Potassium deficiency syndrome of cotton

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Symptoms occur despite seemingly adequate soil levels

Apparent potassium deficiency symptoms appear in many San Joaquin Valley cotton fields each year, initially detected in late July and becoming pronounced by late August and September. The malady affects an estimated 200,000 to 300,000 acres (15 to 20 percent) in the Valley.

The potassium deficiency symptoms seem to occur under similar environmental conditions as Verticillium wilt, but the visual symptoms are clearly distinguishable. Plants infected with Verticillium wilt have leaves with mottled patterns of yellow and brownish, or necrotic, blotching resulting in reduced photosynthetic efficiency and defoliation in severe cases. The apparently potassium-deficient plants have classic deficiency symptoms — that is, bronzing of thick, leathery leaves that show no signs of necrosis or defoliation and that snap when bent.

Several anomalies are apparent in the potassium deficiency syndrome. Symptoms appear in areas of fields where the soil test (ammonium acetate extraction) is well above the published critical level. Potassium is a mobile ion in the plant. Deficiencies should thus appear in old leaves, but they typically appear in new leaves. Crops other than cotton seldom show deficiency symptoms in adjacent fields or the same field in subsequent years.

There may be partial explanations for these apparent anomalies. When sensitivity to potassium deficiency was compared in cotton, corn, soybeans, vetch, and wheat at five locations over a 21-year period in Alabama, cotton proved to be the most sensitive. D.M. Bassett, University of California, found that the carpel wall of cotton bolls contains approximately 4 percent potassium and accounts for 60 percent of all the potassium accumulated by the plant. If bolls are not allowed to develop on plants, deficiency symptoms do not develop. Bolls may be stronger sinks for potassium than new leaves, so that symptoms would appear in new leaves during peak boll growth.

Finally, K. Cassman, UC Davis, has demonstrated stratification of soil potassium. Levels in the plow layer are much higher than at lower depths. Current soil test recommendations, which consider only the plow layer, may not be a good index of the soil's ability to supply potassium throughout the growth period.

Field studies

We conducted potassium fertilizer trials at eight locations in Merced and Kings counties in 1982-84 (table 1). Individual tests each had 0, 250, and 500 pounds of fertilizer potassium per acre as common treatments. In each test, potassium was sidedressed 6 inches from the center of the bed at a depth of 6 inches after listing but before planting. All locations had one factor in common — abrupt changes in soil texture due to layering of the profile. Three locations (Merced #1 to 3) had factorial arrangements of Acala SJ-2 and SJC-1 with or without soil fumigation with 100 pounds per acre Pichlor 60 at all three potassium fertilizer rates.

All plots were harvested with grower-owned spindle pickers. Yields were based on lint per acre corrected for moisture

TABLE 1. Characteristics of eight locations used as test sites

Location	Previous crop	Soil K*	Verticillium wilt	Soil type
		ppm		
Merced				
#1	Cotton	120	High	Temple clay loam
#2	Cotton	140	High	Temple clay loam
#3†	Sugarbeets	170	Low	Merced clay
#4	Cotton	148	Low	Columbia loamy clay
#5	Cotton	138	Medium	Columbia sandy clay loam
#6‡	Dry beans	180	Medium	Silty loam
Kings				
#1	Cotton	74	Medium high	Grangeville sandy loam
#3	Cotton	74	Medium low	Grangeville sandy loam

* Ammonium-acetate-(NH_4OAC) extractable soil potassium.
† Merced #3 had 20 tons of manure per acre added before the crop.
‡ Merced #6 had potassium fertilizer added in previous years.

TABLE 2. Acala SJ-2 lint yields at various potassium rates and locations

Location	Lint yields: Potassium rates (lb/acre) None	250	500	Mean	Significant response
	lb/acre				
Merced					
#1	443	609	585	546	Yes
#2	546	720	708	658	Yes
#3	676	739	696	703	No
#4	916	905	942	921	No
#5	879	931	939	916	No
#6	883	858	980	907	No
Kings					
#1	608	840	811	753	Yes
#3	975	1,108	1,166	1,083	Yes
Mean	741	839	853	811	Yes

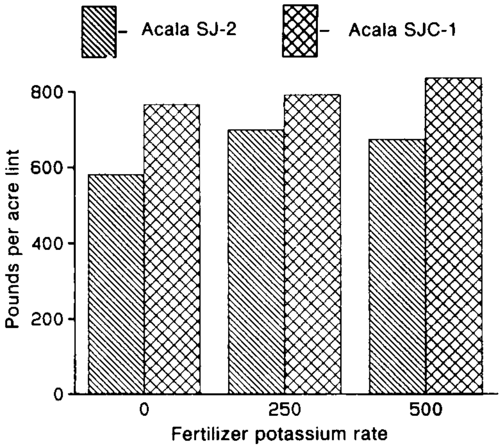


Fig. 1. Additional fertilizer potassium resulted in significantly different responses in the two Acala varieties tested.

