Impact of Soil Applied Potassium on Cotton Yield and Profitability

By Mike Stewart and Gaylor D. Morgan

The frequency and severity of K deficiency symptoms is increasing on some highly productive cotton-producing soils in Texas.

The effects of K fertilizer rate and placement were investigated to determine their impact on cotton yield, fiber quality parameters, and profitability.

Where response to K was observed, band outperformed broadcast applications, with significant improvement in yield and return on investment.

Texas produces more cotton than any other state in the U.S. Over the three most recent years of production (2013-15), Texas has produced 40% of total U.S. cotton (USDA-NASS, 2016). Most of this production comes from the High Plains of Texas—the largest contiguous cotton-producing region in the world. But other areas within the state such as the Trans-Pecos, Rolling Plains, Rio Grande Valley, Blacklands, and Coastal Prairie regions also produce significant amounts of cotton (**Figure 1**). **Table 1** illustrates the economic importance of Texas cotton production relative to other common crops.

A major factor affecting both cotton yield and quality is the availability of adequate and balanced nutrition. Potassium is an especially important nutrient in cotton production. It reduces the incidence and severity of wilt diseases, increases water use efficiency, and affects fiber properties like length, strength, and micronaire. It is important in maintaining sufficient water pressure within the boll for fiber elongation, and for this reason bolls are a major sink for K. Cotton takes up about 60 lbs of K_2O per bale of lint produced. The need for K increases dramatically during early boll set, and about 70% of uptake occurs after first bloom. Potassium deficiency may be expressed as a full season deficiency, or it may not appear until late season since this is the period of greatest demand. A shortage of K compromises lint yield and quality, and results in plants that are more susceptible to drought stress and diseases.

Soil K has mostly been considered adequate in cotton-producing regions of Texas; however, the frequency and severity of K deficiency symptoms on the highly productive clay soils in the Central Blacklands and Gulf Coast regions have increased in recent years. This increased occurrence of K deficiency in cotton, and other row crops, is a major concern for producers, agribusiness, and scientists. This study was undertaken to investigate the effect of K fertilizer rate and placement on cotton yield, fiber quality parameters, and profitability in the the region's fine textured soils.

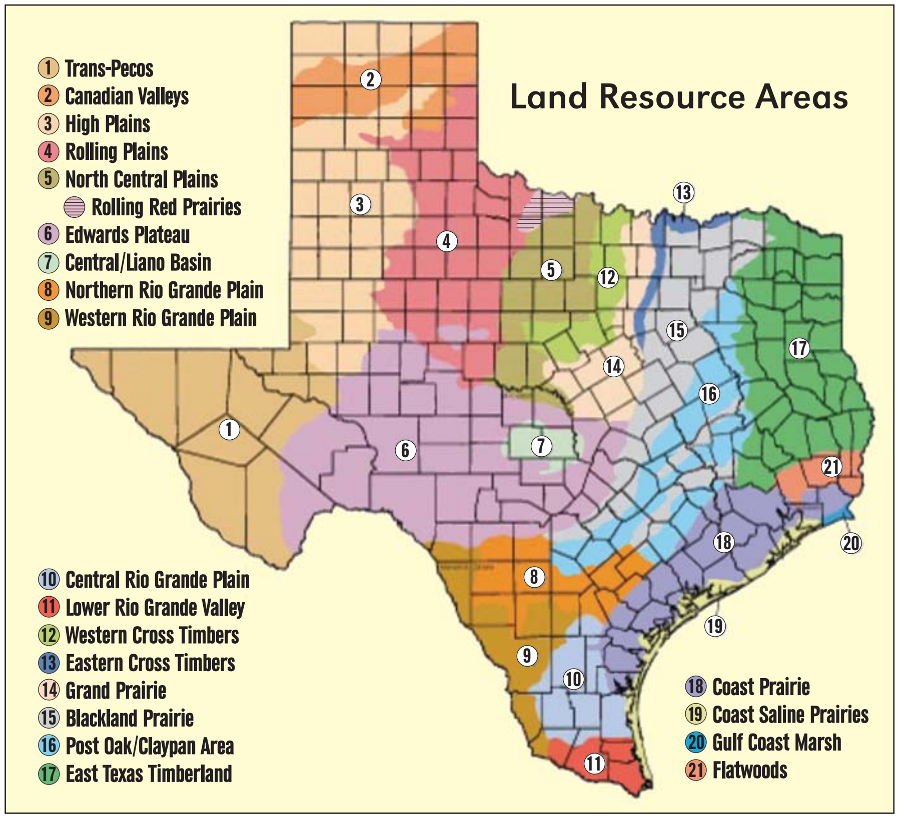


Figure 1. Land resource areas of Texas. © 2010 Texas Almanac graphic.
Source: Natural Resources Conservation Service of the U.S. Department of Agriculture.

