May 1, 1941

To the Committee on Graduate Study:

I am submitting to you a thesis written by Lofton Allen Davidson entitled "The Response of Certain Crops to Potassium on Several Soil Types in Tennessee." I recommend that it be accepted for nine quarter hours credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agronomy.

Eric Winters
Major Professor

We have read this thesis
and recommend its acceptance:

J. B. Washko

A. D. Mueller

Accepted for the Committee

C. C. Smith
Dean of the Graduate School

THE RESPONSE OF CERTAIN CROPS TO POTASSIUM ON SEVERAL SOIL TYPES IN TENNESSEE

A THESIS

Submitted to
The Committee on Graduate Study
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

by

Lofton Allen Davidson

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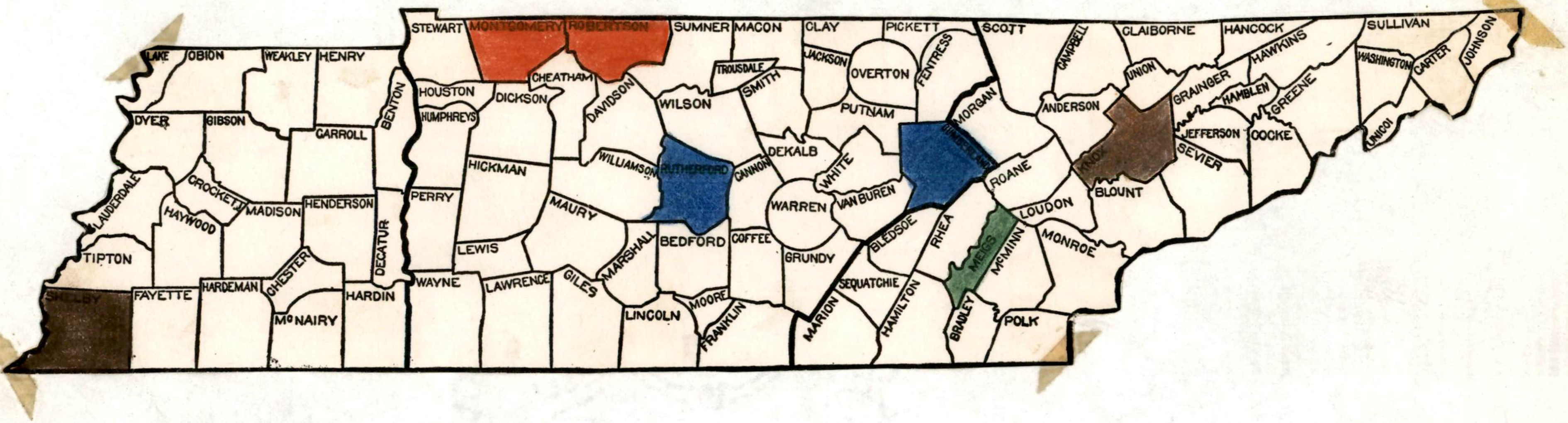
INTRODUCTION

Current fertilizer recommendations are frequently based on the results of soil tests carried out by rapid chemical methods. These chemical methods are designed to extract the more readily soluble and hence supposedly "available" nutrients in the soil. The amounts of such available nutrients that must be present in the soil for profitable plant growth can be determined only by actual field trials. When a sufficient body of data from both field and laboratory research has been accumulated, then fertilizer recommendations can be made safely on the basis of the chemical tests alone. For example, if a soil sample contains less than that amount of a given nutrient which field trials have shown to be necessary for proper growth of a certain crop, then fertilizer applications of that nutrient can be expected to give profitable returns.

The experimental data which form the basis for correlating quick test results with field yields have been obtained, for the most part, in regions other than Tennessee. Since regional differences in climate, soil, and farming practices are great, it is unsafe to accept quick test correlations worked out in other areas as a basis for fertilizer recommendations in Tennessee. The purpose of this study was to obtain data on quick test correlations which might contribute toward more accurate fertilizer recommendations for Tennessee conditions.

The magnitude of this task was such that one individual could deal successfully with but a small portion of the problem. Therefore, it was advisable to limit this study to a single nutrient element, potassium, and to include but a few crops on a limited number of different soil types.



Legend

- Corn plots
- Cotton plots
- Tobacco plots
- Corn and cotton plots
- Corn and alfalfa plots

Figure 1. Map of Tennessee showing the location of experimental plot areas

PROCEDURES AND METHODS

General plan. In order to make correlations between available potassium in the soil and the increase in yield from potassium applications, several crops were grown under farm conditions on selected areas of representative soil types. Constant amounts of nitrogen and phosphorous were added to all plots. The amount of potassium applied was varied and the effect of this element on yield was determined.

Selection of plot areas. Plot areas were chosen, wherever possible, on soil types that are important in the production of the specific crops to be studied, and in a section of the state where that crop is of major economic importance. Alfalfa, which requires frequent observation and periodic harvesting, was restricted in location to Knox County for the sake of convenience. Plot areas of corn were located in Knox, Cumberland, and Rutherford Counties; cotton in Meigs and Shelby Counties.

Special care was taken to select areas that showed as little soil variation within their boundaries as possible. In this way, it was hoped to obtain reliable yield data with a minimum number of replicates.

