricultural limestone is applied (Extension Plant and Soil Science, 1998). Limestone is recommended for cotton production on soils with a pH of 6 or less; therefore, producers following recommendations will use B on an annual basis. Relatively small amounts of B are required to support the processes of cotton growth and development of the boll (Stewart, 1986). Boron deficiency may result in small, deformed bolls, poor fruit retention, and reduced lint yields (Murphy and Lancaster, 1971). Combining B and K as a foliar application may enhance plant uptake and yields on soils with limited extractable K and low B levels (Woodruff et al., 1987). There is evidence that K and B play a significant role in carbohydrate metabolism and translocation in plants. Howard et al. (1998b) reported higher yields from foliar-applied B + K compared with soil-applied B or check yields. Foliar applications of a B + K solution increased yields 13% compared with the check. The same findings also reported higher yields from foliar application of K solutions buffered to pH 4 compared with unbuffered K solutions. Foliar B solutions are strongly buffered to pH 8, which may restrict plant response and nutrient uptake. The objective of this study was to evaluate the effect of buffering B and K solutions applied at and immediately following bloom for no-till cotton production.

METHODS AND MATERIALS

A field experiment was initiated in 1995 and continued through 1997 on a Collins silt loam at the West Tennessee Experiment Station in Jackson, Tennessee. Evaluation of a general soil sample of the research area showed a pH of 6.6 and Mehlich-1 extractable K of 190 kg ha^{-1} (high level). Based on these two evaluations, B is recommended at 0.56 kg B ha^{-1}, while K is recommended at 28 kg ha^{-1} (Extension Plant and Soil Science, 1998).

The experimental design was a randomized complete block with treatments replicated five times. Foliar treatments included: (i) 0.11 kg B ha^{-1} foliar unbuffered; (ii) 0.11 kg B ha^{-1} buffered to (a) pH 6 and (b) pH 4; (iii) 4.1 kg K ha^{-1} unbuffered; (iv) 4.1 kg K ha^{-1} buffered to (a) pH 6 and (b) pH 4; (v) 0.11 kg B ha^{-1} plus 4.1 kg K ha^{-1} applied unbuffered (vi) 0.11 kg B ha^{-1} plus 4.1 kg K ha^{-1} buffered to (a) pH 6 and (b) pH 4; (vii) untreated check. An experimental boric acid compound HM 9751 also was applied at 0.11 kg B ha^{-1}. In 1995 and 1996, foliar solutions containing the buffer compound Buffer Xtra Strength were applied at the rate required to buffer the B + K solution to pH 4 (7.1 mL L^{-1} of solution). All foliar treatments were applied in 93.3 L H_2O ha^{-1}. A single spray nozzle (8003) was centered above each of the plot rows (97-cm spacing).

The cultivar Deltapine 50 was planted in 1995 and 1996; Deltapine 5409 was planted in 1997. Experiments were planted between 1 and 15 May. Individual plots were 9.1 m long and four rows wide with cotton planted in 0.97-m rows. Immediately after planting, ammonium nitrate was broadcast at 90 kg N ha^{-1}, triple superphosphate was broadcast at 15 kg P ha^{-1}, and KCl was broadcast at 28 kg K ha^{-1}. Previous research indicates that four foliar B applications at 0.11 kg ha^{-1} are an effective means of B application for cotton production (Howard et al., 1998b). Previously recommended production practices (Shelby, 1996) were used during the season.

Foliar K was applied as KNO_3 in 1995, but K_2SO_4 was substituted in 1996 and 1997 to eliminate possible confounding of the foliar N effect on yields. Foliar B was applied as Solubor DF ($Na_2O{\cdot}5B_2O_3{\cdot}10H_2O$); [17.4% B]. Solution pH levels (pH 6 and 4) were adjusted immediately before application using Buffer Xtra Strength, an anionic buffering agent. All solutions were reformulated before each application and were applied within 30 min after tank pressurization. Foliar treatments were applied at bloom and repeated on a 7-d interval for a total of four applications.

