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L. K. STROMBERG

P O T A S H O N C O T T O N

1961 Field Trials

L. K. Stromberg, Farm Advisor

The problem of potash deficiency in cotton in Fresno County has been studied for the past five years. A few of the answers to the problem have been obtained, but there is much more to be learned.

From past field trials and surveys tentative minimum levels of potash in the soil as well as in mature plants were established. These critical levels are useable but potash levels in the plants grown in some of the fine textured soils may have to be revised upward. The 1961 field trials were designed to answer these questions:

(1) How much potash fertilizer is necessary to obtain the maximum yield?

(2) Do various strains and varieties of cotton respond differently to the addition of potash?

(3) Will cotton take up adequate potash if we broadcast before planting or is sidedressing after the plants are established more effective?

(4) How late in the season can potash be applied and still give a satisfactory increase in yield?

(5) Does the present model of Acala 4-42 pick up potash as effectively as the older models we grew before we recognized these deficiency symptoms?

Not all of these questions were answered completely, but much light was shed on each of the questions.

All the 1961 trials were made on the John R. Adams and Sons farm located on the west side of Cornelia Avenue, 3/4 mile south of Conejo Avenue. This is 4 miles southwest of Caruthers.

Soil Type: Calhi loamy sand

Soil Analyses:

	Average of 20 Samples	Range
pH	6.89	6.60-7.50
Moisture Holding Capacity	11%	-
Soluble Salts	122 ppm	115-185
Exchangeable* Calcium	324 ppm	280-535
Exchangeable* Magnesium	25 ppm	17-41
Exchangeable* Potassium	48 ppm	39-59

* Total exchangeable, using sodium acetate extraction.

Fertilizers: All plots received 300 lbs. of 16-20-0 applied in early June and 250 lbs. of 21-0-0 applied in late June. This made a total of about 100 lbs. of Nitrogen and 60 lbs. of P_2O_5 per acre. Different rates of potash were broadcast March 8, 1961. Muriate of potash used.

Planting Date: Planted April 6. This planting destroyed by wind on April 13. The field was replanted in the same rows on April 22.

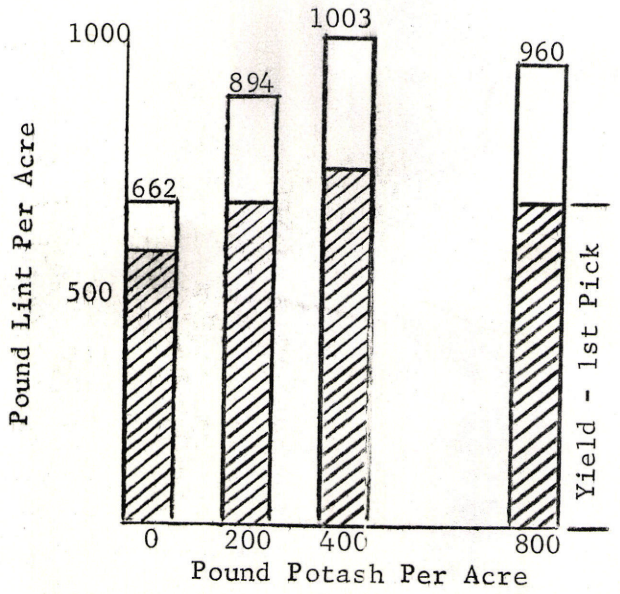
The soil was fumigated to control rootknot nematodes. The field was irrigated by sprinklers. Last irrigation was applied about August 26. The results of cotton varieties and potash rates are shown in the following table:

Rate of Potash on Several Varieties of Cotton

Variety	Pounds Potash (K_2O) Per Acre 0	200	400	800
Acala 4-42	642	864	1013	963
Variety B	702	887	1013	914
Variety C	676	958	1013	1005
Variety D	666	809	953	919
Variety E	624	851	1023	900

LSD 5% = 59 lbs. per acre.
LSD 1% = 82 lbs. per acre.

