SOME EFFECTS OF STRAW MULCH ON ORCHARD SOILS

by

WILLIAM GERALD AMSTEIN

B. S., Massachusetts Agricultural College, 1927

A THESIS

submitted in partial fulfillment of the requirements

for the degree of

MASTER OF SCIENCE

KANSAS STATE AGRICULTURAL COLLEGE

1928

TABLE OF CONTENTS

INTRODUCTION

The two factors of primary importance in dealing with soils on which apple trees are grown are moisture and nitrates. Good management methods must consider these at all times. Practical experience has shown that under Kansas conditions straw mulch and clean cultivation are methods that tend to conserve moisture and nitrates. Both methods effectively control weeds but although other workers have found that a straw mulch depresses the nitrates, its use results in more vigorous tree growth and in higher yields of fruit than does clean cultivation. Why this occurs becomes a question of some importance.

This is not a new field that is being exploited but rather one that needs clarifying in the light of present day accumulated results. It is thought that some of the methods employed in this study may prove new and give interesting results. The work as here prosecuted constitutes a part of Project No. 25 of the Agricultural Experiment Station and is directly applicable to the needs of orchardists in this section.

ACKNOWLEDGMENTS

The writer acknowledges with pleasure the valuable advice and assistance of R. J. Barnett, Professor of Horticulture, under whose direction the work was done; to F. L. Duley, Professor of Soils, for advice in soil analysis, method of study and for use of soils laboratory facilities; to W. F. Pickett, Assistant Professor of Horticulture, for data on the rate of growth of trees in the station orchard; and to the Physics Department, for rainfall data through the season.

THE PROBLEM

This is to be a study of nitrates, moisture, temperature and ammonia under straw mulch in a sixteen-year-old apple orchard. The variety is Delicious and the trees have been under this treatment for seven years. As a check a comparison of adjacent areas under clean cultivation will be made. The work will be divided into its several phases and will be referred to as separate units that together comprise the problem.

Moisture and nitrates are the principal bases of this work. There is much contradiction in the literature regarding these two factors. Albrecht (1), Scott (19) and Beaumont (4), have, in part, studied moisture and nitrates making use of a suitable mulch material as has been the case in this work. Their results do not agree. From a study conducted here over a period of two years and from the results of my predecessor, Tozzer (22), in this same work under Kansas conditions, it seemed probable that results differing from those of any of these workers could be expected.

Few, if any, investigators have deemed it necessary to remove their work from the position of studying residues of moisture and nitrates. It is proposed to attempt this in the work here undertaken. The data will be evidence of the results. The plan by which this is accomplished will be outlined in the discussion of the plot layout.

Phase I of this problem deals with moisture and nitrates under straw mulch with and without tree roots removed. There is a wide variation in accepted ideas. Beaumont (4), states that "at no time within the period studied did the average nitrate content of the cultivated plots reach that of the mulched plots although at three times in 1925 the curves for the two almost converged". This was under conditions as sampled after mulch had been allowed to accumulate for several seasons. Other workers report a different result . Albrecht (1) reports that nitrates are depressed where a fresh mulch is applied. He does not allow the mulch material to accumulate but removes it, plows the ground and puts on a new mulch once each year. It is possible that there will be differences in moisture and nitrate content where trees are and are not present that will be significant.

Phase II deals with moisture and nitrates under clean cultivation areas with roots and roots removed. These results will also serve as a check for the conditions found in the straw mulch plots.

Phase III deals with the ammonia content of the orchard soil. Several workers have submitted evidence to show that plants are capable of utilizing ammonia (8). Not all plants are equally capable. Some seem to show no preference in assimilating ammonia or nitrates. It is to study the possibility that apple trees are capable of utilizing ammonia that this portion of the problem is included.

Phase IV deals with soil temperatures under the several plots. It is expected that the temperature under straw mulch will be lower than under clean cultivation.

In order to have a record of relative vegetative vigor, twig and girth measurements were taken on the trees under study in plots II and IV.

MATERIALS AND METHODS

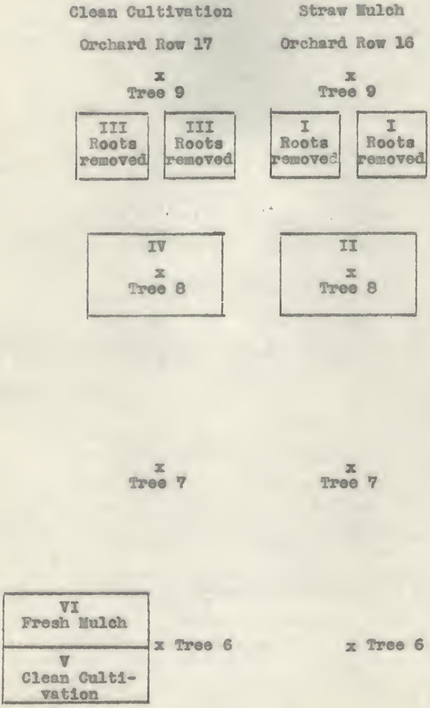
Laying Out of Plots

The plots for the experiment were selected about March 1. Considerable time was given to this in order that future observed changes could not be classed as influenced by site variations. The plots are located as shown in figure 1.

