Virginia Cooperative Extension

PUBLICATION 418-025

Potassium Fertilization of Cotton

A. Ozzie Abaye; Extension Agronomist, Alternative Crops, Virginia Tech

Introduction

Potassium (K) is an essential nutrient for normal plant growth and development, which plays a particularly important role in fiber development. Potassium deficiency results in decreased fiber quality and lowered yields. If K is limited during active fiber growth, there is a reduction in the turgor pressure of the fiber resulting in less cell elongation and shorter fibers at maturity. Anything which restricts root growth, such as disease, insect damage, nematodes, root pruning, poor drainage, soil acidity, or compaction, reduces nutrient uptake and may increase K deficiency.

The widespread K deficiency that has occurred across the Cotton Belt has been related to: (i) the use of earlier maturing, higher-yielding, fast-fruiting cultivars (Ossterhuis et al., 1990), (ii) planting of cotton on soils low in available K (Kerby and Adams, 1985), and (iii) the relative inefficiency of cotton in absorbing K from the soil compared to other crop species (Cassman et al., 1989).

Potassium distribution and uptake in the cotton plant

A bale of cotton requires around 52 lb K_2O (43 lb K). Most of the K is in the burs, stalks, and leaves at harvest, and is returned to soil (Figure 1) . The lint and seed remove only about 11 lb of K_2O per acre.

Maximum accumulation of K occurs near the start of flowering (Figure 2) . Mullins and Burmester (1991) reported maximum daily K uptake rates of 2.2 to 3.5 lb K/acre/day 63 to 98 days after planting (flowering period). This type of demand by the plant would require a soil with an extremely high capacity to supply K.

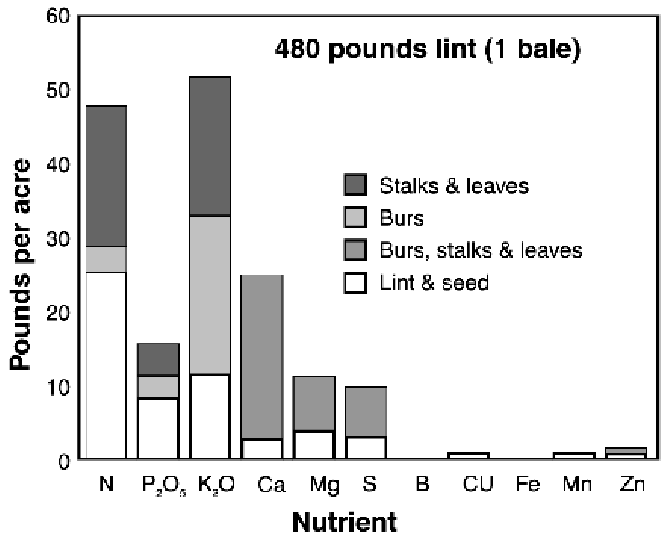

Figure 1. Nutrient distributions in the cotton plant (Bassett et al., 1970)

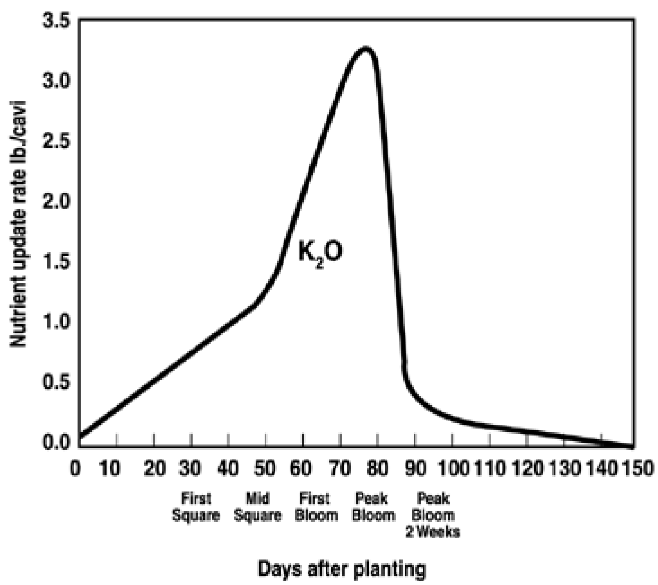

Figure 2. Nutrient uptake rates reached maxium during mid-bloom and declined rapidly as the boll matures (Mullins and Burmester. 1990).

www.ext.vt.edu

Produced by Communications and Marketing, College of Agriculture and Life Sciences,
Virginia Polytechnic Institute and State University, 2009

Potassium Deficiency Symptoms

Rosolem and Mikkelsen (1991) observed a sequence of increasing sensitivity to K deficiency among cotton plant parts: leaves < bolls < roots < stems. This result indicates that by the time the K deficiency symptoms are manifested in the leaves, all other plant parts are already affected.