AVERAGE YIELD - 5 VARIETIES



Conclusions for Acala 4-42:

1. All rates of potash produced highly significant increases in yield over the check or zero potash.

2. The 400 and 800 pound rates of potash produced highly significant increases in yield over the 200 pound rate.

3. There were no significant differences in yield between 400 and 800 pounds of potash.

Conclusions for other varieties:

1. At the maximum yields (400 lbs. potash) variety D yielded significantly less lint per acre than all other varieties tested.

2. There were no significant differences between the maximum yields of Acala 4-42 and varieties B, C and E.

3. In all varieties, all rates of potash produced highly significant increases in yield over the check.

Further interpretations of the yield data are not made here but can be determined by carefully reviewing the data as shown.

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The stand of cotton was not uniform. There was a large number of wide skips in the planted rows of all varieties and in all treatments.

All skips over 3 feet long were measured. A 4 foot skip was recorded as one foot, a 6 foot skip as 3 feet of missing row, 10 feet as a 7 foot skip, etc. Following are the percent of planted row recorded as skips:

Variety	% Skip
Acala 4-42	8.2
B	8.0
C	6.8
D	8.6
E	15.2

Lbs. Potash/Acre	% Skip
0	8.1
200	8.5
400	7.3
800	13.6

Even though these skips are of considerable size, several methods of statistical analyses failed to show that they significantly altered the yield. This is because the skips were erratically distributed in the field.

The trends, however, indicate that Variety E consistently had a poorer stand than all others. Where 800 pounds of potash per acre was applied, the number and length of the skips were also generally greater. It seems reasonable to assume that since 800 pounds of potash (1333 lbs. of muriate of potash) was applied on the soil surface and turned into a planting bed, an excessive amount of salt may have reduced the germination or damaged the young seedlings.

Models of Acala 4-42

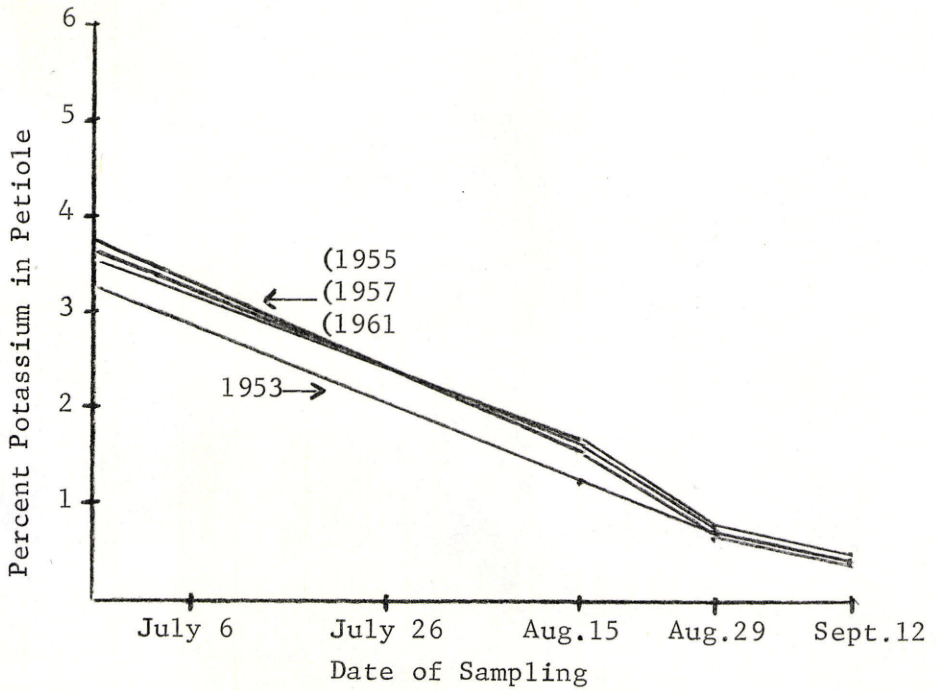
Symptoms of potash deficiency of cotton have become more widely recognized in recent years.

