

Yield and Petiole Potassium Levels of Cotton as Affected by Potassium Fertilization

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BACKGROUND INFORMATION AND RESEARCH PROBLEM

Well-balanced potassium (K) nutrition is an important requirement for producing a high-quality, high-yielding cotton (*Gossypium hirsutum* L.) crop. Potassium plays an important role in translocation of sugars and activation of many of the enzymes required 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 influence cotton yield and lint quality. During the past two decades cotton production systems have changed by advancements in technology and introduction of new fast-fruited cultivars. Information on cotton response to K fertilization under current production practices will enable us to provide cotton growers with economically sound K-fertilizer recommendations.

In recent years researchers have evaluated the potential for using spectral radiometry to assess the nutritional status of crops. Spectral radiometry is a rapid non-destructive technique, which if proven suitable can significantly improve our ability to monitor crop nutritional status in-season. One such method is the use of a chlorophyll meter. One of the commonly used instruments is a Minolta SPAD (soil plant analysis development) meter. The SPAD meter measures the difference in light absorption at 430 and 750 nm (Wood et al., 1992). The former is the transmittance peak for chlorophyll 'a' and 'b', and the latter is in the near-infrared region. The instrument converts the difference in light absorption at these two wavelengths into a numerical SPAD value ranging from 0 to 80 as an index of plant chlorophyll content. As a part of ongoing efforts to improve K-fertilizer recommendations for cotton production in Arkansas, a field experiment was conducted to evaluate the effect of K-

fertilizer rate on yield and petiole-K concentration of two modern cotton cultivars. A second objective of the study was to evaluate the potential for using spectral radiance measurements for predicting K status of cotton leaves.

PROCEDURES

A replicated field experiment was conducted at the University of Arkansas Cotton Branch Experiment Station (CBES) in Marianna, Ark., during the 2004 growing season on a Calloway silt loam. The experimental design was a randomized complete block with a split-plot treatment structure where cotton cultivar ('Stoneville 4892' and 'Paymaster 1218') was the main-plot factor and K rate (0, 30, 60, 90, 120, and 150 lb K₂O/acre) was the subplot factor. All K treatments were applied on 16 July except the highest K rate plots which received 120 lb K₂O/acre on 16 July and the remaining 30 lb K₂O/acre on 3 Aug. Each experimental treatment was replicated four times. Individual plots were 43-ft long and 12.5-ft wide allowing for four rows of cotton with 38-inch row spacings. Prior to planting, all plots were fertilized on 5 May with ammonium sulfate and triple superphosphate to supply 30 lb N and 46 lb of P₂O₅/acre, respectively. A solution of urea ammonium nitrate (32% N) was knifed in to supply an additional 60 lb N/acre on 16 July. On 6 August, 30 lb N/acre was broadcast on all plots. All plots were established with conventional tillage and recommended pest-management practices were followed. Cotton was planted on 12 May, seedlings emerged on 25 May, first bloom occurred on 21 July, and cotton was harvested with a mechanical picker on 16 October. Prior to application of any soil amendments, two composite soil samples were collected from the 0- to 6-inch soil depth of each replication in the

experimental area. Soil samples were extracted with Mehlich-3 solution (1:10 ratio) and the elemental concentrations were measured by inductively coupled plasma atomic-emission spectroscopy (ICP-AES). Soil pH was measured by a 1:2 (weight:volume) soil-water mixture extraction.

Leaf fluorescence and chlorophyll content were measured three weeks after first flower on 11 August on 10 uppermost, fully expanded main-stem leaves (4th node from the top) in each plot on 'Paymaster 1218' cotton cultivar. Fluorescence was measured using a modulated fluorometer (Osi-FL) and chlorophyll content was measured using a Minolta SPAD 502 chlorophyll meter. Cotton petiole samples were collected from the 5th node from the top of 20 plants selected randomly at five dates including the week before the first bloom and the first four weeks of bloom. Cotton petioles were dried overnight at 70°C and ground to pass a 1-mm sieve. A 0.075 g sub-sample was mixed with 21 mL of 2% acetic acid, shaken for 10 minutes, and then filtered. Petiole concentrations of K, P, and S were determined by ICP-AES. Analysis of variance was performed to evaluate the effect of cotton cultivar, K application rate, and their interaction on seedcotton yields and petiole-K concentration using SAS PROC GLM procedure. Significant treatment means were separated by the Waller-Duncan test when appropriate.