Drainage or cross wash would seem to be negligible and leaching from the straw plots would not increase the moisture or nitrate content of adjoining plots. Because of the small total area involved, any changes observed will be considered the result of the treatments rather than to variations of the soil types.

Originally a group of several apple trees was to be included in this study but to avoid the difficulties mentioned above one tree under straw mulch and one under clean cultivation were selected. Adjoining each of the trees on the north, two plots, forty square feet in area, were made free of growing roots. This was accomplished by digging a trench fifteen inches wide to a depth of four feet in order to cut off any roots from the nearby trees. To prevent roots reappearing during the course of

FIGURE 1. DIAGRAM OF PLOT LAYOUT



the study, an additional cutting was mad May 10. The mulch was kept in as uniform a condition as possible and a fresh application of straw was made April 28.

Plot I was located between trees 8 and 9 in row 16 and is under straw mulch with tree roots removed. Plot II is the area about tree 8, row 16 and is under a straw mulch. Plots III and IV are under clean cultivation. Plot III is an area between trees 8 and 9 in row 17 and has had all tree roots cut off. Plot IV surrounds tree 8 in row 17 and, like plot II, contains an apple tree.

The "new straw" area, plot VI, and the adjoining check plot V, are located on row 17 near tree 6. This tree is very small and has not a root system sufficient to demand the nitrates available in these two plots. The quantity of old straw applied to plot VI covered it to a depth of ten inches before settling.

SOIL DETERMINATIONS

<u>Sampling</u>. The soil samples were taken with a four foot King soil sampler to a depth of three feet in each plot. These soil samples were taken in one foot sections. Four borings were taken from each plot to represent the first foot. Because of the larger quantity of sample

obtained and the lessened chance for variation in the second and third foot layers, three borings were made to each of these depths. The samples on plots II and IV were taken at seven to ten feet from the tree trunks and care was exercised not to come closer than fifteen inches to previous sampling holes. A definite schedule for locating samples was worked out in the beginning and, by making use of it throughout, the possibility of striking old holes was reduced. As a further precaution to stop water's accumulating in sample holes, fine soil was used to fill them after each three foot sample was removed. With the plots that were root free a very definite schedule was necessary because of the small area available for sampling. The plan followed was to take two samples each from both the east and west sections of them. These samples of like depth were placed together and a uniform mixture taken for study.

Moisture Determinations. Two fifty-gram samples were weighed out and placed in evaporating dishes to determine the moisture content. They were dried in an electric oven at a temperature of 100°C. for fifteen hours, after which the samples were weighed. An average was made of the weights thus obtained and the moisture content calculated on the dry soil basis and expressed as a percentage.

Nitrate Determinations. At the same time a fifty-gram sample was weighed out and placed in a battery jar for nitrate determination. The phenoldisulphonic colorimetric method was used as described in U. S. D. A. Bureau of Soils Bulletin No. 31. At various times tests were made to detect chlorides, but no appreciable quantities were observed. Two 50 c. c. samples were taken for evaporation. The readings were averaged and nitrates computed as parts per million.

Ammonia Determinations. At the same time a 50-gram sample was weighed out and placed in a quart milk bottle and stoppered. Ammonia was determined as described in Emerson's book (9) entitled Soil Characteristics, page 99, with this change: the bottles were placed in a shaker machine and it allowed to run for thirty minutes. They were then allowed to remain over night. Samples, 250 c. c., were measured out and distilled into standard acid and titrated as in Emerson's directions (9). Extreme care was necessary to prevent any ammonia contamination and for this reason weighing was done under conditions that to a large extent cut down objectional features and safe-guarded results.

Temperature Readings. Each plot was provided with a standard soil thermometer, that previously had been checked as to its accuracy. The bull of the thermometer was placed seven inches below the surface of the ground so as to prevent any extreme variations that might result from direct solar heat. Readings were taken at regular intervals during the day. Several times a study was made of the variations as they exist over long periods of the day.

Twig and Girth Measurements. Growth data were secured by cooperation with station workers. Trees under study were made a part of the regular route of the observer. Measurements were taken at weekly intervals and gave, along with yield records, an accurate indication of response by the trees. The measurements were taken on ten representative twigs, carefully spaced, on each tree. The girth growth was measured with a centimeter tape at a definite height above ground and at a point indicated by a mark painted around the trunk.

Rainfall Data. The record of rainfall used was obtained from the college station which is about one mile from the orchard where these studies were made. Differences in rainfall between these two points should be small.