Table 1. Total cash receipts (farm gate value), contribution to GDP, and economic output for selected agricultural commodities in Texas, 2014.

	Total cash receipts, $	Total contribution to GDP, $	Economic output, $
Cotton	2,169,527,000	1,954,526,900	5,118,001,000
Corn	1,308,269,000	1,082,200,100	2,814,399,300
Grain sorghum	541,265,000	447,734,400	1,164,390,400
Wheat	436,840,000	361,354,000	939,747,200
Livestock[1]	14,248,322,600	10,707,650,200	34,886,300,500
Forages	1,790,363,700	1,681,688,600	3,924,539,800
Total	20,494,587,300	16,235,154,200	48,847,378,200

[1]Livestock category includes beef cattle and calves, dairy, sheep, and goats, but does not include swine or poultry.
USDA-ERS, 2014. From Hanselka et al., 2016.

Abbreviations and notes: K = potassium; KCl = potassium chloride; S = sulfur; ppm = parts per million. IPNI Project TX-56

Table 2. Cotton study sites, soil K levels (0-6 in.), K recommendation, and cotton variety.

Year and Location	Soil series	Soil test K, ppm	*Recommended K, lb K_2O/A	Cotton variety
2012				
Williamson	Burleson clay	60	60	DP 0935 B2RF
2013				
Williamson	Burleson clay	65	60	Phytogen 499 WRF
Wharton	Lake Charles clay	150	0	DP 0935 B2RF
2014				
Williamson	Burleson clay	105	20	Phytogen 499 WRF
Wharton	Lake Charles clay	180	0	ST 6448 GLB2

*Recommendation from Texas A&M Univ. lab for 2 bale/A lint yield (Texas A&M, 2016).

The study was conducted on a limited scale in 2012 with only one site in the Blacklands region (Williamson Co.) on the Stiles Farm. Results from 2012 were of such interest that the study was subsequently expanded in 2013 and 2014 to include additional farmer field sites in Williamson Co., Hill Co. (Blacklands), and Wharton Co. (Gulf Coast Region). Locations for 2013 and 2014 in Blacklands (Williamson and Hill Co.) and Gulf Coast (Wharton Co.) regions were chosen based on past foliar K deficiency observations. **Table 2** shows soil series, K soil test level (0 to 6 in.), university recommended K fertilizer input (based on a 2 bale/A yield goal), and cotton variety for the site years reported in this article. There were two site years in Williamson Co. and one in Hill Co. that are not reported here since they were not responsive to either rate or placement of K fertilizer. These sites were well above the K sufficiency level of 120 ppm (Texas A&M, 2016), ranging from about 230 to 400 ppm K. It should be noted that soil samples were collected to a depth of 4 ft., but only the 0 to 6 in. depth is reported in this paper.

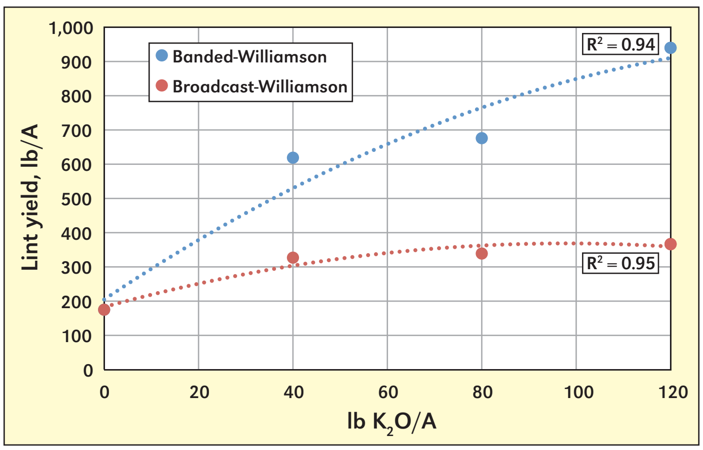


Figure 2. Lint yield response to K fertilizer and placement at the 2012 Blacklands site (Williamson Co.).