Is this because we have learned to recognize these as specific symptoms of a deficiency rather than to pass them off as "natural" leaf symptoms that show up as the crop matures? This may reasonably account for part of our concern.

Have we reached a period in our farming development when our less fertile soils are becoming depleted by crops? This also may be true in part.

Has our present model of Acala 4-42 lost the ability to pick up and use the potash as well as the older models? A trial was designed to check this possibility.

Through the cooperation of Mr. John Turner, Director of the U. S. Cotton Field Station, seed of 1953, 1955, 1957, and 1961 models of Acala 4-42 was planted in the field without the addition of fertilizer potash. To check the ability of each model to assimilate potassium, leaf (petiole) samples were taken five times during the growing season. Each sample was analyzed for potassium. The data are shown in the following graph:



It can readily be seen that all the later models (1955, 1957 and 1959) performed equally well while the 1953 model was consistently poorer in its ability to pick up potassium.

These figures would indicate that if any change has been made at all in Acala 4-42, the later models are better foragers of potassium than those formerly planted.

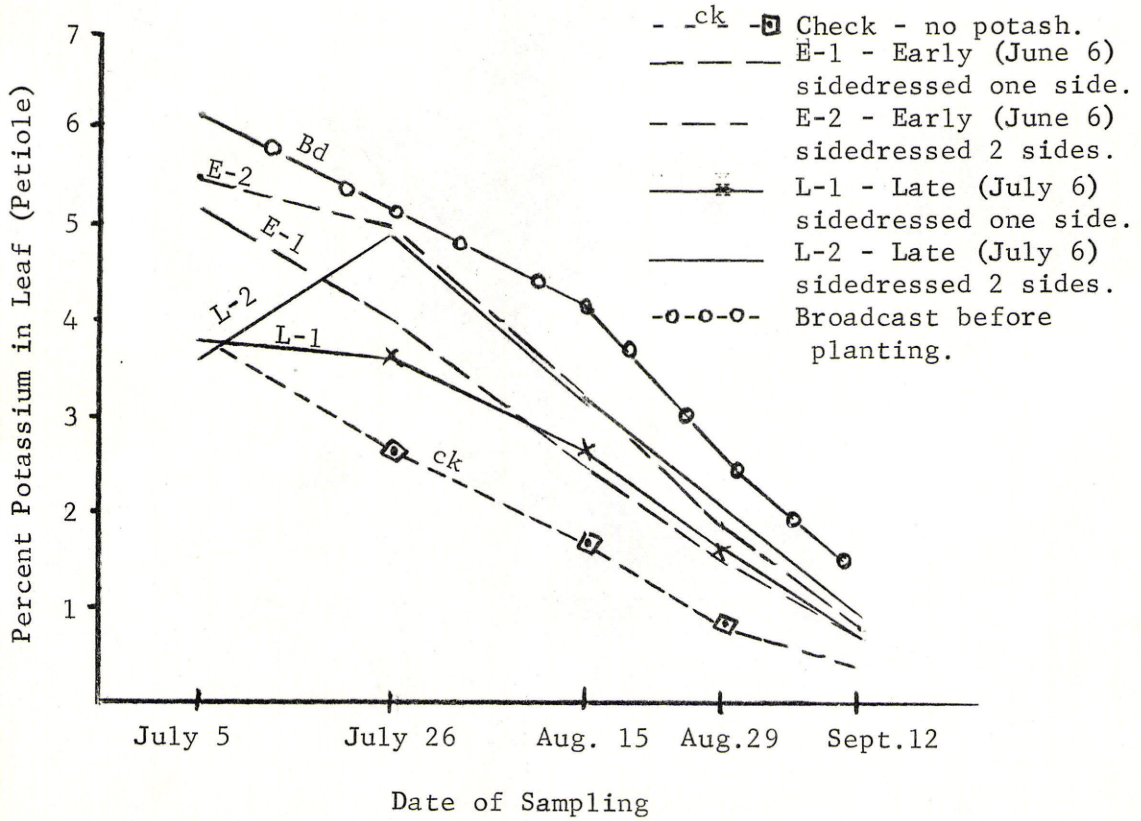
When, Where and How Should Potash be Applied?

