POTASSIUM REQUIREMENTS FOR NARROW ROW COTTON

John Sloan, Bill Langston and Jim Heitholt
Texas Agricultural Experiment Station
Dallas, TX

Abstract

Previous research on the Northern Texas Blackland soils has failed to show a clear or consistent cotton response to soil-applied or foliar-applied potassium fertilizer. The objectives of this study were 1) to quantify the effect of soil-applied potassium fertilizer on the quantity and quality of cotton lint yield at various row spacings; 2) to determine the ability of post-flowering, foliar-applied potassium fertilizer to improve cotton yield; and 3) to determine how K fertilization affects K distribution within the plant. Research was conducted at the Texas Agricultural Experiment Station Research farm at Prosper, Texas during the 2000 and 2001 growing season. During both years, 0, 40, and 80 lbs/acre of KCl was applied to 20-, 30-, and 40-inch row spacing cotton crops. Foliar applied KNO_3-K was applied biweekly starting shortly after first flowering. Growing seasons varied greatly from one year to the next with high temperature and drought during the 2000 growing season followed by adequate moisture and lower temperatures for the 2001 growing season. Twenty- and 30-in cotton row spacings did not respond to soil- or foliar-applied K during either growing season, but there was some evidence that lint yields for 40-in cotton rows responded positively to soil-applied K fertilization. The response was clearest for the droughty 2000 growing season. Analysis of cotton tissue from the 2001 growing season showed that soil-applied K also increased K concentrations in the stem tissue of 40-in row cotton. There was no clear cotton response to foliar applications of KNO_3.

Introduction

Narrow row cotton (NRC) is a relatively new production technique that may allow farmers to increase cotton yield per unit of land and thus increase their profit margin. The primary advantages of NRC is that individual plants need only 3-4 bolls per stalk to obtain high yields, which may shorten the required growing season (Delaney et al., 1999). A shorter growing season translates into lower pest control costs and more efficient use of sunlight and water resources (McFarland, et al., 1999).

Cotton response to soil-applied K fertilizer has been demonstrated on acid to neutral soils (Cope, 1981; Howard and Roane, 1999), but the benefits of K fertilization to cotton production on calcareous clay soils, such as those predominant in the Northern Blacklands of Texas, are less conclusive. In California, Tennessee and Arkansas, foliar applied K fertilizer has consistently resulted in increased cotton lint production (Oosterhuis, 1994, Weir, 1999). In contrast, research with soil-applied and foliar-applied K near Dallas, Texas has shown cotton responses ranging from negative, to no response, to increased lint yield (Knowles et al., 1993, 1994). These inconsistent results are probably related to the high K-fixing capacity of the montmorillonitic and vermiculitic clay soils present in the Texas Blacklands (Hipp and Thomas, 1967; Olk et al., 1995). Oosterhuis (1999) suggested that variable yield responses to foliar fertilization were probably due to a variety of factors, including incorrect timing of applications, the use of inappropriate fertilizer materials, insufficient attention to soil available nutrients, and environmental conditions. Additional research is needed on the calcareous Blackland soils of Texas to clarify whether cotton yields are increased by the use of soil and/or foliar applied potassium fertilizers. The objectives of this study were 1) to quantify the effect of soil-applied potassium fertilizer on the quanity and quality of cotton lint yield at various row spacings; 2) to determine the ability of post-flowering, foliar-applied potassium fertilizer to improve cotton yield; and 3) to determine how K fertilization affects K distribution within the plant.

Materials and Methods

Overview

Research was conducted at the Texas A&M University Research Farm at Prosper, Texas during the 2000 and 2001 growing season. The soil was a Houston Black clay (pH 7.8). Available K, measured by Mehlich3 extraction prior to fertilizer application, was 42.7 ± 8.6 lb/A in the 2000 plots and 268 ± 11.6 lb/acre in the 2001 plots. The experimental design consisted of three potassium fertilizer rates (0, 40, and 80 lb/acre) superimposed on three cotton row spacings (20, 30, and 40 inch) and replicated four times. In addition to the soil-applied K, a duplicate set of plots received biweekly applications of foliar-applied KNO_3 starting at first flowering. The complete list of treatments are shown in Table 1.

