Cotton Response to Potassium and Phosphorus Fertilization in a Silt Loam

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RESEARCH PROBLEM

Potassium (K) and phosphorus (P) are two macronutrients required for cotton production (*Gossypium hirsutum* L.). Cotton yield or quality can be impacted if sufficient amounts of either nutrient are not available for plant uptake. Two field experiments were conducted to evaluate the effect of K and P fertilization on cotton yield and petiole concentrations of K and P.

BACKGROUND INFORMATION

Potassium plays a pivotal role in lint development and P is essential for energy transfer within the cotton plant. A one ton crop of cotton removes 63 lb P_2O_5/acre and 126 lb K_2O/acre (Jones, 2002). Insufficient quantities of either nutrient can adversely affect cotton yield or quality. Similar to N, petiole K concentration is used as a diagnostic tool to assist growers with making in-season foliar K application decisions. Cotton production practices have dramatically changed during the past three decades. An example is the introduction of new, fast-fruiting cultivars. These cultivars may have different nutritional requirements than the obsolete cultivars that were originally used to develop our current fertilizer and petiole K monitoring recommendations. In order to provide Arkansas growers with up-to-date technical information, new field experiments are needed to evaluate the effect of K and P fertilizer rates on cotton yield and nutrient concentrations in the petiole.

PROCEDURES

Two separate, replicated field experiments were conducted at the University of Arkansas Cotton Branch Experiment Station (CBES) in Marianna, AR, during the 2002 growing season to evaluate the effect of K and P fertilization on cotton yield and petiole K and P concentrations, respectively. The soil at the experimental site is mapped as Loring silt loam. Prior to planting, two composite soil samples were collected from the top 6 inches of each plot; each composite sample consisted of eight 1-inch diameter samples from the eight cotton rows. Soil samples were extracted with Mehlich-3 solution (1:10 ratio) and concentration of elements in the soil extract was measured by Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES). Nitrate, pH, and EC were measured by standard University of Arkansas soil testing procedures and results were tabulated (Tables 1 and 2). Cotton (Stoneville 4892) was planted in 38-inch row spacings on 21 May using recommended conventional tillage practices for both experiments.

Individual K fertility plots were 90 ft long and 25 ft wide and P plots were 200 ft long and 25 ft wide. Potassium fertilizer was applied at 0, 30, 60, and 120 lb K_2O/acre as muriate of potash (KCl) and P was applied at 0, 30, 60, and 90 lb of P_2O_5/acre as triple super phosphate. Both fertilizers were mechanically incorporated into the soil prior to planting. All experimental plots received a blanket application of 60 lb N/acre as NH_4NO_3 at the pinhead square stage. The design of both experiments was a randomized complete block with four replications of each treatment. Cotton petiole samples were collected for 10 consecutive weeks starting on 1 July and ending on 5 September. The first two weeks, 24 petioles from the fifth node from the top were randomly collected from each plot. The final eight weeks, 16 petioles from the fifth node from the top were randomly collected from each plot. Cotton petioles were dried overnight at 70°C and ground to pass a 1-mm seive. A 0.075-g sub-sample was also 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. At maturity, seedcotton yield was measured from the center four rows of each plot with a 4-row cotton picker equipped with an AgLeader™ cotton yield monitor. Analysis of variance was used to evaluate the effect of K or P fertilizer rates on cotton yield and petiole nutrient concentrations with significant treatment means separated by the Waller-Duncan test.

RESULTS AND DISCUSSION

K Fertilization

Seedcotton yield ranged from 1685 to 1846 lb/acre (calculated lint yield 590 to 684 lb/acre) and was not significantly affected by K fertilizer rate (Table 3). This was somewhat unexpected since according to current recommendations a yield response to K fertilizer is anticipated when preplant soil-test K concentrations are <200 lb K/acre. Petiole K concentrations increased as K fertilizer application rate increased for the first seven sample times but were not affected at the final two sample dates (Table 4). Within each sample time, petiole K started to decline one week after the first bloom (July 22) and consistently decreased throughout the rest of the growing season (Table 4). This is consistent with the general trend of K utilization by growing cotton plants. Petiole K was consistently below the lower sufficiency range (listed in Table 4) for all treatments amended with <120 lb K_2O/acre. This suggests that on this soil the current K sufficiency ranges, established with older cultivars, may not be accurate for prescribing in-season K fertilizer applications or that perhaps the subsoil contains a significant amount of plant available K.

P Fertilization

Seedcotton yield ranged from 2412 to 2717 lb/acre (calculated lint yield range 824 to 951 lb/acre) and was not significantly affected by P fertilizer application rate (Table 5). This was not unexpected since preplant soil-test P was high enough (Table 2) that only a small amount (10 lb P_2O_5/acre) of P fertilizer was recommended by University of Arkansas cotton fertilization guidelines. This indicates that the current upper limit of soil-test P for cotton appears to be appropriate or could possibly be lowered. Petiole-P concentrations were not affected by P fertilizer application rate and there was no consistent trend in concentration changes for petiole P during the season (Table 6).

