A STUDY OF THE RESPONSE OF PEACH TREES TO POTASSIUM FERTILIZATION

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A STUDY OF THE RESPONSE OF PEACH TREES TO POTASSIUM FERTILIZATION

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INTRODUCTION

One of the greatest soil fertility problems in orchards today is that of finding methods of applying to each orchard, or a particular part of the orchard, the latest information relative to plant nutrition. Due to the variable soil conditions this problem often can be condensed to the question. "How can we best determine the present nutrient status or nutrient needs of any single peach tree?"

Soil type alone is not a safe basis for making lime or fertilizer recommendations, because past treatments or cropping practices may have modified the present soil fertility status to such an extent as to overshadow differences in soil type characteristics. Therefore, it seems logical and necessary to use all means available to diagnose nutrient needs of any tree or group of trees which appear abnormal either in terms of yield or fruit quality.

In recent years some Michigan peach orchards have been found where leaf symptoms indicated potassium deficiencies, and following potash applications, subsequent leaves were a normal green color and the yields were improved. The question arose as to how prevalent is this need for potash in Michigan orchards. How many peach orchards are in the symptom stage of potash deficiency, and how many have border-line cases where no symptoms are recognized but some potash is needed? What are the conditions responsible for this apparent increase in potash needs?

The research results presented herewith deal with several methods of measuring chemical conditions in plants and soils under Michigan conditions as follows:

1. Fertilizer applications to peach orchards where the effects on growth and yield could be observed. Such trees also served for chemical studies.

2. A study of the foliage symptoms shown by trees under different soil conditions and treatments.

3. The application of soil tests on orchard soils in determining fertilizer needs.

4. The use of "foliar analysis" for diagnosing the nutrient status of fruit trees.

5. A comparison of tissue "quick-tests" with other diagnostic procedures indicated above.

During the seasons of 1947 and 1948 periodic leaf samplings were made of several experimental orchards, for various chemical tests. The studies were made largely on material collected from the following three orchards:

(1) Eric Kerlikowski, near Coloma, Michigan,

(2) William Fooy, near Bangor, Michigan, and

(3) V.M. Dilley, near Lacota, Michigan.

This paper attempts to assemble and compare the results of the different testing procedures and observations with the hope of increasing their value for diagnostic purposes.

In this study, emphasis is directed toward the questions: "What is adequate potassium in the leaf to produce normal foliage and maximum yields of high quality fruit; and do leaf symptoms give sufficient warning of declining or unbalanced nutrient supplies?" In attempting to answer these questions a comparison was made of leaf symptoms with other known measures of potassium adequacy, such as ash analysis of leaves,tissue tests, and yield and growth measurements.

REVIEW OF LITERATURE

To date most of the research on diagnostic methods for determining nutrient déficiencies of fruit trees has been confined to ash analysis of dried leaves and petioles, often referred to as "leaf analysis" or"foliar diagnosis". For the most part "leaf analysis" results have been interpreted in relation to the appearance of certain leaf symptoms associated with adequate or deficient supplies of nutrients. According to the literature there is considerable agreement on the potash requirements of peaches.

Van Slyke (26,27) found peach crops to be larger consumers of plant food than apples on an acre basis. Peaches use about one-third more N, P, and K; twice as much calcium, and considerably more magnesium than do apples.

By ash analysis methods Lilleland and Brown (16) found that individual trees may show a distinctly higher potassium level in one season and a consistently lower potassium level the following season. Their results indicate the importance of other factors and preclude the establishment of one critical level for indicating potassium deficiency in bearing trees. In a survey of the potassium content of peach leaves from 130 orchards Lilleland and Brown (17) used ten basal leaves of the current season's growth from ten trees as a composite sample. They found that the potassium content was about the same in July and August but was lower in both the early and late season tissue (leaves). Samples from trees which bore heavy crops showed reduced potassium as did trees suffering from dry weather. Leaf samples from the 130 orchards averaged 2 per cent potassium with a range of from 0.6 to 3.4 per cent.

Leaves containing less than 1 per cent potassium, on a dry weight basis, are likely to show potassium deficiency according to Cullinan and Waugh (7). Leaves with a potassium content of from 1 to 1.25 per cent have not shown deficiencies but are likely to benefit from potassium application. When leaves have 2 per cent or more potassium, no beneficial response to potassium additions is to be expected.

The use of chemical tests on green leaves for determining the status of certain nutrient elements in plant sap has been increasing rapidly. Thornton, et al (25) adapted methods, already used as quick tests for phosphates and potash in soils, to indicate the relative levels of these nutrients in plant sap. These tests were calibrated especially for corn and have been adapted to other crops.

Cook (4), using the Simplex testing kit, has developed plant sap testing procedures which are rapid and can be used both in the field and laboratory for diagnosing nutrient deficiences. Generally connective tissue, such as petioles, is extracted with a weak acetic acid solution. The procedure allows the tissue to remain in the chemicals and the results are read colorimetrically.

Boynton and Peech (2) have developed a semiqualitive colorimetric procedure for determining magnesium and potassium in dried apple leaves (without ashing). Schrader (24) of Maryland has used the flame photometer to analyze sap extract prepared by use of the Warring blender. Potassium and sodium are readily determined by this method.

For tissue testing purposes McCollan (18) suggests that if we are familiar with the quantities of elements found in good plants and in deficient plants we can interpret many crop troubles by making chemical analyses. He suggests using the upper stems, petioles or leaf blade depending on the plant to be tested, because these are such vital parts in the plant's nutritional functions. Scarseth (23) proposes the use of tests for unassimilated ions in translocation tissue and assumes tests will establish the limiting factor in growth and will give indications before the deficiency symptoms appear.

The amount of potassium required depends on the amount of nitrogen used according to Davis and Hill (12). Cullinan, et al (5,8) and Dunbar and Anthony (13) point out that high nitrogen and low potassium gave the most severe potassium deficiency symptoms while low nitrogen and low potassium gave little potassium deficiency. Since sandy soils are most generally used for growing peaches in Michigan, due in part to a more favorable climatic location (15, 28), nitrogen is needed in carefully controlled quantities. Complete fertilizers for orchards have been recommended by Rawl (21), Boynton (1), Savage (22), Musser (19), and Davidson and Blake (9).

EXPERIMENTAL METHODS

Tissue Tests

Garrard (14) working with Thornton (25) and others of Purdue University over the past several years, has developed a modification of the regular Purdue test for potassium which seems to work satisfactorily on peach leaves. The use of this modified test for potassium in green tissues has been the basis for comparing the potassium nutrient status in peach leaves in several orchards in the present study. The results obtained from the tissue tests have been compared to leaf symptoms and ash analysis where available.

A comparison of the regular Purdue potash tissue test procedure (25) and the modified procedure for use on peach leaves is given in the accompanying tabulation.

Regular Purdue Potash Tissue Test

One-half teaspoonful of finely cut leaves in vial; add
10 cc. Potash No. 1 solution.
Shake 1 minute; add
5 cc. Potash No. 3 solution by running down side of tube to get layer of alcohol on top.
Mix in alcohol carefully with a slow rotary motion;
Let stand 3 minutes.
Read amount of precipitate according to Potash chart.

Modified Potash Tissue Test

a. One teaspoonful (1.4 grams) of finely chopped leaves; add
One-eighth teaspoonful of Potash-free activated charcoal,
Add 10cc. of 15 per cent $NaNO_2$ (adjusted to pH 5.0 with acetic acid)
Shake one minute, filter through fast filter paper (total extraction time is three to four minutes)

b. To 2½ cc. of filtrate add
5 cc. of Purdue K No. 1;
Mix to uniformity, then add
2½ cc. of K No. 3 (95% ethyl alcohol), added slowly down side of vial to form layer on top.
Let stand one minute to start precipitation.
Mix slowly by rotary motion.

c. Read results after three minutes.

Discussion and Results of Tissue Tests

The modified Purdue test was studied by varying the:

(a) size of sample
(b) amount of extract used
(c) amount of K No. 1 solution or precipitating solution
(d) amount of K No. 3 solution

In Table I are shown some comparisons of variations in readings on fresh green leaves of two trees, tree 4, high in potassium, and tree 11, low in potassium, both from row 11 in the Kerlikowski plots.

From the results presented in Table I it is evident that considerable deviation from the regular Purdue procedure can be made without affecting appreciably relative differences in the test results. However, the regular Purdue procedure seems to be the most desirable for the size equipment and convenience of manipulation.

Table I. Influence of variations in procedure on tissue test results*; expressed as ppm in extract.

grams of leaf	.7	1.05	1.4**	2.1		
tree 4	254	327	418	458		
tree 11	55	112	222	320		
cc. of extract	**.5**	**1.5**	**2**	**2.5****	**3**	**4**
tree 4	92	260	292	327	358	366
tree 11	17	84	120	128	136	152
cc. of K No. 1	**1.2**	**2.5**	**4**	**5****	**6**	**7**
tree 4	448	448	382	327	320	237
tree 11	222	222	200	180	148	128
cc. of alcohol	**1**	**1.5**	**2.0**	**2.5****	**3**	**4**
tree 4	343	306	374	418	458	458
tree 11	---	208	176	222	272	409

* Regular amount used except in component being tested.
** Amount used in regular test.