In past years it has been observed that where potash has been broadcast before planting, the plant response appeared to be better than where it was sidedressed after the plants had been established. However, we had no figures to support our observations.

In 1960, we determined that potash sidedressed as late as July 20, was as effective as that applied on May 24 or July 1. However, the total uptake of potash by the plants in this trial was quite low. Could this be because the potash was applied to only one side of the plant row? Is applying it to both sides more effective?

To answer these questions a trial was laid out to compare a preplant broadcast, sidedressing on one side and two on sides early in the season and sidedressing on one side and on two sides late in the season.

To check the uptake of potassium, leaf samples were again taken five times during the growing season and analyzed for potassium. The following graph is a summary of the results taken from 4 replications. All plots had 400 lbs. potash (K_2O) per acre. Fertilizer drilled in 9 inches from the plant 6 inches deep.



Even though these results could not be analyzed statistically it is apparent that:

(1) Broadcasting the potash on the soil prior to planting seems to be more effective than any of the sidedressing treatments used.

(2) Sidedressing 2 sides was more effective than one side only.

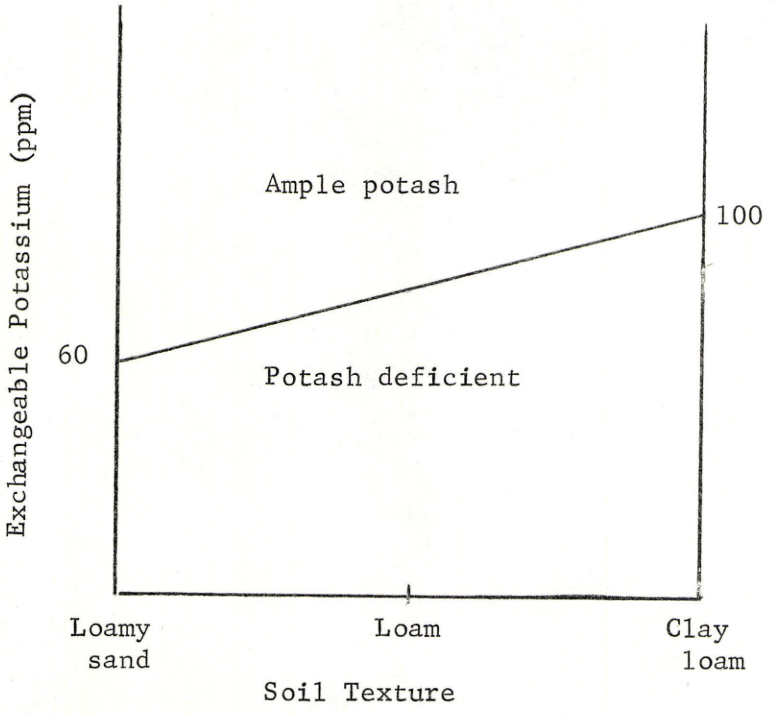
(3) Sidedressing potash on July 6, was just as effective as sidedressing on June 6.

(4) All potash treatments picked up more potassium than the check or zero treatments.

