Potassium Partitioning In Cotton

Taylor Coomer, Derrick Oosterhuis, and Leo Espinoza

The Fluid Journal • Official Journal of the Fluid Fertilizer Foundation • Fall 2015 • Vol. 23, No. 4, Issue #90

▼ DOWNLOAD

Summary: Potassium (K) is very mobile, moving throughout the plant with K concentrations in individual plant parts shifting throughout the growing season. Results from this study showed that K partitioning decreased in leaves and increased in reproductive components over the growing season, but there were no cultivar differences between growth stages at individual K levels. Results also showed that PHY499 was a lower yielding cultivar than DP0912 and ST5458, especially in low K environments.

For cotton to grow and develop properly, plants need to uptake the necessary amount of nutrients and use those nutrients in a beneficial fashion. It is well established that cotton requires a certain nutrient tissue concentration to achieve and maintain growth rates (Siddiqi et al., 1987).

One of the most essential and abundant nutrients in cotton is potassium (K) second only by mass to nitrogen (N) (Marschner, 1995). Potassium plays a vital role in plant growth and metabolism. Potassium deficiencies can affect numerous plant characteristics such as reductions in lint yield and biomass production (Pettigrew and Meredith, 1997).

Traditional K deficiency symptoms differ from recent K deficiency symptoms due to genotypic changes in cultivars over time (Oosterhuis et. al. 2013). Even though K is not a component of any singular plant part, physiologically, K is an essential macronutrient for plant growth and development and affects many fundamental physiological processes such as cell pH stabilization, regulating cell metabolism by acting as a negative charge neutralizer, maintaining cell turgor by acting as an osmolyte (Marschner, 1995), activating enzymes and regulating the stomatal mechanism (Dong et al., 2004).

Whole plant K accumulation generally follows a curve that has maximum uptake around 112 days after planting. However, K is very mobile, moving throughout the plant with K concentrations in individual plant parts that shift throughout the growing season (Gerardeaux et al., 2010).

The K uptake curve follows a similar pattern of dry matter production. However, dry matter production continues after K uptake has reached a maximum. Mullins and Burmester in 1990 showed that mature cotton took up an average of 99 to 108 kg K ha-1 with 24.8 percent of K in the shoots, 20 percent in the leaves, 36.5 percent in capsule walls and 18.4 percent in the seed. Plant dry matter can have as much as 10 percent K by weight, but the optimum range for cotton is 2 to 5 percent (Oosterhuis et al., 2013). Cottons bolls can accumulate K to concentrations above 40 mg g^{-1} of the dry weight (Kafkafi and Xu, 1996). Potassium uptake is slow during the seeding stage, increases rapidly at flowering, and slows after the maximum is reached at boll maturity.

> "One of the most essential nutrients in cotton is K, second only by mass to N."

Cotton's K requirements are highest during boll set because bolls are a major K sink. During the development of a boll, K concentrations in plant tissue increase from 10 g kg-1 to 55 g kg^{-1} at maturity. There have been few studies observing K partitioning in recent transgenic, high-yielding cultivars.

Objective

This study, therefore, was conducted to investigate the effects of K deficiency on the partitioning of K in boll components and leaves beginning at squaring and continuing through six weeks after first flower.

Methodology

A field trial to evaluate K partitioning was conducted at the Lon Mann Cotton Research Station of the University of Arkansas. Three cotton cultivars, DeltaPine 0912 B2RF, Phytogen 499 WRF, and Stoneville 5458 B2F, were planted on May 21, 2014. All fertilization, except K, was applied according to soil test recommendations. Four treatments of 0, 33.6, 67.2, and 100.8 kg K ha-1 (0, 30, 60, and 90 lb K ac-1) were applied as potassium chloride (KCL) at approximately pinhead square (PHS) on June 25. Plots were four 1-m (38 inches) wide and approximately 15.24 m (50 feet) long. Plots were furrow irrigated as needed.