Each individual plot was 1/40 acre in size. Ordinarily, plots of row crops were seven rows wide and about 50 feet long, depending on width of row. Three rates of potassium fertilization were used in duplicate making six individual plots per series or experimental plot area. Plots receiving the same treatment were never adjacent (See Figure 2), thus providing a partial check against soil variation.

Planting and culture. The various crops on the experimental plot areas were planted and cultivated at the same time and in the same manner as the remainder of the field in which the plots were located.

PLOT RECORD CROP ____________ DATE ____________

Location: County _________________ Specific location ____________________

____

Operator's name ________________________ Address ______________________

Soil type ________________________ Uniformity _________ Slope _______

Remarks ____

____

Soil treatment:

Year	Crop grown	Lime	Manure	Fertilizer	Crop yield	Remarks

Laboratory data:

Surface: pH____ K ________ Exch. Cap. __________ % Sat. _____________

Subsoil: pH____ K ________ Exch. Cap. __________ % Sat. _____________

Fertilizer treatment:

Amount and Form

Plot	Lime	N	P	K
1.				
2.				
3.				

Crop yields:

Date of harvest __________________

Plot

1. ____
2. ____
3. ____

Figure 2. Record blank used for each experimental plot area

<u>Fertilization and harvesting</u>. The following standard application of nutrient elements was made to all plots planted in row crops: forty pounds of nitrogen (N), fifty pounds of phosphoric acid (P_2O_5), and sufficient ground limestone to neutralize the equivalent acidity of the nitrogen carrier. The rates of potassium application were different for each crop and therefore will be noted under the respective crops.

All fertilizer ingredients, including potassium, were weighed on a spring balance and then mixed together thoroughly in a rotary soil mixer. The fertilizer was applied to row crops with a No. 210 Planet Jr. garden fertilizer drill in bands 2 inches from each side of the seed and approximately 4 inches deep. Application followed planting as closely as possible, except for tobacco, then it preceded plant setting in order to avoid mechanical injury to the plants.

Plot areas were harvested a few days prior to the general field harvest in order to avoid interference with the regular operations of the cooperator. The outside rows on each plot were not harvested in order to eliminate the possible influence of the fertilizer treatment of adjoining plots. Weighings of the yield from each plot were made on a spring balance supported by a tripod. Since the harvesting procedure for the various crops differed, it will be discussed separately for each crop.

<u>Corn</u>. The rates of application of KCl to corn were 0, 50, and 150 pounds per acre. The corn was harvested late in October. The grain from each plot was weighed in the field and approximately 5 pound samples were taken to the laboratory to determine shelling percentage and air-dry weight.

The corn plots in Knox County and one in Cumberland County were harvested by the cooperators due to a misunderstanding and the yield data were not obtained.

Tobacco. In all cases but one, the fertilizer application was made after the rows had been marked but before the plants were set. Sulfate of potash was applied at the rate of 0, 100, and 300 pounds per acre.

Plants were harvested as they ripened. They were placed on sticks tagged with indentifying numbers and allowed to cure with the remainder of the crop.

After curing, 30 plants were selected at random from each plot. The leaves were stripped from these representative plants and arranged in three major classes: leaf, seconds, and lugs. The tobacco in each class was grouped by plots and weighed. Each class was then graded by a Federal tobacco grader.

The weight of each grade was then computed on an acre basis for each plot. Average prices for the 1939 season were used to compute the acre value of the crop.

Cotton. Cotton received the same fertilizer treatment as corn. Two pickings were made. Seed cotton yield per plot was weighed in the field but no lint or moisture determinations were made.

Alfalfa. Established stands of alfalfa two years or older were used for the experiment. Plots received no fertilization other than the KCl, which was applied as a top dressing in May, 1940, at the rates of 0, 100, and 300 pounds per acre respectively.

Three representative samples, each one-thousandth (1/1000) acre in area, were harvested from each individual plot with hand operated grass shears. Green weights were determined in the field and two pound samples from each plot were air-dried in the laboratory and the total dry weight of hay per acre computed.

Three cuttings were made from each plot during the 1940 season.

Collection and preparation of soil samples. Two composite samples, one of the surface to a depth of six (6) inches and one of the subsoil from six to fifteen (6-15) inches, were taken from each plot area before fertilization. Approximately fifty (50) borings with a soil auger were made to secure each composite.

Soil samples were dried, crushed, passed through a 20 mesh sieve and mixed thoroughly. The samples were stored before analysis in air tight glass containers to prevent contamination with ammonia or other vapors in the laboratory atomosphere. All analyses of the samples were made in the laboratory at Knoxville.

Analytic methods. Soil reaction was determined with a Beckman glass electrode; available phosphorous by Truog's method[1]; replaceable potassium with the sodium perchlorate method outlined by Bray[2] with modifications. Since potassium determinations are difficult to duplicate by different operators, complete details of the procedure as used in this test will be given:

> Reagents used are the same as those described by Bray[2]. Add to a five (5) gram sample of air-dry soil in a vial, ten (10) ml. of twenty-two (22) percent sodium perchlorate solution. Shake vigorously for one minute and pour on a dry filter paper placed in a filter

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[1] Truog, E. 1930 The Determination of Readily Available Phosphorous in Soils, J. Am. Soc. Agron. 22: 874-882

[2] Bray, R. H., Potassium, Phosphorous, and other Tests for Illinois Soils (Urbana: University of Illinois, College of Agriculture, October 1940), pp. 1-9, 14

tube.