Two modifications have been made in the test procedure as originally recommended. Less clearing agent (such as Darco G 60) can be used on peach leaves; only one-eighth teaspoon per test seems adequate. In order to get a wider range of reading on the amount of precipitate in the potassium tests a Cenco photometer, with a red filter, was used. First comparisons were made with standard solutions of such strength that gave readings as ppm, corresponding to the color chart as given in Purdue circular #204 (25). Second, the photometer readings compared to the published Purdue chart as follows:

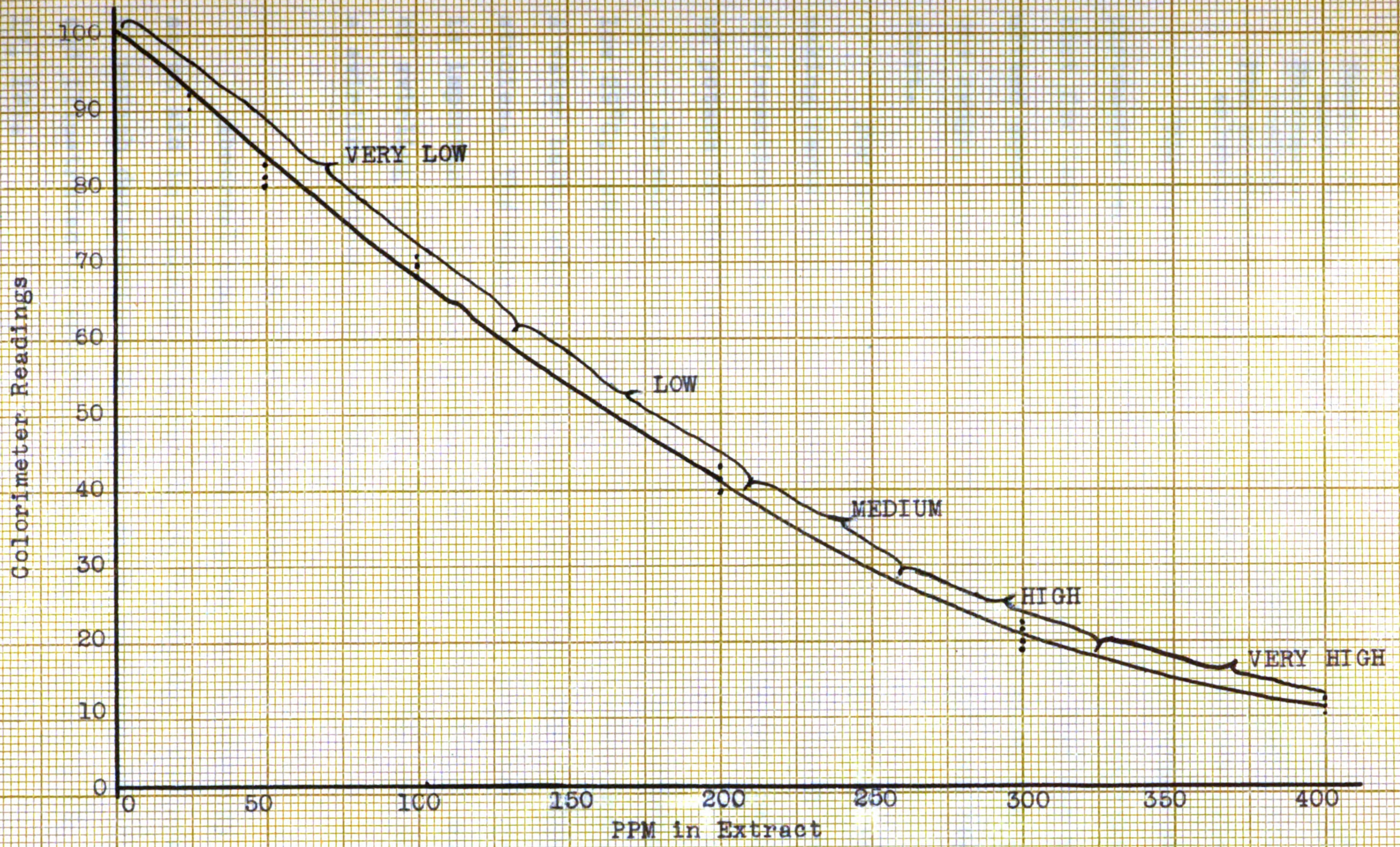


Figure 1. STANDARD CURVE FOR POTASSIUM IN PEACH LEAVES FOUND BY COLORIMETER READING ON STANDARD SOLUTIONS WITH READING ON PURDUE CHART INDICATED

Purdue color chart reading	very high	high	medium	low	very low
Photometer reading	0-18	19-28	29-40	40-60	60-100
PPM in standard solution	512-350	349-278	277-212	211-132	132-0

The strength of standards, Purdue chart readings, and photometer readings are shown in Figure 1. It was found that for laboratory purposes, the photometer readings permitted smaller variations to be recorded, even within any one range, such as "high","medium","low" as per the regular chart.

For pratical diagnostic purposes in the field and for making fertilizer recommendations, the regular chart will differentiate closely enough between the high and low ranges of potash in the leaves.

In making the test the temperature should remain below 29°C; above this temperature precipitation is erratic. A water bath, maintained at about 18°C, was used in these studies. The method of mixing the alcohol and other reagents is important. It was found satisfactory to use a short period of swirling to initiate precipitation, and after one minute, a swirling motion until completely mixed.

Deficiency Symptoms

Abnormal symptoms of tree leaves are frequently used as an aid in diagnosing nutrient deficiencies. The symptoms of potash deficiencies on peach leaves have been described and illustrated in several publications (7, 9, 10, 13, 14, 15, 17, 19).

Plate 1. Peach twigs showing varying degrees of potassium deficiency symptoms. See page 12 for descriptions.

In this study the leaves of peach trees were classed into five groups as to their degree of apparent potash deficiency.

1. Very severe--leaves rolled upward, young leaves were curled laterally, red areas merged and died giving rough margins. Some leaves turned yellowish. Trees showed a reduction in size and less fruit buds were set. Eighteen leaves weighed approximately five grams.

2. Severe--reduced growth, few laterals, all but new leaves showed curling, reddish spots and color along the margins. In late season the margins have dead areas. Leaves were thinner more spongy, and less turgid than normal leaves. Fifteen leaves weighed approximately five grams.

3. Moderate--middle leaves on higher twigs on south side of tree show bean pod effect created by curling upward and crinkling along midrib. Young leaves in late season were very small, V-shaped, red spots are small, light red or lacking. Twigs are smaller in diameter and reddish. Thirteen leaves weigh approximately five grams.

4. Slight--slightly smaller leaves, lighter color, may not show any curling, no color spots develop, twigs seem more reddish and smaller than normal tree leaves. The condition of the tree is best observed at some distance from the tree.

5. Normal--thick twigs, large dark leaves, and plenty of terminal and lateral growth. Nine mature leaves weigh approximately five grams.

Ash Analysis

Several people have cooperated in the study of collecting the related data from the several orchards. Leaf samples were collected by Dr. T.A. Merrill, Department of Horticulture, Michigan State College for 1945 and 1946 from the E. Kerlikowski plots. In 1947 and 1948 the writer continued this sampling so that to date a three year trend in ash content of peach leaves has been secured. Under the direction of Dr. E.J. Benne, Department of Agricultural Chemistry, Michigan State College, these leaf samples were analyzed for nitrogen, phosphorous, potassium, calcium, magnesium and manganese. Procedures used in these determinations included the chloroplatinate method of precipitating potassium (20).

Yield and Growth Measurements

Yields of peaches for three years, 1946-1948, were taken on the Dilley orchard by the owner, Mr. V.M. Dilley of Lacota, Michigan. Each row was harvested separately, weighed and the peaches graded as to size. The trees, if overloaded, were thinned as in any commercial orchard. Growth measurements were made in 1945 and 1946 by Mr. H.L. Garrard, Field Agronomist, American Potash Institute, Homewood, Illinois and Mr. Charles Mann, Soil Conservationist, Fennville, Michigan. Fifty typical terminal shoots on each plot of five trees were checked for number of buds, diameter and length of terminals, and number of laterals on each terminal.

EXPERIMENTAL PLOTS

Eric Kerlikowski Farm

A series of plots of Red Haven peaches on the Eric Kerlikowski farm, seven miles northeast of Coloma, Michigan, consisting of eight rows of ten trees each, were established by Mr. J.A. Porter, Department of Soil Science and Mr. T.A. Merrill, Department of Horticulture, Michigan State College in 1944. The layout of the plots is shown in Table II. The sandy loam soil of 1 per cent slope has a pH of 5.2 to 7.2 depending on the soil treatment. Alfalfa preceded the peaches and occupied the area for several years. In 1944 the two year old trees showed severe to moderate potassium deficiency symptoms.

Table II. Layout of the Kerlikowski Plots and the relative degrees of potassium deficiency of the individual trees in 1947.