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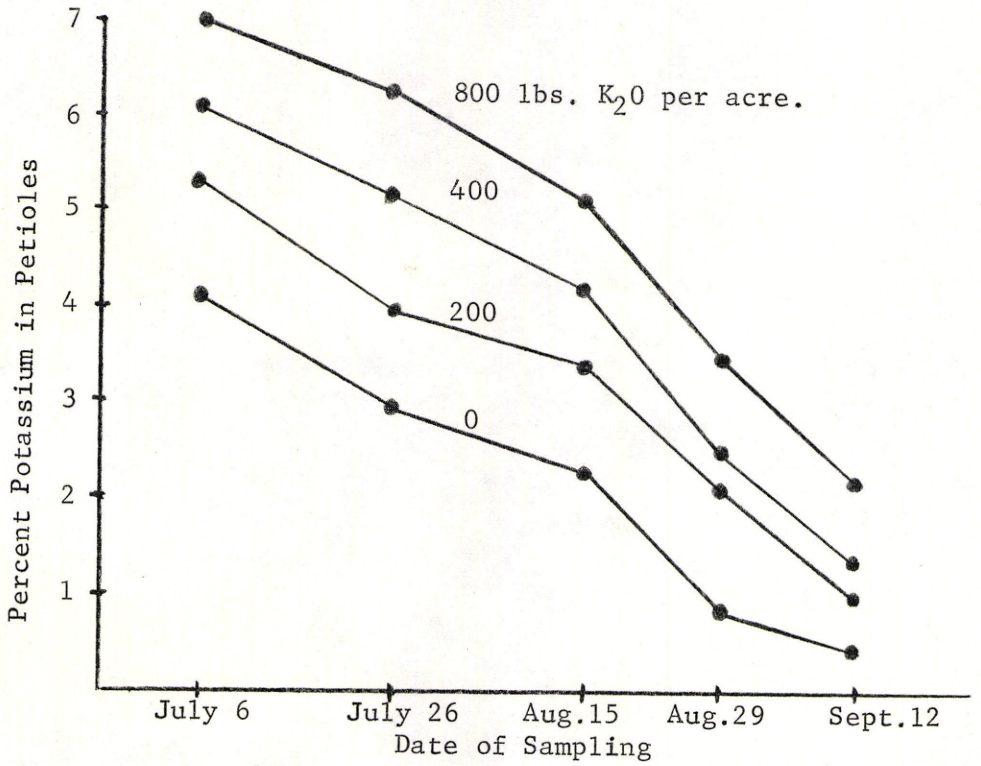
From our test plots and leaf and soil surveys in Fresno County over the past seasons we set tentative minimum levels of potassium in the soil and leaves (petioles) to predict the need for additional potash fertilizers. Our work this year permits redefinition of the limits previously set.

For loamy sands and sandy loam soils there should be a minimum of 60 parts per million (ppm) of exchangeable potassium (K). Clay loams should have a minimum of 100 ppm. A graph of the minimum levels may look like this



The petioles (stems of the leaves) at maturity--about the first week of September--should have a minimum of 1.25% potassium on a dry weight basis. Both of these figures are slightly higher than the minimum levels established after the 1959 season.

The potassium found in the petioles shows a close relationship to the potash applied to the soil. The following graph shows the plant levels for each rate of applied potash throughout the growing season.



All plants in the check and 200 pound rate of potash showed deficiency symptoms. A few individual plants in the 400 pound rate exhibited slight deficiency symptoms early in September.

DISCUSSION AND RECOMMENDATIONS

Both the soil analysis and the leaf analysis have shortcomings.

The soil analysis is difficult mainly because the deficiency of potash in Fresno County soils is usually spotty. A composite soil sample of a field may show an adequate supply of potash when, in fact, a fourth of the field may need an additional supply.

Areas most likely to be deficient are those spots that have been scraped when the land was graded for irrigation. Excessively sandy areas are more often found to be deficient but severe deficiencies have been noted in loam and clay loam soils.

Leaf analyses are helpful if the grower is not familiar with the characteristic symptoms of potash deficiency that appear late in the season. Once a grower is able to recognize the symptoms, laboratory analyses will probably not be necessary to confirm a deficiency.

