Plant Potassium Partitioning During Progression of Deficiency Symptoms in Cotton

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The progression of potassium (K) deficiency in cotton at mid-maturity is accompanied by declining K levels in all plant organs beginning at the shoot apex and progressing downward. Stored K from apparent luxury consumption may serve as a reservoir during a K shortage and boll filling.

THE USE of faster-fruiting and higher-yielding cotton varieties has resulted in the widespread occurrence of K deficiency across the U.S. Cotton Belt. However, the onset of K deficiency has been difficult to predict from soil and tissue tests. Furthermore, the response to soil or foliar K applications has been variable.

Potassium in Cotton

Potassium deficiency symptoms in modern, high-yielding cotton varieties first appear on leaves of the upper canopy. This is not consistent with characteristics of a nutrient which is highly mobile in the plant. It is the mobility of K that creates a problem in attempting to predict the tissue deficiency threshold. If a plant organ that is highly sensitive to K availability is approaching a deficiency, the remainder of the plant may still contain adequate K. A decline in petiole K may only indicate a shift in the K source:sink ratio, not the beginning of a deficiency.

Potassium is an essential nutrient with numerous important roles in plant growth and development. It is not a constituent of any structural component, which may allow it to be stored in apparent luxury amounts and remobilized during a period of reduced availability or increased demand. This is not considered in current plant growth models, but is reflected in the season-long decline of petiole K from the uppermost fully expanded leaf.

Procedures

A study was initiated to determine how K is distributed throughout the cotton plant during the progression of K deficiency and to improve our understanding of the onset of K deficiency in cotton and of K limitation.

Cotton (variety DP 20) was germinated in approximately 2 gallon pots of sand in a growth chamber with a photoperiod of 12 hours, adequate light, photosynthetic day/night temperature of 86/77 F°, and day/night relative humidity of 50/80 percent. Plant nutrients were provided by solution. When the main-stem leaf at main-stem node 12 was the size of a quarter dollar (almost one inch), K was withheld from the nutrient solution given to half the plants.

Plants in each treatment were harvested 2, 7, 12, 16 and 21 days after K was withheld and grouped into (1) main-stem and sympodial leaves, (2) main-stem and sympodial petioles, (3) main-stem and sympodial branches, (4) fruit, and also into (5) lateral roots, and (6) tap roots. Plant components were dried, ground, and assayed for K.

Study Results

Lateral root K of the no-K plants declined sharply immediately after K was withheld. After 12 days the K level in these plants had declined from 4.5 percent to less than 1 percent. Tap root K declined more slowly in the no-K plants and never dropped below 1 percent (**Figure 1**).

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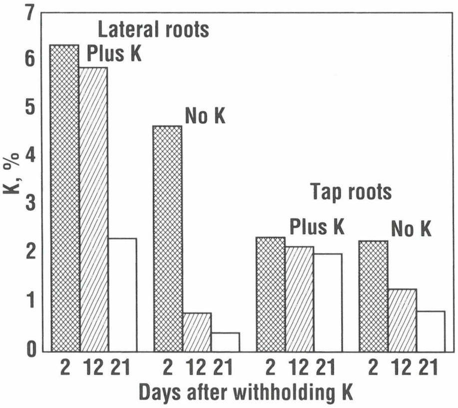

Figure 1. Root K concentration at 2, 12, and 21 days of treatment.

Leaf K concentration was highest in the lower plant canopy and declined as main-stem nodal position increased. Two days after withholding K, apical leaf K was lower in the no-K plants. Leaf K declined first in the upper leaves and then in leaves lower in the plant canopy. For example, after 12 days all leaves above main-stem node 8 contained less than 2 percent K, but at 21 days all leaves above main-stem node 6 had fallen to this level (**Figure 2**).

Petiole K exhibited trends similar to leaf K. The only observed difference was that petiole K did not begin dropping in the no-K plants until after 2 days of withholding K (data not shown).

Interestingly, stem K was highest in the uppermost main-stem nodal regions and declined in a downward direction. Stem K was also unaffected after 2 days in the no-K plants. Similar to the leaf and petiole K, treatment differences in stem K appeared greater in the apical regions after 12 and 21 days (**Figure 3**).

Fruit (bolls) K exhibited no clear trends with main-stem nodal position. After 2 days of withholding K, all fruit in both treatments contained approximately 2.5 percent K. Fruit K did not appear to decline in the no-K plants until after 7 days (data not shown). After 21 days of no K, the K content of the oldest fruit in the