Leaf blades and petioles were collected before each foliar application to evaluate treatment effects on plant K concentrations. Leaf blade and petiole B concentrations were not evaluated in this test. Twenty leaf blades and petioles were collected per plot from the topmost fully developed leaf, generally the third or fourth from the tip. These plant materials were washed, dried at 64°C, and ground for tissue analysis. Potassium was extracted from the ground plant material by using 2% (v/v) acetic acid solution (Baker et al., 1994), and K concentrations were determined on a Perkin Elmer (Norwalk, CT) 3100 atomic absorption spectrophotometer. Following the findings of Percell et al. (1995), extractable leaf and petiole K were evaluated rather than total digestible K.

A recommended defoliant was applied when 60% of the bolls, averaged across tests, were open. Lint yields were determined by mechanically picking the two center plot rows twice each year. Cotton was first picked approximately 2 wk after application of the defoliant, with a second picking approximately 3 wk after the first picking. The interval varied due to weather and picking schedule. Percentage of lint was

Table 1. Mixed model ANOVA of buffered foliar B and K solutions on first-harvest, second-harvest, and total no-tillage lint cotton yields.

Source	df	Yields by harvest period					
		1st		2nd		Total	
		Type III *F*	*P* > *F*	Type III *F*	*P* > *F*	Type III *F*	*P* > *F*
Year (Y)	2	81.5	0.001	70.1	0.001	41.9	0.001
Error a	8						
Foliar (F)	10	3.4	0.001	1.90	0.052	5.1	0.001
F × Y	20	1.0	0.438	1.55	0.076	0.6	0.880
Error b	120						

determined by combining seed cotton subsamples from individual treatments across replications (<4.5 kg) and ginning on a 20-saw gin with dual lint cleaners. Lint yields were calculated by multiplying lint fraction by plot seed cotton weights. Total lint yield was calculated by adding the first- and second-harvest lint yields.

The statistical analyses of lint yield and plant K concentration were conducted using mixed model procedures of the Statistical Analysis System (SAS Institute, 1997). The mixed model procedure provides Type III *F* statistical values as indicators of significance, but it does not provide mean square values or the error terms for normal mean separation. Therefore, mean separation was evaluated through a series of protected pair-wise contrasts among all treatments (Saxton, 1998). Treatment means for multi-comparisons (unbuffered vs. buffered solutions) were contrasted (single degree of freedom) using the estimate statement in mixed model procedures. This approach provided greater statistical confidence than either pair-wise or standard multiple comparisons of treatments (Table 1).

RESULTS AND DISCUSSION

Foliar treatments significantly affected first-harvest and total yields at $P < 0.05$ (Table 1). Treatments also had a significant effect on second-harvest yields at $P = 0.052$. The treatment effect on each harvest period was consistent during the three years as evidenced by the nonsignificant treatment by year interaction (foliar × year). Due to this consistency, treatment effects on yields will be discussed as 3-yr averages. This nonsignificant treatment by year interaction also indicated that differences that may have resulted from changing either cultivars or foliar K sources did not significantly affect yields.

Table 2. Effect of buffering on foliar B and K solutions on first- and second-harvest and total no-tillage cotton lint yields.

B	K	pH	Yields by harvest period		
			1st	2nd	Total
-----kg ha^{-1}-----			----------------kg ha^{-1} ----------------		
0.11	0	8.5	1014cd†	186abc	1200ef
0.11	0	6	1063abc	176bc	1240b-e
0.11	0	4	1073abc	189abc	1262b-e
0.11	4.1	8.5	1017cd	206a	1223de
0.11	4.1	6	1039bcd	199ab	1237cde
0.11	4.1	4	1120a	206a	1326a
0	4.1	9.5	1067abc	197ab	1264a-e
0	4.1	6	1071abc	207a	1278a-d
0	4.1	4	1093ab	209a	1302ab
0.11‡	0	3	1091ab	209a	1300abc
0	0	6.6	977d	167c	1144f

† Yield means within each harvest period followed by the same letter are not significantly different at $\alpha = 0.05$.

‡ Experimental boric acid compound HM 9751 (Helena Chemical, Memphis, TN).