Tree and treatment		Row 7 Lime Spaded	Row 9 No lime surface	Row 11 No lime spaded	Row 13 Lime surface
3	NPK	5	5	5	5
4	NPK	5	5	5	5
5	NP	3	-	3	4
6	NP	4	4	4	4
7	N	4	4	4	4
8	N	4	3	5	5
9	N-K	-	5	5	5
10	N-K	5	-	5	5
11	N	3	3	3	3
12	N	3	3	3	3

N--.5, 1.0, 1.25# $(NH_4)_2SO_4$ per tree in April of 1945, 46, 47.
P--4# 0-20-0 per tree on October 4, 1944
K--4# 0-0-60 per tree on October 4, 1944
Symptoms--1, very severe;2, severe; 3, moderate; 4, slight; 5, normal.

For sampling purposes only trees in every other row, (7,9,11,13) were used. Leaves of individual trees in these plots were taken for ash analysis during the past four years (1945 to 1948 inclusive). Starting in 1947 individual tree leaf samples were collected at monthly intervals for testing for potassium by the modified Purdue test. (See Table XII, Appendix) Soil samples from the surface six-inch layer under each tree were tested for pH, available phosphorus, and available potash by Miss Eldora Shine of the Michigan State College soil testing laboratory, using the Simplex soil testing procedure.

Leaf Analysis

Ash analysis is most often used in foliar analysis due to its accuracy even though it is the most time consuming.

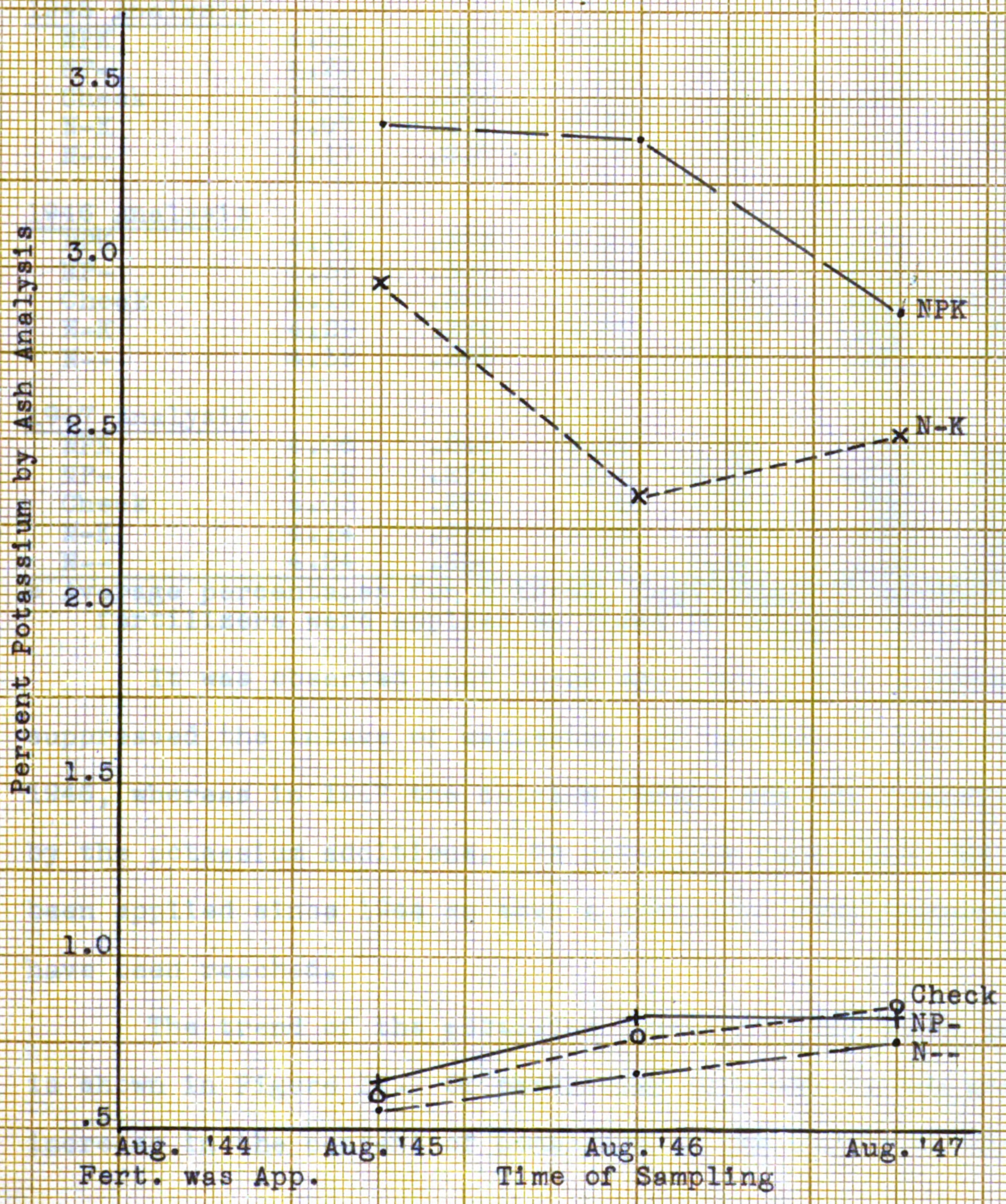
Table III shows a summary of three years analysis of the individual tree data that is included in the Appendix, Table XIV.

Nitrogen application has been uniform to all the trees. No large variation occured in the nitrogen content of the leaves as a result of either phosphorus or potassium fertilizer treatment. Although the content of phosphorus appears low there has been no measurable effect on the growth of the tree by the phosphorus application.

Manganese was low in trees seven and eight of most rows. The pH of the soil under these trees was near neutral, the highest of the area. Several trees showed slight manganese

Figure 2. THREE YEAR TREND IN POTASSIUM CONTENT OF PEACH LEAVES FROM KERLIKOWSKI PLOTS

Average of eight individual tree samples



deficiency symptoms as indicated by a light green mottling between the veins of the leaves. In all instances of manganese deficiency the manganese content of the ash was below .006 per cent.

Table III. Summary of ash analysis of peach leaves from the Kerlikowski plots.*

Per cent of	N	P	K	Ca	Mg	Mn
1945 Analysis						
NPK	4.08	.250	3.41	.959	.301	.0066
NP-	4.23	.269	.61	1.28	.482	.0070
Check	3.74	.289	.60	1.30	.634	.0044
N-K	3.97	.219	2.97	.916	.301	.0055
N--	4.17	.257	.55	1.26	.667	.0060
1946 Analysis						
NPK	4.16	.273	3.36	.99	.324	.0110
NP-	4.39	.300	.83	1.09	.477	.0105
Check	4.13	.304	.76	1.207	.561	.0039
N-K	4.29	.276	2.36	.942	.385	.0071
N--	4.32	.285	.67	1.12	.536	.0075
1947 Analysis						
NPK	4.06	.248	2.85	1.48	.418	.0128
NP-	4.28	.272	.84	1.36	.544	.0112
Check	4.03	.275	.88	1.55	.629	.0067
N-K	4.14	.255	2.52	1.39	.459	.0107
N--	4.24	.260	.76	1.37	.535	.0086

* Average percentages for 8 trees, regardless of whether fertilizers were applied on limed or unlimed soil.

It was observed that large applications of potassium suppressed the intake of magnesium and calcium in 1945 and 1946, whereas in 1947 the calcium intake was not suppressed by the potassium additions. No potassium fertilizer had been applied since 1944 so that a potassium equilibrium may have been reached.

The trend of the potassium levels for the three years is shown in Figure II. Of particular interest is the gradual increase in the content of potassium in the leaves of the

"untreated potassium"trees. For example the check row increased from .60 per cent in 1945 to .76 per cent in 1946, and to .88 per cent in 1947. In 1945 the leaves of the trees treated with potassium had a much higher content of potassium than the untreated trees. The leaves of the NPK treated trees decreased from 3.41 per cent potassium in 1945 to 3.36 per cent in 1946, and 2.85 per cent in 1947.

Discussion

The Kerlikowski orchard provided different levels of potassium fertilization from which leaf samples could be taken for analysis. The summary in Table IV shows a comparison of green tissue test, deficiency symptoms, soil tests, and ash analysis as a measure of differences in the potassium content of the leaves from this orchard for 1947.

Green tissue quick tests were run on leaves of individual trees at monthly intervals over a period of six months in order to determine the seasonal trend in the potassium content of the leaves. In 1947 the trees high in potassium showed little variation throughout the season. Leaves from trees of the medium potassium level showed a decline late in the season and leaves from trees low in potassium decreased until a very low potassium content was reached by midsummer. In late season no further drop was noticed in this low group.

