Effect of Potassium Fertilization on Yield and Petiole Potassium Levels of Two Modern Cotton Cultivars

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RESEARCH PROBLEM

Proper potassium (K) availability is essential for cotton (*Gossypium hirsutum* L.) growth and lint development, since K plays an important role in translocation of sugars and activation of many of the enzymes responsible for various plant metabolic processes (Coker et al., 2003). Plant demand for K is particularly high during fruit development (Oosterhuis et al., 2003). Therefore, K deficiency will negatively impact cotton yield and lint quality.

BACKGROUND INFORMATION

The fast-fruiting, high-quality cultivars introduced in the past two decades may have different nutritional requirements than the obsolete cultivars that were originally used to develop most of our current K-fertilizer recommendations. In order to improve future K-fertilization practices for cotton, a field experiment was conducted to evaluate the effect of K-fertilizer application rate on yield and petiole K concentration of two modern cotton cultivars.

PROCEDURES

A replicated field experiment was conducted at the University of Arkansas Cotton Branch Experiment Station (CBES) in Marianna, Ark., during the 2003 growing season on a recently leveled field. The experimental design was a completely randomized block with a split- plot treatment structure where cotton cultivar was the main plot factor and K rate (0, 30, 30, 60, and 90 lb K_2O/acre) was the subplot factor. One of the 30-lb K_2O/acre treatments received an additional late-season K application of 60 lb of K_2O/acre on 12 September. Each experimental treatment was replicated four times. Stoneville 4892 and Paymaster 1218 were the two test cultivars. Individual plots were 50-ft long and 12.6-ft wide allowing for four rows of cotton with 38-in. row spacings. All plots received a blanket application of 50, 40, and 2 lb/acre of N, P_2O_5, and B, respectively, prior to planting on 2 June 2003. All plots also received agricultural limestone at the rate of 1 ton/acre prior to planting and an additional application of 30 lb N/acre on 7 July. Potassium treatments were mechanically broadcast and then lightly incorporated by field cultivation on 23 June. Conventional tillage and pest management practices were followed. Cotton was planted on 5 June and harvested with a mechanical picker on 24 October. The late planting date was due to unfavorable weather conditions on more than 17 days during May. Prior to application of any soil amendments eight composite soil samples were collected from the 0- to 6-in. soil depth of the experimental area using a 50 × 50 ft grid. Composite soil samples were collected from the 0- to 6- and 6- to 12-in. depths of all plots after crop harvest in mid-November. Soil samples were extracted with Mehlich-3 solution (1:10 ratio) and the concentration of elements in the soil extracts were measured by inductively coupled plasma atomic emission spectroscopy (ICP-AES). Soil pH, and electrical conductivity (EC) were measured in a 1:2 (weight:volume) soil-water mixture. Cotton petiole samples were collected from the 5th node from the top of 20 plants selected randomly. Cotton petioles were dried overnight at 70ºC and ground to pass a 1-mm seive. A 0.075 g sub-sample was mixed with 21 mL of 2% acetic acid, shaken for 10 minutes, and filtered. Petiole concentrations of K, P, and S were determined by

ICP-AES. Petiole samples were collected at four dates including the week before the first bloom and the first three weeks of bloom. Analysis of variance was performed to evaluate the effect of cotton cultivar, K application rate, and their interaction on seedcotton yields, petiole K, and post-harvest soil properties using SAS. Significant treatment means were separated using the Waller-Duncan test.

RESULTS AND DISCUSSION

Statistical analysis of seedcotton yields, petiole K concentrations, and post-harvest soils data indicated that there was no significant cultivar or cultivar × K rate (interaction) effects. Therefore, all data were averaged across cultivars. Pre-application soil-test data indicated that the soil at this site was acid with an average soil-test K of 175 lb K/acre, where a response to K fertilization was expected (Table 1). Seedcotton yields ranged from 1180 to 1720 lb/acre and were not significantly (P =0.05) affected by K fertilizer rate (Table 2). The lack of a significant yield response to K fertilization was somewhat unexpected since according to current recommendations a yield response to K fertilization is anticipated when soil-test K is <350 lb K/acre. A number of factors may have contributed to lack of response to K fertilization, including late planting, low initial soil pH, and soil variability within the research area since the site was precision graded approximately a week before planting.