RESULTS AND DISCUSSION

Statistical analysis of seedcotton yields and petiole-K concentration data indicated that there was no significant cultivar or cultivar × K rate (interaction) effects. Pre-application soil-test data indicated that the soil was slightly acidic (pH 6.0) and soil-test K was 209 lb K/acre, which is considered 'Medium' for cotton and thus the benefits of K fertilization would be possible, but nominal (<15% yield increase, Table 1). Seedcotton yields ranged from 2170 to 2518 lb/acre and were not significantly ($P=0.05$) affected by K-fertilizer rate, although we observed a trend for seedcotton yield to increase as K fertilizer rate increased (Table 2). Data suggest that additional research is needed to correlate Mehlich-3-extractable K with cotton-yield response to K fertilization.

Petiole-K concentrations increased as K-fertilizer rate increased and decreased with time (i.e., cotton development, Table 2). Potassium fertilization significantly increased petiole-K concentrations during the week before bloom and the 3rd and 4th week of bloom. Early in the season, petiole-K concentrations were above the critical concentrations currently in use by the University of Arkansas Cotton Nutrient Monitoring Program for all plots. However, petiole-K concentrations in the check plots dropped below the critical levels during the 3rd and 4th week of the bloom.

Leaf fluorescence of Paymaster 1218 cotton ranged from 0.52 to 0.62 [(Fms-Fs)/Fms], but there were no consistent differences among K-fertilizer rates (data not shown). Likewise, there was no consistent effect of K-fertilizer rate on leaf chlorophyll (data not shown). Low K may decrease the activity of some enzymes, such as rubisco, but this was not observed. Additional research will be conducted in the future to investigate the potential utility of these measurements for monitoring the K nutritional status of cotton.

PRACTICAL APPLICATION

The two modern cotton cultivars tested in this experiment had similar K requirements. Potassium fertilization failed to increase cotton yields, regardless of cotton cultivar, despite below optimal soil-test K levels. Petiole-K concentrations were a reflection of K fertilization rates and generally decreased during the growing season. Petiole-K concentrations in cotton that received K fertilizer were consistently above the critical levels set forth by the University of Arkansas Petiole Nutrient Monitoring Program.

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Table 1. Selected chemical properties of soil samples collected from the 0- to 6-inch depth of experimental sites.

pH ^z	OM ^y (%)	NO ₃ -N ^x	P ^w	K ^w	Ca ^w	Mg ^w	Cu ^w	Zn ^w
----- (lb/acre) -----								
6.0	1.6	4	66	209	2350	460	2.3	4.4

^z Soil pH was measured in a 1:2 (weight:volume) soil-water mixture.

^y OM, soil organic matter determined by Weight Loss on Ignition.

^x NO₃-N measured by ion-specific electrode.

^w Mehlich-3-extractable soil nutrients (1:10 extraction ratio).

Table 2. Effect of soil-applied K fertilizer, averaged across cultivars, on seedcotton yield and petiole-K concentration on a Calloway silt loam at CBES in 2004.

K ₂ O rate (lb/acre)	Seedcotton yield (lb/acre)	Petiole-K concentration by sample time				
		14 July wk before bloom	21 July 1 st wk of bloom	27 July 2 nd wk of bloom	9 August 3 rd wk of bloom	16 August 4 th wk of bloom
----- (% K) -----						
0	2170	4.68	4.21	3.20	2.76	1.97
30	2195	5.10	4.77	3.78	3.35	2.40
60	2345	5.42	4.55	3.57	2.98	2.62
90	2518	5.46	4.76	3.93	4.06	2.85
120	2335	5.41	4.82	3.43	3.98	3.32
150	2422	5.41	4.78	4.20	4.47	3.42
Minimum sufficiency level ^z		4.0	4.0	3.5	3.0	2.5
MSD at 0.05 ^y	NS	0.57	NS	NS	0.74	0.62

^z Published by Snyder et al. (1995)

^y Minimum Significant Difference as determined by Waller-Duncan Test (NS, not significant at $P=0.05$).