Leaf symptoms and chemical analyses of petioles are valuable only if cotton is to be followed by cotton the next year.

Leaf symptoms can be used very effectively for outlining those areas in the field that are deficient. These can be sketched out by the grower late in the fall and used as a guide in spot treating his field. Potash can then be broadcast on these deficient areas before planting cotton the following year. Very few fields need an over-all application of potash.

If it has been definitely determined that potash is deficient on sandy soils, an application of 300 to 400 pounds actual potash (K_2O) per acre should be applied. This will require from 500 to 670 pounds of muriate of potash (potassium chloride, KCl) per acre. 600 to 800 pounds of sulfate of potash may be used, but for cotton, the muriate is suggested because of price. For other crops, however, it is suggested that a grower determine whether or not the muriate will be harmful.

Note: The amount required for loams and clay loams are not known but presumably an even greater amount may be necessary to overcome a severe deficiency.

In brief then:

(1) Don't use potash until you have determined that a deficiency really exists.

(2) Spot treat if you possibly can--it's cheaper that way.

(3) Apply enough to overcome any reasonable deficiency.

(4) After a massive application of potash, additional amounts will probably not be required for a few years if cotton is grown continuously. Although cotton is sensitive to potash deficiencies it is a spare user when compared to other crops such as alfalfa or potatoes.

ACKNOWLEDGEMENTS

Mr. Forrest Fullmer, Agronomist for the American Potash Institute, assisted greatly in both the laboratory and field work connected with the studies discussed in this report. This was genuinely a cooperative project.

The assistance of Mr. John Adams, the farmer-cooperator is gratefully acknowledged.

Members of the staff of the U. S. Cotton Field Station, Shafter, California, assisted in many phases of this work. Special thanks go to Mr. John Turner, Director and Mr. Merrill Lehman of the California Cotton Planting Seed Distributors for help and encouragement.

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Co-operative Extension Work in Agriculture and Home Economics,
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Need for Potassium Fertilizer on Cotton

determined by leaf and soil analyses

Fertilizer trials and field studies in 1957, 1958, and 1959 indicated that the soil in some cotton fields in the San Joaquin Valley was deficient in available potassium, and the application of potassium fertilizers significantly increased cotton yields. Where available soil potassium is in low supply, cotton plants show distinctive visible deficiency symptoms.

Deficiency symptoms have not been observed in Fresno County before mid-August, when the plants are about 120 days old. The symptoms appear only in the top third of the plant and are of the greatest severity in the youngest mature leaves.

The first symptom of potassium deficiency is premature wilting, which begins when the potassium content of the petioles of the youngest mature leaves—measured on a dry basis—drops to about 1%. Leaves well supplied with potassium are soft and feel like suede, but when the potassium content of the petioles drops to between 1% and 0.6% the leaves become thick, leathery and brittle. When crumpled in the hand, snapping and cracking of such leaves can be heard distinctly.

At a potassium level in the petioles below 0.6%, the leaves deteriorate rapidly. Leaf edges curl upward and turn yellow, followed by burning of the edges and interveinal yellowing. Eventually, large necrotic—dead—spots develop between the veins of the leaves. A fungus often infects the leaves during the necrotic spot stage.