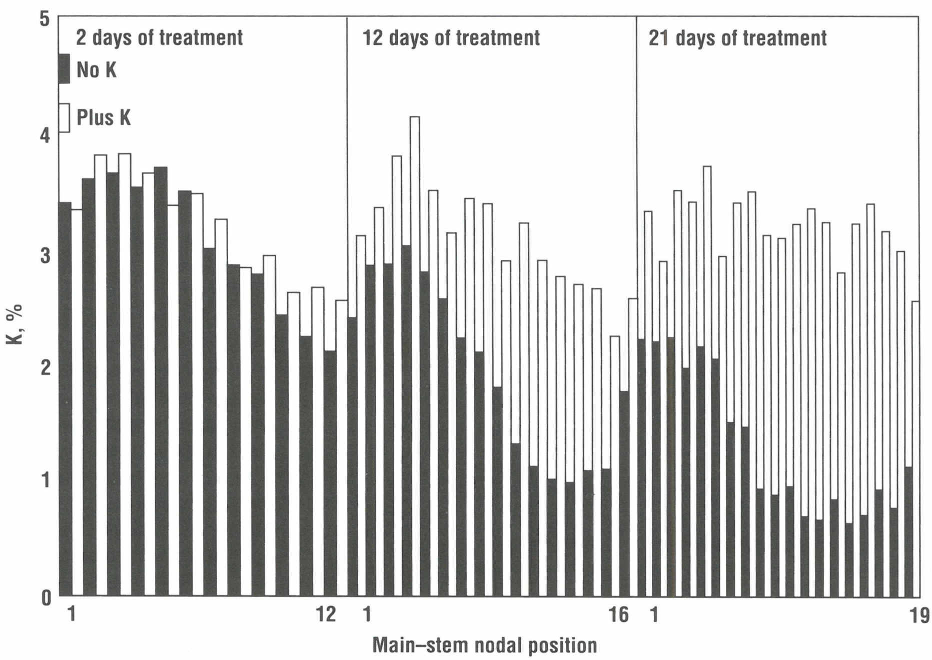

Figure 2. Leaf K concentration at each main-stem location at 2, 12, and 21 days of treatment.

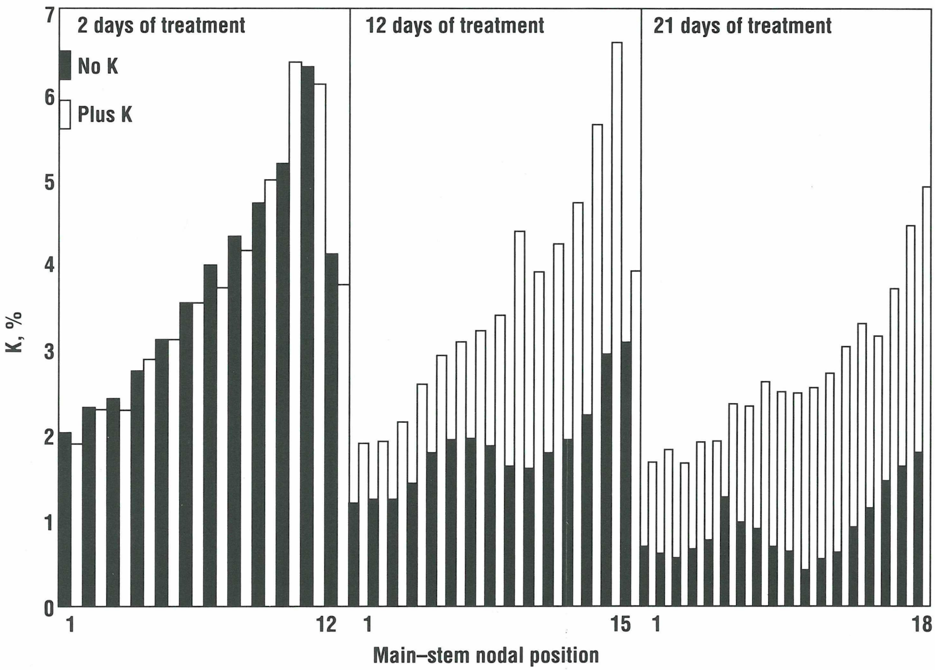

Figure 3. Stem K concentration at each main-stem location at 2, 12, and 21 days of treatment.

no-K plants seemed lower than that of the younger fruit (**Figure 4**).

Results of this study indicate that cotton roots and leaves are the most sensitive organs to K limitations, while bolls are the least sensitive, and stems and petioles are intermediate. When petiole test results indicate a K shortage, boll K may continue to be sufficient due to K movement from excessive storage in other plant organs.

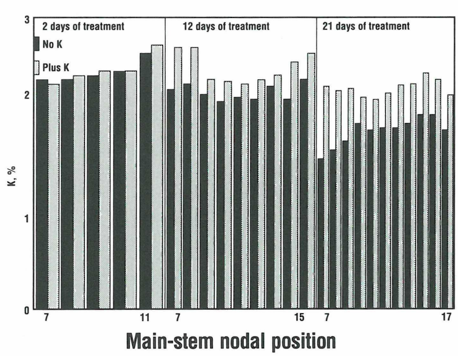

Figure 4. Fruit K concentration at each main-stem location at 2, 12, and 21 days of treatment.

Conclusions

From these results it is evident that the K status of a cotton plant cannot be accurately predicted using diagnostic tissue test results of the petioles from a single main-stem location. Also, it is our conviction that a cotton plant can store excess K in apparent luxury amounts, which can serve as a reservoir during times of K shortage and boll filling.

In order to more fully understand the severity of a pending K shortage, we believe that petioles from mid-canopy main-stem nodes should be compared with those of the upper canopy.

Other researchers (Rosolem and Mikkelsen) reported a sequence of increasing sensitivity to K deficiency among cotton plant parts (leaves<bolls<roots<stems) such that when K deficiency symptoms are clearly visible in the leaves, all other plant parts are already affected. However, our data show the progression of sensitivity to K deficiency to be bolls<stems<leaves <roots. When K deficiency symptoms are visible in the leaves, boll development will continue due to remobilization from other organs. ■