Measure 2 ml. of filtrate into a 16.5 x 50 mm. flat bottomed glass vial. Add 6 drops of formaldehyde, shake, and then add 6 drops of cobaltinitrite solution. Shake again and allow to stand for approximately 30 seconds to 1 minute.

Tilt the vial slightly and add 2 ml. of a 50-50 mixture of pure synthetic methyl and iso-propyl alcohols. The alcohol mixture must be added slowly down the side so that two layers of liquid are formed. Immediately begin a slow rotary movement holding the vial on a flat surface. When the layers begin mixing, as evidenced by formation of a precipitate, mix more rapidly by removing the vial from the flat surface and rotate with an elliptical undulating motion until the two layers are thoroughly mixed. Care should be taken to prevent air bubbles from forming as they will interfere with the final reading. Allow this mixture to stand for approximately two minutes. The precipitate should remain in suspension.

Take a clean 16.5 x 50 mm. flat bottomed vial and hold it one (1) inch above some thin black lines on a turbidity chart that has a small bulb supplying light from below. The turbidity chart and light supplying equipment are described in Figure 3. With a medicine dropper add the suspension to the clean vial until the small lines on the turbidity chart are barely perceptible. Practice is usually necessary to duplicate readings. Measure with calipers and rule the depth of suspension required to obscure the lines and with the aid of a conversion table, compute from this measurement the number of pounds of potassium per acre.

Data for a conversion table is obtained by running tests as described above but using in place of soil filtrate standard concentrations of from ten (10) to one-hundred (100) parts per million of potassium in sodium perchlorate solution. Each concentration will have a specific corresponding depth of suspension. The conversion table is made by listing the various concentrations of potassium tested in a vertical column directly opposite a column containing the depths of suspension corresponding to the respective concentrations. To convert a given concentration in parts per million into pounds of potassium per acre, multiply the parts per million of potassium by four (4).

Special precautions: The results of the test vary with temperature changes. For accurate readings, solution temperature throughout the test must be maintained fairly constant and in no case must exceed 25° C. Most satisfactory results are obtained when the temperature is 18 to 22° C. Standard solutions should be run regularly as a check on possible contamination or deterioration of the reagents. Cobaltinitrite deteriorates with age and exposure to light. The main supply should be kept in a brown bottle in a darkened storeroom. For daily use, a small brown dropper bottle should be in the laboratory. The small bottle should receive a fresh supply from the storeroom before use if there are long intervals between tests. Readings of all tests should be made with a constant, uniform source of light and the same turbidity chart.

Base exchange capacity was determined as described by Olson and Bray[3]. Briefly, the details are as follows:

Leach the samples with 500 ml. of normal neutral $NH_4C_2H_3O_2$ on Buechner funnels. Total bases are determined in this leachate. Excess $NH_4C_2H_3O_2$ is removed from the soil sample by leaching with 300 ml. of absolute methanol. The sample is then leached with 300 ml. of 0.1 N HCL. This leachate is then transferred quantitatively into 800 ml. pyrex Kjeldahl flasks and made alkaline by the addition of NaOH pellets (phenolphthalein indicator). The NH_3 is then distilled into Erlenmeyer flasks containing 25-50 ml. of standard acid. Excess acid is back titrated with 0.1 N NaOH using a mixed indicator (methyl red and methylene blue) to determine the end point.

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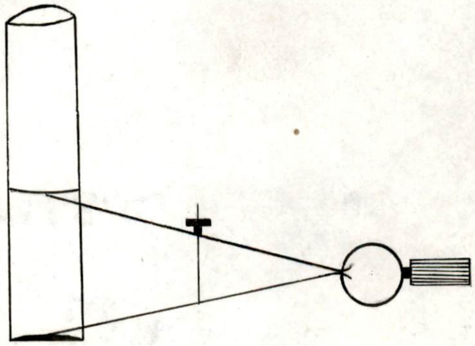
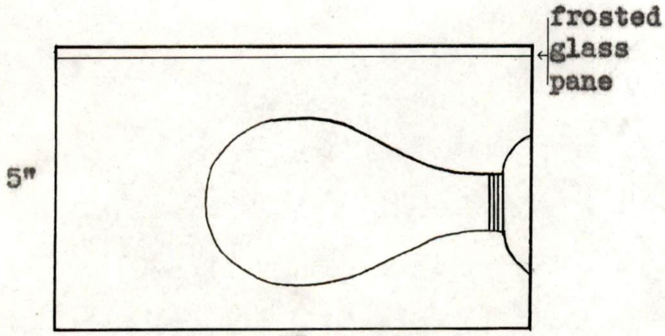
3 Olson, L.C. and Bray, R.H. 1938 The Determination of the Organic Base Exchange Capacity of Soils. Soil Sci. 48: 487

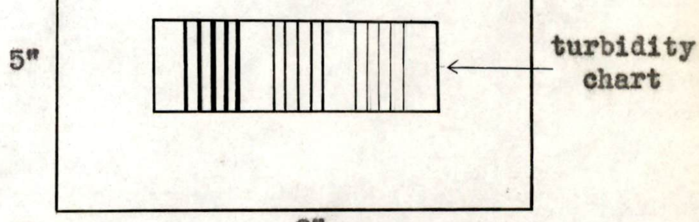
16.5 mm. x 50 mm. flat-bottom vial and calipers



Convenient light-supplying box made of ½" board with mounted turbidity chart



Cut-away side view showing the location of light bulb and glass pane



Top view showing opening that exposes turbidity chart under the frosted glass pane

Figure 3. Equipment used in making readings of the tests for potassium

DATA AND OBSERVATIONS

The results of the laboratory analyses of the several plot samples are given in Table I. Data on pH, available P, and exchange capacity are included in addition to those for replaceable potassium, since such additional information often proves helpful in evaluating crop growth.