LITERATURE REVIEW

In reviewing the literature dealing with orchard soil management only that directly contributing to the subject under study was abstracted. There are many general references but few that deal with the specific problem studied. The following references cited in the bibliography were reviewed in the thesis of C. W. Tozzer at the Kansas State Agricultural College (1927) and consequently will not be reviewed again: Sievers and Holtz (1926), Sachs (1926), Scott (1916), Woodbury, Noyes and Oskamp (1917), Ballou and Lewis (1920), Murray (1921), Bosa (1923), Albrecht (1921), Albrecht and Uhland (1925), and Collison and Conn (1925).

Beaumont (1927), of Massachusetts, states that at no time did the average nitrate content of the cultivated plots reach that of the mulched plots. The time at which they most nearly converged was during the most active growing period. Mulch served to conserve moisture and stabilize the temperature.

Cullinan and Baker (1927) in Indiana in a supplementary report on work instituted by Woodbury, Noyes and Oskamp (1917) found that the root system under straw mulch is relatively shallow as compared with the depth of the total root system of trees under clean cultivation. Also, that smaller fluctuations occur in moisture and temperature throughout the year under mulch than under any other treatment.

Oskamp (1915) has reported that the soil at root depth cools off more slowly under straw mulch in the fall and warms up more slowly in the spring than under tillage. "The extreme diurnal and annual fluctuations in soil temperature noted under tillage are more equalized under straw mulch."

Prince (1918) states that the variation between soil samples from the same treatment would vary as greatly as those from different treatments.

Karraker (1927) found in his work at Kentucky that there is a wide variation in nitrates over small areas that are difficult to account for as cropping or other losses.

Cullinan (1921) at Purdue found that apple roots under mulch were much more numerous, long, slender, and fibrous. Ninety percent of the root systems of the trees under straw mulch treatment were in the first two feet of the soil. Seventy-five to eighty percent of the root systems of these trees was in the first twelve inches with a network of the fibrous roots just underneath the surface of the soil, or penetrating the straw mulch itself. Trees under straw mulch produced more fruit and made as great twig growth as those under clean cultivation over a five year period.

Davis (1927) at the Ottawa Station reporting on the ability of the apple tree to use ammonia from ammonium sulphate states his belief that there is no certain indication that apple trees are capable of using ammonia as a direct source of nitrogen; although the trees actually did better than under a no nitrogen or under a check treatment.

Waksman (1923) of the New Jersey Station during a study of ammonia accumulation in the soil found that the variability between the duplicate determinations and the difference in the amount of ammonia formed from the different nitrogenous materials are of such a nature that one may question the value of the ammonification test altogether. This is more justified when the results obtained by investigators who study the ammonification tests are compared with the results obtained with the bacterial numbers and nitrifying capacity of the same soils. These two yield uniform results.

Martin (1925) at the Cornell Station found that incorporated straw, in general, caused a decline in the amount of nitrates accumulated and that this was quantitative. After decomposing for twelve months its depressive effect upon nitrification was lessened and nitrification in fact went on more readily in the straw treated plots.

Harper (1925) finds no correlation between the ammonia content and total nitrogen content of the soils he studied; the accumulation of nitrates or the soil reaction. The ammonia content of a soil is evidently in equilibrium with the products of protein hydrolysis and nitrification, just as the nitrate content is in equilibrium with the ammonia content of the soil and the plants and micro-organisms. Ammonia content does not exceed 20 parts per million and most soils contain less than 10 parts per million. Occasionally the ammonia content of some soils may be as high as 60 to 70 parts per million. This may be due to conditions unfavorable for nitrification or too vigorous ammonification or it may be the result of these factors acting simultaneously.

Lohnis (1923) draws the conclusion that in certain cases nitrate formation in soils shows variations at different times of the year which are not caused by variations in temperature or moisture content. Fall and spring maxima and winter and summer minima have been most often observed. It is considered out of the question that these variations are caused by physical factors. Biological factors probably exert an essential influence.

Hootman and Wells (1927) working in a young Michigan orchard, that was conducted under several systems of soil management found clean cultivation and straw mulch to be the best two systems of orchard soil management. In conclusion they state that mulch seems to be as good as clean cultivation and that it cuts down the amount of money that need be invested in an orchard through its early bearing age.

Stewart (1914) in his work at the Pennsylvania Station states that moisture is conserved most efficiently by a good mulch or straw manure. In using a mulch it must be heavy enough to prevent weeds growing up through it.

DISCUSSION OF RESULTS

Throughout this discussion when possible straw mulched plots are referred to as Group A and clean cultivated plots as Group B. Figures and tables will be so located that they are available for immediate reference.

The initial sampling, March 11, was designed to give a measure of conditions as they exist in orchard soils previous to tree growth. The several plots had uniform moisture and nitrate contents, referred to by Lohnis (13) as a usual early season condition, that made a satisfactory point to begin the work. Unfortunately the weather during the latter part of March was so unseasonably warm as to start nitrification and tree activity much earlier than usual.

