A Four-Year Study of Cotton Yield Response to Potassium Nutrition With or Without Irrigation

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RESEARCH PROBLEM

Potassium (K) nutrient deficiency costs the cotton (*Gossypium hirsutum* L.) producer in terms of fiber yield and quality. Throughout the growing season, climatic and numerous other factors may regulate the occurrence of and plant response to K deficiency. Sporadic K deficiencies have been noted in Arkansas cotton as the developing bolls exert a greater demand on plant K resources. Additional information is needed about the use of supplementary, foliar-applied K to rectify K deficiencies in field-grown cotton under varying soil K and moisture levels. Thus, our study objective was to evaluate the potential response of cotton yield and quality to foliar K application under water-deficit stress and soil K deficiency.

BACKGROUND INFORMATION

The change to modern cotton cultivars, which fruit in a shorter period of time, mature earlier, and have greater total-K requirements, has placed an emphasis on understanding plant uptake and utilization of K throughout the growing season (Oosterhuis, 1995). Although K may be taken up in luxury amounts by the cotton plant prior to peak demand, K deficiencies often occur late in the growing season when the large, developing boll load becomes the dominant sink for available K. Factors that interfere with the strong source-sink relationship of K in cotton will directly influence the efficiency of K use and the potential for high lint yields (Mullins and Burmester, 1990; Oosterhuis, 1995). Although yield and economic advantages of timely foliar-K applications to supplement soil-applied K have been documented (Oosterhuis, 1999; Weir, 1999), the impact of mid-season water-deficit stress on the efficiency of foliar-K uptake and yield response to foliar-K fertilization needs further investigation.

RESEARCH DESCRIPTION

Cotton growth, K partitioning, physiology, and lint yield under varying water levels and K fertility were studied in 1999 in field plots located at Rohwer (Coker and Oosterhuis, 1999), in 2000 at Clarkedale and Rohwer (Coker and Oosterhuis, 2000), in 2001 at Clarkedale (Coker et al., 2002), and at Fayetteville in 2002. This report describes the 2002 study with reference to the previously conducted studies (cited above) with identical treatments. Eight treatment combinations of well-watered (irrigated) or dryland (non-irrigated) conditions; high (preplant, soil-applied K) or low-soil K (unfertilized or no preplant K); and with or without foliar K were arranged in a split-split plot design with five or six replications. In 2002, the cultivar Suregrow 215 BR was planted on a well-drained Captina silt loam on the Main Agricultural Experiment Station Farm located in Fayetteville, AR. Each plot consisted of four 30-ft long rows spaced 39 inches apart. Preplant granular KCl fertilizer was hand broadcast to designated plots (high soil K) prior to planting at recommended rates based on University of Arkansas fertilizer recommendations for cotton. The average Mehlich 3 extractable soil K was 241 lb K/acre (Table 1). Preplant K fertilizer application rates ranged from 50 to 96 lb K_2O/acre. Foliar KNO_3 was applied (4.4 lb K_2O/acre/week or 10 lb KNO_3/acre) for four consecutive weeks starting one week after first flower with a CO_2 backpack sprayer calibrated to deliver 10 gal/acre. Irrigation events were scheduled in well-watered plots according to the University of Arkansas Irrigation Scheduling Program. An infrared thermometer was used to measure the temperature of the uppermost, full-expanded main-stem node leaves starting at the first flower stage in all plots to monitor plant stress (data not shown). At major phenological stages, measurements were made of photosynthesis, specific leaf weight, ^{13}C discrimination, chlorophyll, adenosine tri-phosphate, soluble carbohydrates, membrane integrity, antioxidant enzymes, and Rubidium translocation in the uppermost fully-expanded leaves. Final lint yield and components of yield were determined from each plot by hand picking a 3.28 ft length from each of the two center rows and counting and weighing the bolls. Lint yield and components of yield comparisons were made using the SAS General Linear Model procedure and PDIFF option within LSMEANS statements.

RESULTS

Although we observed similar yield responses to soil-applied K at Fayetteville in 2002, the yield responses to foliar-applied K were noticeably greater compared to responses observed during previous seasons at Rohwer or Clarkedale (Table 1). Foliar-applied K increased lint yield ($P \leq 0.05$) by 211 lb/acre when preplant K fertilizer was applied (high soil K). When preplant K fertilizer was not applied (low soil K), the mean lint yield response to foliar-applied K was approximately 90 lb/acre, although it was not statistically different than lint yield without foliar-applied K. Thus far, our studies have shown a small lint yield increase to foliar-applied K when preplant K was not applied (low soil K) as opposed to when preplant K fertilizer was applied (high soil K) when averaged across all three test sites during the past four years.