The graph in Figure III gives a comparison of green tissue tests with ash analysis. Close agreement was found in the high potassium leaves whereas considerable variation

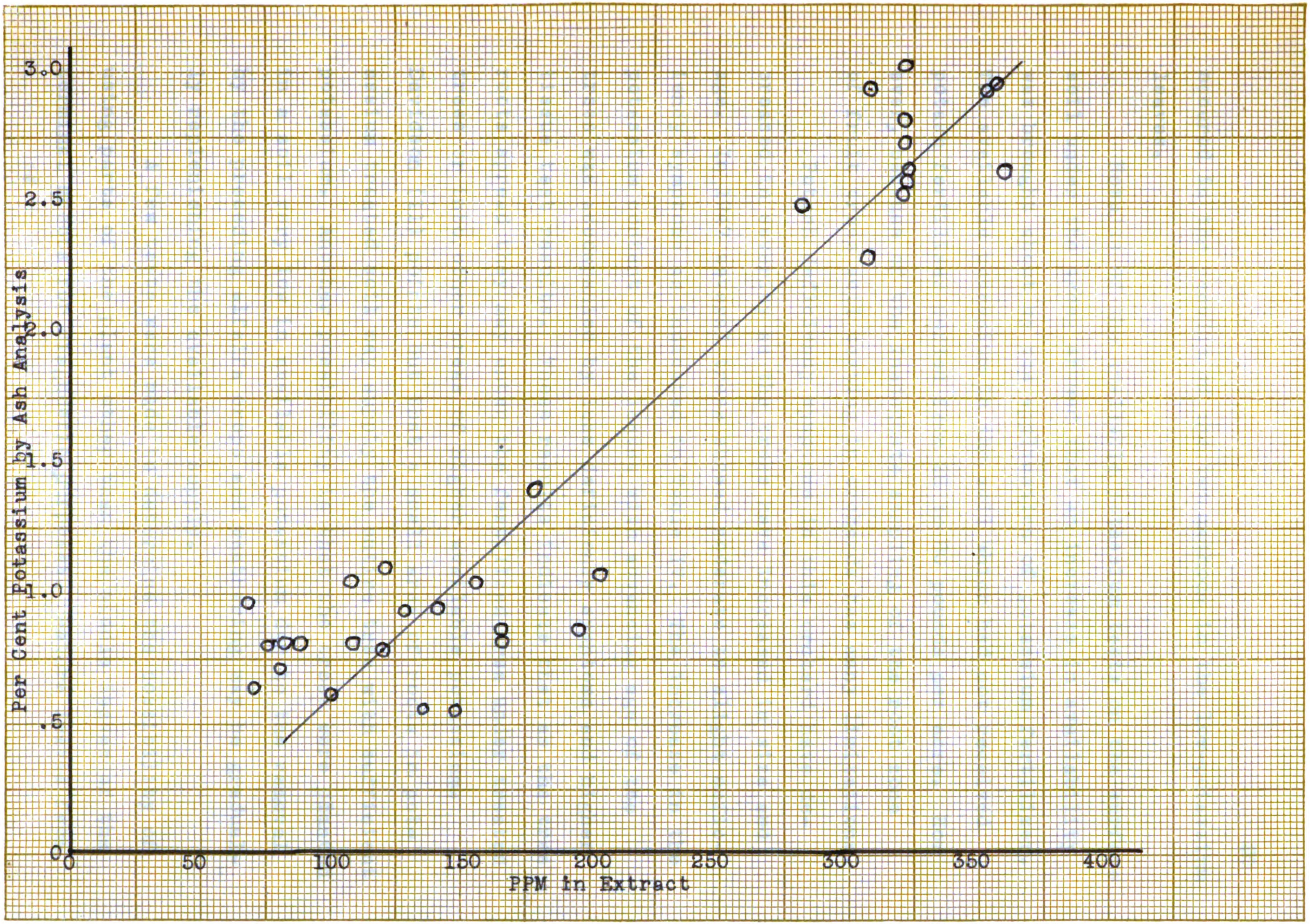


Figure 3. THE RELATIONSHIP BETWEEN TISSUE TESTS AND ASH ANALYSIS IN MEASURING THE POTASSIUM CONTENT OF PEACH LEAVES.

occured in the results of the two methods in the low-potassium leaves.

Results of the available potassium tests on the surface soil under the trees showed that an increase in availability was brought about by the application of potassium fertilizer. The available potassium in the soil which had not received potash fertilizer varied from 28 to 80 pounds per acre. How ever, because of the inadequate sampling of the root zone of fruit trees soil testing in orchards has many limitations.

Potash deficiency symptoms in this orchard have decreased in severity as the trees have increased in size and age. In 1947 several trees showed moderate to slight deficiency symptoms as indicated in Table IV. The increase in the potassium content of the leaves with advancing age of the trees was accompanied by less deficiency symptoms and higher tissue test results. These results indicate that as the tree roots spread they may enter the fertilized area under treated trees or into other areas of higher available potassium. Davidson (11) points out that a small area of roots in potassium treated soil may supply the entire tree with sufficient potassium. Another possibility is that the trees were planted in a soil very low in available potassium due to the removal by the preceding alfalfa crops and weathering may be gradually replenishing the available supply.

A few tests were made to determine the possibility of using parts of the plant other than the middle leaves of the terminal shoots for diagnostic purposes. Mature leaves from

Table IV. A comparison of green tissue tests,. deficiency symptoms, soil tests, and ash analysis in diagnosing potassium deficiencies in peach trees on the Kerlikowski plots for 1947.

Row, Tree, and Treatment			ppm in Tissue Extract	Deficiency Symptom Rating(1)	Available K_2O in Sur. Soil(2)	Per cent K by Ash Analysis
7	3	NPK	358	5	280	2.95
	4		320	5	188	3.03
	5	NP-	76	3	80	.81
	6		172	3	68	1.40
	7	N	120	4	64	1.09
	8		100	4	40	0.62
	10	N-K	320	5	328	2.58
	11		128	3	108	.92
	12	N--	67	3	40	.95
9	3	NPK	358	5	216	2.93
	4		366	5	188	2.63
	5	NP-	128	1*	62	.47
	6		196	4	56	.84
	7	N--	204	4	72	1.12
	8		172	3	40	- --
	9	N-K	358	5	184	- --
	11	N--	164	3	68	.84
	12		108	3	45	.76
11	3	NPK	320	5	131	2.81
	4		306	5	128	2.93
	5	NP-	164	3	37	.79
	6		70	4	28	.76
	7	N--	108	4	37	.67
	8		156	5	34	1.04
	9	N-K	278	5	252	2.49
	10		320	5	260	2.73
	11	N--	88	3	40	.79
	12		80	3	40	.72
13	3	NPK	320	5	260	2.66
	4		335	5	180	--
	5	NP-	80	4	40	.79
	6		140	4	37	.93
	7	N--	92	4	40	--
	8		124	5	28	.77
	9	N-K	306	5	264	2.28
	10		320	5	284	2.54
	11	N--	148	3	39	.56
	12		136	3	49	.56

(1). 1,very severe; 2,severe; 3,moderate; 4,slight; 5,normal
(2). Pounds per acre
* Injured

about the middle of the terminal shoots were used in all the regular testing procedures. In order to compare test results on leaves of different ages, leaves were selected from the tip, from the middle, and from the base of the terminal shoots of a tree showing severe potassium deficiencies. Parts per million in the tissue extract of the young leaves averaged 64, of the middle leaves 27, and of the older leaves 76; all of which are in the very low range. The use of middle leaves of the terminal shoots is suggested by Cullinan (6) and McCollan (18).

Dried ground leaves were tested by the modified Purdue quick test method using the regular procedure and testing solutions. However, instead of 1.4 grams of green tissue, .14 grams of dried tissue was used in 10 ml. of extracting solution. The readings, using this amount of dried material, were about the same as those obtained by green tissue tests. For laboratory procedure the use of dried tissue eliminates the need for keeping the testing material in a fresh state.

Tests were made on the petioles of peach leaves, and on both green and ripe fruit. Two grams of finely chopped fruit gave colorimeter readings comparable to those found by the green leaf tissue. The use of fruit for testing purposes is limited because of varying degrees of ripeness, differences in the set of fruit and size of fruit, and differences in the tree size.

Plate 2. A young peach tree in the Fooy orchard near Bangor, Michigan showing severe potassium deficiency symptoms. (Notice the rolled leaves and small terminal twigs.)

William Fooy Farm

In 1947 a young peach orchard on the William Fooy farm, four miles southeast of Bangor, Michigan was found to show severe potassium deficiency symptoms by Oscar Dowd of the Soil Conservation Service. The soil is an Ottawa sand with a slope of 4 per cent. Previous to setting out the orchard, the land had been in alfalfa for a long period of time with little or no fertilizer applied. Three varieties of peaches, Red

Table V. Plot layout and deficiency symptoms* of individual trees in the Fooy orchard at the start of the experiment.