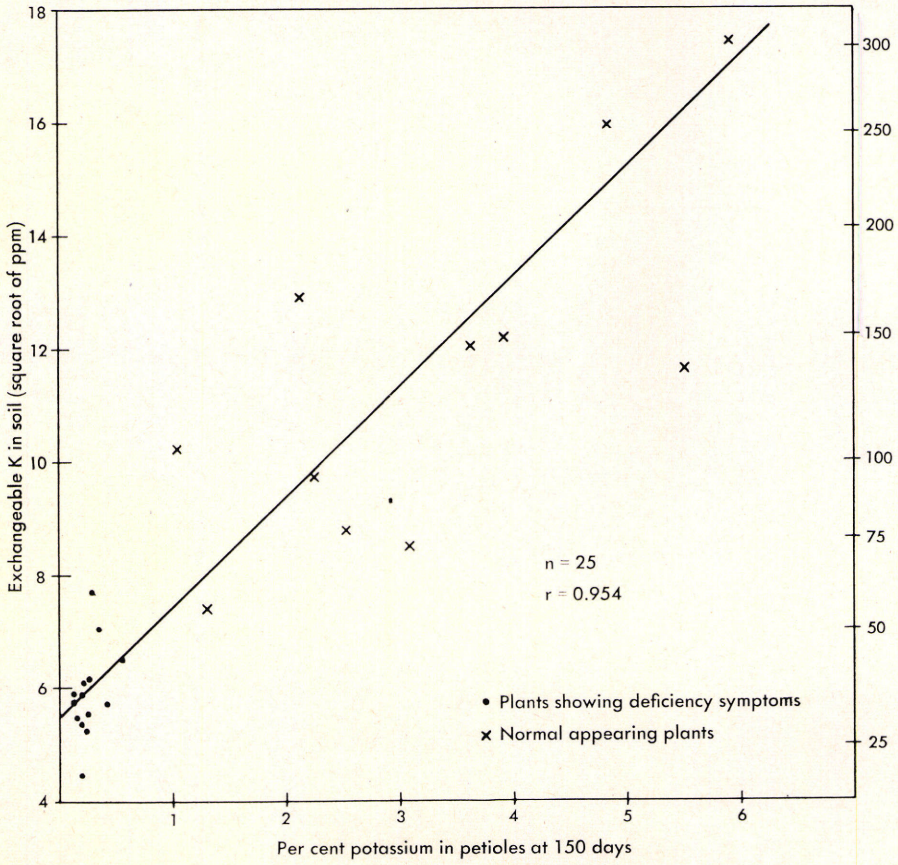
The upper portion of a cotton plant deficient in potassium.

When the petiole potassium level drops to 0.20%–0.15% the leaves die and fall from the plant. As a result, defoliation of the top leaves is sometimes so heavy it becomes impossible to take meaningful petiole samples.

In areas of severe potassium deficiency the main stem of the cotton plant becomes weak and brittle. Lodging is common.

The relationships between leaf symptoms and potassium levels in the petioles have been confirmed—almost without exception—in nearly 300 samples taken over a wide area during the late summers of 1958 and 1959.

Relationship between percent potassium in cotton petioles and the square root of exchangeable potassium in the soil.



Studies in 1959

Studies made in 1959 to correlate petiole potassium levels in plants about 150 days old with exchangeable potassium in the soil revealed a high coefficient of correlation between petiole potassium and a function of soil potassium in samples taken from 25 widely separated fields.

During the studies, field trials were established in locations where potassium deficiency was suspected because of

visible symptoms. In all cases the symptoms of potassium deficiency were corrected and the yield of lint cotton was increased an average of 207 pounds per acre by the application of 245 pounds of potash per acre in the 16 replicated experimental plots.

Petioles from all plots with and without potassium fertilizer in the 1959 field trials were sampled several times during the season.

The high correlations between the soil and petiole potassium found in the survey and the soil and petiole levels found in the test plots suggest some working minimums for potassium.

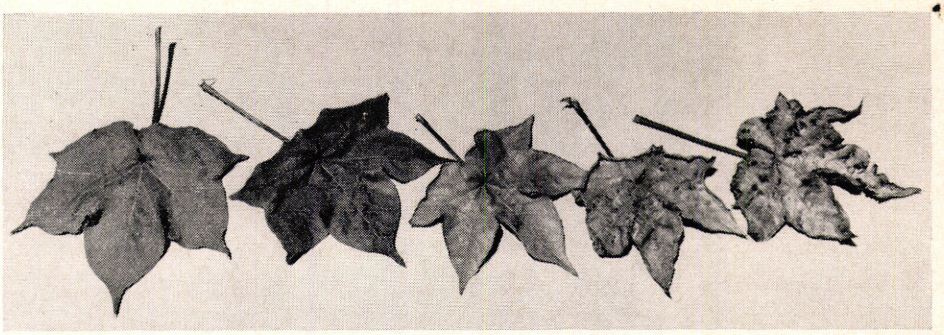
It appears that at early bloom—75 days—the petioles of the youngest mature leaves should have a minimum of 4.5% potassium, measured on a dry basis. Also, it appears that at 130 days the petioles should have at least 1% potassium.

