TENNESSEE

Potassium Fertilization of Cotton Produced on Loess-Derived Soils

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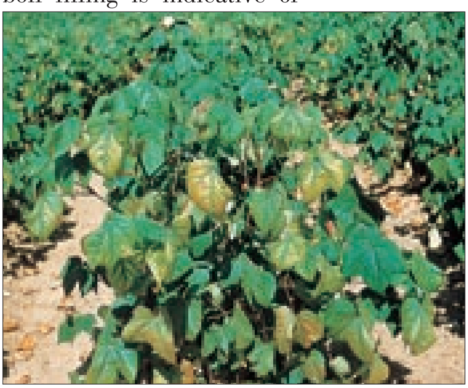
Fast-fruiting cotton cultivars grown on loess-derived west Tennessee soils commonly display K deficiencies during boll filling, despite the apparent adequacy of soil K. Loess-derived soils are prevalent in the region and are responsible for the vast majority of the cotton production in the state and are also found in several other Mississippi Valley states (16 million acres), including Arkansas, Mississippi, Kentucky, Missouri, and Illinois. Potassium deficiency symptoms commonly appear in older leaf tissue, as K is a mobile element in the plant and rapidly translocated to young tissue and other sinks. However, in fast-fruiting cultivars, they first appear in younger leaf tissue, indicating K requirements exceed plant uptake. The high K demand during boll filling is indicative of the importance of this essential nutrient in the development of the fruiting body. Indeed, the boll contains approximately 60% of all K accumulated in the plant. A K deficiency during this critical stage of development affects both yield and quality of cotton fiber.

High-yielding and fast-fruiting cotton varieties produced on loess-derived soils often display potassium (K) deficiency symptoms during boll filling. Deficiencies result from the combined influence of K fixation by vermiculitic soils and insufficient soil K test data to identify appropriate K fertilizer recommendations. The results of this study clearly demonstrate the need for additional fertilizer K, relative to current recommendations, for cotton production on loess-derived soils.

Numerous studies have suggested that the current soil K test ratings are suspect relative to cotton production. In order to address the K deficiency problems in the short-term, the Tennessee Agricultural Experiment Station increased the recommended K fertilization rate for cotton produced on medium testing soils, from 72 to 108 lb K_2O/A. Despite this modification, it was still evident that a re-evaluation of the fertilizer K recommendations was needed. For example, a comparison of soil test K and cotton yield data obtained at the Milan Experiment Station in west Tennessee illustrates the mismatch between the current soil test ratings and the yield response (**Figure 1**).

Recent University of Tennessee research has established the characteristics



Production of fast-fruiting cotton cultivars on loess-derived soils may require greater soil K levels than currently recommended.

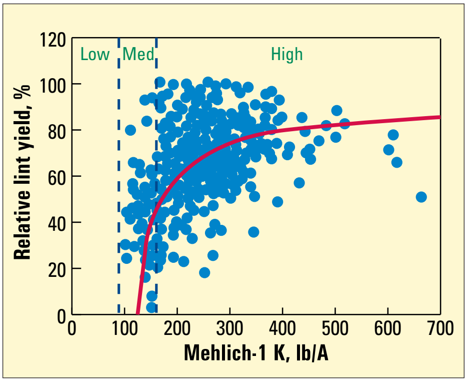


Figure 1. Relative cotton lint yield compared to soil test K levels determined two weeks after spring fertilization of loessial soils at Milan, Tennessee. The vertical dashed lines represent the current soil test ratings of the Tennessee Agricultural Experiment Station.

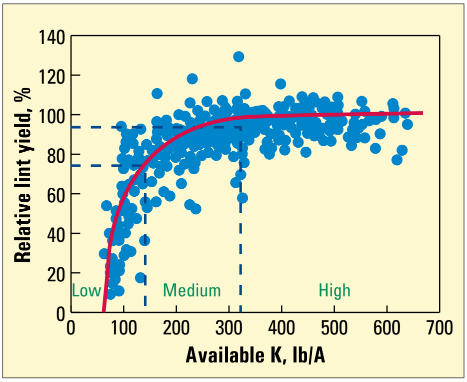


Figure 2. Relative cotton lint yield compared to available soil K (soil test K determined prior to fertilization + fertilizer K) determined for numerous locations in west Tennessee. The division between a low and a medium testing soil occurs when the relative yield is 75%; the medium to high break occurs when relative yield is 95%.

of loessial soil that are responsible for restricted K availability. Specifically, it was found that the clay fraction is composed of vermiculite and hydroxy-interlayered vermiculite (HIV), which is a natural weathering product of vermiculite in slightly acidic soils. These clay minerals are responsible for the exchange and nutrient retention capacity of a soil. However, they are also well-known for their K (and ammonium) fixation capabilities.