Row and treatment	Date and amount of potash application		Peach Varieties								
			Red Haven			Hale Haven			Fertile Hale		
7 N			1	2	3	3	3	3	4	4	1
8 N			2	2	2	2	3	3	4	4	1
9 N-K	1.5#	9/18/47	2	4	3	1	4	3	4	4	1
10 N-K	2.5#	9/18/47	1	2	1	2	3	3	4	4	1
11 NP			1	1	3	3	4	4	3	4	1
12 NP			2	2	2	2	4	3	4	4	1
13 NPK	1.5#	4/3/48	2	2	3	2	4	4	4	3	2
14 NPK	2.5#	4/3/48	2	1	3	1	3	3	3	3	2
15 NPK	2.5#	9/18/47	1	2	2	3	3	3	4	3	1
16 NPK	2.5#	8/1/47	2	3	2	2	3	4	4	4	1
17 N			2	3	2	1	4	4	4	3	1
18 N			2	2	3	1	3	3	4	3	1
19 N-K	1.5#	9/18/47	3	3	2	2	3	4	3	4	1

N--½# 20-0-0 April 3, 1948
P--6.4# 0-20-0 September 18, 1947
K--Applied as 0-0-60; varied in date and rate as indicated.

* The figure 1 represents the most severe symptoms of potassium deficiency.

Haven, Hale Haven and Fertile Hale are included in the orchard. An outline of the orchard showing the plot arrangementand the degree of potassium deficiency exhibited by each tree at the beginning of the experiment in August 1947 is given in Table V. Leaf samples were taken from Red Haven trees representing different degrees of potash starvation as indicated by deficiency symptoms, late in the season of 1947. Analyses were run on these samples to determine the potassium levels and to follow the response to fall applied fertilizer. Row sixteen received 2.5 lbs. K_2O, as KCl, per tree spaded in on August 18. On September 1, the trees showed no response to the fertilizer, but by October 2, the leaves showed a definite response as indicated by the marked change from 58 to 278 ppm of potassium in the tissue extract. As pointed out by Chandler (3) about six weeks is required after the application of potassium for it to show up in the leaves of peach trees. Young leaves of the same trees showed a similar increase as is indicated in Table VI.

Table VI. Parts per million of potassium in peach leaves representing different degrees of potash starvation, taken from the Fooy orchard in 1947.

Sample	Description	Aug.1	Sept.1	Oct.2
1	Very severe	64	70	212*
2	Severe	--	73	172*
3	Moderate	--	61	148
4	Slight	84	88	164
5	R.15 (fert.)	--	92	100
6	R.16)unfert.)	--	58	278
7	R.15 young leaves	--	--	116
8	R.16 young leaves	--	--	292

*Samples deteriorated in storage so that more K was released during extraction.

In 1948 tissue test results of leaf samples for potassium were compared by treatment and by variety to determine the effect of both spring and fall application of potassium. Although the Red Haven trees showed more severe potash deficiency symptoms than did the Hale Havens, no significant differences were found in the tissue test results. The higher potassium content, as shown by more ppm of potassium in tissue extract, in July compared to August, indicates that the "no-potassium" trees were approaching a critically low level by August 1. The results are presented in Table VII. Deficiency symptoms in 1947 were classed as severe with a rating of "2" while those of the same trees in 1948, where treated with potash, were greatly improved. In rows eleven, twelve, and seventeen the deficiency symptoms were more severe in 1948 due to unbalanced fertilizer creating a larger demand for potassium.

Table VII. A summary of the green tissue test results of the Fooy plots in 1948.

Row and	Treatment	Potassium (ppm) July 2	Aug.1	Potassium Deficiency Symptoms (1)
Red Haven				
7,8	N--	96	64	2
9	N-K	448	343	4
11,12*	NP	188	84	1
11,12	NP	254	124	2
13	NPK/2	418	400	4
14	NPK	448	409	4
16	NPK	458	409	3
17	N--	196	152	1
19	N-K/2	372	391	5
Hale Haven				
7,8	N--	88	116	3
9	N-K	372	391	5
11,12	NP	196	148	3
16	N-K	448	409	5

(1) 1, very severe; 2, severe; 3, moderate; 4, slight; 5, normal
* From trees showing very severe symptoms.

Discussion

In the Fooy plots, perhaps the most significant observation was the great response of peach trees to potash fertilizers. This appears to be another example of alfalfa depleting the land to a very low potassium level (25# available K_2O per acre) prior to setting out the orchard. Marl applied to this area twelve years ago has maintained the pH near neutrality. This, coupled with depletion of available potassium by the alfalfa, has caused some of the young peach trees to show severe potassium deficiency symptoms.

It is of interest to note the varietal differences as to size of trees and severity of potassium deficiency symptoms. Red Haven trees showed decidedly more deficiency than did Hale Haven although the soil test and green leaf tissue test results for potassium were not significantly different for the two varieties. Furthermore, the Hale Haven trees were the largest. The Fertile Hale seedlings were one year younger than the Hale Havens or Red Havens when planted. The leaves of Red Haven variety were slightly lighter colored and showed the most severe deficiency symptoms.

Unexpectedly, the heavy rates of potash fertilizer, spaded into the root zone, caused some injury to the trees and in certain instances the trees were killed. After the application of 2.5# K_2O per tree, as KCl, on August 1, 1947, a heavy rain fell and no serious injury resulted although the edges of a few leaves on one tree in row sixteen turned brown. The application of potash made on September 18,1947 caused death of all the trees of rows ten and fifteen. There had been a light rain immediately preceding the application of fertilizer and the soil was sufficiently moist for the potash to go into solution. There was no additional rain for several days and the high salt concentration proved fatal to the trees. Trees fertilized with the high rate of potassium in the spring showed no harmful effects. Perhaps a surface application of 2.5# K_2O would cause no difficulty, especially in sod orchards. Small trees with root systems not extended into the fertilized areas did not show any harmful effects.

Dilley Farm

The experimental area on the V.M. Dilley farm consisted of thirty-six Red Haven peach trees divided into six plots of six trees each. The plots are located on about a 3 per cent slope. The soil is sandy with a pH of 5.5 to 6.2 and is low in organic matter and nutrients. In 1943 the two year old trees showed what was thought to be potash deficiency symptoms.

Table VIII. Showing the experimental layout on the Dilley farm.

Row	Treatment	Trees					
1	N--	x	x	x	x	x	x
2	N-K	x	x	x	x	x	x
3	NP-	x	x	x	x	x	x
4	NPK	x	x	x	x	x	x
5	N/2 PK	x	x	x	x	x	x
6	N--	x	x	x	x	x	x

N--1# NH_4NO_3 per tree annually
P--12.5# 0-20-0 spaded in around tree, August 1944
K--8.2# 0-0-60 applied in solution by injection into root zone, August 1944.

Mr. Charles Mann of the Soil Conservation Service, Fennville, Michigan treated a few trees with a light application of 0-0-60 and these showed improvement in foliage in 1944. In August 1944 the six plots were started as outlined in Table VIII.

Water injection of the potash was used in an effort to get quick response to potash application. In addition in July 1946 the cover crop in all the plots was treated with 500# NH_4NO_3 broadcast; 759# 0-20-0 was applied to rows receiving phosphorus; 500# 0-0-60 on rows receiving potassium; and 1500# 0-10-20 on rows receiving both phosphorus and potassium. These applications were made on the sod in an effort to increase its vigor.

Green Leaf Testing Results

The test results in Table IX show that there was a slight seasonal trend in the leaf content of potassium. Early in the growing season (June and July), a higher potassium content was found and again in late season the

Table IX. The results of the tissue tests of peach leaves from the Dilley plots.

Row and treatment	Date of Sample and ppm of potassium in tissue extract						Per cent potassium 1946(1)
	Jul.1, 1947	Aug.1, 1947	Sept.1, 1947	Oct.2, 1947	Jul.2 1948	Aug.1 1948	
1 N--	132	100	100	192	212	204	.48
2 N-K	313	382	350	358	418	418	2.32
3 NP-	156	148	172	124	192	144	.48
4 NPK	266	232	278	292	400	366	2.14
5 N/2 PK	285	285	320	306	391	382	2.02
6 N--	108	76	148	76	217	212	.55

(1) Ash analysis of 1946 included for comparison.

Row 3 NP- Row 4 NPK

Plate 3. Showing the difference in tree size due to potash fertilizer. (Deficiency symptoms were evident on Row 3 at the time the picture was taken.)

Row 4 NPK Row 3 NP-

Plate 4. The effect of potassium on time of blossoming and leaf development of peach trees. Blossoms and leaves on the left row appeared one week earlier than on the row on the right without potassium. (Dilley orchard)

potassium in some leaves was higher. Because the leaf samples did not change greatly during midseason (August), this time seems most satisfactory for leaf sampling for diagnostic purposes. Ash analysis for 1946 shows the very low content of potassium at that time on the "no-potassium" trees. In 1948 the per cent of potassium by ash analysis was expected to be higher as those trees showed less deficiency in 1948 than in 1946.

Prune plums grown on the same farm show potassium deficiency symptoms different from those of peaches. On plum trees the lower leaves of the spurs of second year wood turn yellowish and die at the margins. The top, fast growing, terminals of these same trees do not show any deficiency symptoms but by leaf tissue tests the indication of deficiency can be found. The modified Purdue test on plum leaves presented two problems: first, the filtering was very slow, of both petioles and blades, even with fast filter paper, and second, the larger cell structure of the plum leaf allowed more potassium to be released into the extracting solution. When peaches and plums have the same potassium content, as shown by ash analysis, the plum leaves show more potassium by quick tests. In plums the petiole is longer than in peaches and it can be used more easily in testing.