Buffering B, B + K, and K foliar solutions to pH 6 and 4 generally resulted in a higher first-harvest lint yield compared with the check (Table 2). The data in Table 2 shows that yields produced by buffering the B + K solution to pH 6 did not affect yields when compared with the check. First-harvest yield increases from the foliar treatments (except for pH 6 B + K) were 3.8 to 14.6% higher than the check. Increased first-harvest yields from foliar applications indicated an improvement in early boll development that may have been restricted by reduced availability of nutrients to the plant (Howard et al., 1998a). Contrast analyses showed foliar applications of unbuffered solutions (B, B + K, K) increased first-harvest yields by 56 kg ha^{-1}, solutions buffered to pH 6 increased yields by 80 kg ha^{-1}, while solutions buffered to pH 4 increased yields by 118 kg ha^{-1} (Table 3). These yield differences progressively increased with buffering to pH 4 and all yields were significantly greater than the check. These contrast analyses also indicated that first-harvest yields were not improved by solutions

Table 3. Contrast analyses of first- and second-harvest and total no-tillage lint cotton yields as affected by buffered foliar B and K solutions.

Contrasted treatments	Yields by harvest					
	1st		2nd		Total	
	Diff.†	*P*	Diff.	*P*	Diff.	*P*
Unbuffered solutions vs. check	56	0.033	29	0.017	85	0.002
pH 6 solutions vs. check	80	0.003	23	0.055	103	0.001
pH 4 solutions vs. check	118	0.001	34	0.006	153	0.001
Unbuffered vs. pH 6 solutions	25	0.176	2	0.783	23	0.231
Unbuffered vs. pH 4 solutions	63	0.001	5	0.570	68	0.001
pH 6 vs. pH 4	38	0.041	7	0.399	45	0.018
Foliar B vs. foliar K	27	0.149	21	0.017	47	0.013

† Diff., differences in yield between contrasted treatments.

buffered to pH 6 compared with unbuffered solutions. Further buffering of solutions to pH 4 increased yields compared with the unbuffered solutions (63 kg ha^{-1}) and solutions buffered to pH 6 (38 kg ha^{-1}). These contrast analyses also show that foliar B solutions (unbuffered, pH 6, and pH 4) did not increase first-harvest yields relative to foliar K solutions. Even though contrast data indicated that unbuffered solutions of B, B + K, and K increased yields, the yield data reported in Table 2 indicate that foliar K was primarily responsible for first-harvest yield increases. These data differ from those of an earlier study (Howard et al., 1998b) in that unbuffered foliar K solutions did not increase first-harvest yields relative to the check. These data indicated the inconsistency of the foliar treatments' effectiveness, as pointed out by Oosterhuis et al. (1994). This inconsistency also indicates the need for improved research protocols for delineating small treatment differences that may be associated with foliar research. A treatment resulting in a yield difference of 38 kg ha^{-1} (pH 6 vs. pH 4) was significant, while another treatment resulting in a yield difference of 27 kg ha^{-1} (foliar B vs. foliar K) was not significant, a situation which indicates the need for protocol improvement for more precise evaluations and detection of smaller differences.

Second-harvest yields (P = 0.052) were improved by foliar K applications compared with foliar B (unbuffered, pH 6 buffered, and pH 4 buffered) or check yields (Table 2). Foliar applications of the experimental boric acid compound HM 9751 increased second-harvest yields relative to the check and pH 6 buffered B yields. Second-harvest yields were increased by the foliar K and foliar K + B treatments (buffered and unbuffered). These increases ranged from 18.0% (unbuffered foliar K) to 25.1% (pH 4 buffered K and experimental boric acid compound). Although a 25% increase seems unusually high, based on a 167 kg ha^{-1} check yield, the increase is 42 kg ha^{-1}. Contrast analyses showed that increases from applying the unbuffered and pH 4 (B, B + K, and K) solutions were 29 and 34 kg ha^{-1}, respectively, and were larger than the check yields (Table 3). Buffering to pH 6 (B, B + K, K) increased second-harvest yields at P = 0.055 (23 kg ha^{-1}). The contrast analyses also indicated that second-harvest yields were primarily increased by the foliar K applications (Table 3). Higher second-harvest yields indicated that foliar K contributed to late boll development as would be expected when deficiencies, whether hidden or visible, occur in the upper portion of the plant, or when conditions allow late-set bolls to mature (Howard and Gwathmey, 1995).

Total lint yields, averaged across three years, were increased by the foliar treatments relative to the check yield (Table 2). Total yield increases ranged from 4.9 to 15.9%, based on the check yield. This range is slightly higher than that for first-harvest, 3.8 to 14.6%, reflecting treatment effects on second-harvest. Foliar application of B + K solutions buffered to pH 4 increased total lint yields by 15.9%, while applying pH 4 foliar K increased yields by 13.8%. The slightly higher yield of B + K solution compared to K alone was also noted in previous research (Howard et al., 1998b), in which unbuffered B + K solutions increased yields by 13%, while unbuffered K solutions increased yields by 8.4%.