Evidence of the influence of K on the nutrient retention capacity of a soil can be seen by examining the cation exchange capacity (CEC) when the soil is saturated with different ions. For example, loessial soils saturated with calcium (Ca^{2+}), the dominant native exchangeable cation on the exchange complex, have CEC values that range from 8.71 meq/100g ($cmol_c$/kg) to 12.16 meq/100g. Potassium-saturated soil displays CEC values that are significantly lower, ranging between 4.12 meq/100g and 8.13 meq/100g. These data directly indicate that a portion of the K retained by the clay fraction of the vermiculitic loessial soils can not be displaced and is unavailable for crop uptake. In addition, the K that remains exchangeable is difficult to displace by native cations, such as Ca^{2+}, further reducing K availability.

Based on field observations and the mineralogical character of loessial west Tennessee soils, it was hypothesized that the current Mehlich 1 soil K test ratings and fertilizer rate recommendations are not sufficient to maximize the production of fast-fruiting cotton cultivars. In order to address this problem, studies were initiated at three locations in west Tennessee: Milan Experiment Station in Milan, West Tennessee Experiment Station in Jackson, and Ames Plantation Experiment Station near Grand Junction. The study involved several soil types, including Memphis, Lexington, Loring, and Henry soils (Hapludalfs, Fragiudalfs, and Fragiaqualfs). A randomized complete block design with five field replicates and seven broadcast K fertilizer rates: (0, 30, 60, 90, 120, 150, and 180 lb K_2O/A) was tested at each location. Plots also received nitrogen (N) at 80 lb/A as ammonium nitrate (NH_4NO_3) and 30 lb P_2O_5/A as triple superphosphate. The plots were seeded with the cotton cultivars DP 50 (during 1995 and 1996) and DP 5409 (1997

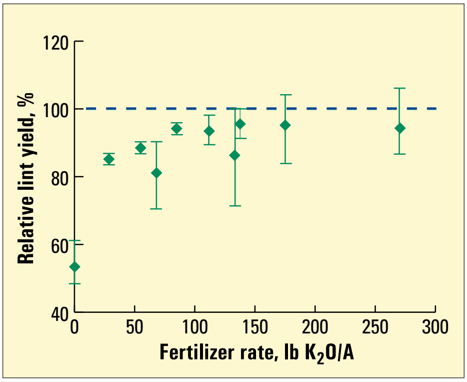


Figure 3. Relative cotton lint yield response to K fertilization on low-testing loessial soils. The error bars represent to 95% confidence level.

TABLE 1. Currently used and proposed Tennessee Agricultural Experiment Station soil K test (Mehlich1) results and associated ratings.

	Soil test rating			
	Low	Medium	High	Very high
	lb K/A			
Current	<90	90-160	160-320	>320
Proposed	<140	140-320	>320	–

through 1999) and managed in no-till. Soil K fertility status was evaluated each fall prior to K fertilization, using a Mehlich 1 extraction of 0 to 6 in. soil samples.

Annual fertilizer K rate explained most of the variability in relative yield. The best fit with relative yield resulted when the extractable soil K level (before annual fertilizer K application) and the annual fertilizer K rate were combined and considered as available K. (This does not necessarily imply that fertilizer K rates should be added to the extractable soil test K level for other soils, other extractants, or other crops. Nor does it imply that the fertilizer K rate will result in a 1:1 incremental change in soil test K level.) The available K levels in the soils that generate a relative yield of 75% of the maximum (the cut-off between low-testing and medium testing soils) is 140 lb K/A (**Figure 2**). Correspondingly, the available K that identifies a high-testing soil is approximately 320 lb K/A.

A comparison of soil test results to those that are currently employed by the University of Tennessee Agricultural Experiment Station is made in **Table 1**. According to our results, soil K test levels required to achieve a particular rating for cotton production should be modified. In essence, soils that currently rate medium or high should actually rate low or medium, respectively. In addition to a change in the soil K ratings, the experimental evidence also supports a change in the fertilizer recommendations. A comparison of yield response to fertilizer K rate (**Figure 3**) indicates that maximum yield on low-testing soils is achieved when the K fertilizer rate is in excess of 180 lb K_2O/A. A similar evaluation for medium testing soils indicates that maximum yields will be achieved with a K fertilization rate of 110 lb K_2O/A.

As a result of our evaluations, it is evident that the production of fast-fruiting cotton cultivars on loess-derived soils requires greater soil K levels than currently deemed acceptable. Modifications in the evaluation of soil K and in the fertilizer recommendations will be necessary. First, soils that currently rate medium and high testing must be classified as low and medium testing for cotton production. Second, the fertilizer recommendation for a low testing soil must be increased from 140 lb K_2O/A to 180 lb K_2O/A. BC

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