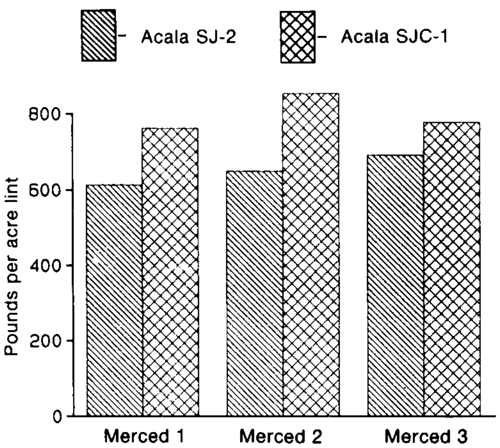
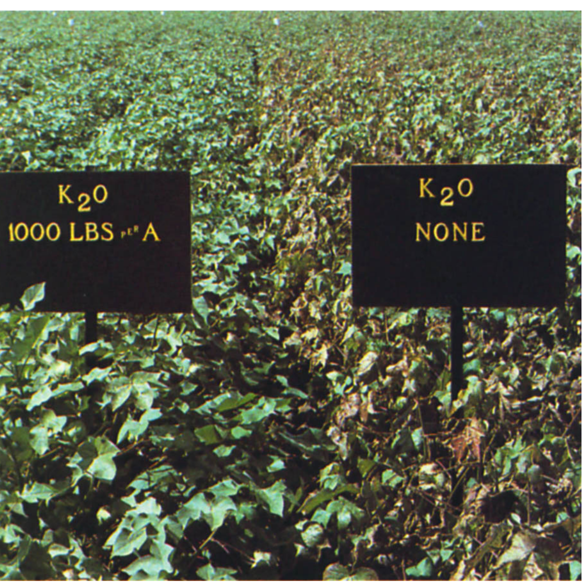


Fig. 2. The differences in yields by location were also highly significant, with Acala SJC-1 outyielding Acala SJ-2.



Response of cotton to additional potassium fertilizer is evident.

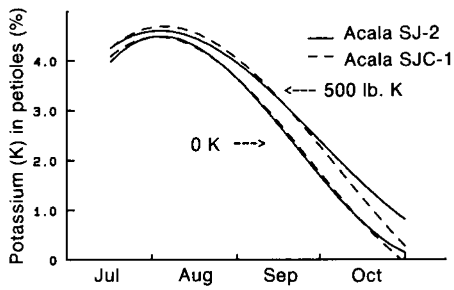


Fig. 3. Effect of variety and potassium fertilizer rate on seasonal petiole potassium percentage (average of eight tests).

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Results

Locations ranged in average yield from 546 to 1,083 pounds of lint per acre (table 2). Averaged over locations, adding 250 pounds potassium per acre increased yields 98 pounds per acre. Additional fertilizer did not increase yields further. Four locations (Merced 1 and 2, and Kings 1 and 3) significantly responded to fertilizer potassium, while the other four (Merced 3 to 6) did not. The four locations with a significant response to fertilizer potassium had an average increase of 175 pounds of lint per acre compared with only 35 for the four locations showing no response. This single degree of freedom comparison (1 of 14 possible) explained 67 percent of the location-by-potassium rate interaction.

The remainder of the results are based on the three locations (Merced 1 to 3) where varieties, potassium rates, and soil fumigation were all common treatments. Averaged across all factors, Acala SJC-1 yielded 798 pounds per acre compared with only 651 for Acala SJ-2. This difference was highly significant and demonstrated the improved performance of Verticillium-wilt-tolerant varieties under these conditions.

The interaction between varieties and potassium fertilizer rate is significant (fig. 1). This interaction occurs because Acala SJC-1 is vastly superior to Acala SJ-2 without added potassium fertilizer, because Acala SJ-2 is more responsive to the first increment of fertilizer (250 pounds per acre) than Acala SJC-1 is, and because Acala SJC-1 responds to the second increment of potassium fertilizer while Acala SJ-2 does not.

The variety-by-location interaction was also highly significant (fig. 2). The single degree of freedom comparison in which Merced 1 and 2 (big advantage for Acala SJC-1) differed from Merced 3 (small advantage for Acala SJC-1) accounted for 75 percent of the interaction. Soil test potassium, applied manure, and Verticillium wilt level (table 1) indicate this result should be expected.

There was no overall response to soil fumigation with Pichlor 60. The interaction between fumigation and location was significant. Statistical comparison indicates fumigation increased lint yields by 127 pounds per acre at Merced 2 and 3. Merced 3 would not be expected to respond, but Merced 2 should have responded because of high Verticillium wilt. The effects of fumigation are unclear.

Petiole potassium

Leaf petiole samples were taken from each of the eight tests at five times during the growing season (see average for all tests, fig. 3). There were no statistical differences in petiole potassium between varieties. Plots receiving potassium fertilizer had higher levels throughout the season. Petiole potassium was near 4 percent until mid-August, when it began to decline, reaching deficient levels by late September. This decline coincides with the time of heavy boll load.

Conclusions

Symptoms resembling potassium deficiencies occur in cotton fields that have sufficient potassium according to past recommendations based on soil analysis. Where symptoms occur in the field, research has demonstrated that yield responses do result from potassium fertilizer application. Acala SJ-2 is more susceptible to the problem and shows the greatest response to initial fertilizer. Although Acala SJC-1 (Verticillium wilt tolerant) does not respond as much as Acala SJ-2 does to the initial amount of fertilizer, it responds to higher fertilizer rates, whereas Acala SJ-2 does not.

Where symptoms exist in fields, Acala SJC-1 has outyielded Acala SJ-2 in every comparison. The varieties do not differ in petiole potassium level. Addition of potassium fertilizer does increase petiole potassium, but levels still drop to the critical point late in the season when maximum boll load occurs.

Additional research in the areas of possible pathogenic organisms involved, soil chemistry and soil physics, crop rotation, and varietal tolerance is in progress. Although a great deal of information has been developed regarding the problem of potassium-like deficiency symptoms, a full understanding must await further findings.

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