Apparently the exchangeable potassium in the soil should be present at a minimum of 60 ppm—parts per million—in the surface 12″. As the studies are continued, the minimum levels may be increased.

Deficiency symptoms have been identified on a wide range of soils on the east side of the San Joaquin Valley. However, entire fields seldom show evidence of potassium deficiency. Visible plant symptoms and probable minimums of petiole and soil potassium—as determined by analyses—should indicate need of potassium fertilizer for cotton in some fields in the San Joaquin Valley cotton growing areas.

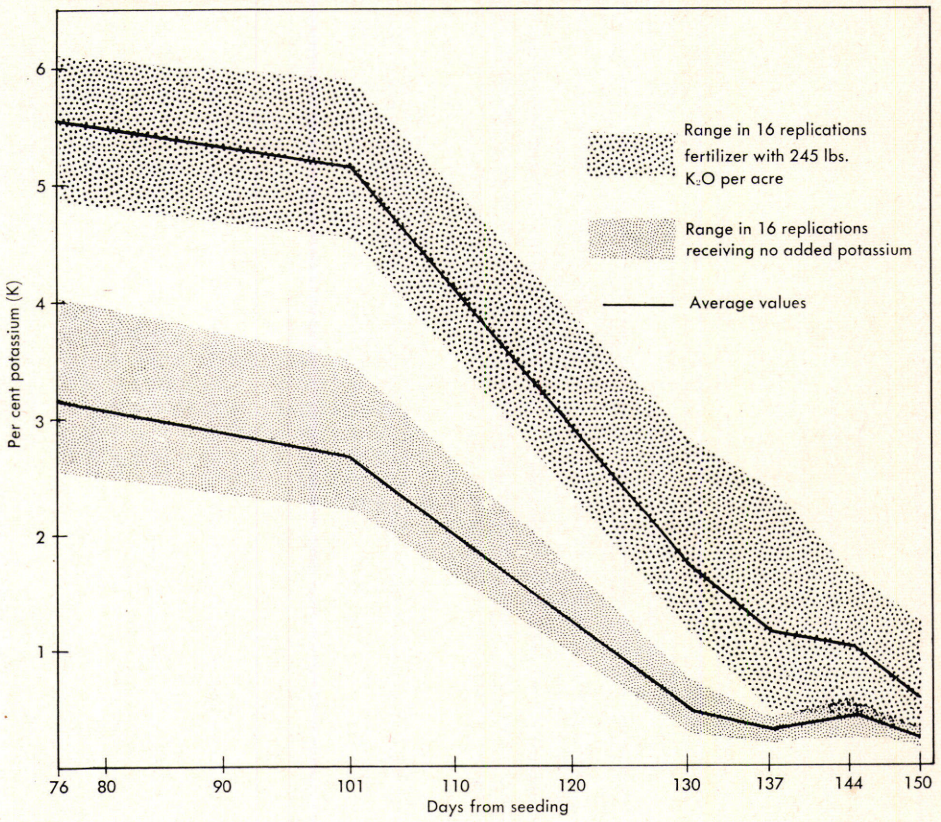
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Forrest Fullmer of the American Potash Institute assisted in the above studies.



A normal cotton leaf on the left and progressively severe potassium deficiency symptoms to the right.

Relationship of soil and petiole potassium in field fertilizer trials in 1959.



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