Contrast analyses indicated that compared to the check, the unbuffered B, B + K, and K solutions increased yields 85 kg ha^{-1}, the solutions buffered to pH 6 resulted in a 103 kg lint ha^{-1} increase, and the solutions buffered to pH 4 resulted in a 153 kg lint ha^{-1} increase (Table 3). Again, buffering foliar solution to pH 4 increased lint yields compared to yields from unbuffered applications and solution buffered to pH 6. Although data are not presented, foliar application of Buffer Xtra Strength, the buffer compound alone, at a rate required to buffer the B + K solution to pH 4 (highest buffer rate) did not improve yields relative to the check over 2 yr. Therefore, yield differences influenced by solution buffering are a result of improved foliar solution efficiency relative to the unbuffered solution. This

Table 4. Leaf blade and petiole K concentrations as affected by B and K buffered foliar solutions.

B	K	pH	Leaf blade K concentrations			Petiole K concentrations		
			Weeks after bloom			Weeks after bloom		
			1	2	3	1	2	3
--kg ha^{-1}--			------------------------g kg^{-1} ------------------------					
0.11	0	8.5	0.93de†	1.07cde	0.81cde	2.98a	3.11a	2.23abc
0.11	0	6	0.92e	1.05de	0.79e	2.81a	2.76a	1.99bc
0.11	0	4	0.93de	1.04de	0.80de	2.95a	2.89a	1.95c
0.11	0.41	8.5	0.97b-e	1.12a-d	0.93a	3.04a	3.17a	2.26ab
0.11	0.41	6	1.00ab	1.14ab	0.92a	3.01a	3.18a	2.44a
0.11	0.41	4	1.05a	1.17a	0.94a	3.02a	3.19a	2.48a
0	0.41	9.5	0.99a-d	1.12a-d	0.88a-d	3.06a	3.09a	2.21abc
0	0.41	6	1.00abc	1.13abc	0.91ab	3.07a	3.20a	2.51a
0	0.41	4	1.00abc	1.08b-e	0.90abc	2.98a	3.15a	2.45a
0.11‡	0	3	0.98b-e	1.09b-e	0.83b-e	2.92a	3.08a	2.26abc
0	0	6.6	0.93de	1.07cde	0.78e	2.85a	2.77a	1.97bc

† Yield means for each collection period followed by the same letter are not significantly different at $\alpha = 0.05$.

‡ Experimental boric acid compound HM 9751 (Helena Chemical, Memphis, TN).

buffering effect is further substantiated by the yields produced by foliar application of the experimental boric acid compound HM 9751 that had a solution pH of 3.0. Applying B solutions buffered to pH 4 increased total yields by 10.3%, while the acid compound HM 9751 resulted in a 13.6% increase. Although the yield differences between the two foliar compounds are not significant, they do point out the probability that buffering of foliar solutions improves efficiency.

Contrast analyses also indicated, as observed for first-harvest yields, that foliar K applications were responsible for the higher yields relative to foliar B, although yields produced by both treatments were greater than the check. Generally, foliar fertilization is associated with improved yields in the top of the crop and is reflected in the second harvest (Oosterhuis, 1993; Howard and Gwathmey, 1995). In this experiment, both first-harvest and second-harvest yields and, consequently, total yields were improved by the foliar B and K applications. This result indicates that K availability and plant uptake were lower than optimum as indicated by previous research (Howard et al., 1998a). For this no-till research, fertilizers were surface-applied, which allows nutrient stratification (Howard et al., 1999). Stratification of nutrient K associated with surface applications may reduce K uptake of tap rooted plants even on the present study's soil [190 kg ha^{-1} of extractable K (high), plus 28 kg K ha^{-1} broadcast in the spring].

Conventional-till yields produced on two silt loam soils of high-extractable K, Loring (fine-silty, mixed, active, thermic Oxyaquic Fragiudalfs) and Lexington (fine-silty, mixed, active, thermic Ultic Hapludalfs), were increased in only one of the eight site-years included in the study, while no-till yields were increased in five of the eight site-years (Howard et al., 1997). The study reported that conventional-

Table 5. Contrasted treatment effect on leaf blade and petiole K concentrations.