The exchangeable potassium ranged from 100 to 300 pounds per acre in the surface soils, and from less than 80 to 190 pounds in the subsoil, except for one sample which had 300 pounds. It will be noted that practically all subsoil samples have considerably less exchangeable potassium than the corresponding surface samples.

The plots growing alfalfa all had pH values of 6 or above in the surface soil. The pH values of the other plots varied from 4.8 to 7.3 in the surface soil. The subsoil samples in almost every case were lower in pH than the corresponding surface samples.

Available P_2O_5 ranged from 25 to 175 pounds per acre in the surface soil, however, most samples had less than 100 pounds. Only one subsoil sample contained more than 40 pounds of P_2O_5.

Values for exchange capacity are all below 14.5 m.e. In general, subsoil values for exchange capacity are somewhat higher than for the corresponding surface samples.

Yield data for each crop will be presented separately.

Corn. All the data are given in Table II. Experimental plot area no. 9 on Hartsells very fine sandy loam produced an average yield of 35.9 bushels where no potash was added, 40.0 bushels where 25 pounds of potash were added, and 47 bushels where 75 pounds of potash were added. The calculated increase in percent for the two rates of potash added are 11.4

TABLE I. DATA ON SOIL SAMPLES

Crop	Exper. Plot Area	Soil Type	Cooperator	County	Surface(0-6") Sample				Subsoil(6-15") Sample			
					K[1]	E.C.[2]	pH	P_2O_5	K[1]	E.C.[2]	pH	P_2O_5
Alfalfa	1	Cumberland silt loam	J.C.Brown	Knox	280	5.6	6.8	75	80	7.3	5.5	20
	2	Decatur silt loam	L.Livesay	Knox	170	9.8	6.2	40	80	10.7	5.6	25
	3	Decatur silt loam	W.H.Hatfield	Knox	100	13.5	6.7	175	80	14.4	5.6	60
	4	Sequoia silt loam	H.Warwick	Knox	300	9.1	6.0	60	300	11.5	5.5	20
	5	Cumberland silt loam	Univ. of Tennessee	Knox	100	6.6	6.6	100	80	8.1	6.3	40
Tobacco	6	Cookeville silt loam	J.T.Murphy	Robertson	160	6.3	5.7	50	100	7.7	5.2	10
	7	Dickson silt loam	B.F.Rosson	Montgomery	160	6.4	7.3	50	80	10.5	4.6	10
	8	Cookeville silt loam	Thad Corbin	Robertson	220	8.1	5.5	50	140	8.2	5.5	10
Corn	9	Hartsells very fine sandy loam	J.T.Edwards	Cumberland	190	6.2	5.4	25	100	6.8	4.7	10
	10	Hartsells very fine sandy loam	V.Williams	Cumberland	190	5.7	5.4	100	80	4.9	4.8	25
	11	Hagerstown silt loam	B.Williamson	Rutherford	180	8.1	6.8	50	80		5.6	25
Cotton	12	Cumberland silt loam	C.Friddell	Meigs	320	6.7	5.3	50	190	7.2	5.0	10
	13	Greendale cherty loam	E.B.McKenzie	Meigs	125	5.1	7.0	75	80	4.6	6.2	10
	14	Sitka silt loam	L.E.Davidson	Shelby	190	4.3	4.8	75	160	10.0	4.5	25

[1] In terms of pounds per acre
[2] Exchange Capacity

and 30% respectively. Plants on the areas receiving no applications of potash showed definite abnormalities in growth. The stalks were shorter, thinner, and weaker, and the leaves showed the color markings characteristic of potassium deficiency.

The yields on experimental plot area no. 10, also on Hartsells very fine sandy loam, were somewhat lower than above. Where no potash was applied the yield was 32.9 bushels; with an addition of 25 pounds of potash, an increase of 5.1 bushels, or 15.5% was obtained; with 75 pounds of potash, an increase of 10.6 bushels or 32.0% was obtained. Plants on the areas receiving no potash showed abnormalities in appearance very comparable to those described above.

The highest level of production was obtained on Hagerstown silt loam which had been in alfalfa for the preceding 4 years. The yield where no potash was applied was 61.0 bushels; 25 pounds of potash increased the yield 11.6 bushels or 19.0%; 75 pounds of potash gave an increase of 13.8 bushels or 22.6%. The plants on the areas receiving no potash were as tall as the other plants but the stalks were slender and weak and the leaves showed mild development of the potassium deficiency symptoms.