<u>Phase I</u>. The moisture and nitrate content under straw mulch with trees present, Plot II, was of primary importance in this work. The first analysis showed the nitrate content as 30 parts per million and the moisture to be 30 percent. It showed an increase in nitrate on March 25 and until May 2 it averaged 15 parts per million higher than plots in Group B. At this date the effect of the addition of fresh mulch was noticeable and the average nitrate content of Group A was somewhat lower than Group B. The moisture content of plot II was high throughout the season, averaging 28 percent, and was surpassed only by plot I also in Group A but with tree roots absent. The average nitrate content for the season in the first foot of Group A was higher than the same depth in Group B or in any combination of layers in Group B. See tables I, II, V, VI, and VII, and figures 3, 4, 9, 10, 11, and 14.

Plot I had an average nitrate content very close to that of plot II; but during the period of greatest tree growth it showed, as a result of removing active roots, a slightly higher nitrate content. For the same reason the moisture content of plot I was higher than plot II. Detailed data are shown in figures 5 and 9.

TABLE I

PERCENT OF SOIL MOISTURE, 1928

Plot No.	Layer in.	March 11	March 24	April 4	April 18	May 2	May 10	May 23	June 7	June 15	June 21	June 27	July 5
I	0-12	31.41	35.68	31.23	31.58	34.56	32.8	32.98	35.13	34.4	29.87	34.95	34.4
II	0-12	28.04	25.31	25.63	32.8	31.9	33.3	33.69	30.89	29.70	32.63	31.75	35.13
III	0-12	31.23	25.94	27.71	28.37	25.63	27.55	30.21	29.20	29.20	25.78	29.37	31.58
IV	0-12	33.69	21.80	23.61	27.06	21.80	26.26	29.20	29.53	27.39	23.30	26.58	26.10
V	0-12					28.21	27.71	30.21	29.87	28.04	27.06	30.89	29.70
VI	0-12					28.87	31.75	31.58	34.4	31.23	29.53	36.98	33.51
I	12-24	30.04	26.58	27.55	28.37	31.41	29.87	29.70	30.89	27.55	26.58	30.89	30.04
II	12-24	31.41	20.63	27.88	28.37	29.03	30.89	29.53	30.72	28.53	26.74	31.23	30.89
III	12-24	28.87	20.19	20.19	22.85	21.51	23.91	27.55	27.06	23.61	26.74	27.23	28.87
IV	12-24	26.26	20.48	22.40	17.92	18.48	23.46	24.22	26.58	23.15	22.25	20.77	23.61
V	12-24					23.61	26.42	26.58	28.21	22.85	24.69	27.23	26.10
VI	12-24					23.46	26.74	27.39	30.72	27.55	24.84	26.10	27.88
I	24-36	28.04	27.06	26.58	23.91	28.21	26.74	26.58	28.21	27.23	23.00	25.47	28.21
II	24-36	28.37	19.05	24.38	21.51	23.46	27.39	27.23	26.90	25.31	25.94	26.90	26.42
III	24-36	19.90	13.65	18.16	15.74	15.87	17.10	20.85	22.85	20.34	20.77	19.33	22.25
IV	24-36	20.12	16.69	19.47	14.68	13.90	19.76	17.23	20.48	17.65	17.23	17.65	22.25
V	24-36					19.90	23.91	20.48	24.38	19.90	21.21	22.40	19.33
VI	24-36					21.51	23.61	17.79	28.53	24.07	26.26	26.26	26.58

TABLE II

AVERAGE PERCENT OF MOISTURE IN FIRST THREE FEET OF SOIL, 1928

Plot No.	March 11	March 24	April 4	April 18	May 2	May 10	May 23	June 7	June 15	June 21	June 27	July 5
I	29.83	29.77	28.45	27.95	31.39	29.80	29.75	31.41	29.73	26.48	30.43	30.88
II	29.27	21.66	25.96	27.56	28.13	30.53	30.15	29.50	27.85	28.44	29.96	30.81
III	26.67	19.93	22.02	22.32	21.00	22.85	26.08	26.37	24.38	24.43	25.64	27.57
IV	26.69	19.66	21.83	19.89	18.06	23.16	23.55	25.53	22.73	20.93	21.67	23.99
V					23.91	26.01	25.76	27.49	23.60	24.32	26.84	25.04
VI					24.61	27.37	25.52	31.22	27.62	26.88	29.78	29.32

