# SOIL POTASSIUM FERTILITY GUIDELINES FOR COTTON IN CALIFORNIA

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## Introduction

Irrigated cotton (Gossypium hirsutum) is a major crop of the San Joaquin Valley (SJV) of California with an acreage exceeding 1.1 million acres in 1995. Over the past 20 years new cultural production techniques and cultivars have improved seed and lint yields. With these new cultural practices and cultivars attention has been focused on updating fertility management of Acala cotton varieties. A primary focus of this research has been to address late-season K deficiencies which limits lint yield on approximately one-fifth of the annual acreage (Gulick et. al 1989).

Potassium deficiency has primarily been identified as a compound problem, partially the result of the mineralogy of the subsoils of the SJV and with cotton root physiology. Work of Page et al. (1963) has associated cotton K deficiency with vermiculitic soils which strongly retain K making it relatively unavailable to cotton. On these soils added K, be it incorporated with crop residue or fertilizer material is readily absorbed by vermiculite clay in the surface soil (Cassman 1986). Work of Brouder and Cassman (1990) have indicated that cotton root density and surface area was significantly greater at a subsoil depth of 5-12 in. than at other depths. Surface root densities of cotton were significantly lower than other crops (i.e. barley, soybean and corn). Thus late-season cotton K deficiency is attributed to subsoils low in available K which have high vermiculitic clay contents and a cotton root system of relatively low surface root density.

## Methods and Materials

In 1993 at sixteen locations, 1994 fourteen locations and 1995 nine locations potassium field experiments were conducted in Merced, Kings, Fresno, Madera, Kern and Tulare counties to evaluate seed/lint yield response to K fertilizer across the San Joaquin Valley. All locations were planted to the Acala cotton variety Maxxa and cultural production practices followed those of the individual producer. At squaring deep band treatments of 0 and 400 lbs. per acre of $K_2O$ applied as KCl were made at a depth of six inches adjacent to the row in replicated field plots. Although this rate of K application may appear to be excessive, earlier work of Cassman et al (1989) indicated significant lint yield responses to very high rates of application. Cotton petiole samples were taken at three phenological growth stages beginning at first bloom. At maturity eight foot of row was harvested on which seed yields, lint yield and lint quality were determined. At each location pre-plant soil samples were taken at depths of 0-5, 5-15, and 15-30 inches and evaluated for phytoavailable potassium using the following methods: 1.0 N ammonium acetate extractant (Gavlck et al 1994); Mehlich 3 extractant; ammonium bicarbonate - DTPA extractant; 1.0 N boiling nitric acid (Cassman et al 1989); 1.0 N barium acetate; a proprietary method known as the Unocal extraction test; 0.02 N calcium chloride soluble K; sequential washing; soil saturated paste solution potassium; and resin extractable potassium. In addition soils were evaluated for potassium fixation capacity using a modification of a buffering capacity technique described by Cassman et al (1990).

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## Results

There were significant cotton lint yield responses to K fertilizer at sixteen of the forty-two locations. Yields of 0 $K_20$ plots ranged from 747 to 1,728 lbs. $ac^{-1}$ with an average increase in lint yield to 400 lbs. of $K_20$ of 126 lbs. $ac^{-1}$ across all sites. Of the ten soil K methods evaluated, 1.0 N ammonium acetate, Mehlich 3, 0.5 N ammonium bicarbonate - DTPA (AB-DTPA) and 1.0 N barium acetate extractants were all correlated with lint yield response. Across locations soil saturated paste solution K, nitric acid extractable K, resin extractable K and the Unocal-K extractions were not correlated with lint yield responses to K fertilizer. Results have shown lint yield response is best described using subsoil samples of the 5-15 inch depth, independent of the soil K extraction method utilized. Higher correlations of yield response to extractable K in subsurface samples is attributed to higher root density found at these depths relative to the surface samples and represents the depth which is most important to cotton K nutrition. These results are in good agreement with previous work of Brouder and Cassman (1990 and 1994). Based on Cate-Nelson statistical analysis (Dahnke and Olson, 1990) of the 1993 and 1994 data the soil critical value for K at the 5-15 inch depth is 110 mg $kg^{-1}$ using the 1.0 N ammonium acetate or the Mehlich 3 extractants. Overall these two methods predicted lint responses on approximately 80% of the responding sites. The AB-DTPA and barium soil K extractants, based on Cate-Nelson statistical analysis, were equally good predictors of cotton lint yield with soil critical concentrations of 65 and 75 mg $kg^{-1}$ respectively. It is hypothesized that these extractants are generally better due to their decreased propensity for extracting unavailable soil K from soil clay minerals. Cotton petiole concentrations of K at peak bloom were highly correlated with subsoil (5-15 inch depth) 1.0 N ammonium acetate and Mehlich 3 extractable K and were best described by quadratic functions.

Potassium fixation results indicate soils which are capable of fixing greater than 60% of applied potassium fertilizers had significant lint yield responses at four of five locations. Soils with a K fixation capacity less than 60%, for all but two locations, did not have significant lint yield responses to K fertilizer. The one responding site which was less than 20 % K fixation was also very low clay and ammonium acetate extractable K at all soil depths. These results suggest that sub-soil K fixation associated with vermiculitic soils is indicative of sites likely to respond to K fertilizers. Particle size analysis suggests that K fixation is generally associated with the fine silt fraction (2-10 um) of these sub soils and is attributed to vermiculitic minerals.

Generally all locations had cotton petiole concentrations in excess of 3.0% at the onset of bloom, yet subsequent petiole sampling indicated dramatic declines in petiole K concentrations which were location dependent. Based on Cate-Nelson statistical analysis cotton petiole concentrations of 0 K plots of less than 3.50% at first bloom and 2.75% K at peak bloom were indicative of sites having cotton lint yield responses to K fertilizer. Cotton petiole concentrations of 0 K plots prior to defoliation, (five-six weeks post initiation of bloom) indicated that concentrations less than 1.50% were indicative of sites having lint yield responses to K fertilizer. Although sampling at this date is too late for use in fertilizer management in the current year, it can be used as a tool for potassium fertility management of subsequent cotton crops. There was a high correlation (r=0.72) between petiole K concentrations for the 2nd and 3rd sampling dates. Rapid declines in petiole K was indicative of subsoils with high K fixation potentials. Overall, cotton petiole K at peak bloom and prior to defoliation are reliable indicators of K sufficiency and are highly correlated with preplant subsoil K levels by several extraction methods.

## Summary

In developing a potassium fertilizer management program for Acala cotton varieties in SJV of California this research strongly supports an integrated soil-plant analysis program which evaluates both soil potassium availability and K fixation potential in conjunction with in season petiole analysis. A soil testing strategy using preplant subsoil samples representative of the cotton root zone using standard soil K extractants is useful in predicting the probability of K fertilizer response.

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