Tobacco. The results of the experiments with tobacco were so voluminous that a separate table was prepared for each individual experimental plot area.

Experimental plot area no. 6 on Cookeville silt loam showed an increase in returns per acre for applications of 50 pounds of potash but gave no additional response when 150 pounds of potash were applied (Table 3). The average return per acre from plot 2 exceeded that from plot 1 by $53.94. Plot 3 gave a very negligible increase over plot 2, and its replicate showed a decrease of $43.94. Injury resulting from root rot in the area

TABLE II. RESULTS OF EXPERIMENTS WITH CORN

Plot Area	Soil Type	Exch. K Content[1] Surface	Subsoil	Plot No.	K_2O[2] Applied	Yield of Shelled Corn Bushels Per Acre Each Plot	Duplicates Av.	Per Cent Increase Over Check Plot
9	Hartsells	190	100	1A	0	33.2	35.9	----
	very fine			1B	0	38.6		
	sandy loam			2A	25	38.3	40.0	11.4
				2B	25	41.7		
				3A	75	45.0	47.0	30.0
				3B	75	49.0		
10	Hartsells	190	80	1A	0	33.6	32.9	----
	very fine			1B	0	32.2		
	sandy loam			2A	25	39.4	38.0	15.5
				2B	25	36.6		
				3A	75	45.0	43.5	32.0
				3B	75	42.0		
11	Hagerstown	180	80	1A	0	59.6	61.0	----
	silt loam			1B	0	62.5		
				2A	25	75.6	72.6	19.0
				2B	25	69.5		
				3A	75	78.1	74.8	22.6
				3B	75	71.5		

[1]Pounds of potassium per acre
[2]Pounds of potash (K_2O) per acre

on which this plot was located could easily account for these differences.

Little difference was observed between treatments on experimental plot area no. 6 until the latter part of the growing season. By that time the plants on the plots receiving potash had grown larger and had developed longer leaves. Very striking differences were noticed during grading when samples from various plots were compared. Leaves from plants receiving potash ran uniformly longer and brighter than those from plants receiving no potash. Leaves from plot 3 that received 150 pounds of potash were harvested before maturity was reached. This, of course, resulted in a lower grade than if maturity had been reached.

Throughout the growing season, the potassium treatment on experimental plot area no. 7 on Dickson silt loam resulted in a noticeable improvement of the growing crop in proportion to the amount of potassium application (Figure 4). Differences were noted concerning freedom from disease, size of plant, and length and quality of leaf. After curing, leaves from plants receiving no potash were shorter, darker, and of definitely poorer quality. The average increase in returns from plot 2 over plot 1 was $20.41 (Table 4). The average increase in returns from plot 3 over plot 1 was $54.93.

Experimental plot area no. 8 on Cookeville silt loam showed no observable difference between various treatments during the growing season (Table 5). After curing, differences in grades on treated plots as shown in Table V were apparent. These differences, although rating a better grade, did not command a premium on the 1939 market and all the plots returned approximately the same income.

<u>Cotton</u>. Results from all experiments with cotton are contained in

Table VI. In the regions where tests were conducted, the 1940 season was very unfavorable for cotton production. Because of cool weather in the spring and early summer, the early crop growth was delayed. Moisture conditions were unfavorable and variable throughout the season. Early freezes destroyed many bolls at an immature stage and further reduced yields.

On experimental plot area no. 12 located on Cumberland silt loam, little difference was observed throughout the growing season between treated and untreated plots. Yields failed to show any appreciable difference except for plot 3, which showed an average increase of 225 pounds of seed cotton per acre.

Experimental plot area no. 13, located on Greendale cherty loam, was subjected to very severe disease complications that practically destroyed the plots having no potassium treatment as well as the remainder of the farmer's field. The average yield from plot 1 was 112 pounds of seed cotton, as compared with 468 pounds from plot 2 and 786 pounds from plot 3.

On experimental plot area no. 14, on Sitka silt loam, the increase of plot 2 over plot 1 was 310 pounds of seed cotton or 38.2%. Plot 3 failed to give any increase over plot 2.

Alfalfa. Five alfalfa plots were continued through the season of 1940. No differences in yields between the treated and untreated plots were observed during the 1940 season.

No potash

Note: Small plants, leaves curled at edges and ends, small thin leaves and weak midribs

150 pounds of potash per acre

Note: Large uniform plants, thick broad leaves with strong mid-ribs

Figure 4. Tobacco plots showing response to potash on experimental plot area 7

TABLE III. RESULTS OF TOBACCO EXPERIMENTS, PLOT AREA 6
Soil Type-Cookeville silt loam

		Leaf				Seconds				Lugs			
Plot No.	Applied K_2O[1]	Grade	Leaf Wt.[4]	Pound Value Cents	Plot[3] Value Cents	Grade	Leaf Wt.[4]	Pound Value Cents	Plot[3] Value Cents	Grade	Leaf Wt.[4]	Pound Value Cents	Plot[3] Value Cents
1A[2]	0	-B2F45	7.5	19.25	144.4	B4F45	1.1	13.25	14.6	X4G	1.8	6.00	10.8
1B[2]	0	B3F45	7.9	16.75	132.3	X2F	0.8	10.50	3.4	X4G	1.8	6.00	10.8
2A	50	B2F45	9.2	20.50	188.6	B4F45	1.1	13.25	14.6	X4FV	0.7	7.50	5.3
2B	50	B2F45	8.8	20.50	180.4	C4F45	1.1	12.00	13.2	X3FV	1.3	8.75	11.4
3A	150	-B2F46	8.8	20.09	176.8	C4F46	1.9	12.50	23.8	X3F	.7	9.25	6.5
3B	150	B3F45	8.2	16.75	157.4	C4F45	1.7	12.00	20.4	X3FV	1.3	8.75	11.4

