POTASSIUM DEFICIENCY IN COTTON PHYSIOLOGICAL ASPECTS AND TISSUE SAMPLING

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Abstract

Widespread late-season potassium (K) deficiency in the US Cotton Belt has focused attention on K nutrition of cotton (*Gossypium hirsutum* L.). Cotton is more sensitive to low K availability than most other major field crops, and often shows signs of K deficiency on soils not considered K deficient. Preplant soil tests provide a means for estimating overall K fertilizer requirements, whereas petiole analysis has become a valuable diagnostic tool for assessing nutrient status and determining K requirements during the growing season. However, petiole analysis has not always been reliable, and there is some uncertainty about K threshold levels. This report describes studies conducted in Arkansas from 1992 to 1996 on the K nutrition of cotton. Specific objectives addressed are: (a) K partitioning in plant components in relation to tissue sampling, (b) changes in various physiological processes with the onset of K deficiency, and (c) the influence of K deficiency on gas exchange and carbon discrimination.

The onset of K deficiency in growth chamber experiments was first detected in roots, followed by stems, petioles and leaves, and then in the fruit. In field studies, partitioning of K into leaves, petioles, and bolls by main-stem node at various times (near pinhead square, at flowering, and during boll development) showed that upper canopy petioles are less sensitive to K deficiency than those lower in the canopy. The onset of K deficiency in growth chamber experiments was first detected in upper canopy petioles and then subsequently in mid- and lower-canopy petioles as K deficiencies developed. These experiments suggested that whole plant K can be determined more accurately if petiole K is determined from two separate main-stem locations. Luxury storage of K in the cotton plant, particularly prior to peak demand for K by the boll load, could possibly perplex tissue diagnostic recommendations. Petiole K showed the highest concentration in the plus-K treatment, while leaf K showed the lowest concentration. All organ K concentrations in the no-K treatment were less than 10 g kg^{-1} at 19 and 26 days after withholding K. Large numerical differences were observed at 19 and 26 days in leaf area, leaf dry weight, root dry weight, and square dry weight.

Visual K deficiencies were first observed in growth chamber experiments 19 days after K was withheld, along with reductions in leaf chlorophyll concentration, and significant reductions in leaf photosynthesis. However, leaf ATP and nonstructural carbohydrate concentrations were higher 19 and 26 days after withholding K than in the control, which may have been the result of reduced utilization and translocation of these metabolites. Our studies show that reductions in leaf physiological processes and plant growth did not occur until the petiole K concentration fell below 0.88% on a dry weight basis. Therefore, reductions in lint yield and quality should not develop until this critical petiole level is attained. Accompanying the decreased photosynthesis as the K deficiency developed in the no-K treatment, was a decreased carboxylation efficiency and an increased CO_2 compensation point, which is attributed to declined leaf K concentration, changes in net photosynthesis, and respiration in the light. Potassium deficiency also resulted in increased stomatal and non-stomatal limitations to A. Gas exchange studies showed stomatal conductance was most limiting 13 days after withholding K, whereas instantaneous measurements at 19 and 26 days indicated non-stomatal conductances were most limiting. However, carbon isotope analyses, which integrated stomatal and non-stomatal conductances over the entire analysis period, indicated that the most limiting resistance to net photosynthesis was stomatal. Decreased carbon isotope discrimination in the no-K treatment is also in agreement with increased stomatal limitations. During a mild K deficiency, increased stomatal resistance results in a decrease in photosynthesis, as the deficiency becomes more acute, biochemical factors also contribute.

Our studies show that reductions in leaf physiological processes and plant growth did not occur until the petiole K concentration fell below 0.88% on a dry weight basis. Therefore, reductions in lint yield and quality should not develop until this critical petiole level is attained. Furthermore, our results suggested that whole plant K can be determined more accurately if petiole K is determined from two separate main-stem locations. Luxury storage of K in the cotton plant, particularly prior to peak demand for K by the boll load, could possibly perplex tissue diagnostic recommendations and may explain the inability of present tissue testing methods to accurately predict a pending K deficiency. This accounted for storage may also partly explain why responses to foliar-applied K fertilizers only give significant yield increases 40% of the time in field trials in the Cotton Belt. These findings should enhance our understanding of the changes that occur in physiological processes as K deficiency develops. The information will improve our understanding of tissue diagnosis for a pending K deficiency.

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