Petiole K concentrations were generally below the critical K levels currently in use by the University of Arkansas Cotton Nutrient Monitoring Program (Table 3). Petiole K concentrations were not affected by K application rate early in the season, but were significantly different only when measured on 20 August. Petiole K concentrations on 20 August tended to increase as early-season K rate increased, although the petiole K concentrations were always below the established sufficiency level of 3.5%.

Post-harvest soil chemical properties are presented in Table 4. Post-harvest soil-test K in the surface and subsurface horizons was not affected by K application rate. Soil-test K in the 0- to 6-in. depth ranged from 249 to 267 lb K/acre. According to current University of Arkansas guidelines, 30 lb K_2O/acre is recommended when soil-test K is 250 to 350 lb K/acre, suggesting that, in this experiment even after K fertilization, K deficiency may have limited seedcotton yields. Perhaps the lower yield potential of late-planted cotton also reduces the K nutritional requirements needed for cotton to achieve its maximum yield potential. This is consistent with the petiole K data where the K concentrations were generally below the current sufficiency levels (Table 3).

PRACTICAL APPLICATION

The two modern cotton cultivars tested in this experiment had similar K requirements. Potassium fertilizer application failed to increase cotton yields regardless of cotton cultivar, despite an initial soil-test K concentration that was below the level considered as optimum. Petiole K concentrations were also below the current sufficiency levels throughout the season, regardless of the K fertilizer application rate.

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Table 1. Selected properties from the 0- to 6-in. soil depth for K fertilizer application at the Cotton Branch Experiment Station (CBES) in 2003.

pH[z]	EC[z]	OM[y]	NO_3-N[x]	P[w]	K[w]	Ca[w]	Mg[w]
	(μmohs/cm)	(%)	----------	----------	(lb/acre)	----------	----------
5.4	20	1.1	4	55	175	1953	567

[z] Soil pH and electrical conductivity (EC) measured in a 1:2 (weight:volume) soil-water mixture
[y] OM, soil organic matter determined by Weight Loss on Ignition.
[x] NO_3-N measured by ion-specific electrode.
[w] Mehlich-3 extractable soil nutrients (1:10 extraction ratio).

Table 2. Effect of K fertilizer rate, averaged across cultivars, on seedcotton yield at the Cotton Branch Experiment Station (CBES) in 2003.

K-fertilizer rate	Seed-cotton yield
(lb K_2O/acre)	(lb/acre)
0	1570
30	1720
30 + 60[z]	1180
60	1370
90	1520
MSD at 0.05[y]	NS

[z] 30 lb K_2O/acre applied before planting and 60 lb K_2O/acre was applied on 12 September.
[y] Minimum Significant Difference as determined by Waller-Duncan test.

Table 3. Effect of K fertilizer rate, averaged across cultivars, on cotton petiole K concentrations at the Cotton Branch Experiment Station (CBES) in 2003.

	Petiole K			
K fertilizer rate	7 August wk before first bloom	14 August 1st wk of bloom	20 August 2nd wk of bloom	28 August 3rd wk of bloom
(lb K_2O/acre)	----------	(%)	----------	----------
0	2.8	2.9	1.6	1.8
30	3.2	2.7	1.7	2.0
30 + 60[z]	2.6	2.0	1.3	1.8
60	3.3	2.8	1.8	2.3
90	3.4	2.9	2.6	2.4
Minimum sufficiency level[y]	4.0	4.0	3.5	3.0
MSD at 0.05[x]	NS	NS	0.8	[w]

[z] 30 lb K_2O/acre were applied before planting and 60 lb K_2O/acre were applied on 12 September.
[y] Published by Snyder et al., 1995.
[x] Minimum Significant Difference as determined by Waller-Duncan test, NS = not significant.
[w] Unable to perform statistical analysis due to loss of samples from two of the four replications.