[1]Pounds of potash (K_2O) applied per acre
[2]A and B received identical treatment
[3]Aliquot of 30 plants
[4]Pounds of leaves from 30 plants

TABLE III. (Cont.) RESULTS OF TOBACCO EXPERIMENTS, PLOT AREA 6
Soil Type-Cookeville silt loam

Plot No.	Weight Stalks Pounds Per Plot[2]	Weight Stalks Pounds Per Acre[3]	Total Yield Pounds Per Plot[2]	Total Yield Pounds Per Acre[3]	Average Yield Per Acre[3] Pounds	Total Value Per Plot[2]	Total Value Per Acre[3]	Average Value Per Acre[3]
1A[1]	2.4	280	10.4	1216.8	1222.6	$1.69	$198.67	$187.86
1B[1]	2.6	308	10.5	1228.5		1.51	177.26	
2A	3.0	351	11.0	1287.0	1298.7	2.08	243.95	241.90
2B	2.8	327	11.2	1310.4		2.05	239.85	
3A	3.0	351	11.4	1333.8	1322.1	2.07	242.31	220.13
3B	2.9	339	11.2	1310.4		1.69	197.96	

[1]A and B received identical treatment
[2]Aliquot of 30 plants
[3]Computed on the basis of 3500 plants per acre

TABLE IV. RESULTS OF TOBACCO EXPERIMENTS, PLOT AREA 7
Soil Type-Dickson silt loam

Plot No.	Applied K_2O[1]	Leaf				Seconds				Lugs			
		Grade	Leaf Wt.[4]	Pound Value Cents	Plot[3] Value Cents	Grade	Leaf Wt.[4]	Pound Value Cents	Plot[3] Value Cents	Grade	Leaf Wt.[4]	Pound Value Cents	Plot[3] Value Cents
1A[2]	0	B3D45	7.4	19.00	140.6	X2D	2.4	11.00	26.4	X3D	1.1	9.25	10.2
1B[2]	0	B3D45	8.2	19.00	155.8	X2D	1.9	11.00	20.9	X4D	0.8	7.50	6.0
2A	50	B3F45	8.7	18.00	156.6	X2F	1.4	10.50	14.7	X4F	0.8	8.00	6.4
2B	50	B3D46	10.1	19.25	194.4	X2D	1.1	11.00	12.1	X3D	0.9	9.25	8.3
3A	150	B3D45	9.8	19.00	186.2	X2D	2.1	11.00	23.1	X4D	0.5	7.50	3.8
3B	150	-B2D46	10.1	22.09	220.9	X1D	1.0	12.50	12.5	X4D	1.3	7.50	9.8

[1]Pounds of potash (K_2O) applied per acre
[2]A and B received identical treatment
[3]Aliquot of 30 plants
[4]Pounds of leaves from 30 plants

TABLE IV. (Cont.) RESULTS OF TOBACCO EXPERIMENTS, PLOT AREA 7
Soil Type-Dickson silt loam

Plot No.	Grade	Trash Lugs Leaf Wt.[3]	Trash Lugs Pound Value Cents	Plot Value Cents[2]	Weight Stalks Pounds Per Plot	Weight Stalks Pounds Per Acre[4]	Total Yield Pounds Per Plot[2]	Total Yield Pounds Per Acre[4]	Average Yield Per Acre[4] Pounds	Total Value Per Plot[2]	Total Value Per Acre[4]	Average Value Per Acre[4]
1A[1]	X5D	1.1	5.75	6.3	3.4	397.8	12.0	1404.0	1404.0	$1.83	$214.70	$217.91
1B[1]	X5D	1.1	5.75	6.3	3.1	362.7	12.0	1404.0		1.89	221.13	
2A	X5FG	0.9	5.00	4.5	3.4	397.8	11.8	1380.6	1503.4	1.82	213.17	238.32
2B	X5D	1.8	5.75	10.4	4.3	503.1	13.9	1626.3		2.25	263.45	
3A	X5DG	0.9	4.25	3.8	3.8	444.4	13.3	1556.1	1561.9	2.16	253.77	272.84
3B	X5D	1.1	5.75	6.3	3.5	409.5	13.4	1567.8		2.49	291.92	

[1] A and B received identical treatment
[2] Aliquot of 30 plants
[3] Pounds of leaves from 30 plants
[4] Computed on the basis of 3500 plants per acre

TABLE V. RESULTS OF TOBACCO EXPERIMENTS, PLOT AREA 8
Soil Type-Cookeville silt loam