PRACTICAL APPLICATION

Potassium fertilizer application failed to increase cotton yields on a Loring silt loam with preplant soil-test K ranging from 192 to 199 lb K/acre. However, petiole K concentration increased as K fertilizer rate increased. In this experiment the current lower sufficiency range for petiole K was not an accurate assessment of the need for K fertilization since cotton yield did not respond to K fertilization. Sufficiency ranges may need to be recalibrated for petiole monitoring to be an effective diagnostic tool for prescribing in-season foliar K application. No yield response to P fertilization was observed when preplant Mehlich-3 extractable (1:10 ratio) soil-test P ranged from 72 to 76 lb/acre. This soil-test P is equivalent to approximately 50 lb/acre in current recommendation where 1:7 soil:solution ratio is used. The current upper levels of soil-test P for cotton appears to be appropriate for identifying soils that are not responsive to fertilizer application. However, to prevent excessive P buildup in Arkansas soils additional soil-test calibration data are needed.

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Table 1. Selected chemical properties before fertilizer application of the top 15 cm of soil at K fertilization study conducted at the Cotton Branch Experiment Station during 2002.

K rate	pH	Mehlich-3 extractable nutrients[z]					
		NO_3-N	P	K	Mg	Ca	B
(lb K_2O/acre)		---------- (lb/acre) ----------					
0	6.4	26	75	194	419	2626	0.9
30	6.3	38	73	199	419	2714	1.0
60	6.5	34	73	194	417	2681	3.4
120	6.3	28	74	192	424	2798	0.9

[z] Modified Mehlich-3 extraction procedure (1:10 extraction ratio).

Table 2. Selected chemical properties before fertilizer application of the top 15 cm of soil from P fertilization study conducted at the Cotton Branch Experiment Station during 2002.

P rate	pH	Mehlich-3 extractable nutrients[z]					
		NO_3-N	P	K	Mg	Ca	B
(lb P_2O_5/acre)		---------- (lb/acre) ----------					
0	6.7	14	76	255	271	1736	0.6
30	6.6	13	72	244	253	1601	0.5
60	6.7	13	72	235	250	1646	0.6
90	6.7	12	72	240	248	1612	0.8

[z] Modified Mehlich-3 extraction procedure (1:10 extraction ratio).

Table 3. The effect of K fertilizer rate on cotton yield at the Cotton Branch Experiment Station during 2002.

K rate	Seedcotton yield	Lint yield	Lint yield
(lb K_2O/acre)	---------- (lb/acre) ----------		(bale/acre)
0	1685	590	1.21
30	1954	684	1.46
60	1846	646	1.34
120	1839	644	1.33
Significance	NS[z]	NS	NS

[z] NS= not significant at P = 0.05 probability level.

Table 4. Effect of K fertilizer rate on cotton petiole K concentration at the Cotton Branch Experiment Station during 2002.

K rate	Seedcotton yield	Sampling date July 8	July 15[z]	July 22	July 29	Aug. 5	Aug. 12[y]	Aug. 19	Aug. 26	Sept. 3
(lb K_2O/acre)	(lb/acre)	----------	----------	----------	----------	[Petiole K (%)]	----------	----------	----------	----------
0	1685	2.5	1.8	3.2	3.0	1.7	1.2	1.2	1.0	1.0
30	1954	2.8	2.1	3.8	3.4	2.1	1.6	1.5	1.5	0.9
60	1846	3.2	2.5	4.1	3.6	2.4	2.0	2.0	1.5	1.3
120	1839	4.1	3.1	4.6	4.3	2.9	2.4	2.3	1.2	1.2
Lower sufficiency level[x]		4.0	4.0	4.0	3.5	3.0	2.5	2.0	1.7	1.3
Significance		**[v]	**	*	+	**	**	**	NS[w]	NS
MSD (0.05)[u]		0.4	0.4	0.8	1.2	0.3	0.5	0.6	NS	NS

[z] First bloom on 19 July.
[y] Cut-out occurred on 17 August; first open boll on 9 September.
[x] Published by Snyder et al., 1995.
[w] NS = not significant.
[v] **, *, + significant at P = 0.01, 0.05, and 0.10 probability level, respectively.
[u] Minimum Significant Difference as determined by Waller-Duncan test.

Table 5. The effect of P fertilizer rate on cotton yield at the Cotton Branch Experiment Station during 2002.

P rate	Seedcotton yield	Lint yield	Lint yield
(lb P_2O_5/acre)	---------- (lb/acre)	----------	(bale/acre)
0	2412	844	1.75
30	2593	908	1.88
60	2354	824	1.71
90	2717	951	1.98
Significance	NS[z]	NS	NS

[z] NS = not significant at P = 0.05 probability level.

Table 6. Effect of P fertilizer rate on cotton petiole P concentration at the Cotton Branch Experiment Station during 2002.

P rate	Seedcotton yield	Sampling date July 8	July 15[z]	July 22	July 29	Aug. 5	Aug. 12[y]	Aug. 19	Aug. 26	Sept. 3
(lb P_2O_5/acre)	(lb/acre)	----------	----------	----------	----------	[P (mg/kg)]	----------	----------	----------	----------
0	1685	2.5	1.8	3.2	3.0	1.7	1.2	1.2	1.0	1.0
0	2412	1068	916	2030	2157	1734	999	1599	1822	1876
30	2593	1063	898	2038	2340	1766	992	1622	1629	1759
60	2354	1014	904	1997	2428	1691	1034	1536	2236	2123
90	2717	1266	937	2199	2558	1616	931	1580	1787	2054
Significance		NS[x]	NS	NS	NS	NS	NS	NS	NS	NS

[z] First bloom on 19 July.
[y] Cut-out occurred on 17 August with first open boll on 9 Sept.
[x] NS = not significant at P = 0.05 probability level.