Growth Measurements

The trees fertilized with potassium in the deficient areas have shown an increased trunk circumference and larger diameter of twigs. In 1946 and 1947 measurements were taken of fifty typical terminals from each plot of the Dilley orchard. The average length and diameter of terminals and the average number of buds on the new growth was determined. The results are shown in Table X.

Table X. The effect of potash fertilizer on terminal growth and fruit bud formation on peaches[1] (Dilley orchard)

Row and Treatment	Average length of terminals in inches		Average diameter of terminals in inches		Average number of buds on this new growth	
	1946[2]	1947[3]	1946	1947	1946	1947
1 N--	8.3	15.6	.123	.173	7.6	3.0
2 N-K	11.6	22.5	.204	.220	12.9	14.0
3 NP-	5.8	11.4	.111	.144	4.9	2.4
4 NPK	12.3	20.4	.156	.206	12.0	13.7
5 N/2 PK	10.7	22.8	.154	.219	6.1[4]	13.0
6 N--	14.3	15.1	.148	.158	9.1	7.1
Per cent increase of K treatments over no-K treatments	22	56	34	36	44	226

(1) Taken by H.L. Garrard, Field Agronomist, American Potash Institute, Homewood, Ill. and Charles Mann, Soil Conservation Service, Fennville, Michigan.
(2) April 25
(3) May 16
(4) No nitrogen used in 1945 on this row, thus the reduced number of fruit buds for 1946.

Potassium deficient trees had twigs of smaller diameter than normal trees. In these plots the diameter increase of terminals of the "potassium" over the "no-potassium" treated trees was 35 per cent. The smaller number of fruit buds on the "no-potassium" trees was sufficient to provide a light set of fruit but the yield data in Table XV, Appendix, indicate the limited yield obtained from these trees. The longer terminals on the potassium treated trees provided larger trees

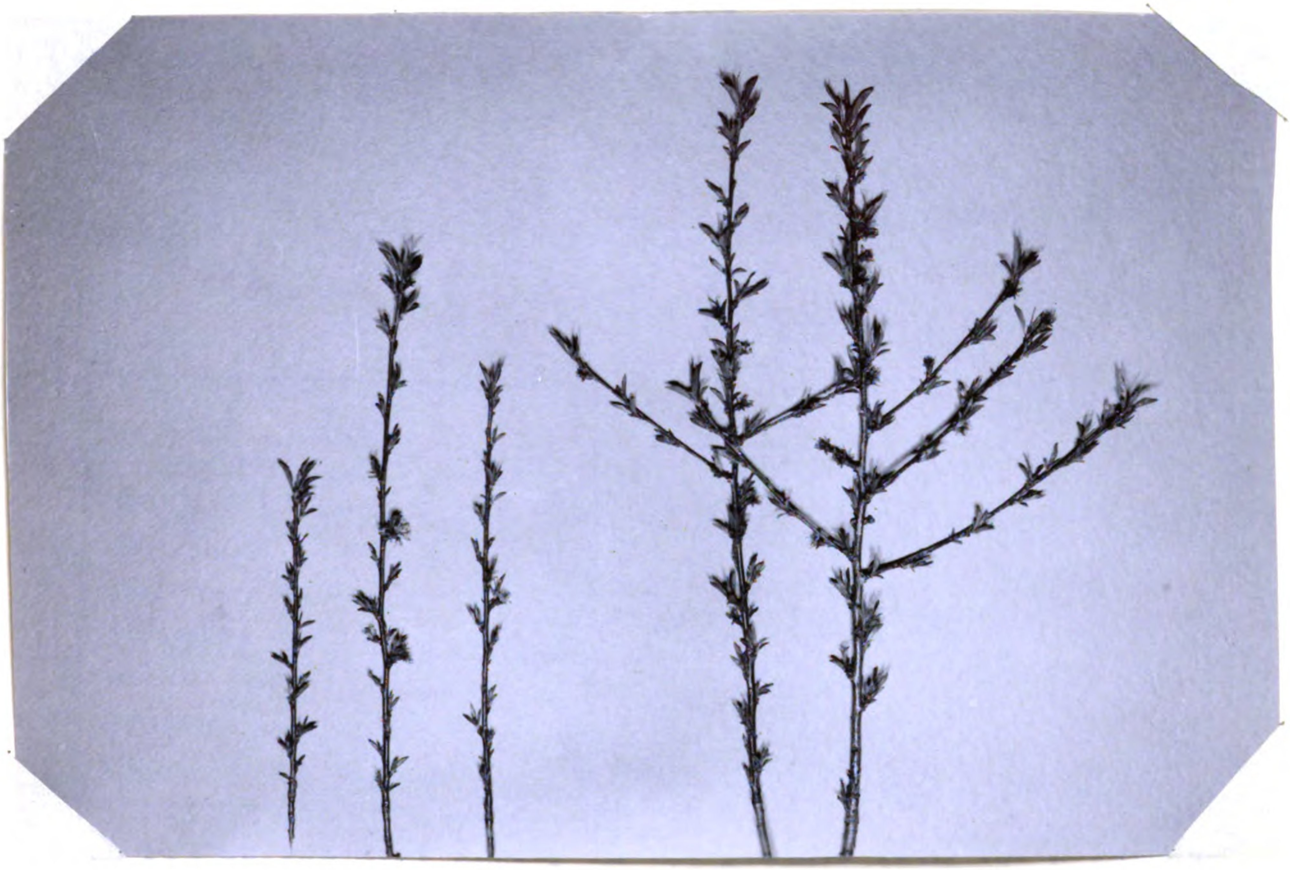


Plate 5. The relative amounts of terminal shoot growth and early spring growth of the peach trees treated with NP- on the left and NK on the right. (Dilley orchard)

as shown in Plates III and IV, page 30. In 1947, the diameter measurements were made May 16, after growth had begun therefore the diameters were larger than those taken in 1946.

Peach Storage Tests

Samples of Red Haven peaches from the Dilley plots were selected during the second picking on August 18, 1948 for storage tests. Metal trays which held fifty peaches each were filled in the field and placed in storage units in the Horticulture Building, Michigan State College, at a temperature of 65°F. The rate of rot infection is shown graphically in Figure IV. The NP treatment resulted in the greatest and most rapid loss due to rotting. In one sample from the N-K treatment the rate of rotting was very low while in a second sample the rate was much higher and so the average of the two is shown in Figure IV. In this one test the fruit of the NP treatment shows the greatest rate of rot infection. Brown rot spread more slowly in the peaches from the potassium treated plots than from those receiving N or NP.

Samples of peaches placed in storage at 41°F. did not show significant differences in keeping quality that could be attributed to differences in fertilizer treatment. Field observation indicated that the trees were showing less potassium deficiency each year and it is possible that similar tests on fruit from trees more deficient in potassium would show a greater benefit from potassium fertilization on keeping quality of the fruit.