One meter of whole plants was sampled from four replications from each of the 12 treatments at PHS, first flower (FF), three weeks after first flower (FF3), and six weeks after first flower (FF6). Whole plant samples were then separated into four main plant components: stems, leaves, petioles, and reproductive components (squares, flowers, and bolls). Plant components were dried at 60oC for at least one week, weighed, ground, and analyzed for K concentration. This experiment was also analyzed as a two factor factorial completely randomized design with four replications. Statistics were analyzed using JMP Pro 11 (SAS Institute, Cary, North Carolina) with alpha level of 0.05 as an indication of significance. Differences between treatments were determined using Tukey's HSD test. Before partitioning and yield data were analyzed, outliers were determined using the multivariate method of jackknife distances.

Yield data were obtained at harvest on October 23, 2014. Partitioning data were separated by K levels with growth stage and cultivar as main factors. Yield data

Table 1. Percent of total K in leaves at four growth stages, pinhead square (PHS), first flower (FF), three weeks after first flower (FF3), and six weeks after first flower (FF6) of cotton plants treated with two K levels, 0 and 100.8 kg K ha^{-1}.

K Level	PHS	FF	FF3	FF6
0 kg K ha^{-1}	52.15 a	39.6 b	25.99 c	11.18 d
100.8 kgK/ha^{-1}	49.87 a	41.11 b	23.94 c	11.14 d

Different letters indicate significant differences among the growth stages within the same K level, according to Tukey's HSD test (p<0.05).

Table 2. Percent of total K in reproductive components at four growth stages, pinhead square (PHS), first flower (FF), three weeks after first flower (FF3), and six weeks after first flower (FF6) of cotton plants treated with two K levels, 0 and 100.8 kg K ha^{-1}.

K Level	PHS	FF	FF3	FF6
0 kg K ha^{-1}	2.1 d	8.28 c	39.28 b	70.07 a
100.8 kgK/ha^{-1}	3.05 c	7.43 c	38.41 b	60.75 a

Different letters indicate significant differences among the growth stages within the same K level, according to Tukey's HSD test (p<0.05).

