IMPACT OF SOIL APPLIED POTASSIUM ON COTTON YIELD ACROSS THE COTTON BELT

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Abstract

The frequency and severity of potassium (K) deficiency symptoms in cotton (*Gossypium hirsutum* L.) have increased in some areas of the U.S. Cotton Belt over the past decade. Insufficient levels of plant available K in the soils of these regions may be reducing lint yield and fiber quality and leading to decreased profits for cotton producers. Deficiency symptoms may be observed beginning at first flower but increase in severity as the boll load and boll fill periods progress (Reddy et al., 2000). Potassium plays a major role in several critical processes, including photosynthesis, activation of protein enzymes, disease and drought stress mitigation, and fiber development. Previous research has reported 44 lb K/acre/bale will be removed annually with lint and seed harvest (Oosterhuis, 2001). Increased yield potential in new varieties and better insect management have pushed cotton yields to three to four bales per acre and can exceed five bales on irrigated land. Greater yield potentials put a substantial demand on the roots' ability to take up sufficient quantities of K and other nutrients to meet the physiological demand of the plant, seed, and lint. As K demand continues to increase, deep profile soil samples indicate a reduced level of plant available K in some production areas. According to the Nutrient Use Geographic Information System (NuGIS) webpage, K_2O balance is negative (-11 to -50 lb/a) for the majority of the cotton production regions (IPNI, 2012). It is well documented that cotton is more sensitive to low K availability than most other major field crops, and often shows symptoms of K deficiency in soil not considered deficient (Cassman et al, 1989).

The objectives of this research were to: 1) quantify soil K levels, at depth, from several major cotton production regions in the Cotton Belt experiencing K deficiencies; and 2) evaluate the impact of application method and K rate on cotton lint yield, quality, and return on investment (ROI). Based on these results, soil K recommendations will be re-evaluated and modified as appropriate to optimize yields.

The 2015 trials were initiated at 12 locations across the U.S. Cotton Belt, including Virginia (VA), North Carolina (NC), South Carolina (SC), Alabama (AL), Mississippi (MS), Louisiana (LA), Tennessee (TN), Arkansas (AR), Oklahoma (OK), Texas (TX) and Arizona (AZ). There were three research locations in TX in 2015: Lubbock, Williamson, and Wharton Counties. In 2016, trials were divided into sites that were conducted at a new location (8) and sites superimposed over the 2015 sites with an identical plot plan, called multi-year sites (8). States using new locations for research sites, included: AL, AR, LA, MS, NC, OK, TX (Lubbock and Williamson County), and VA. Soil samples were collected four to six weeks prior to planting from all locations in 2015, 2016, and 2017 and were analyzed using the Mehlich III extraction method at depth increments of 0-6", 6-12", 12-24" by the Texas A&M AgriLife Extension Soil, Water and Forage Testing Laboratory (College Station, TX). Potassium treatments, injected and broadcast application methods, were applied two to four weeks prior to planting cotton at rates of 0, 40, 80, 120, and 160 lb/A K_2O. The granular treatments (muriate of potash, KCl, 0-0-60) were broadcast applied and incorporated to an approximate depth of two inches with tillage. Liquid K fertilizer treatments (solution of KCl, 0-0-15) were injected approximately six inches deep and four inches to the side of the seed row.

Nitrogen, P, and other nutrients were applied at the recommended rate to ensure nutrients were not limiting and obtain maximum yield potential for each location. The cotton variety planted at all locations was DP 1321 B2RF in 2015 and DP 1522 B2XF in 2016 and 2017. The plots were arranged in a randomized complete block design with four replications. Plot dimensions varied by location but were generally four rows wide and greater than 40 feet in length. In-season plant measurements included stand counts, plant height, total nodes, and leaf samples collected at four weeks after first flower. Leaf samples were sent to the Texas A&M Soil, Plant, and Water testing lab for K mineral analysis. After harvest the cotton was ginned and fiber samples sent to Cotton Inc. for HVI analysis. These data were analyzed in SAS 9.4 using Fisher's LSD means separation to determine treatment differences.