Table 4. Effect of K fertilizer rate on surface (0- to 6-in.) and subsurface (6- to 12-in.) post-harvest soil-chemical properties.

K fertilizer	pH[z]		EC[z]		OM[y]		NO_3-N[x]		P[w]		K[w]		Mg[w]	
rate	0-6"	6-12"	0-6"	6-12"	0-6"	6-12"	0-6"	6-12"	0-6"	6-12"	0-6"	6-12"	0-6"	6-12"
(lb N/acre)			(μmohs/cm)		--- (%)	-----	----------	----------	----------	(lb/acre)	----------	----------	----------	----------
0	5.5	5.7	30	28	1.2	1.2	3.3	4.3	78	79	274	270	432	402
0	5.3	5.3	42	31	1.3	1.2	6.8	5.9	53	47	253	226	686	663
30	5.3	5.0	36	33	1.3	1.3	6.8	6.1	53	49	249	237	633	625
30+60[v]	5.1	4.8	42	39	1.3	1.2	4.6	4.9	52	47	267	241	757	767
60	5.1	5.0	44	33	1.3	1.2	5.9	5.8	54	47	258	240	701	712
90	5.0	4.9	43	32	1.3	1.1	4.0	3.9	51	46	267	231	734	728
MSD at 0.05[u]	NS	0.5	NS	7	NS	0.1	NS	NS	NS	NS	NS	NS	NS	NS

[z] Soil pH and electrical conductivity (EC) measured in a 1:2 (weight:volume) soil-water mixture
[y] OM, soil organic matter determined by Weight Loss on Ignition.
[x] NO_3-N measured by ion-specific electrode.
[w] Mehlich-3 extractable soil nutrients (1:10 extraction ratio).
[v] K_2O applied at 30 lb/acre before planting and 60 lb K_2O/acre on 12 September.
[u] Minimum Significant Difference as determined by Waller-Duncan Test (NS, not significant).

Effect of Phosphorus Fertilization on Cotton Yield and Soil Properties on Two Sites

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RESEARCH PROBLEM

Phosphorus (P) plays an important role in cotton (*Gossypium hirsutum* L.) growth and production. Many plant metabolic processes will not proceed without adequate P because P is a major component of molecules involved in energy transfer in plants. While P toxicity is very rare in most agricultural soils, excessive build-up of P in agricultural soils and its potential transport into surface waters is an environmental concern. Therefore, to maintain balanced plant nutrition and protect the environment, accurate P-fertilizer recommendations are required.

BACKGROUND INFORMATION

In Arkansas, P-fertilizer recommendations are based on soil-P extracted with a modified Mehlich-3 (M3) solution (1:7 soil:solution). Also, most of the correlation and calibration research supporting cotton P fertilization has been conducted with cultivars that are no longer in use. However, this database is currently the best available scientific information for P fertilization of cotton in Arkansas. However, the University of Arkansas Soil Testing and Research Laboratory may change the current extraction procedure from the modified-M3 to the standard M3 (1:10 soil:solution) extraction procedure, which extracts more P from soil. The objectives of replicated field experiments, conducted at two sites, were to i) evaluate the effect of P fertilization and cotton cultivar on seedcotton yield and ii) evaluate the effect of P fertilization on soil properties. The outcomes of the research will be used to improve the accuracy of future P-fertilizer recommendations for cotton in Arkansas.

PROCEDURES

Two replicated field experiments were conducted at the University of Arkansas Cotton Branch Experiment Station (CBES) in Marianna, Ark., and a grower's field (Parten Farm, Lee County) to assess cotton cultivar and soil response to applications of 0 to 90 lb P_2O_5/acre as triple superphosphate. At the CBES, two modern cotton cultivars, PayMaster 1218 and Stoneville 4892, were planted. At the Parten Farm, only Stoneville 4892 was planted. At both sites, experimental plots were 50-ft long and contained four rows spaced 38-in. apart.