TABLE III

SOIL TEMPERATURE

Date	Mulched			Cultivated		
	Plot I	Plot II	Plot VI	Plot III	Plot IV	Plot V
	°F	°F	°F	°F	°F	°F
3/20	56	54		69	67	
3/24	58	57		68	66	
3/28	57	55		66	65	
4/2	54	52		70	69	
4/7	56	55		66	62	
4/12	57	55		65	64	
4/18	52	53		63	61	
4/24	51	48		60	59	
5/2	53	56		72	70	
5/7	55	57	62	73	70	69
5/9	54	56	56	73	70	74
5/10	59	55	58	79	74	77
5/15	60	62	63	74	70	74
5/19	60	57	60	72	70	73
5/21	62	60	61	73	71	74
5/23	65	62	68	75	72	74
5/28	68	66	75	79	76	76
6/2	66	65	66	72	70	72
6/4	64	62	68	74	73	73
6/6	63	59	63	71	69	70
6/11	66	63	67	74	74	64
6/15	67	63	66	77	77	74
6/18	69	65	69	77	77	76
6/19	70	66	70	77	77	78
6/20	72	67	71	85	85	84
6/21	71	66	71	75	75	73
6/22	72	67	71	81	81	80
6/23	72	68	72	79	79	80
6/24	69	65	69	76	76	82
6/25	70	65	70	79	79	78
6/26	72	66	71	79	80	81
6/28	72	73	72	80	76	81
6/29	72	73	72	81	76	81
6/30	73	68	72	82	78	82

TABLE III - continued

7/2	76	72	76	86	81	87
7/3	79	74	76	92	85	90
7/5	80	76	78	94	90	92
7/7	81	77	80	96	85	95
7/9	79	74	79	88	82	87
7/10	78	74	77	86	81	86
7/11	78	72	76	87	89	86
7/12	77	72	76	85	84	85
7/13	78	72	77	92	90	89
7/14	76	72	76	82	80	79
7/15	78	73	76	88	87	88
7/16	77	75	78	88	86	85
7/17	80	73	78	92	88	94
Av.	67.2	64.3	77.8	75.6	80	70.42

TABLE IV

SOIL TEMPERATURE--AVERAGES BY MONTHS

Month	Mulched			Cultivated		
	Plot I	Plot II	Plot VI	Plot III	Plot IV	Plot V
	°F	°F	°F	°F	°F	°F
March	56	54.5		66.75	65	
April	54	52.6		64.8	63	
May	59.5	59	61.6	74.4	71.44	73.88
June	69.4	65.9	69.5	76.69	73.9	77
July	78.23	73.5	70.42	77.8	75.56	80

TABLE V

NITRATES, PARTS PER MILLION, 1928

Plot No.	Layer in.	March 11	March 24	April 4	April 18	May 2	May 10	May 23	June 7	June 15	June 21	June 27	July 5
I	0-12	20	67	63	55	43	41	67	79	53	43	70	27
II	0-12	50	73	93	56	42	41	44	36	97	36	111	38
III	0-12	29	30	29	14	42	45	56	58	34	66	30	42
IV	0-12	13	19	31	18	18	36	68	77	46	56	22	51
V	0-12					51	58	64	141	60	83	114	85
VI						43	52	96	66	34	36	29	56
I	12-24	10	52	30	26	28	24	30	46	25	24	34	25
II	12-24	22	38	42	26	27	32	23	28	36	24	39	53
III	12-24	16	59	32	22	17	25	27	29	38	26	55	43
IV	12-24	14	27	27	23	45	17	47	34	34	30	36	32
V	12-24					88	20	26	35	22	28	45	28
VI	12-24					110	22	52	31	26	19	19	38
I	24-36	11	89	26	22	24	26	28	35	23	19	27	33
II	24-36	12	69	32	35	30	35	22	31	29	28	21	35
III	24-36	24	34	29	44	34	35	62	106	50	74	71	40
IV	24-36	54	23	29	35	49	29	42	37	55	45	58	41
V	24-36					85	11	26	24	15	27	33	24
VI						40	8	18	22	22	13	31	24

TABLE VI

AVERAGE NITRATES IN PARTS PER MILLION, 1928

Plot	Layer	March		April		May			June				July
No.	in.	11	24	4	18	2	10	23	7	15	21	27	5
I	0-36	14	71	40	28	32	30	42	53	27	29	44	28
II	0-36	28	60	56	30	33	36	30	32	54	20	57	42
III	0-36	23	41	30	27	31	35	42	64	41	55	52	42
IV	0-36	27	23	29	25	37	27	52	49	45	44	39	41
V	0-36					23	30	39	67	29	46	64	46
VI	0-36					25	27	55	40	27	23	26	39
I	12-36	10	69	28	24	26	25	29	41	24	22	31	29
II	12-36	17	54	37	31	29	34	23	30	32	26	30	44
III	12-36	20	47	51	53	26	30	45	68	44	50	63	42
IV	12-36	34	25	28	29	47	28	45	36	44	38	47	37
V	12-36					10	16	26	30	19	28	39	26
VI	12-36					16	15	35	27	24	16	25	31

TABLE VII

AVERAGE PARTS PER MILLION NITRATES AND RANK AT VARIOUS DEPTHS, 1928

Layer in.	Plot I P.P.M.	Plot I Rank	Plot II P.P.M.	Plot II Rank	Plot III P.P.M.	Plot III Rank	Plot IV P.P.M.	Plot IV Rank	Plot V P.P.M.	Plot V Rank	Plot VI P.P.M.	Plot VI Rank	Av. of all plots
0-12	49	4	60	2	38	6	39	5	81	1	51	3	53
12-24	30	4	32	1-2	32	2-1	31	3	27	6	28	5	30
24-36	30	4	31	3	50	1	41	2	21	5	19	6	32
0-36	36	5	41	2	40	3	37	4	43	1	33	6	38
12-36	31	4	32	3	42	1	36	2	24	5-6	24	5-6	32