Potassium deficiency symptoms fall into two categories, those that occur at the bottom of the plant on the lower, older or mature leaves (Sparague, 1964), and the more recently described symptoms (Weir et al., 1986) that show up at the top of the plant late in the season. The K deficiency symptom is the same for both lower and upper canopy leaves. An explanation given for this by Dr. Oosterhuis, cotton physiologist at the University of Arkansas, is that modern cultivars develop bigger yields over a shorter fruiting period, and K moving upward from the roots is intercepted by the developing boll load at the expense of the upper leaves. Also, because of earlier fruiting, modern cotton cultivars may have less time to accumulate K in above ground plant components before the onset of peak fruiting, as compared with older cultivars.

The K deficiency symptom first described by Sparague (1964) was a yellowish-white mottling of the older foliage that changes the leaf color to light yellowish-green. Yellowish spots begin to appear between the veins, then the center of these spots die and numerous brown specks occur at the leaf tips, around margins and between veins. The tips and margins break down first and begin to curl. These symptoms occur at the bottom of the plant on the lower, older or mature leaves. As the physiological breakdown progresses, the whole leaf becomes reddish-brown, dries, and finally becomes rust colored and brittle. Many leaves are prematurely shed, bolls fail to develop properly and may fail to open or only partially open, and the fiber is of poor quality. In the 1960's in Arkansas and in the 1980's in Alabama, K deficiency symptoms were found on young cotton leaves at the top of the plant. While the K deficiency symptoms are similar to the traditional symptoms, they occur first at the top of the heavily fruiting plants and progress from younger to older leaves.

Soil and Foliar Potassium Fertilization Management

Soil applied K

The need for K rises dramatically when bolls are set on plants because developing bolls have a high K requirement. It is crucial that potassium be available when the plant is setting fruit on the first position of the first several branches, because 70 to 75 percent of the total yield occurs from first position bolls on the first 7 or 8 fruiting branches. Modern varieties are very different from the older indeterminant cultivars. The length of the flowering period has been reduced from 5 to 7 weeks to 3 to 5 weeks in newer varieties. Thus the current varieties produce a larger crop during a shorter period of time.

Potassium requirements of cotton can be met by preplant soil application of K and/or mid-season sidedress applications of K. Soil K, as measured by a soil test, needs to be maintained at a high level in order to assure an adequate supply for a later date. Even a high level of K in the top soil may not be adequate for some of the new high-yielding cotton varieties. For example, moisture affects potassium availability. Drought conditions during the critical period of boll filling will force the cotton plant to use moisture in the subsoil if roots are deep. If the crop is stressed for moisture and the boll load is heavy, low sub-soil K can result in late season deficiency.

Foliar Fertilization with Potassium

Foliar fertilization is not meant to take the place of a sound soil fertilization program. Foliar K applications under certain conditions, however, can supplement soil applied K to increase yield and improve fiber quality of fast-fruiting cotton varieties. Foliar K applications offer the opportunity to correct the deficiency more quickly (within 20 hours) and efficiently, especially late in the season when soil application of K may not be effective. Results from foliar applications of K fertilizer, including tests in Virginia, have been inconsistent in showing an increase in cotton lint yield. However, Dr. D. Howard (University of Tennessee) reported an increased yield response from foliar K fertilization when applied in a no-till system. He suggested that the response to foliar applied K under no-till conditions could be due to the fact that root development may not be as extensive as in conventional tillage.

The timing of any foliar spray, especially during the growth stage, is critical to the optimum efficiency of the foliar treatment. The recommended growth stages in cotton for foliar-applied K are at square initiation, at flower initiation, and at peak boll development. It is important to recognize that it is generally cheaper to supply K from soil-applied potash than it is to make supplemental, foliar-application.

Foliar applications have the advantage of allowing producers to add the necessary K when: tissue analysis indicates a pending shortage, large fruit load is expected, or deficiency symptoms appear. Three to four foliar applications of K should be made during peak boll development at 7 to 10 day intervals beginning about 2 weeks after flowering begins. A minimum rate of approximately 3 lb/acre of K should be used at each application. The recommended source of K for foliar fertilization is potassium nitrate (KNO_3), although other sources such as potassium sulphate have been used.

Tissue Diagnoses of Potassium Deficiency

Potassium deficiency in cotton can be determined by analysis of soil and plant tissue. See Figure 3 . Tissue tests can not only assess the nutrient status of a cotton crop, but they can also determine fertilizer recommendations during the growing season. Research indicates that the uppermost main-stem leaf petiole (Figure 4) is a more sensitive indicator of plant K status than leaf blade (Baker et. al. 1992)

