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Annual Fertilizer Applications On A Peach Orchard Soil

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Conclusions

1. Annual applications of superphosphate at the rate of 6 pounds of 20% superphosphate under mature Sullivans Early Elberta peach trees resulted in increases in phosphorus in the soils at a depth of 0 to 6 inches.

2. Under very heavy rates of annual application the available phosphorus was significantly higher than the check trees to a depth of 12 to 18 inches.

3. Trees which received no phosphate fertilizer had analyses of 5 to 25 pounds of P_2O_5 equivalent per acre. These trees did not grow or yield as well as trees which received phosphate fertilizer and had higher phosphorus analyses in their soils.

4. Annual applications of 1 1/2 pounds of 50% muriate of potash to mature trees resulted in a large increase in exchangeable potassium in the soil at 0- to 6-inch depth.

5. Potassium analyses of less than 150 pounds per acre were typical for soils not receiving potash. Analyses of over 400 pounds per acre resulted from annual applications of potash.

6. Three times the rate of potash application mentioned above resulted in movement of this element downward to at least 18 to 24 inches.

7. Applications of nitrate of soda caused the pH of the soil to rise and applications of ammonium nitrate caused the pH to drop.

INFLUENCE OF ANNUAL FERTILIZER APPLICATIONS ON A PEACH ORCHARD SOIL

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Peach orchards are often located on hillsides to provide good air drainage for frost protection. Often these hill soils are either already eroded or subject to erosion. In many instances the soils are not naturally as fertile as bottom soils or level soils which are less subject to erosion.

Since peach orchard soils are often low in readily available mineral nutrients, it would be desirable to know the influence of continual applications of phosphorus, potassium and nitrogen fertilizers on these soils. This information would help the growers to determine the need for additions of these fertilizers to their orchards to promote more tree growth and better yield.

A long-time fertilizer experiment at Holly Springs, Mississippi was used as a source of soil samples for this study. Very heavy annual rates of application of nitrogen, phosphorus and potassium fertilizers under part of the trees permitted a study of depth of movement of phosphorus and potassium in the soils which were cultivated shallow only. This information could be useful in interpreting tree growth, since peaches are a very deep rooted crop.

Materials and Methods

An orchard of Sullivans Early Elberta peach trees was set in a Grenada silt loam soil in 1946. The trees were spaced 20 x 20 feet apart and annually a furrow was plowed between the rows to a depth of 12 inches to minimize cross-feeding between rows.

The orchard was clean cultivated during the summers with the area under the tree hoed clean. In the winter an oat cover crop was planted between the trees.

In the spring of 1948 one experiment was begun with two-tree plots surrounded by border trees. This NPK factorial experiment included nitrogen at the rate of one pound nitrate of soda or ½ pound of ammonium nitrate per tree per year of age. The phosphorus was applied at the rate of one pound of 20% superphosphate per tree per year of age, and the potassium at the rate of ¼ pound of 50% muriate of potash per tree per year of age. The maximum amount of fertilizer was reached at 6 years of tree age and this amount was continued thereafter.

In the spring of 1950 another experiment was begun on the border rows, between the NPK test rows of the first experiment. Three levels of NPK were used as follows: NPK at the rates described in the first experiment; 2 NPK at twice these rates per tree annually; and 3 NPK at three times the annual rates used for the NPK plots in the first experiment. At six years of age and each year thereafter the trees at the 3 NPK level each received 18 pounds of nitrate of soda or 9 pounds of ammonium nitrate, 18 pounds of 20% superphosphate and 4½ pounds of 50% muriate of potash.

All of the phosphate and potash fertilizer and two-thirds of the nitrogen were applied in the spring before growth began. The remainder of the nitrogen was applied in late June or early July. The fertilizer was distributed evenly over the area under the limb spread of the tree and mixed in the soil by hoeing shallow. In both experiments the treatments were located at random in each of four blocks in the orchard.

Beginning in 1948, and each year thereafter, soil samples were collected from one tree of each plot in the test orchard. The same trees were sampled annually. A total of one quart of soil per tree was formed by sampling the 0- to 6-inch depth in

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the undisked area under the trees using a composite of soil from 10 holes per tree. In 1958 soil samples were collected at 6-inch levels to 36 inches. In order to eliminate mixing of the various levels, a large hole was bored to the beginning of the new level; then a small hole was bored to the proper depth for the sample.

The soil testing procedures were as follows:

pH — Soil reactions were determined on a soil-water suspension of a 1:2 ratio using a glass electrode.

Potash — Available potassium was measured by shaking 5 gms. of soil with 20 ml. (1:4 ratio) of a solution that was 0.5 N hydrochloric acid (HCl) and determined flamеometrically using a Perkin-Elmer Flame-photometer.