At the CBES, the experiment was arranged as a completely randomized split-plot design where cultivar was the main plot factor and P rate was the subplot factor with six replications of each treatment. Standard tillage and pest control practices were followed. All plots were fertilized with a blanket application of 100 lb K_2O/acre as muriate of potash (KCl) and 100 lb N/acre. One-half of the N was applied as urea before planting and the other half was applied as urea ammonium nitrate when plants were at the first week of the bloom. Phosphorus treatments were broadcast by hand and incorporated. Cotton was planted on 2 June and harvested on 17 October 2003 using a mechanical picker that harvested the two center rows of each plot.

The experimental design at the Parten Farm was a completely randomized block with five replications of each P rate. Nitrogen and K applications were similar to the CBES site, except that an additional 25 lb N/acre and 30 lb K_2O/acre were applied when plants were at the third week of the bloom. Cotton was planted on 28 April and harvested on 9 October 2003. Similar to the experiment at CBES standard tillage and pest management practices were followed.

At both sites, composite soil samples were collected from the 0- to 6-in. depth prior to P fertilizer application and after cotton harvest. Soil samples were extracted with Mehlich-3 solution (M3, 1:10 ratio) and concentration of elements in the soil extract was measured by inductively coupled plasma atomic emission spectroscopy (ICP-AES). Soil nitrate was extracted with aluminum sulfate and measured with an ion-specific electrode. Soil pH and electrical conductivity (EC) were measured in a 1:2 (weight:volume) soil-water mixture.

Analysis of variance was performed to evaluate the effect of cotton cultivar and P fertilization on seedcotton yield and soil properties. Significant treatment means were separated using the Waller-Duncan test.

RESULTS AND DISCUSSION

Prior to application of P fertilizer, M3-extractable P in the top 6 in. of the two soils was 64 lb P/acre at the CBES and 82 lb P/acre at the Parten field (Table 1). The soil surface horizon pH at CBES was more acid (5.6) than the Parten field (7.3). There were no significant cultivar ($P > 0.05$) or cultivar × P (interaction, $P > 0.05$) effects on seedcotton yields at CBES. Therefore, yields were averaged across both cultivars. Seed-cotton yields were not significantly ($P > 0.05$) increased by P fertilization and ranged from 2631 to 3287 lb/acre suggesting that P deficiency did not limit yield and both cultivars had similar P requirements (Table 2).

At the Parten field, seedcotton yields were not significantly affected ($P > 0.05$) by P fertilization with yields ranging 5271 to 5396 lb/acre. The difference in the seedcotton yields between the two sites was attributed in part to earlier planting date and a relatively more favorable soil pH at the Parten site. Similar to the CBES site and despite higher overall yields, seedcotton yield was not limited by P deficiency at the Parten Farm.

Since there were no significant cultivar ($P > 0.05$) or cultivar × P rate ($P > 0.05$) effects at the CBES, therefore, soil properties were averaged across cultivar (Table 3). Application of P rates of 45 lb P_2O_5/acre significantly ($P < 0.05$) increased M3-extractable P in the top 6 in. of soil at this site. However, the response to increasing P rates was not linear. Although not significant ($P > 0.05$), similar trends were observed at the Parten Farm, except that the magnitude of the increase in M3-extractable soil-test P was not as large as at the CBES site (Table 4).

PRACTICAL APPLICATIONS

In these two field experiments cotton planted in two soils with initial M3-(1:10 soil:solution) extractable levels of 64 and 82 lb P/acre did not respond to P fertilization suggesting that seedcotton yields were not limited by P deficiency. Cotton cultivar and the cultivar × P rate interaction did not influence seedcotton yields. These data provide a good starting point for designing additional studies to develop accurate, agronomically and environmentally sound P-fertilizer application rates for cotton production in Arkansas.