Contrast treatments	Plant collection periods					
	1st		2nd		3rd	
	Diff.	*P*	Diff.	*P*	Diff.	*P*
	g kg^{-1}		g kg^{-1}		g kg^{-1}	
	Leaf blade K comparisons					
Unbuffered vs. check	0.04	0.175	0.03	0.243	0.08	0.020
pH 6 solutions vs. check	0.04	0.113	0.03	0.212	0.07	0.045
pH 4 solutions vs. check	0.06	0.022	0.03	0.331	0.09	0.014
Unbuffered vs. pH 6 solutions	0.01	0.199	0.01	0.719	0.01	0.972
Unbuffered vs. pH 4 solutions	0.03	0.180	0.01	0.763	0.01	0.852
pH 6 vs. pH 4	0.01	0.340	0.01	0.509	0.01	0.824
Foliar B vs. foliar B + K	0.08	0.001	0.08	0.001	0.13	0.001
Foliar B vs. foliar K	0.07	0.001	0.06	0.047	0.10	0.001
Foliar B + K vs. foliar K	0.01	0.524	0.03	0.095	0.03	0.173
	Petiole K comparisons					
Unbuffered vs. check	0.17	0.185	0.35	0.040	0.30	0.028
pH 6 solutions vs. check	0.11	0.413	0.24	0.157	0.28	0.040
pH 4 solutions vs. check	0.13	0.327	0.30	0.074	0.36	0.009
Unbuffered vs. pH 6 solutions	0.06	0.501	0.07	0.539	0.09	0.363
Unbuffered vs. pH 4 solutions	0.05	0.624	0.05	0.694	0.06	0.529
pH 6 vs. pH 4	0.02	0.885	0.03	0.821	0.03	0.777
Foliar B vs. foliar B + K	0.11	0.229	0.26	0.031	0.34	0.001
Foliar B vs. foliar K	0.13	0.187	0.22	0.061	0.33	0.001
Foliar B + K vs. foliar K	0.01	0.907	0.03	0.769	0.01	0.987

till yields were not increased from broadcasting K rates above that recommended (28 kg ha^{-1}). For the eight site-years, no-tillage yields were increased 1 yr after broadcasting 28 kg ha^{-1} (recommended rate), 3 yr after broadcasting 58 kg ha^{-1}, and 1 yr after broadcasting 112 kg K ha^{-1}.

The K concentrations for both leaf blades and petioles collected at bloom are not reported because treatment differences were not observed (Table 4). K concentrations in leaf blades and petioles were not affected by the foliar B solutions, regardless of buffering. This result was expected because K was not foliar-applied to these B-only treatments; however, the B + K solution buffered to pH 4 resulted in the highest mean K level for both leaf blades and petioles for the three sampling periods, although differences were not significant when compared with other foliar K treatments (Table 5). In the foliar K treatments, leaf blade K concentrations were consistently higher than the check 3 wk after bloom. The B + K solutions buffered to pH 6 and pH 4 increased K concentrations of leaf blades 2 wk after bloom compared with the untreated check.

Petiole K concentrations were not affected by foliar K until 3 wk after bloom (Table 4). The finding that buffering K solutions to pH 6 and 4 results in higher petiole concentrations 3 wk after bloom agrees with previous research by Howard et al. (1998b). They showed that petiole K from solutions buffered to pH 4 was greater than the check 3 wk after application. Apparently, higher plant K concentration that results from foliar applications was responsible for the higher yields of both tests.

CONCLUSIONS

Buffering foliar B and/or K solutions improved the response of no-till cotton to foliar applications. Buffering foliar B and/or K solutions to pH 4 improved the first-harvest, second-harvest, and total lint yields of no-till cotton over the 3 yr examined here. Four foliar applications each growing season of a mixture of B + K buffered to pH 4 increased first-harvest yields by 14.6% and total yields by 15.9% compared with the check yields. Total lint yields were increased from 6.9 to 15.9% by foliar applications of the B + K solutions (unbuffered, pH 6, and pH 4). Foliar K solutions (unbuffered, pH 6, and pH 4) increased total yields from 10.5 to 13.8%, while foliar B (unbuffered, pH 6, and pH 4) increases ranged between 4.9 and 10.3%.

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