Phosphorus — The available phosphorus was determined by procedure devised by Lancaster (unpublished data, 1955). Briefly, the method was as follows: 5 gms. of soil were shaken with 20 ml. of extracting solution for 10 minutes and phosphorus in the extracting solution determined colormetrically, according to the molybdenum blue procedure using 1-amino-2-napthol-4 sulfonic acid as a reducing agent. The extractant consisted of a solution that was of 0.35 N to acetic acid, 0.15 N to lactic acid, 0.03 N to NH_4F, 0.10 N to $(NH_4)_2SO_4$ and 0.21 N to NaOH. The pH of the final solution was 4.25 + .05 and was adjusted by adding glacial acetic acid or solid NaOH as required.

Results

Phosphorus: The application of superphosphate fertilizer in the spring, either alone or with nitrogen or potash, always resulted in higher available phosphorus in the soil samples at 0 to 6 inches depth in late fall, table 1. The average available phosphorus in the soil under all trees receiving phosphate fertilizer was 286.6 pounds per acre for the five years shown in table 1. Whereas, for soils which received no phosphate fertilizer it was only 11.4 pounds. Neither nitrogen nor potassium had any significant influence on the analyses for phosphorus in the soils.

After eleven annual applications of phosphate fertilizers the soils were sampled in 6-inch levels to 36 inches to determine the downward movement of this element. When samples of soils under all trees receiving phosphate in the NPK factorial experiment were compared with those receiving none there were significantly

Table 1.—The influence of annual applications of nitrogen, phosphorus and potassium fertilizers on the pounds of P_2O_5 equivalent per acre in the soil at a depth of 0 to 6 inches under Sullivans Early Elberta peach trees planted in 1946 at Holly Springs, Mississippi.

Treatment	1949	1951	1953	1955	1957
Nitrogen	3.7	2.1	4.3	5.0	14.0
Phosphorus	135.5	219.0	291.5	367.0	393.0
Potassium	5.2	8.0	14.0	16.7	14.7
Nitrogen, Phosphorus	216.4	87.2	289.8	325.2	367.3
Nitrogen, Potassium	3.6	6.4	9.0	9.9	20.0
Phosphorus, Potassium	255.9	246.0	290.3	367.0	336.7
Nitrogen, Phosphorus, Potassium	380.9	168.7	241.0	360.7	336.7
Check	5.6	9.4	14.3	40.5	21.0
L. S. D. .05	145.4	111.6	54.1	45.2	67.1
.01	198.0	152.0	73.7	61.1	93.1
Summary of means for all trees receiving each fertilizer element					
Nitrogen	151.2	66.1	136.0	175.2	184.5
No Nitrogen	100.7	120.5	152.5	197.8	205.4
Phosphorus	247.2**	180.2**	278.1**	355.0**	372.5**
No Phosphorus	4.7	6.4	10.4	18.0	17.4
Potassium	161.5	107.2	138.6	188.6	191.1
No Potassium	90.3	79.4	149.9	184.4	198.8

*Significant at .05 level. **Significant at .01 level.

higher amounts of phosphorus as deep as the 24- to 30-inch level as shown in table 2.

In the experiment with 3 rates of NPK fertilizer application the penetration of phosphorus under 3 (NPK) rate was significantly greater than the check to a depth of 12-18 inches—table 3. Over twice as much phosphorus was recorded at this depth.

Potassium: The addition of 1 1/2 pounds of 50% muriate of potash under mature peach trees in the NPK factorial experiment resulted in an average analysis for the five years shown in table 4 of 433.8 pounds of potassium per acre as contrasted to only 122.5 pounds where none was added. The addition of nitrogen fertilizer resulted in significantly lower analyses for potassium in four out of five years shown in table 4. When nitrogen was applied, larger trees resulted, and therefore the trees required a larger part of the potassium available in the soil. This greater consumption by the trees may have been responsible in part for the lower analyses.

The average pounds of exchangeable potassium in the soil per acre for the five years shown in table 4 was 152.7 for check trees; 278.4 for NPK trees and 591.7 for the trees receiving only potash fertilizer. This indicates that part of the potash applied under the NPK trees was used by the greater tree growth which resulted, in contrast to the trees receiving only potash which had higher potassium analyses.

Table 2.—The influence of annual applications of nitrogen, phosphorus and potassium fertilizers under Sullivans Early Elberta peach trees planted in 1946 at Holly Springs, Mississippi on the pounds of P_2O_5 equivalent per acre in the soil at various depths in the fall of 1958.