Plot No.	Applied K_2O[1]	Leaf				Seconds				Lugs			
		Grade	Leaf Wt.[4]	Pound Value Cents	Plot[3] Value Cents	Grade	Leaf Wt.[4]	Pound Value Cents	Plot[3] Value Cents	Grade	Leaf Wt.[4]	Pound Value Cents	Plot[3] Value Cents
1A[2]	0	B1F45	3.9	25.50	99.5	B4F46	1.1	13.75	15.1	X2F	1.5	10.50	15.8
1B[2]	0	B1F46	3.9	27.50	107.3	+B4F46	1.2	14.90	17.9	X3F	2.1	9.25	19.4
2A	50	A2F46	3.9	26.00	101.4	C3F46	1.7	15.00	25.5	X2F	1.4	10.50	14.7
2B	50	A2F46	3.7	26.00	96.2	C4F46	1.9	12.50	23.80	X2F	1.8	10.50	18.9
3A	150	-B1F46	3.7	25.50	94.4	C3F46	2.0	15.00	30.0	X2F	1.2	10.50	12.6
3B	150	A2D46	4.7	27.00	126.9	C3F46	1.9	15.00	28.5	X2F	1.2	10.50	12.6

[1] Pounds of potash (K_2O) applied per acre
[2] A and B received identical treatment
[3] Aliquot of 30 plants
[4] Pounds of leaves from 30 plants

TABLE V. (Cont.) RESULTS OF TOBACCO EXPERIMENTS, PLOT AREA 8
Soil Type-Cookeville silt loam

Plot No.	Weight Stalks Pounds		Total Yield Pounds		Average Yield Per Acre[3] Pounds	Total Value		Average Value Per Acre[3]
	Per Plot[2]	Per Acre[3]	Per Plot[2]	Per Acre[3]		Per Plot[2]	Per Acre[4]	
1A[1]	2.0	468	6.5	1521.0	1602.9	$130.4	$305.14	321.75
1B[1]	1.9	444.6	7.2	1684.8		144.6	338.36	
2A	1.9	444.6	7.0	1638.0	1689.3	141.6	331.34	328.34
2B	2.1	491.4	7.4	1731.6		138.9	325.03	
3A	1.8	421.2	6.9	1614.6	1719.9	137.0	320.58	356.85
3B	2.2	514.8	7.8	1825.2		168.0	393.12	

[1]A and B received identical treatment
[2]Aliquot of 30 plants
[3]Computed on the basis of 3500 plants

75 pounds* 25 pounds No pounds 25 pounds

*Potash per acre

Figure 5. Cotton plots showing response to potash on experimental plot area no. 13

TABLE VI. RESULTS OF EXPERIMENTS WITH COTTON

Plot Area	Soil Type	K Content[1] Surface	Subsoil	Plot No.	K_2O[2] Applied	Yield of Seed Cotton, Pounds Per Acre Each Plot	Average of Duplicates
12	Cumberland silt loam	320	190	1A	0	1280	1242
				1B	0	1204	
				2A	25	1260	1240
				2B	25	1222	
				3A	75	1505	1465
				3B	75	1425	
13	Greendale cherty loam	125	80	1A	0	50	112
				1B	0	174	
				2A	25	000	468[3]
				2B	25	468	
				3A	75	522	786
				3B	75	1050	
14	Sitka silt loam	190	160	1A	0	660	810
				1B	0	960	
				2A	25	1525	1120
				2B	25	985	
				3A	75	1090	1055
				3B	75	1020	

[1]Pounds of potassium per acre
[2]Pounds of potash (K_2O) per acre basis
[3]Yield from one plot

DISCUSSION

An accurate correlation between data on exchangeable potassium and data on increase in yield from potassium applications to a given crop growing on a definite soil type would permit prediction of potassium needs in the future on the basis of exchangeable potassium determinations alone. Though the data assembled are fragmentary and incomplete, certain tentative correlations of the above character seem warranted. The discussion and development of correlations are presented separately for each crop.

Corn. The exchangeable potassium levels in all soils where corn plot areas were located were quite comparable, approximately 190 pounds in the surface, and 100 pounds or less in the subsoil. At these potassium levels, moderate applications of potassium, 25 pounds of potash per acre, gave profitable returns. The average increase in yield for this application was about 15%, or around 6-7 bushels at normal yield levels. The economic response in these experiments seem closely related to plant deficiency symptoms. The small application (25 pounds) eliminated all abnormal growth symptoms and the data show that larger amounts above this point increased the yield at a much slower rate, which might not be profitable under ordinary economic conditions.

How much exchangeable potassium must be present in the soil before fertilizer applications cease to be effective in raising yields was not determined. However, it should be emphasized that variations in the subsoil as well as in the surface potassium content will have an important bearing on this point.

The greater yield on the Hagerstown soil was probably due largely to differences in fertility level. This soil had a high pH, 6.8, and had recently received adequate amounts of fresh O. M. thus making conditions favorable for rapid growth and efficient utilization of the applied fertilizers. It is reasonable to expect in general that favorable growth conditions within a soil will result in more efficient use of applied fertilizers.

Tobacco. Variations in quality of the tobacco crop have such a marked effect on price and hence, net returns per acre, that total yield alone is inadequate to compare the effects of fertilizer treatments. On this account, the interpretation of the results of potassium applications on tobacco is considerably complicated. The best measure available appeared to be gross value of the crop when carefully graded. However, on all experimental plot areas the total weight of leaf per acre tends to increase with increase in potassium application.