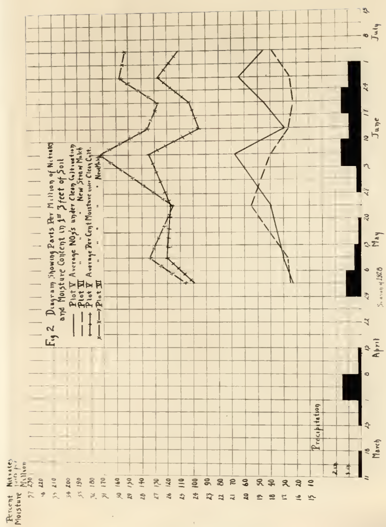


Fig 2 Diagram Showing Parts Per Million of Nitrates and Moisture Content in 1st 3 feet of Soil

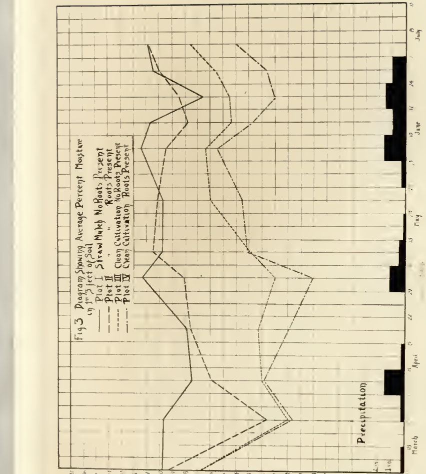


Fig 3 Diagram Showing Average Percent Moisture in 1st 3 feet of Soil
Plot I Straw Mulch No Roots Present
Plot II " " Roots Present
Plot III Clean Cultivation No Roots Present
Plot IV Clean Cultivation Roots Present
Precipitation
Percent Moisture
March
April
May
June
July

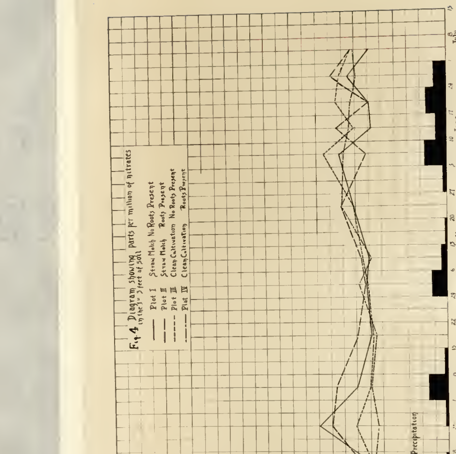


Fig. 4 Diagram showing parts per million of nitrates in the 1st 3 feet of soil
Plot I Straw Mulch No Roots Present
Plot II Straw Mulch Roots Present
Plot III Clean Cultivation No Roots Present
Plot IV Clean Cultivation Roots Present
Nitrates Parts Per Million
Precipitation
March
April
May
June
July