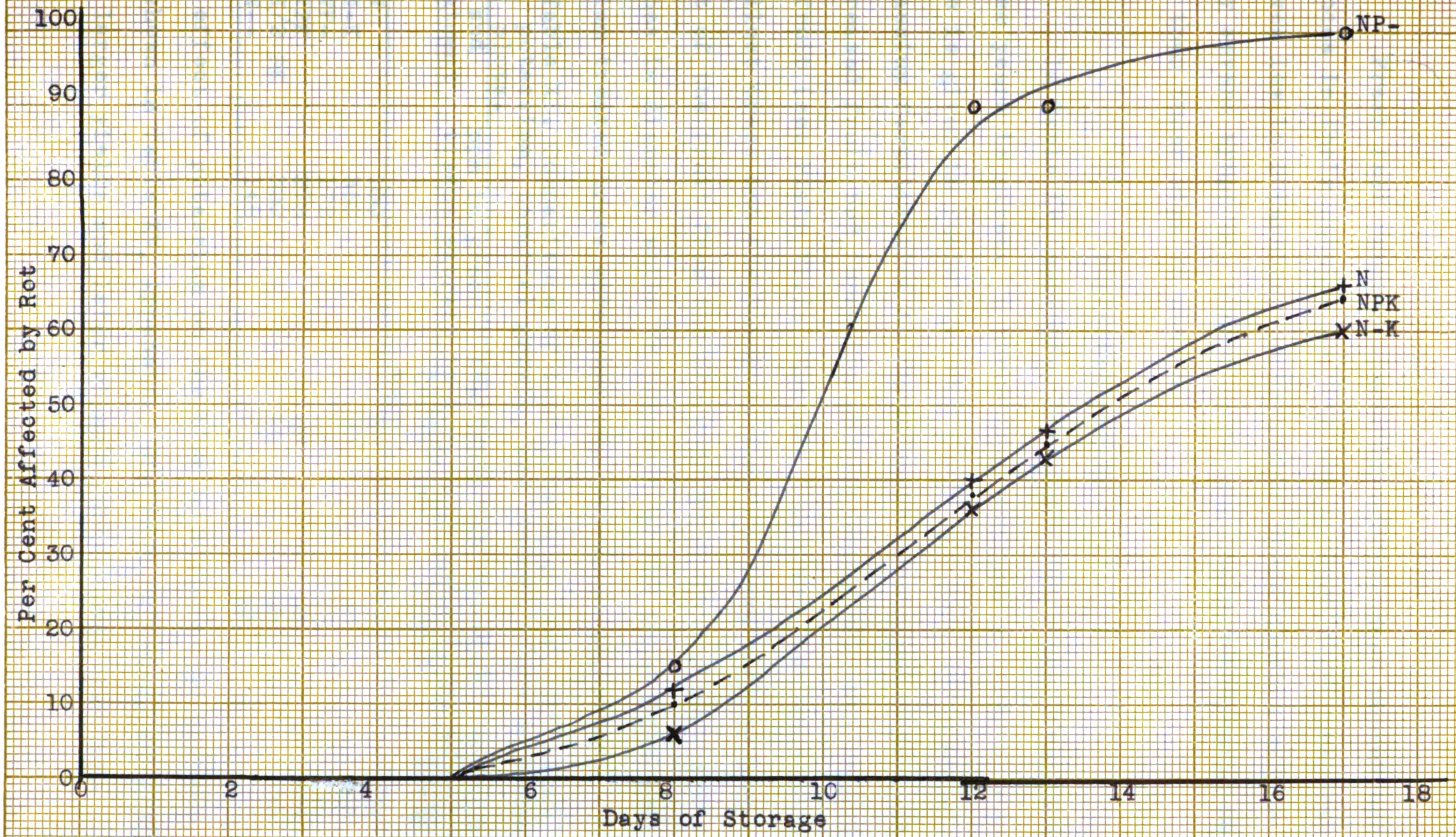


Figure 4. EFFECT OF FERTILIZERS ON KEEPING QUALITY OF PEACHES
From V.M. Dilley Plots, Stored at 65°F.

Fresh leaf samples placed in cold storage showed differences in their keeping quality due to fertilizer treatment. Leaves low in potassium, particularly those showing severe or very severe symptoms, turned brown and began decomposing earlier than those high in potash.

Yield Measurements

In Table XV, Appendix, the yield for each picking for three years is given. A three year average, in pounds, per tree is given in Table XI. The yield has been affected by potassium fertilization in three ways: increased tree area, increased fruit bud formation and increased size and quality of fruit (see Plate VI.). The NP- treatment row has both the smallest trees and the lowest yield. In 1946 only 15 per cent of the fruit from the NP- treatment row was over two inches in diameter while 77 per cent of the fruit from potassium treated trees were over two inches in diameter.

Table XI. Comparisons of leaf potassium, available soil potassium, terminal growth, and average yield on Dilley plots.

Row and treatment		ppm in green tissue extract	Available K_2O in sur. soil	Terminal growth '47	3 yr. ave. yield/tree
			Pounds per acre	Inches	pounds
1	N	100	2	15	44
2	N-K	350	20	22	76
3	NP-	172	11	11	14
4	NPK	278	40	20	68
5	N/2 PK	320	44	23	55
6	N--	148	3	15	30

The effect of potassium on the time of ripening of peaches is shown in Table XV, Appendix. All rows receiving potassium had larger yields and later ripening fruit than the "no-

Plate 6. The effect of potassium fertilizer on the shape and size of Red Haven peaches. (Dilley orchard)

potassium" rows. The second picking was small or lacking in those trees not receiving potassium.

The soil test for available potassium in the surface soil under the trees was low when compared to that of the Kerlikowski plots. Since the potassium was injected into the root zone three years previously the surface soil does not give a high reading.

SUMMARY

For many years nitrogen fertilization and clean cultivation with cover crôps has been the general soil management practice in orchards in southwestern Michigan. In recent years many fruit growers have become more soil conservation minded and some are using sod and complete fertilizers in peach orchards. The fertilization of orchards in sod presents a number of problems that do not pertain to orchards in clean cultivation.

For the most part, this study was concerned with the possibilities of using tissue tests and soil tests as aids in diagnosing potash deficiencies in peach trees.

The results of these studies indicate that:

(1). There are several orchards in southwestern Michigan which respond favorably to potassium fertilization. Many of these orchards are on soils which have been depleted of available potassium.

(2). Where extra heavy applications of potassium are placed in the root zone there is danger of salt injury. Applications

made to the surface or spaded in during favorable moisture conditions would not be expected to cause injury.

(3). Because of the difficulties in adequately sampling the root zone of trees, soil tests are of limited value in determining fertilizer needs.

(4). As peach trees advance in age, the potassium deficiency becomes less; however, a light application to young trees may be very beneficial.

(5). The Modified Purdue method for determining potassium in peach leaves correlates closely with the more time consuming ash analysis methods used.

(6). Tissue tests are a useful guide in diagnosing potassium deficiency of peach trees.

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APPENDIX

Table XII. Parts per million of potassium in the extract of green leaves from individual trees receiving different fertilizers--Kerlikowski plots.

Row, and Treatment	Tree,		August 1, 1947	Sept.1, 1947	Oct.2, 1947	July 1, 1948	Aug.1, 1948
7	3	NPK	358	366	374	400	343
	4	NPK	320	382	374	400	366
	5	NP	76	156	180	204	180
	6	NP	172	184	180	266	204
	7	N	120	136	74	180	140
	8	N	100	164	42	232	132
	10	N-K	320	350	327	409	343
	11	N	128	164	92	212	148
	12	N	67	144	64	176	112
9	3	NPK	358	358	343	391	320
	4	NPK	366	374	335	418	343
	5	NP	128	92	73	116	156
	6	NP	196	184	76	204	217
	7	N	204	172	112	152	176
	8	N	172	136	96	204	196
	9	N-K	358	366	320	391	350
	11	N	164	184	100	248	164
	12	N	108	152	128	212	128
11	3	NPK	320	327	356	428	335
	4	NPK	306	327	313	438	350
	5	NP	164	180	70	217	148
	6	NP	70	132	67	172	100
	7	N	108	92	88	116	100
	8	N	156	144	120	246	172
	9	N-K	278	327	306	---	172
	10	N-K	320	366	327	418	320
	11	N	88	136	92	184	164
	12	N	80	144	100	248	217
13	3	NPK	320	343	327	418	350
	4	NPK	335	335	320	409	335
	5	NP	80	92	84	212	132
	6	NP	140	124	92	272	217
	7	N	92	88	55	248	188
	8	N	124	120	67	184	148
	9	N-K	306	297	292	409	358
	10	N-K	320	327	335	400	374
	11	N	148	76	52	217	108
	12	N	136	96	55	237	112

Table XIII. Effect of fertilization on pH, available phosphorus and potassium content of surface soil under individual trees in Kerlikowski orchards.[1]

Tree and Treatment	Row 7 Surface Limed			Row 9 Spaded No lime			Row 11 No lime Surface			Row 13 Limed Spaded		
	pH	P	K	pH	P	K	pH	P	K	pH	P	K
3 NPK	5.6	3.2	280	6.0	3.2	216	5.3	10.0	131	6.6	16.0	208
4 NPK	5.8	3.8	188	6.2	3.4	186	5.6	7.3	128	6.8	8.8	180
5 NP	6.0	3.4	80	5.3	5.0	62	5.2	6.8	37	6.6	4.6	40
6 NP	6.3	2.6	68	5.6	6.6	56	5.4	5.7	28	6.6	11.0	37
7 N	7.1	1.3	64	6.8	2.2	72	6.3	1.8	37	7.0	2.9	40
8 N	7.0	1.2	40	7.2	2.0	40	6.8	2.0	34	7.0	1.8	28
9 NK	--	--	--	6.0	2.1	184	5.2	1.8	252	6.6	1.2	264
10 NK	6.6	1.8	328	--	--	--	5.1	1.0	260	6.6	1.4	284
11 N	6.4	1.3	108	5.5	1.0	68	4.9	1.0	40	6.2	1.3	39
12 N	6.6	1.0	40	5.0	.8	45	5.8	2.6	40	6.0	1.6	49

(1) Composite of 8 samples 0-6" depth taken August 17, 1948. Values for P and K are expressed in pounds per acre.

Table XIV. The effect of fertilizer and lime on the calcium, phosphorus, nitrogen, potassium, magnesium and manganese content of the leaves of Red Haven peach trees on Kerlikowski orchards, 1945.