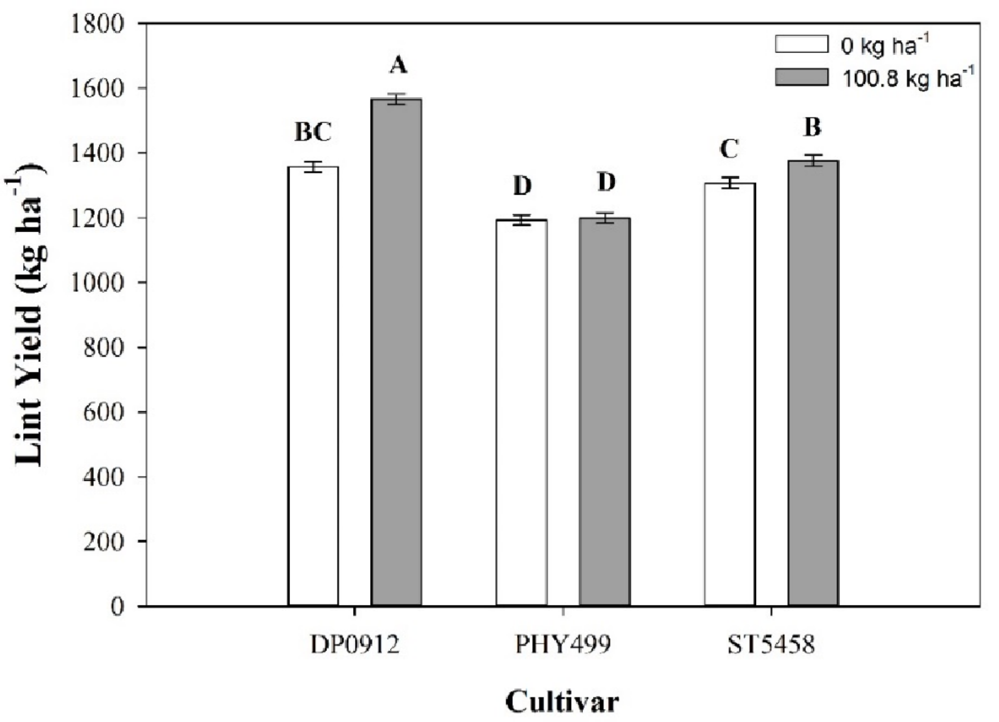

Figure 1. Lint yields (kg/ha) of three cotton cultivars, DeltaPine 0912, Phytogen 499, and Stoneville 5458, at two K levels, 0 and 100.8 kg K ha -1. All values are means ± standard error (n=4). Diffferent letters indicate significant differences across all treatments according to Tukey's HSD test (p<0.05).

were analyzed with K level and cultivar as main factors.

For this article, only K levels of 0 and 100.8 kg K ha^{-1} will be discussed in leaves and reproductive units (squares, flowers, and bolls).

Study results

Leaves. Regardless of the cultivar or K level, percent of total plant K in leaves increased significantly (p<0.05) at each growth stage throughout the growing season (Table 1). There were no cultivar differences in percent of total plant K in leaves at any K level. At 0 kg K ha^{-1}, PHS had the highest percent of total plant K in leaves with a mean percentage of 52.15 percent, and decreased throughout the growing season with 11.18 percent at FF6. At 100.8 kg K ha^{-1}, PHS mean percent total plant K in leaves was 49.87 percent and decreased to 11.14 percent at FF6.

Reproductive components. Potassium partitioning in reproductive components showed no significant (p<0.05) differences between cultivars at either K levels, however, growth stage showed significant differences (p<0.05) at each K level (Table 2). In the 0 kg K ha^{-1} treatments, FF6 had 70.07 percent of total K in RC, and only 2.1 percent of total K in RC at PHS on average. With 100.8 kg K ha^{-1} applied, PHS and FF showed no significant differences (p<0.05) and were lower than FF3 and FF6 with 3.05, 7.43, 38.43, and 60.75 percent total K in RC, respectively (Table 2).

Lint yield analysis showed significant (p<0.05) differences for the interaction of K level and cultivar (Figure 1). The highest lint yield was found in cultivar DP0912 treated with 100.8 kg K ha^{-1} with an average of 1565.52 kg lint ha^{-1}, which was significantly higher than all other treatments. The two lowest yielding treatments were PHY499 100.8 kg K ha^{-1} and PHY499 0kg K ha^{-1} treatments, with yields of 1,198 and 1,193 kg lint ha^{-1}, respectively. DP0912 with 0 kg K ha^{-1} out-yielded both other cultivars at 0 kg K ha^{-1}.

Conclusions

It can be inferred that over the growing season, as boll load increases, K moves from leaves to reproductive components due to an exponential increase in percent of total K in reproductive components and a decrease in percent of K in leaves over time. However, there were no cultivar differences at either K level in either plant part, indicating that these genotypes do not respond differently to low or high K environments.

When yield is considered, both low and high K levels on DP0912 and ST5458 out-yielded either K level of PHY499. DP0912 was numerically the highest yielding cultivar at both K levels, and statistically both DP0912 and ST5458 at 0 kg K ha^{-1} out-yielded PHY499 at 0 kg K ha^{-1}. These results suggested that DP0912 and ST5458 could be potential cultivars to be planted under low K conditions.

Taylor Coomer is an M.S. candidate and graduate research assistant, Dr. Derrick Oosterhuis is a Distinguished Professor with the Department of Crop, Soil, and Environmental Sciences at the University of Arkansas in Fayetteville, and Dr. Leo Espinoza is an Associate Professor and Soil Scientist with the Cooperative Extension Service, University of Arkansas in Little Rock.