Soil-applied K fertilizer (KCl) was broadcast by hand on 10-May-2000 the first year and 15-May-2001 the second year and then incorporated with a disk. A Bt/Roundup-ready cotton variety (Delta Pine 422) was planted one day after fertilizer application during both years. Each row spacing was replicated four times. Each replicate included 4 rows of 40-inch cotton, 6 rows of 30-inch cotton and 8 rows of 20-inch cotton. Individual plots consisted of a 15-ft section of each row spacing. All plots received 85 lbs N A^{-1} of urea-ammonium nitrate fertilizer and a preplant application of Prowl® herbicide. Roundup® was applied post-emergent as needed. Insecticides were applied as needed based on field scouting observations.

Data Collection

Cotton growth was monitored during the growing season for signs of cotton root rot wilt. At the end of the growing season, cotton was harvested by hand from the two center rows of each plot. Cotton lint yield and fiber quality were quantified. Analysis of variance and linear regression statistics were used to determine the effect of K fertilizer rate and foliar fertilization on cotton yield. For the 2001 growing season, complete plants were collected from plots with the 40-inch row spacing. The plants were separated into leaves, stems, unopended bolls, fiber and seeds. The individual plant parts were dried, ground, dry ashed, and analyzed for total K content.

Results

Weather patterns in North Texas were significantly different during each of the two growing seasons for this study. The first season (2000) was affected by frequently maximum daily temperatures >100°F and a late season drought (i.e., > 100 consecutive days without rain). Growing conditions were much better the second season (2001) with only a few days above 100°F and not more than 30 consecutive days without rain.

Yield

2000. Early season cotton growth was promoted by abundant rainfall that continued until the end of June. This was followed by >100 days without significant rainfall at the Prosper farm. Consequently, late season cotton growth was severely limited. We made only one post-flowing foliar application of KNO_3. Subsequent applications were cancelled due to the absence of rainfall. Cotton was harvested by hand from a middle row in each plot. We harvested all plots (20-in, 30-in, and 40-in) that received soil applications of KCl, but we only harvested the 40-in rows from the foliar-treated plots.

Soil-applied KCl had no effect on cotton lint yield for the 20-in and 30-in row spacings (Fig. 1A). Cotton planted in 40-in rows responded positively to KCl applications of 40 and 80 lbs K A^{-1}. A single foliar application of 10 lbs K A^{-1} had no significant effect on cotton lint production from 40-in rows that had received 40 or 80 lbs A^{-1} soil applied KCl-K (Fig. 2). Although the effect was not significant, there appeared to be a positive response to foliar-applied KNO3 for the plots that received no soil applied K.

2001. Cotton yields were quite variable during the second growing season. Statistical analysis showed there were no significant effects due to either soil-applied KCl-K or foliar-applied KNO_3 at the 0.05 level of probability, but the 40-in cotton row spacing responded to soil-applied K at the 0.10 level of probability when no foliar K was applied (Fig. 1B). The soil tested relatively high for available K for the 2001 growing season (268 lb/acre), so this may have prevented a more clear response to soil K fertilization.

Cotton yields for the 2001 growing season were generally higher than those for 2000 (Fig.1). This was expected due to more favorable growing conditions during the 2001 season. However, evidence of a positive response to soil-applied and foliar-applied K was greater for the 2000 growing season, suggesting that cotton plants in the Blackland soils of North Texas may benefit from K fertilization during droughty weather. Potassium deficient plants are know to be more susceptible to drought conditions (Marschner, 1986).

Lint Quality

Lint quality measurements for the 2000 and 2001 growing seasons were within parameters normally observed for cotton (Table 2). Potassium fertilization had no significant or consistent effect on any of the measured lint quality properties. The only significant effect was growing season. In general, cotton fiber from the 2001 growing season was better quality than that from the year 2000. Micronaire and uniformity were both significantly improved during the 2001 growing season. Apparently, the more favorable growing conditions during 2001 allowed the cotton fiber to mature more completely.