Treatment	Soil sampling depth — inches					
	0-6	6-12	12-18	18-24	24-30	30-36
Nitrogen	25.7	14.7	6.3	18.0	25.0	20.0
Phosphorus	393.0	28.3	24.3	28.0	24.3	20.7
Potassium	33.0	20.3	13.0	10.3	21.6	19.0
Nitrogen, Phosphorus	393.0	26.0	17.3	18.6	45.6	18.0
Nitrogen, Potassium	17.3	17.3	18.7	18.6	21.0	12.7
Phosphorus, Potassium	393.0	27.0	23.0	25.3	35.0	21.0
Nitrogen, Phosphorus, Potassium	393.0	25.0	32.3	25.6	18.0	21.0
Check	25.0	28.3	18.3	25.6	18.6	21.3
L. S. D. .05	6.8	18.2	18.1	8.8	11.7	10.1
.01	9.4	25.3	25.1	12.2	16.2	14.1
Summary of means for all treatments receiving each fertilizer element.						
Nitrogen	207.2	20.7	18.6	20.3	27.4	17.9
No Nitrogen	211.0	26.0	19.7	22.3	24.9	20.7
Phosphorus	393.0**	26.5	24.3*	24.4**	30.7**	20.4
No Phosphorus	25.2	20.2	14.0	18.2	21.6	18.2
Potassium	209.0	22.4	21.7	20.0	23.9	18.6
No Potassium	209.2	25.3	16.6	22.6	28.4	20.0

*Significant at .05 level.
**Significant at .01 level.

Table 3.—The influence of three rates of annual application of nitrogen, phosphorus and potassium fertilizers under Sullivans Early Elberta peach trees planted in 1946 at Holly Springs, Mississippi on the pounds of P_2O_5 equivalent per acre in the soil at various depths in the fall of 1958.

Rates of Fertilizer	Soil sampling depth — inches					
	0-6	6-12	12-18	18-24	24-30	30-36
Check	25.0	28.3	18.3	25.7	18.7	21.3
NPK	393.0	34.3	32.3	25.7	18.0	21.0
2 (NPK)	393.0	52.3	27.0	26.3	22.3	19.3
3 (NPK)	393.0	178.7	43.7	26.7	21.0	20.3
L. S. D. .05	1.8	31.9	8.8	9.0	13.5	16.0
.01	2.8	48.3	13.5	13.6	20.4	24.3

After eleven annual applications of muriate of potash the soil analyses showed (table 5) that the potassium had moved downward below the 0 to 6-inch level. Where potash alone was applied to the soil the concentration was higher than for check plots at a depth of 18 to 24 inches. The application of nitrogen fertilizer and the subsequent greater tree size resulted in significantly lower potassium analyses to a depth of 12-18 inches.

The exchangeable potassium was significantly higher under trees receiving 2 (NPK) than the check at a depth of 0 to 6 inches (table 6). When the heavier application of potash was applied under the 3(NPK) trees the potassium was higher than the check to a greater depth (18 to 24 inches).

Nitrogen: Two sources of nitrogen fertilizers were used in the NPK factorial experiment. In 1948, 1949, and 1950 ni-

Table 4.—The influence of annual applications of nitrogen, phosphorus and potassium fertilizers on the pounds of exchangeable potassium per acre in the soil at a depth of 0 to 6 inches under Sullivans Early Elberta peach trees planted in 1946 at Holly Springs, Mississippi

Treatment	1954	1955	1956	1957	1958
Nitrogen	178.5	209.7	102.7	75.3	161.7
Phosphorus	132.7	134.2	61.5	76.7	99.3
Potassium	534.0	650.0	572.0	552.3	650.0
Nitrogen, Phosphorus	127.7	161.7	48.7	42.0	73.7
Nitrogen, Potassium	466.7	526.7	269.5	409.3	319.3
Phosphorus, Potassium	532.2	625.7	459.7	379.0	305.0
Nitrogen, Phosphorus, Potassium	341.5	455.0	298.0	155.0	175.3
Check	188.0	155.0	122.7	155.0	142.7
L. S. D. .05	317.1	124.1	154.6	106.5	177.1
.01	431.6	168.9	210.5	147.8	245.9
Summary of means for all trees receiving each fertilizer element					
Nitrogen	278.6*	338.3	179.7**	170.4**	182.5**
No Nitrogen	346.7	391.3	304.0	290.7	299.2
Phosphorus	283.5	344.2	217.0	163.1**	163.3**
No Phosphorus	341.8	385.4	266.7	298.0	318.4
Potassium	468.6**	564.4**	399.8**	373.9**	362.4
					362.4**
No Potassium	156.7	165.2	83.9	87.2	119.3

Table 5.—The influence of annual applications of nitrogen, phosphorus and potassium fertilizers under Sullivans Early Elberta peach trees planted in 1946 at Holly Springs, Mississippi on the pounds of exchangeable potassium per acre in the soil at various depths in 1958.