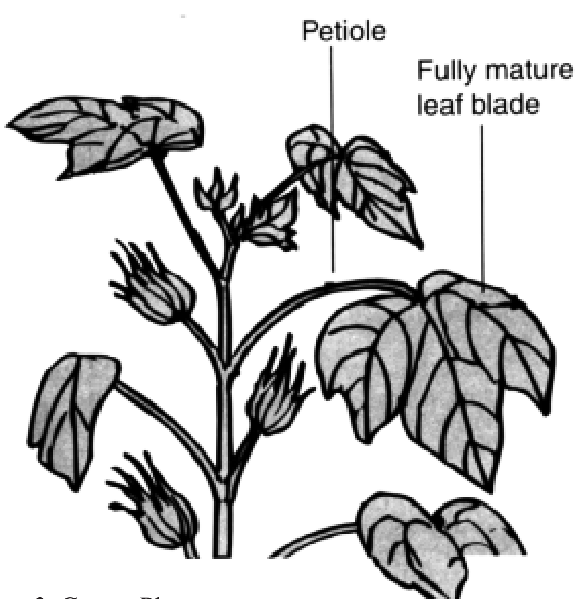

Figure 3. Cotton Plant

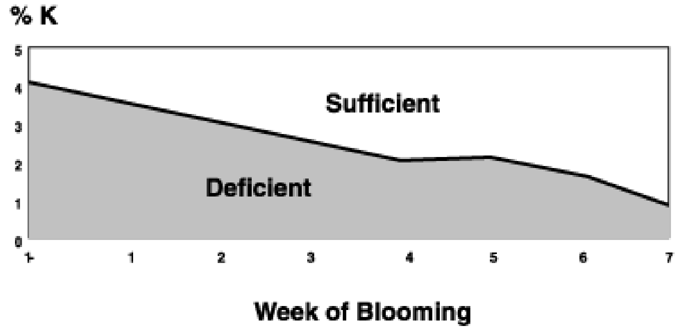

Figure 4. Sufficiency-deficiency range for soulluble K in cotton petioles (University of Arkansas).

Submitting Samples for Analysis

From various locations in the field, collect at least 30 to 40 petioles from the uppermost, mature mainstem leaves. Collect all samples at the same time every day because research conducted by Dr. Jessica Davis, University of Georgia, shows that K levels change as moisture content changes.

Take petioles during early bloom, which is the period of rapid nutrient uptake and growth. Sufficiency levels are established for most nutrients at this state of growth. The petiole sufficiency level of K decreases with time. Scientists at the University of Arkansas have used plant analysis data to develop a sufficiency-deficiency range for all levels of K in cotton. At first flower or early bloom, the K sufficiency level is in the 4 percent range; at peak flower, 3 percent; at first open boll, 2 percent; and prior to harvest, 1 percent. With this information, K deficiency can be predicted as early as the week before first bloom.

Submit plant samples to the laboratory in a clean paper bag.

Summary

The major demand for K by the plant comes at boll set because bolls are the major sink for K. Even in soils rated as high in available K, in-season K shortage can develop due to heavy demand during rapid boll set and fill. Both yield and quality may be reduced due to K deficiency.

Use preplant soil testing to determine K needs. Soil samples should be taken from the top 8 inches and the subsoil. However, fertilization according to soil test recommendations does not always guarantee that late season K deficiency will not occur, especially if yield potentials are high.

Yield and quality losses due to mid-season K deficiency can be minimized with foliar application of K. The bottom line is: observe fields closely! Where petiole testing is not available, visual monitoring can help determine whether a foliar K application is needed.

Finally, build soil fertility levels to high test range over 2 or 3 years by using higher surface K rates.

Literature Cited

Baker, W. H., J. S. Mcconnell, R. L. Maples, and J. Verve. 1992. Soil and Plant methods for diagnosing K deficiency in cotton. pp. 67-70. In Proceedings Beltwide Cotton Conferences. National Cotton Council, Memphis, TN.

Bassett, D. M., W. D. Anderson, and C. H. E. Werkhoven. 1970. Dry matter production and nutrient uptake in irrigated cotton (Gossypium hirsutum L.). Agron. J. 62:299-303.

Cassman, K. G., B. A Roberts, T. K. Kerby, D. C. Bryant, and S. L. Higashi. 1989. Soil potassium balance and cumulative cotton response to annual potassium additions on a vermiculitic soil. Soil Sci. Soc. Am. J. 53:805-812.

Mullins, G. L. and C. H. Burmester. 1990. Dry matter, nitrogen, phosphorus, and potassium accumulation by four cotton varieties. Agron. J. 82:729-736.

Mullins, G. L. and C. H. Burmester. 1991. Phosphorus, and potassium uptake by cotton. Better Crop with Plant Food 75(3):12-13. Potash and Phosphate Institute, Atlanta, GA.

Oosterhuis, D. M., S. D. Wullschleger, R. L. Maples and W. N. Miley. 1990. Foliar feeding of potassium nitrate in cotton. Better Crops with Plant Food 74(3): 8-9. Potash and Phosphate Institute, Atlanta, GA.

Rosolem, C. A. and D. S. Mikkelsen. 1991. Potassium absorption and partitioning in cotton as affected by periods of potassium deficiency. J. Plant Nutr. 14:1001-1016.

Sprague, H. B. 1964. Hunger Signs in Crops. A. Symposium. David McKay Co., New York.

Reviewed by David Holshouser, Extension specialist, Tidewater Agricultural Research and Extension Center