Plant K Distribution

Potassium analysis of individual plant parts from the 40-in rows showed that K concentration was lowest in the cotton fiber (2 to 3 g/kg), was about the same in the leaves, stems and seed (10 to 15 g/kg), and was highest in the unopened cotton bolls (18 to 24 g/kg). In general, neither soil- nor foliar-applied K had a significant effect on K concentration. The only exception was a significantly higher concentration of K in the stems of cotton plants that received 40 and 80 lbs/acre soil-applied KCl-K. This is consistent with the slightly higher yields that were observed for the 40-in row cotton that received no foliar K (Fig. 1).

Conclusion

Results from this study provided glimpses of possible positive cotton responses to potassium fertilization, but the results were somewhat inconsistent and ambiguous. The clearest data was for the 2000 growing season when soil available K was low and a late season drought reduced overall cotton yields. A high amount of available soil K coupled with favorable growing conditions prevented a clear cotton response to K fertilization during the 2001 growing season. There was very little evidence that foliar applied K improved cotton yields or lint quality.

References

Cope, J.T., Jr. 1981. Effects of 50 years of fertilization with phosphorus and potassium on soils test levels and yields at six locations. Soil Sci. Soc. Am. J. 45:342-347.

Delaney, D.P., C.D. Monks, D.W. Reeves, J.S. Bannon, and R.M. Durbin. 1999. Planting dates and populations for UNR cotton in Central Alabama. Proc. Beltwide Cotton Conf. (2):1278-1279.

Hipp, B.W. and G.T. Thomas. 1967. Influence of soil clay type on potassium availability. Texas A&M University, Texas Agricultural Experiment Station. MP-829

Howard, D.D. and R.H. Roane. 1999. Phosphorus and potassium nutrition of cotton produced using two tillage systems. Proc. Beltwide Cotton Conf. (2):1310.

Knowles, T.C., B.W. Hipp, and W.C. Langston. 1993. Cotton responses to fertilizer and drip irrigation in the Texas Blackland. Proc. Beltwide Cotton Conf. (3):1360-1363.

Knowles, T.C., B.W. Hipp, and W.C. Langston. 1994. Nitrogen and potassium nutrition of cotton grown in the Texas Blackland. Proc. Beltwide Cotton Conf. (3):1552-1554.

Marschner, Horst. 1986. Mineral Nutrition of Higher Plants. p. 265. Academic Press Limited. 24/28 Oval Road, Lindon NW1 7DX.

McFarland, M.L., R.G. Lemon, F.M. Hons, and T. Gerik. 1999. Nitrogen management in ultra narrow row cotton. Proc. Beltwide Cotton Conf. (2):1279-1280.

Olk, D.C., K.G. Cassman, and R.M. Carlson. 1995. Kinetics of potassium fixation in vermiculitic soils under different moisture regimes. Soil Sci. Soc. Am. J. 59:423-429.

Oosterhuis, D.M. 1994. Potassium nutrition of coton in the USA with particular reference to foliar fertilization. In G.A. Constable and N.W. Forrester (Eds.) Challenging the Future: Proceedings of the World Cotton Research Conference-1. Brisbane, Australia, February 14-17, 1994. CSIRO pp. 133-146.

Weir, B.L. 1999. Effect of foliar applied potassium on cotton in the San Joaquin Valley of California. Proc. Beltwide Cotton Cong. (2):1307-1309.

Table 1. Description of soil-applied and foliar-applied K treatments.

TREATMENT	DESCRIPTION
1	control – no K fertilizer
2	low rate (40 lb K A^{-1}) of soil-applied KCl
3	high rate (80 lb K A^{-1}) of soil-applied KCl
4	no soil-applied K plus post-flowering foliar-applied KNO_3
5	low rate of soil-applied KCl plus post-flowering foliar-applied KNO_3
6	high rate of soil-applied KCl plus post-flowering foliar-applied KNO_3

Table 2. Effect of row soil-applied and foliar-applied potassium on cotton fiber quality for several row spacings. Values within a column followed by the same letter are not statistically different (Duncan's New Multiple Range Test, p=0.05).