	Soil sampling depth — inches					
Treatment	0-6	6-12	12-18	18-24	24-30	30-36
Nitrogen	161.7	52.7	74.7	84.3	68.3	75.6
Phosphorus	99.3	49.7	67.0	86.3	76.7	97.3
Potassium	650.0	190.3	83.7	89.7	60.7	66.0
Nitrogen, Phosphorus	73.7	39.7	52.0	70.0	53.0	67.0
Nitrogen, Potassium	319.3	77.0	52.7	74.7	56.3	78.0
Phosphorus, Potassium	305.0	110.3	89.7	80.3	55.0	56.3
Nitrogen, Phosphorus, Potassium	175.3	54.0	54.0	66.7	81.0	59.3
Check	142.7	56.0	62.7	70.7	90.7	81.3
L. S. D. .05	177.1	49.6	20.6	17.2	20.7	26.1
.01	245.9	68.8	28.7	23.9	28.8	36.2
Summary of means for all treatments receiving each fertilizer element						
Nitrogen	182.5*	55.8**	58.3**	73.9	64.7	70.0
No Nitrogen	299.2	101.6	75.7	81.7	70.7	75.3
Phosphorus	163.3**	63.4*	65.6	75.8	66.4	70.1
No Phosphorus	318.4	94.0	68.4	79.8	69.0	75.2
Potassium	362.4**	107.9**	70.0	77.8	63.2	64.9
No Potassium	119.3	49.5	64.0	77.8	72.2	80.4

*Significant at .05 level. **Significant at .01 level.

Table 6.—The influence of three rates of annual application of nitrogen, phosphorus and potassium fertilizers under Sullivans Early Elberta peach trees planted in 1946 at Holly Springs, Mississippi on the pounds of exchangeable potassium per acre in the soil at various depths in 1958.

Treatment	Soil sampling depth — inches					
	0-6	6-12	12-18	18-24	24-30	30-36
Rates of fertilizer						
Check	142.7	56.0	62.7	70.7	90.7	81.3
NPK	175.3	54.0	54.0	66.7	81.0	59.3
2 (NPK)	490.3	156.0	95.0	93.0	68.0	74.7
3 (NPK)	577.7	319.3	135.3	112.3	87.3	92.0
L. S. D. .05	121.5	181.5	38.2	34.8	42.5	45.2
.01	184.1	275.0	57.9	52.7	64.3	68.5

Table 7.—The influence of source of nitrogen* fertilizer on pH of soils at a depth of 0 to 6 inches in a Sullivans Early Elberta peach orchard at Holly Springs, Mississippi.

Treattment	1948	1950	1953	1956	1958
Nitrogen	5.37	6.49	4.66	5.54	5.00
Phosphorus	4.98	4.95	5.77	5.10	4.50
Potassium	5.10	5.24	5.27	5.10	4.63
Nitrogen, Phosphorus	5.32	5.90	4.80	5.55	4.87
Nitrogen, Potassium	5.56	6.25	4.82	5.61	5.53
Phosphorus, Potassium	5.05	4.87	5.31	5.16	5.12
Nitrogen, Phosphorus, Potassium	5.39	5.62	4.77	5.47	5.00
Check	5.22	5.37	5.26	5.20	5.00
L. S. D. .05	.36	.24	.28	.24	.29
.01	.49	.32	.38	.33	.40
Summary of means for all trees receiving each fertilizer element					
Nitrogen	5.41*	6.06**	4.77**	5.54**	5.10**
No Nitrogen	5.08	5.12	5.29	5.16	4.82
Phosphorus	5.17	5.34**	5.04	5.32	4.88**
No Phosphorus	5.32	5.84	5.02	5.38	5.04
Potassium	5.27	5.49	5.06	5.35	5.08**
No Potassium	5.22	5.69	5.00	5.35	4.84

*1948-1950 nitrate of soda
1951-1953 ammonium nitrate
1954-1957 nitrate of soda
1958 ammonium nitrate

*Significant at .05 level
**Significant at .01 level

trate of soda was used in both spring and summer applications. This fertilizer resulted in raising the pH from an average of 5.12 for all trees receiving no nitrogen to 6.06 for all trees receiving this fertilizer, see table 7.

When the source of nitrogen was changed to ammonium nitrate the pH after three more years was reduced from 5.29 for all trees receiving no nitrogen to 4.77.

The most pronounced changes in pH were observed when nitrogen alone was applied as compared with the check trees. The soil under the NPK trees was apparently buffered against such wide changes in pH by the nitrogen sources.