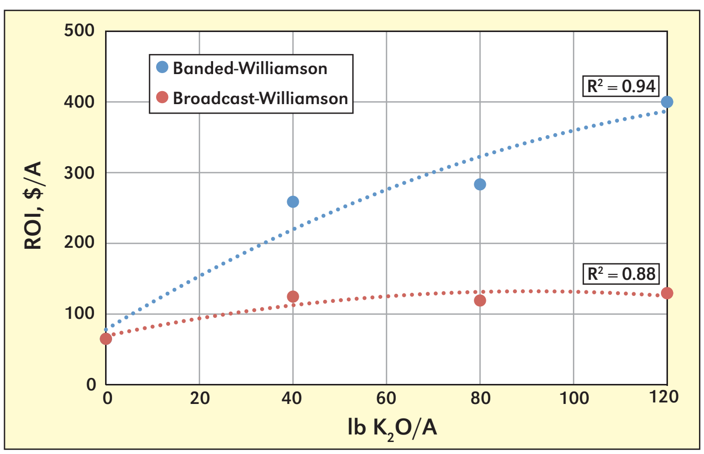


Figure 3. Return on investment (ROI) for 2012 treatments in the Blacklands (Williamson Co.). ROI was calculated by subtracting cost of K fertilizer from the gross lint income, which is affected by both lint yield and quality. Factors such as application and tillage costs, and value from seed were not used in this ROI calculation. Lint values were calculated using the 2013 Upland Cotton Loan Valuation Model from Cotton Inc. and 2013 cotton lint price.

Fertilizer K comparisons included both rate and placement. Potassium fertilizer was either banded to the side (4 in. to side of row and 6 in. deep, or 4x6) or broadcast incorporated prior to planting. Granular KCl (0-0-60) was used for the broadcast treatments, and fluid KCl (0-0-15) was used for the banded treatments. The same source (KCl) was used for both placement variables in order to avoid confounding with nutrients (e.g., S) that might have come with using other fluid K sources. All treatments were applied, and granular application incorporated, about two weeks before planting.

Treatments for the first year (2012) were more limited than subsequent years, with broadcast and banded rates of 0, 40, 80, and 120 lb K_2O/A. For 2013 and 2014 the broadcast incorporated treatment was applied at rates of 0, 40, 80, 120, and 160 lb K_2O/A, and the banded treatment was applied at 0, 20, 40, 80, 120, and 160 lb K_2O/A. The only difference in rates for the placement variable was the omission of 20 lb/A in the broadcast treatment.

Plant measurements during the season included height, total nodes, and nodes to first fruiting branch. After the growing season, plots were harvested, seed cotton weighed, and then ginned. After ginning, samples were sent to Cotton Inc. to determine fiber quality (i.e., fiber length, strength, micronaire, uniformity, and other characteristics).

Results

There was some variation in height and total nodes among the different K treatments, but the biggest visual difference was the presence of K deficiency symptoms in the leaves that received zero or low rates of K fertilizer (see Photo). Plots with higher rates of K did not exhibit deficiency symptoms.

Figure 2 shows lint yield results from 2012. Lint yield was generally increased by K fertilizer, with the banded treatments producing dramatically more lint than broadcast at all rates. **Figure 3** shows return on investment (ROI) for the 2012 treatments. The ROI takes into account the impact of K on both yield and lint quality. The ROI for banded treatments exceeded that for broadcast K, and ranged from about $260 to $400/A. The ROI for the 120 lb banded treatment exceeded that of the control by $335/A. As would be expected, these initial (2012)