Tree & Treatment	Percentage Composition of Peach Leaves					
	N	P	K	Ca	Mg	Mn
Row 7 Surface, limed						
Tree 3 NPK	4.09	.252	3.54	.787	.281	.0078
4 NPK	4.21	.242	3.68	1.08	.278	.0083
5 NP-	4.33	.270	.59	1.39	.496	.0083
6 NP-	4.21	.239	.82	1.40	.562	.0083
7 Check	3.62	.278	.75	1.35	.738	.0045
8 Check	4.09	.280	.53	1.30	.693	.0043
9 N-K	4.20	.218	3.05	1.00	.367	.0058
10 N-K	4.10	.218	2.93	.836	.306	.0064
11 N--	4.30	.260	.65	1.33	.333	.0065
12 N--	4.05	.282	.45	1.28	.540	.0058
Row 9 Spaded, no lime						
Tree 3 NPK	4.09	.270	3.68	.836	.243	.0065
4 NPK	4.14	.246	3.48	1.23	.280	.0076
5 NP-	4.17	.266	.42	1.20	.450	.0097
6 NP-	4.50	.268	.63	1.27	.519	.0075
7 Check	3.56	.272	.62	1.32	.546	.0047
8 Check	3.45	.268	.41	1.36	.625	.0033
9 N-K	4.05	.250	2.89	.941	.376	.0049
10 N-K	3.99	.232	2.91	1.11	.389	.0067
11 N--	4.04	.238	.50	1.22	.574	.0053
12 N--	4.43	.292	.53	1.22	.542	.0057
Row 11 Surface, no lime						
Tree 3 NPK	4.01	.208	3.40	.888	.245	.0063
4 NPK	4.17	.248	3.28	.776	.223	.0063
5 NP-	4.22	.288	.53	1.08	.243	.0070
6 NP-	4.19	.278	.53	1.28	.520	.0079
7 Check	5.90	.314	.43	1.13	.669	.0053
8 Check	3.98	.190	.76	1.33	.498	.0033
9 N-K	3.95	.218	3.22	.974	.348	.0065
10 N-K	4.14	.208	3.44	.770	.328	.0065
11 N--	3.85	.210	.63	1.42	.658	.0069
12 N--	4.23	.256	.72	1.31	.555	.0074
Row 13 Spaded, limed						
Tree 3 NPK	4.05	.260	3.64	.919	.325	.0055
4 NPK	3.90	.270	2.82	1.16	.339	.0048
5 NP-	4.12	.224	.76	1.36	.573	.0056
6 NP-	4.27	.320	.60	1.29	.494	.0050
7 Check	3.71	.308	.47	1.26	.673	.0043
8 Check	3.63	.244	.81	1.34	.634	.0052
9 N-K	3.69	.192	2.96	.880	.444	.0039
10 N-K	3.64	.176	2.33	.809	.391	.0030
11 N--	4.17	.254	.44	1.17	.653	.0058
12 N--	4.29	.264	.47	1.10	.677	.0044

Table XIV. Continued. The effect of fertilizer and lime on the calcium,.phosphorus, nitrogen, potassium, magnesium, and manganese content of the leaves of Red Haven peach trees in Kerlikowski orchards, 1946.

	Percentage Composition of Peach Leaves					
Tree & Treatment	N	P	K	Ca	Mg	Mn
Row 7 Surface, limed						
Tree 3 NPK	3.94	.254	3.51	1.01	.315	.0100
4 NPK	4.21	.254	3.59	1.05	.349	.0095
5 NP-	4.44	.288	.694	1.07	.419	.0122
6 NP-	4.30	.259	1.06	1.18	.492	.0081
7 Check	4.02	.296	1.07	1.11	.563	.0043
8 Check	3.91	.294	.565	1.26	.625	.0041
9 N-K	4.13	.249	3.35	1.03	.335	.0078
10 N-K	4.28	.275	2.77	.864	.286	.0071
11 N--	4.50	.260	.958	1.13	.423	.0061
12 N--	4.25	.288	.333	1.20	.505	.0058
Row 9 Spaded, no lime						
Tree 3 NPK	4.07	.255	3.61	1.08	.262	.0117
4 NPK	4.19	.284	3.11	.966	.383	.0137
5 NP-	4.09	.270	.590	1.11	.419	.0134
6 NP-	4.65	.298	.763	1.13	.408	.0094
7 Check	4.26	.304	.847	1.07	.496	.0034
8 Check	4.03	.300	.515	1.42	.516	.0031
9 N-K	4.49	.313	2.54	.933	.307	.0051
10 N-K	4.17	.271	2.94	1.03	.314	.0083
11 N--	4.16	.281	.575	1.23	.468	.0071
12 N--	4.63	.326	.594	.903	.447	.0116
Row 11 Surface, no limed						
Tree 3 NPK	4.26	.274	3.30	.928	.290	.0144
4 NPK	4.32	.288	3.22	.807	.231	.0149
5 NP-	4.60	.318	.686	.964	.330	.0135
6 NP-	4.37	.314	.607	.981	.375	.0170
7 Check	4.09	.302	.666	1.20	.575	.0044
8 Check	4.13	.281	.908	1.28	.443	.0035
9 N-K	4.38	.274	2.80	1.07	.441	.0082
10 N-K	4.39	.271	2.98	.746	.401	.0090
11 N--	3.95	.252	.617	1.33	.686	.0106
12 N--	4.43	.290	.906	1.07	.556	.0065
Row 13 Spaded, limed						
Tree 3 NPK	4.26	.284	3.14	.979	.407	.0076
4 NPK	4.04	.290	3.56	1.12	.358	.0062
5 NP-	4.34	.337	.966	1.08	.613	.0051
6 NP-	4.34	.315	1.31	1.19	.557	.0055
7 Check	4.51	.364	.840	.999	.715	.0036
8 Check	4.09	.288	.777	1.32	.552	.0047
9 N-K	4.05	.279	1.71	.913	.474	.0066
10 N-K	4.44	.277	1.79	.952	.438	.0047
11 N--	4.16	.281	.676	1.15	.560	.0071
12 N--	4.52	.304	.691	.956	.657	.0054

Table XIV. Continued. The effect of fertilizer and lime on the calcium, phosphorus, nitrogen, potassium, magnesium, and manganese content of the leaves of Red Haven peach trees in Kerlikowski orchards, 1947.

Tree & Treatment	Percentage Composition of Peach Leaves					
	N	P	K	Ca	Mg	Mn
Row 7 Surface, limed						
Tree 3 NPK	3.79	.239	2.95	1.63	.395	.0136
4 NPK	3.92	.230	3.03	1.47	.312	.0123
5 NP-	4.12	.243	.816	1.47	.479	.0107
6 NP-	4.13	.233	1.40	1.48	.570	.0095
7 Check	3.64	.273	1.09	1.60	.708	.0068
8 Check	3.92	.269	.626	1.54	.738	.0068
10 N-K	4.11	.246	2.58	1.46	.466	.0098
11 N--	4.10	.232	.920	1.56	.603	.0082
12 N--	4.14	.258	.951	1.40	.575	.0073
Row 9 Spaded, no lime						
Tree 3 NPK	3.95	.228	2.93	1.50	.395	.0180
4 NPK	4.18	.249	2.63	1.61	.435	.0157
5 NP-	4.02	.244	.468	1.15	.509	.0254
6 NP-	4.54	.274	.844	1.33	.597	.0097
7 Check	4.14	.279	1.12	1.38	.614	.0049
11 N--	4.28	.273	.840	1.31	.489	.0072
12 N--	4.37	.284	.759	1.25	.507	.0132
Row 11 Surface, no lime						
Tree 3 NPK	4.01	.237	2.81	1.46	.422	.0112
4 NPK	4.35	.262	2.93	1.18	.339	.0180
5 NP-	4.37	.289	.786	1.41	.483	.0122
6 NP-	4.35	.303	.755	1.33	.575	.0123
7 Check	4.04	.288	.672	1.33	.550	.0104
8 Check	4.04	.260	1.04	2.00	.570	.0054
9 N-K	4.08	.301	2.49	1.47	.404	.0149
10 N-K	4.08	.245	2.73	1.17	.461	.0175
11 N--	4.08	.271	.786	1.29	.492	.0119
12 N--	4.13	.254	.718	1.45	.526	.007
Row 13 Spaded, limed						
Tree 3 NPK	4.17	.258	2.66	1.49	.457	.0075
5 NP-	4.25	.289	.787	1.40	.594	.0054
6 NP-	4.49	.302	.932	1.31	.542	.0051
8 Check	3.96	.267	.767	1.81	.701	.0061
9 N-K	4.07	.220	2.28	1.52	.500	.0089
10 N-K	4.18	.225	2.54	1.36	.441	.0071
11 N--	4.28	.256	.555	1.22	.553	.0069
12 N--	4.50	.251	.558	1.45	.533	.0064

Table XV. Effect of fertilizer on yield and time of ripening of Red Haven peaches, Dilley plots, 1946-1948.

Row	Treatment, and Year		Pickings(1) 1st.	2nd.	3rd.	Total	Average per tree Each year	3 year
		1946	121	90	--	211	42	
1	N	1947	76	31	50	157	31	44
		1948	285	15	--	300	60	
		1946	146	301	--	447	89	
2	N-K	1947	129	26	100	255	51	76
		1948	365	80	--	445	89	
		1946	66	--	--	66	13	
3	NP-	1947	37	7	--	44	9	14
		1948	80	18	--	98	20	
		1946	125	154	--	279	56	
4	NPK	1947	193	42	75	310	62	68
		1948	350	75	--	425	85	
		1946	93	118	--	211	42	
5	N/2PK	1947	185	61	40	286	57	55
		1948	290	35	--	325	65	
		1946	141	66	--	207	41	
6	N	1947	84	21	5	110	22	30
		1948	90	40	--	130	26	

(1) Yield in pounds from five trees per plot.

[redacted]