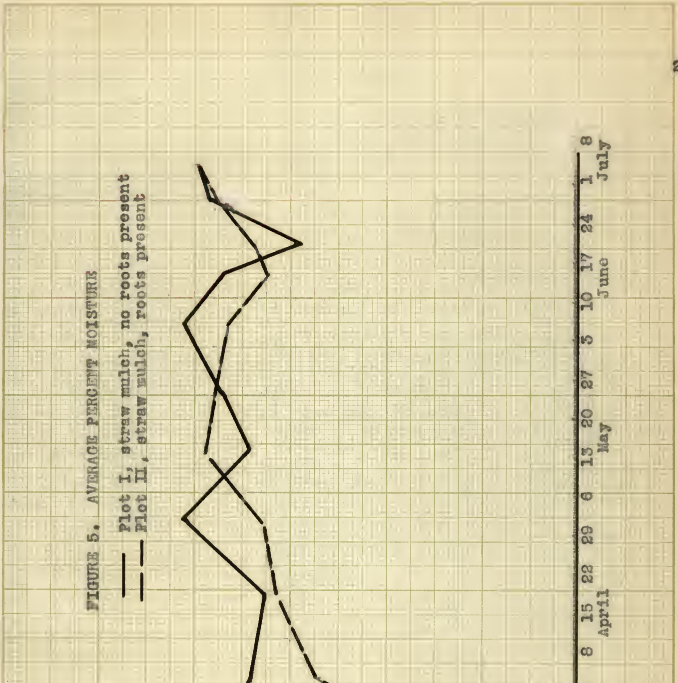


FIGURE 5. AVERAGE PERCENT MOISTURE

FIGURE 6. AVERAGE PERCENT MOISTURE

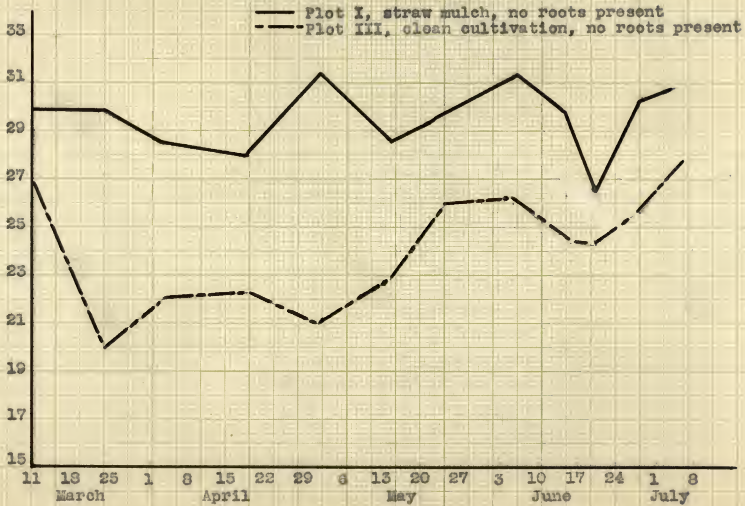


FIGURE 7. AVERAGE PERCENT MOISTURE

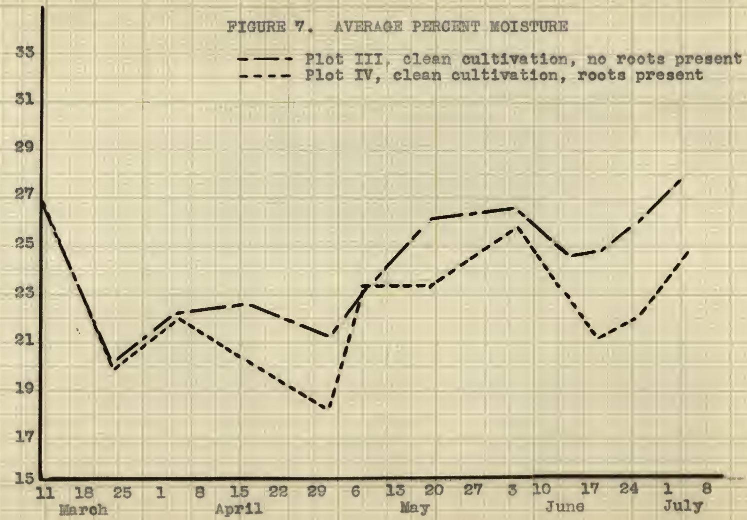
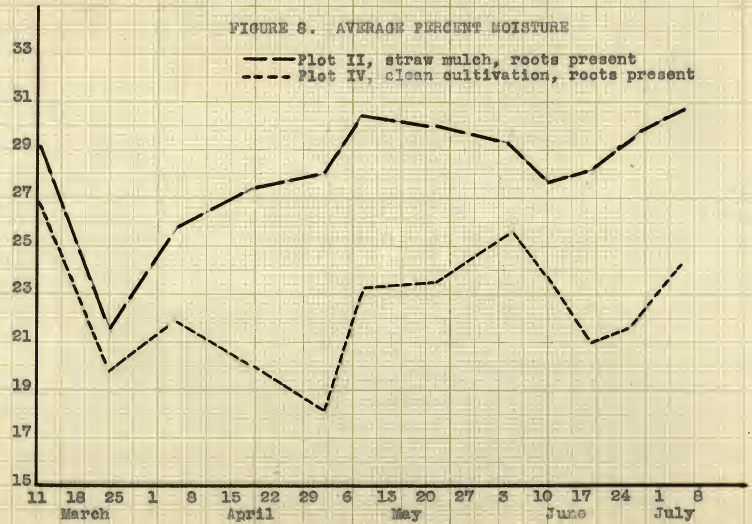