In 2002, cotton lint yields were significantly greater ($P \leq 0.05$) when foliar-K applications were made to dryland (rainfed or non-irrigated) cotton, but not to irrigated cotton. However, when averaged across all three test sites, dryland-cotton lint yields have tended to show slightly greater response to foliar-K application as compared to irrigated-cotton yields. Lint yield response to soil-applied K was significant ($P \leq 0.05$) for irrigated (well-watered) cotton and tended to be positive, although not statistically significant, under dryland conditions in 2002. Across all locations and growing seasons, soil-applied K (high soil K) has increased the mean irrigated cotton lint yield by 5.9%, but had no significant effect on dryland-cotton yields in our studies.

PRACTICAL APPLICATION

Thus far, our studies have shown that the preplant soil K status should be strongly considered when making decisions about foliar K fertilization. Studies during the past three years show significant responses to foliar-applied K on soils with preplant soil-test K <250 lb K/acre, which supports our previous findings (Oosterhuis, 1995). Our results also show that the potential for foliar-K feeding to increase cotton lint yield of dryland (non-irrigated) cotton is similar to that observed for irrigated cotton in the Mississippi Delta. Our current studies also show that soil-applied K fertilizer was beneficial to cotton-lint yields produced under irrigated, but not necessarily dryland conditions in plots where the preplant soil-test K values ranged from medium to high (>250 lb K/acre, Mehlich 3 soil K). Hence, the use of appropriate preplant, soil-applied K fertilizer rates may be particularly important to maximize cotton yields under irrigated conditions. In contrast, foliar-applied K, which can stimulate root uptake of soil K, can be beneficial to cotton-lint yield under dryland or irrigated conditions depending on preplant soil test K values.

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Table 1. Yield response of field-grown cotton over four seasons to mid-season foliar K and preplant soil-applied K averaged over the water, soil K, and foliar K treatments, respectively, at the Rohwer, Clarkedale (Clark), and Fayetteville (Fay) locations since 1999.

	Lint yield						
Treatment	Rohwer 1999	Rohwer 2000	Clark. 2000	Clark. 2001	Fay. 2002	Mean	Mean difference
	(lb/acre^{-1})						[lb/acre (%)]
Avg. over water[z]							
High soil K, no foliar K	1135	1123	948	1359	1286	1170	
High soil K, with foliar K	1133	1116	956	1342	1497[y]	1209	+39(3.3%)
Low soil K, no foliar K	1113	1088	887	1287	1239	1123	
Low soil K, with foliar K	1153	1074	985[y]	1359	1331	1180	+57(5.1%)
Avg. over soil K[z]							
Well watered, no foliar K	1366	1452	1241	1434	1354	1369	
Well watered, with foliar K	1394	1448	1292	1446	1416	1399	+30(2.2%)
Dryland, no foliar K	882	758	593	1212	1171	923	
Dryland, with foliar K	894	742	649	1255	1412[y]	990	+67(7.3%)
Avg. over water and soil K							
No foliar K	1126	1105	917	1323	1262	1147	
With foliar K	1143	1094	970	1350	1414[y]	1194	+47(4.1%)
Avg. over foliar K							
Dryland, high soil K	847	724	640	1228	1336	955	
Dryland, low soil K	929	776	602	1239	1247	957	-2(0.2%)
Well watered, high soil K	1421	1514	1264	1473	1447	1424	
Well watered, low soil K	1338	1386[y]	1269	1407	1323[x]	1345	+79(5.9%)
Water x soil K	[w]	[w]	-	-	-		
Avg. over water and foliar K							
High soil K	1134	1119	952	1350	1391	1189	
Low soil K	1133	1081	936	1323	1285[x]	1152	+37(3.2%)
Preplant soil K level (lb/acre)							
Well watered	264	334	249	263	241	270	
Dryland	253	336	249	289	241	274	

[z] No significant ($P \leq 0.05$) interactions observed between main effects.
[y] Significant at $P \leq 0.05$ for the paired treatments.
[x] Significant at $P \leq 0.10$ for the paired treatments.
[w] Significant at $P \leq 0.05$ for treatment interaction ("-" = no interaction).