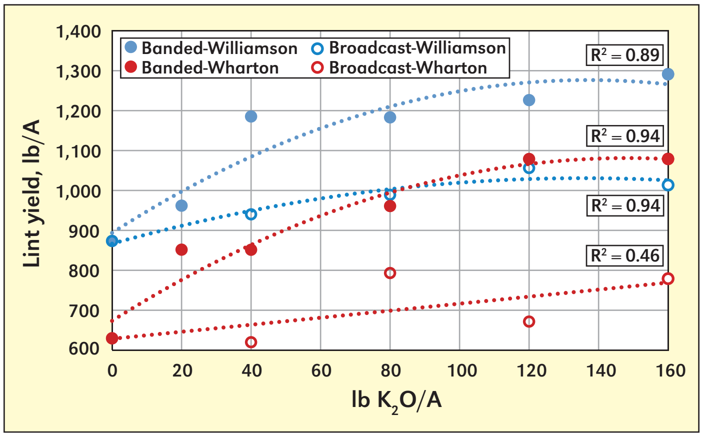


Figure 4. Lint yield for Blacklands (Williamson Co.) and Gulf Coast (Wharton Co.) region sites in 2013.

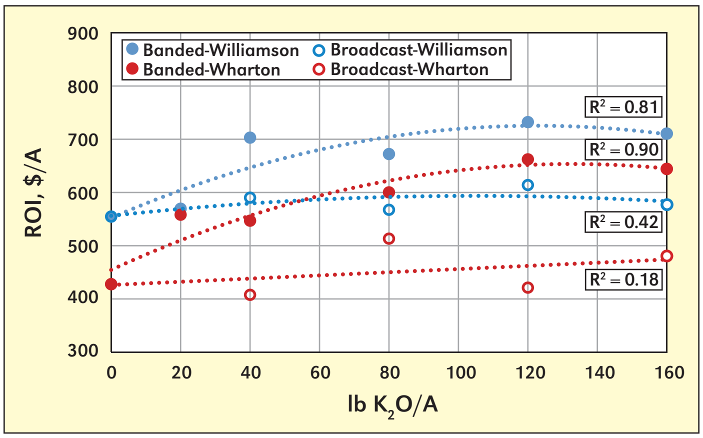
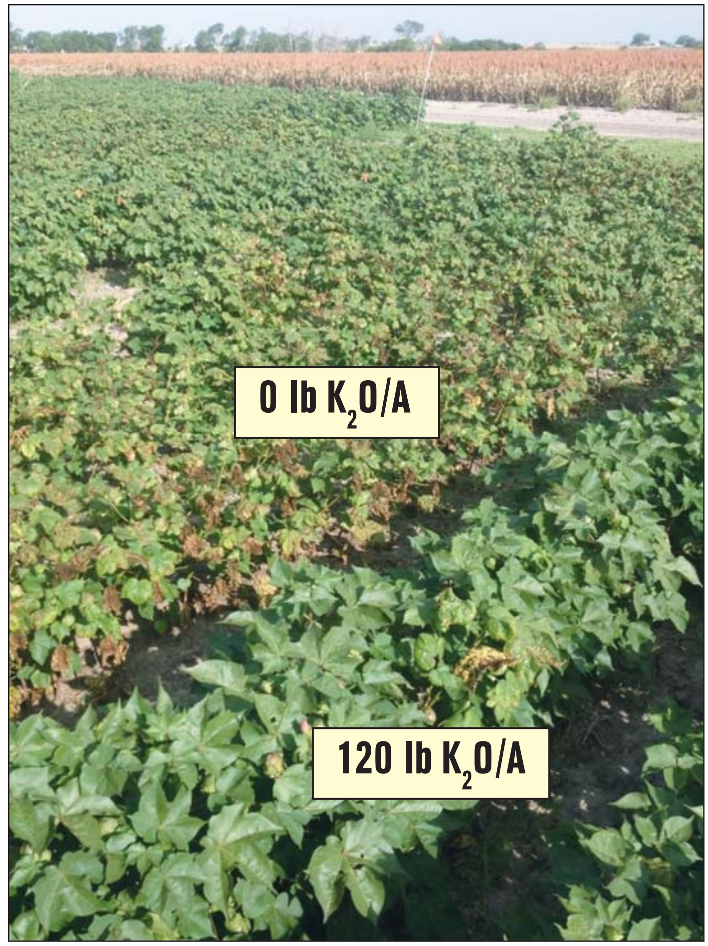


Figure 5. Return on investment (ROI) for 2013 treatments in the Blacklands (Williamson Co.) and Gulf Coast (Wharton Co.) region sites. ROI was calculated by subtracting cost of K fertilizer from the gross lint income, which is affected by lint yield and quality. Factors such as application and tillage costs, and value from seed were not used in this ROI calculation. Lint values were calculated using the 2014 Upland Cotton Loan Valuation Model from Cotton Inc. and 2014 cotton lint price.