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Table 1. Selected properties from the 0- to 6-in. soil depth for two P-fertilization trials at the Cotton Branch Experiment Station (CBES) and the Parten Farm in 2003.

Site	pH[z]	EC[z]	OM[y]	NO_3-N[x]	P[w]	K[w]	Ca[w]	Mg[w]
		(µmohs/cm)	(%)	----------	----------	(lb/acre)	----------	----------
CBES	5.6	24	2.0	6	64	262	2600	564
Parten	7.3	37	1.1	12	82	221	4800	423

[z] Soil pH and electrical conductivity measured in a 1:2 (weight:volume) soil-water mixture
[y] OM, soil organic matter determined by Weight Loss on Ignition.
[x] NO_3-N measured by ion-specific electrode.
[w] Mehlich-3-extractable soil nutrients (1:10 extraction ratio).

Table 2. Effect of P fertilizer rate on seedcotton yields at the Cotton Branch Experiment Station (CBES) and the Parten farm in 2003.

	Seedcotton yields	
P fertilizer rate	CBES	Parten
(lb P_2O_5/acre)	---------------- (lb/acre)	-------------
0	2631	5271
15	2775	5962
30	3193	5668
45	3014	5493
60	3268	5994
90	3287	5396
MSD at 0.05[z]	NS (946)	NS (1054)

[z] Minimum Significant Difference as determined by Waller-Duncan Test.

Table 3. Effect of P fertilizer rate on selected post-harvest soil-chemical properties in the 0- to 6-in. soil depth at the Cotton Branch Experiment Station (CBES) in 2003.

P fertilizer rate	pH[z]	Ec[z]	Om[y]	NO_3-N[x]	P[w]	K[w]	Ca[w]	Mg[w]
(lb P_2O_5 /acre)		(µmohs/cm)	(%)	----------------	----------------	(lb/acre)	----------------	----------------
0	5.9	57	2.5	12	68	367	2450	631
15	5.5	52	2.6	14	60	331	2440	630
30	5.6	53	2.5	15	80	384	2446	613
45	5.9	57	2.5	12	87	384	2610	6558
60	5.7	47	2.5	9	86	357	2414	614
90	5.5	56	2.5	10	89	359	2420	625
MSD at 0.05[v]	NS	NS	NS	NS	17	NS	NS	NS

[z] Soil pH and electrical conductivity measured in a 1:2 (weight:volume) soil-water mixture
[y] OM, soil organic matter determined by Weight Loss on Ignition.
[x] NO_3-N measured by ion-specific electrode.
[w] Mehlich-3 extractable soil nutrients (1:10 extraction ratio).
[v] Minimum Significant Difference as determined by Waller-Duncan Test (NS, not significant).

Table 4. Effect of P fertilizer rate on selected post-harvest soil-chemical properties in the 0- to 6-in. soil depth at the Parten Farm in 2003.

P fertilizer rate	pH[z]	Ec[z]	Om[y]	NO_3-N[x]	P[w]	K[w]	Ca[w]	Mg[w]
(lb P_2O_5 /acre)		(µmohs/cm)	(%)	----------------	----------------	(lb/acre)	----------------	----------------
0	5.9	57	2.5	12	68	367	2450	631
0	6.6	36	0.9	4	33	276	4094	750
15	6.7	37	1.0	5	43	295	4092	795
30	6.5	32	1.0	3	43	262	4068	676
45	6.7	40	1.0	4	44	287	4244	747
60	6.7	40	1.7	4	50	270	4039	763
90	6.8	39	1.0	5	47	271	4083	736
MSD at 0.05[u]	NS	NS	NS	NS	NS	NS	NS	NS

[z] Soil pH and electrical conductivity measured in a 1:2 (weight:volume) soil-water mixture
[y] OM, soil organic matter determined by Weight Loss on Ignition.
[x] NO_3-N measured by ion-specific electrode.
[w] Mehlich-3-extractable soil nutrients (1:10 extraction ratio).
[u] Minimum Significant Difference as determined by Waller-Duncan Test (NS, not significant).