Both plot areas which had 160 pounds of exchangeable potassium in the surface soil gave profitable returns from a 50 pound application of potash. Additions of potash greater than 50 pounds were profitable only on the plot with the lower exchangeable potassium level in the subsoil. This emphasizes the importance of the subsoil nutrient content which should be given adequate consideration in making fertilizer recommendations. Another factor that might have influenced the response of these soils to potash may have been the pH of the surface. The high pH value of the soil responding to the higher applications might have exerted an influence through greater N and P availability.

On the plot which had 220 pounds of exchangeable potassium in the surface soil and 140 pounds in the subsoil, little effect was recorded from potassium fertilization. It must not be concluded that surface soils containing this amount of potassium will not respond to potassium applications if the subsoil were lower in potassium. The data in general are suggestive of the approximate level at which potassium applications cease to be effective for tobacco on these soils. Of course, seasonal differences might affect these limits.

In several cases, the variation between duplicate plots was rather wide. Often this could be explained by the presence of such factors as disease complications or soil variations. However, it points to the desirability of more replications.

Field observations suggest that deficiency symptoms do not appear in visible form except when potassium is very low. Even in the absence of deficiency symptoms, tobacco quality may be markedly lowered by a lack of potassium. Thus, observation of the growing crop is not a reliable guide to the need for potassium fertilization.

Cotton. Small applications of potash to cotton failed to increase the yield when the potassium level in the soil was 320 pounds in the surface and 190 pounds in the subsoil. Thus, no applications of potash would be suggested as profitable under these conditions.

At slightly lower levels, namely, 190 pounds in the surface and 160 pounds in the subsoil, the small application of potash gave a profitable increase, but the large application failed to increase the yield further.

At a still lower level, namely, 125 pounds of potassium in the surface soil and less than 80 pounds in the subsoil the larger applications of potash were more profitable. It should be recalled however that on this experimental area (No. 13), disease and climatic conditions were unfavorable. Furthermore some soil variation which was not detected at first was present in this plot area. These influences necessarily minimize the reliability of the data obtained. But the importance of potassium for satisfactory crop growth where there are disease complications is definitely shown by both observations and crop yields on experimental plot area no. 13 (Figure 4).

Alfalfa. Five alfalfa plots were continued through the 1940 season. The levels of exchangeable potassium in soils where alfalfa plots were located, ranged from 100 to 300 pounds in the surface soils and from less than 80 to 300 pounds in the subsoils.

The lack of response of alfalfa may be due to: (1) the lack of penetration of the potassium to the root zone because of the late date of application; (2) a deficiency of some other nutrient which might possibly be boron; (3) both (1) and (2) above. The possibility of boron deficiency was suggested by the presence of numerous yellow and reddish colored leaves during the second and following cutting periods. Yields harvested from these plots in the summer of 1941 should determine the response of alfalfa to potassium on the soils used in these experiments*.

Suggested Changes in Procedure.

The variation in yields from plots receiving identical fertilizer application in the cotton and tobacco experiments indicate the desirability of certain changes in field methods. To detect soil variations

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*Borax was applied in February, 1941 to portions of all alfalfa plots. Observations and yield data taken in the summer of 1941 on all plots showed an increase in growth due to B applications.

within a plot area, surface and subsoil samples should be taken from individual plots rather than as composites from the entire experimental plot area. As a check on errors and undetected soil variations, three replications of each treatment, rather than two, should be used. To minimize the possibility of soil variation, and permit the use of more replications in a given area, the size of individual plots should be reduced from one-fortieth (1/40) acre to one-hundredth (1/100) acre.

Laboratory procedures as presented in this paper are recommended for use in similar studies.

SUMMARY

The effect of potassium on the yield of corn, tobacco, cotton, and alfalfa was studied on several soils in Tennessee. The exchangeable potassium content of the soils was determined and the following relationships between exchangeable potassium and yield response to potassium fertilization were found:

Corn. Approximately 15% increase in yield was obtained on Hagerstown and Hartsells soils for an application of 25 pounds of potash per acre where the surface soil contained 190 pounds and the subsoil 100 pounds or less of exchangeable potassium. Addition of 75 pounds of potash gave additional increases in yield, but not in the same proportion as the smaller applications.

Tobacco. About 6% increase in weight of leaf and 10-25% increase in gross value were obtained on Cookeville and Dickson soils from 50 pounds of potash where the surface soil contained 160 pounds and the subsoil 100 pounds or less of exchangeable potassium. Increases in weight and value of leaf were negligible on Cookeville silt loam that had 220 pounds of exchangeable potassium in the surface and 140 pounds in the subsoil.

Cotton. No increase in yield was obtained from addition of 25 pounds of potash on Cumberland silt loam where the surface soil contained 320 pounds of exchangeable potassium in the surface and 190 pounds in the subsoil. Large increases in yield were obtained from both small and large applications of potash on Greendale cherty loam where the surface contained 125 pounds of available potassium and the subsoil less than 80 pounds. Increased yields were obtained on Sitka silt loam from applications of 25 pounds of potash where the surface soil contained 190 pounds of exchange-

able potassium and the subsoil 160 pounds.

Alfalfa. No increases in yield during the 1940 season from potash applications were obtained on any soils, probably because of complications due to boron deficiency.