Effect of K fertilization on cotton K deficiency and late season foliar disease in the Texas Blacklands (2013). The 0 lb K_2O/A is in the middle of the image, and the 120 lb K_2O/A was applied in a 4x6 band.

results, particularly the impact of banded K, gained considerable attention and ultimately resulted in the expansion of this project to other sites in 2013 and 2014.

Figure 4 shows 2013 yield results for both the Blacklands (Williamson Co.) and Gulf Coast (Wharton Co.) region sites, while **Figure 5** shows the ROI for each of these sites in the same year. The Wharton Co. site did not show a significant response to any rate of broadcast K fertilizer; however, all rates of injected K showed a significant response over the control. The highest yields at this site (1,080 lb lint/A) were observed where 120 and 160 lb K_2O was banded, and were 450 lb—almost a bale—higher than the control (630 lb lint/A). According to ROI calculations the greatest return at the Wharton Co. site in 2013 was with the 120 lb K_2O banded treatment, where ROI was $662. These results are especially interesting considering that the soil test K level at the Wharton Co. site (150 ppm) was above the critical value of 120 ppm.

For the Williamson Co. site in 2013 only the 120 and 160 lb K_2O broadcast rates showed significant lint yield response when compared to the control; however, all of the banded treatments, except the 20 lb rate, showed significant lint yield response (**Figure 3**), but were not significantly different from each other. So the 40 lb banded treatment optimized both yield and ROI at this site in 2013, with a yield increase of 36% (311 lb lint) over the control and an increase in ROI over the control of $148 (i.e., $555 to $703). The response to K fertilizer at this site was not unexpected since the soil K level (65 ppm) was below the critical level (120 ppm).

Yields were substantially higher at the Wharton Co. site in 2014 than in 2013, conversely, yields at the Williamson Co. site were lower in 2014 than in 2013. Interestingly, there was no effect from K fertilizer treatments at either site in 2014.

Discussion

Cotton response to K fertilizer was clear and dramatic at the Warton and Williamson Co. sites reported here in 2013. But, there was essentially no response in 2014 at these sites. The lack of response cannot be definitively explained. But, the most likely explanation involves rainfall distribution during the season. In 2014 at Williamson Co., soil moisture was not limited early in the season; however, excessive heat and moisture stress occurred during boll fill and resulted in poor fruit set and very low yields across all treatments. At Wharton Co., moisture was not limited and a late maturity variety (ST 6448 GLB2) was grown in the trial. Late maturing varieties create less intense demand on nutrient uptake, including K.

Where cotton was responsive to K fertilizer there was a distinct advantage to band application over broadcast, both for yield and ROI. The reason for the better performance of banding is not completely understood. It has been speculated that since the soils in this study are fine textured there could be some K fixation occurring wherein high charge clay minerals (e.g., vermiculite, highly charged smectite) "fix" broadcast K fertilizer to a greater extent than banded K fertilizer. Detailed mineralogical analysis of these soils is planned to determine whether fixation may be a factor.

Concluding Thoughts

This study illustrates the importance of ongoing efforts to continue to further our understanding of K nutrition and soil interactions. More specifically, the findings here support the need for efforts that explore the new frontiers in K science. In 2015, IPNI tasked an international group of accomplished scientists to identify critical concepts that were missing or were inadequately characterized in existing soil K assessments or K recommendations. In the summary paper produced from this group (IPNI, 2015) the authors state *"Practitioners have often not been able to explain why soil-test K varies across the landscape or over time in response to management practices. Additionally, definitive calibrations of K soil tests to crop responses have not been achievable in some areas"*—a statement befitting the study reported here. Finally, the findings from this study have resulted in the formation of a larger and similar project that is being conducted across 12 cotton-producing states. BC

Acknowledgement

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