Row Spacing	Soil K (lb/A)	Foliar K (lb/A)	Mic	Length	Unif.	Strength	Elon.
					2001		
20	0	0	3.7 cd	1.0 a	79.4 cd	25.5 c	5.9 a
20	40	0	3.8 cd	1.0 a	80.5 c	25.0 c	5.5 a
20	80	0	3.6 d	1.0 a	80.0 cd	25.7 c	5.8 a
30	0	0	3.7 cd	1.1 a	80.4 cd	25.9 c	5.5 a
30	40	0	3.8 cd	1.1 a	80.3 cd	25.6 c	5.8 a
30	80	0	3.8 cd	1.0 a	79.9 cd	24.0 d	5.4 a
40	0	0	3.9 cd	1.0 a	80.4 cd	24.0 d	5.4 a
40	0	10	3.8 cd	1.0 a	79.3 d	25.4 c	5.5 a
40	40	0	3.8 cd	1.1 a	80.4 cd	25.5 c	5.6 a
40	80	0	4.0 c	1.0 a	80.0 cd	24.0 d	5.6 a
40	80	10	3.9 cd	1.0 a	80.2 cd	25.6 c	5.7 a
					2001		
20	0	0	5.9 a	1.0 a	82.7 a	28.9 ab	5.7 a
20	0	30	5.8 a	1.1 a	83.4 a	29.1 ab	5.6 a
20	40	0	5.8 a	1.0 a	82.9 ab	28.8 ab	5.6 a
20	40	30	5.8 a	1.1 a	83.4 a	29.0 ab	5.8 a
20	80	0	5.8 a	1.0 a	82.8 ab	28.1 b	5.5 a
20	80	30	5.8 a	1.1 a	83.2 ab	28.9 ab	5.8 a
30	0	0	5.8 a	1.1 a	83.5 a	29.7 a	5.8 a
30	0	30	5.6 ab	1.1 a	83.5 a	28.9 ab	5.8 a
30	40	0	5.6 ab	1.1 a	82.8 ab	28.5 ab	5.8 a
30	40	30	5.7 ab	1.1 a	82.9 ab	29.4 ab	5.8 a
30	80	0	5.8 ab	1.0 a	82.7 ab	28.3 ab	5.7 a
30	80	30	5.7 ab	1.1 a	83.0 ab	28.7 ab	5.7 a
40	0	0	5.7 ab	1.1 a	83.3 ab	28.8 ab	6.0 a
40	0	30	5.8 a	1.0 a	82.6 ab	28.2 ab	5.8 a
40	40	0	5.9 a	1.1 a	83.1 ab	29.2 ab	5.7 a
40	40	30	5.4 b	1.1 a	82.1 b	28.5 ab	5.7 a
40	80	0	5.6 ab	1.1 a	83.4 a	29.5 ab	6.1 a
40	80	30	5.7 ab	1.1 a	83.0 ab	29.1 ab	5.5 a