Soil tests indicate a range of K levels across the Cotton Belt, with the lowest levels occurring in VA, LA, MS and Williamson-TX new-site locations in 2015. At these locations, K levels were less than 150 mg/kg at the 0-6" depth based on the Mehlich III K critical level or threshold, and as such K fertilizer would have been recommended for a two-bale (approximately 1000 lb/A lint) yield goal. The Lubbock, TX location had K levels much greater than the threshold in 2015 at the 0-6" depth and decreased at deeper depths. In 2016 and 2017, the Lubbock, TX and OK locations had K levels much less than 2016 but still greater than the threshold. The site chosen for the Williamson, TX location in 2016 had K levels less than 100 mg/kg, but the new-site used in 2017 had levels greater than 200 mg/kg K. Potassium levels in 2016 and 2017 at the MS, AL, VA, AR, NC, and LA locations were mostly less than the threshold. Across most locations, soil K levels decrease with depth and indicate some level of K stratification and K mining with depth. The plant growth measurements, leaf tissue K concentrations, and fiber quality data were collected for each location, but this information will not be presented.

There was not significant ($P < 0.05$) yield response at AL, VA, MS, LA, and AR to K rate and application method in 2015, despite all sites being close to the current soil K threshold level of 150 mg/kg. Only a numerical increase in lint yields at AL and LA for the injected application method was observed (except at 80 lb/A at LA). At these locations, a good range of yield potential were identified with yields as high as 2300 lb/a in lint yield. However, despite the high yielding locations and soil K test levels being near soil test threshold levels, no significant increase in lint yield was determined. In the Southwestern locations (TX and OK), a significant yield response was observed at the Williamson County, TX location, despite very low yields. At the Lubbock location with over 350 mg/kg K, a significant yield response was determined with the two highest K application rates for the injected application method resulting in the greatest lint yield. Due to herbicide injury, the trial was not harvested at the OK location. The Wharton, TX location lint yields were on average greater than the Williamson County location and was non-responsive, but soil K levels were well above the current soil K threshold level of 125 mg/kg.

In 2016 at the new site locations, the Williamson County, TX, VA, NC, and AL locations were below the threshold of 150 mg/kg K. A yield response ($P < 0.05$) was observed to increasing K rates at the Williamson county, TX and Virginia locations but not any other locations. The average soil K levels of the other sites exceeded 150 mg/kg K at all depths except at the 6-12" and 12-24" depths at LA and no yield response was observed. The exception was the

Lubbock location, where the highest rates of injected K did provide a significant yield response and was similar to the treatment response in 2015, however, yields were much less in 2016 than 2015. Differences were not determined at the OK location, but a general increasing trend from 0 lb/A to 80 lb/A for both application methods was observed. In 2017, the NC, MS, and AL locations were at least 50 mg/kg less than the threshold K level at all measured depths. The LA location K level was close to the threshold at 0-6" and decreased with depth to levels less than the threshold. All other locations had soil K levels greater than the threshold at each depth. Differences between treatments did not exist at any location in 2017; however, general trends were observed. At the Lubbock, TX location, lint yields were on average closer to the 2015 yields and a small yield increase (approximately 100 lb/A lint) from 0 lb/A to 80 lb/A K was observed for injected K but not broadcast applied. At MS, LA, and AR, lint yields ranged from 500 lb/A (MS) to 1250 lb/A (AR), but differences were not determined. Lint yield at MS on average was much less than in 2015.

There appears to be much that remains unclear about potassium-cotton dynamics. A response was observed more often at locations with lower yield potentials, but also at locations with soil K levels greater than the Mehlich III K threshold of 150 mg/kg. At locations where K fertilizer would have been recommended because K levels were well below the threshold, a response to added K was rarely determined. Further evaluation of data will include calculating nutrient use efficiency and using principal component analysis to identify patterns in data (lint yield, leaf tissue mineral concentrations, and soil macronutrient levels).

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