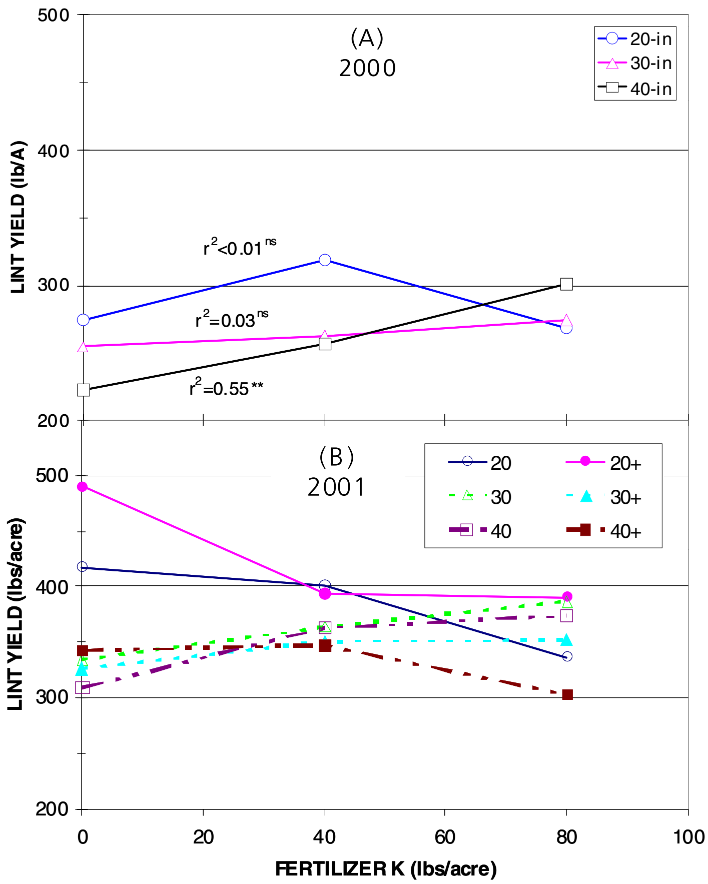

Figure 1. Cotton lint yield as affected by row spacing (20, 30, and 40 inches), soil-applied K fertilizer (0, 40, and 80 lb/Acre), and foliar-applied K (indicated by + in legend) during the (A) 2000 and (B) 2001 growing season.

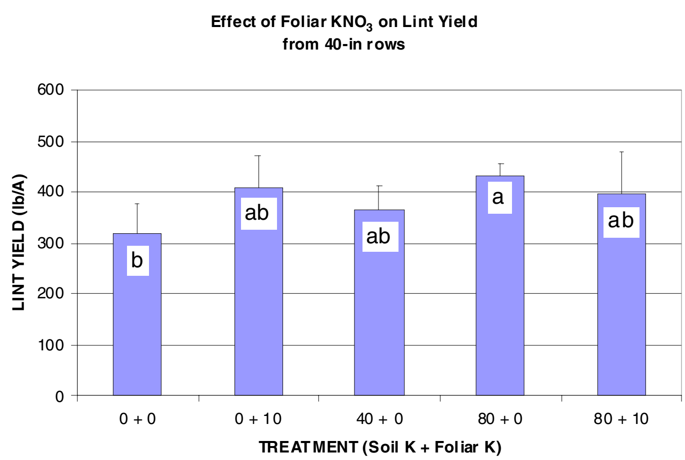

Figure 2. Effect of foliar-applied KNO_3 on cotton lint yield from 40-in row spacings during the 2000 growing season.

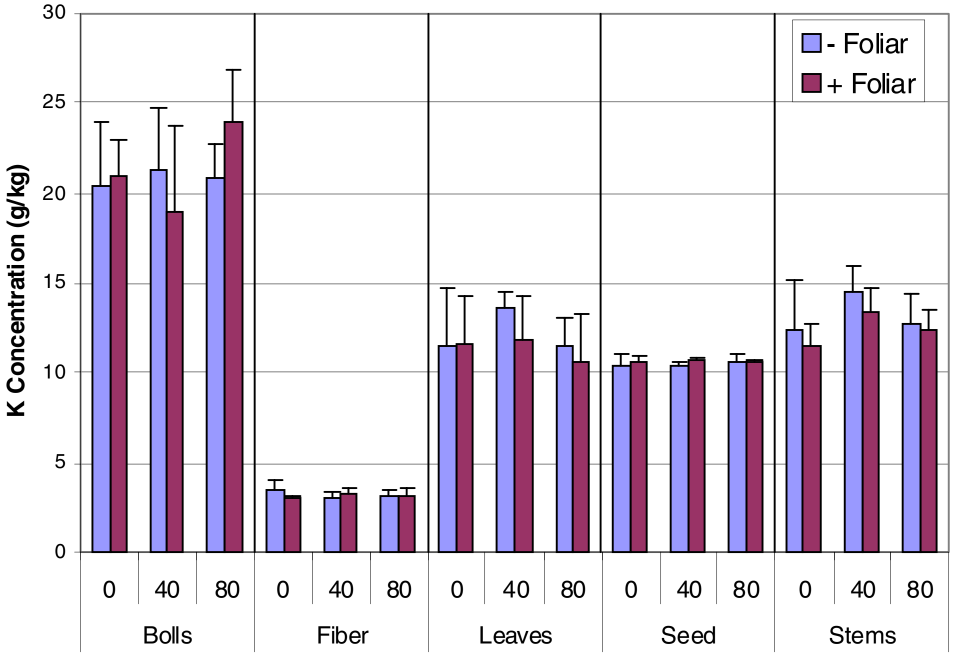

Figure 3. Effect of soil applied and foliar applied potassium on K concentration in various plant parts.