FIGURE 8. AVERAGE PERCENT MOISTURE



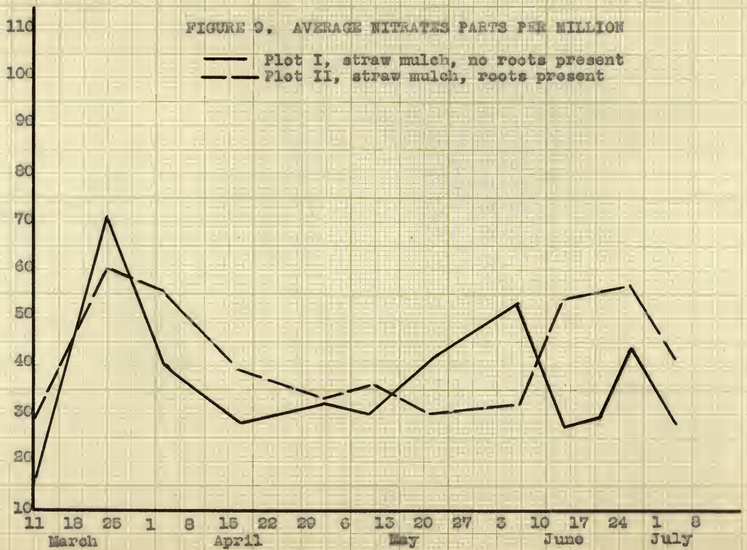


FIGURE 9. AVERAGE NITRATES PARTS PER MILLION

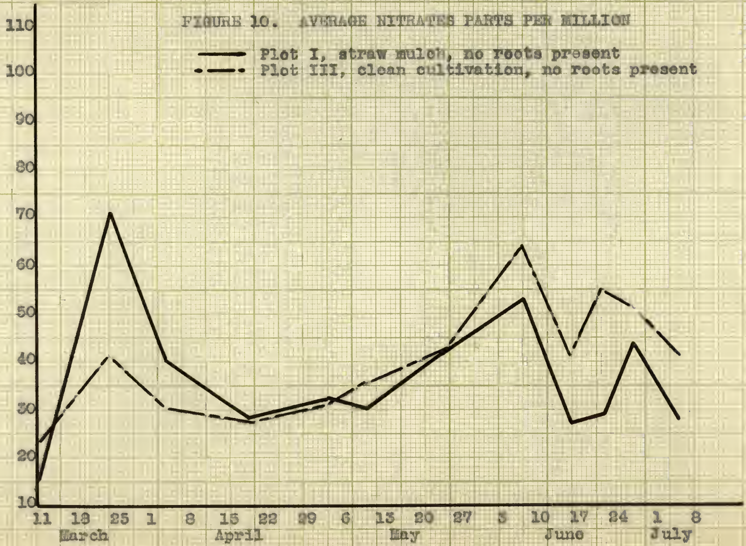


FIGURE 10. AVERAGE NITRATES PARTS PER MILLION

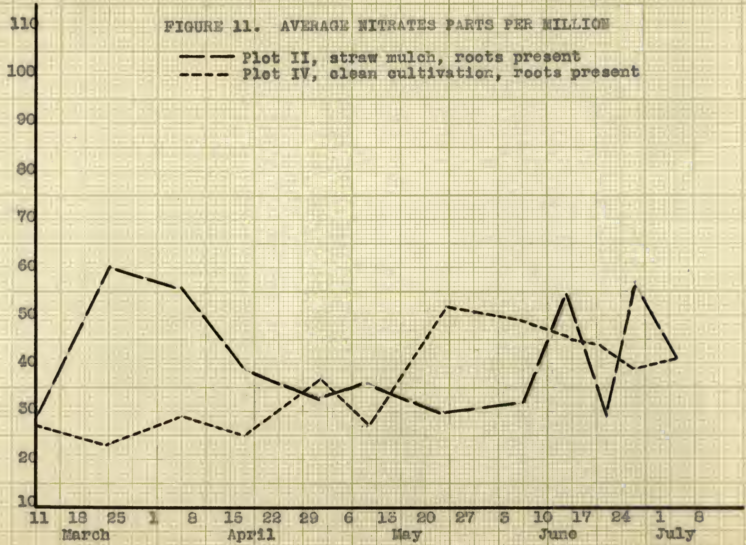
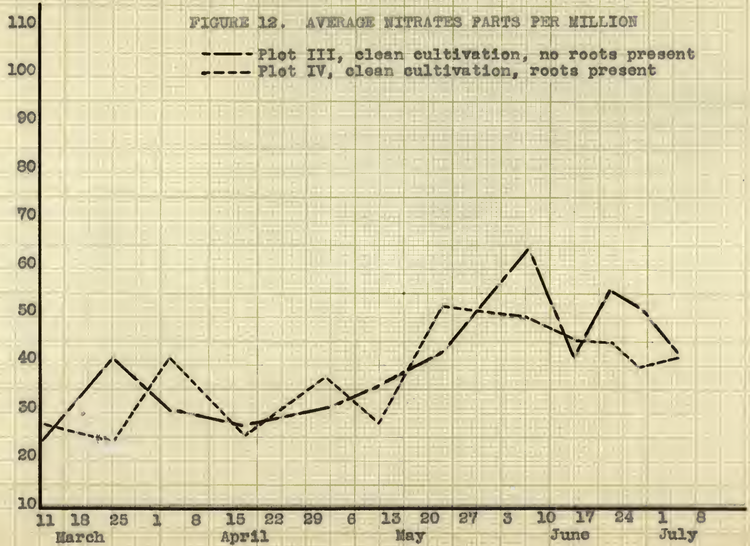


FIGURE 11. AVERAGE NITRATES PARTS PER MILLION

FIGURE 12. AVERAGE NITRATES PARTS PER MILLION



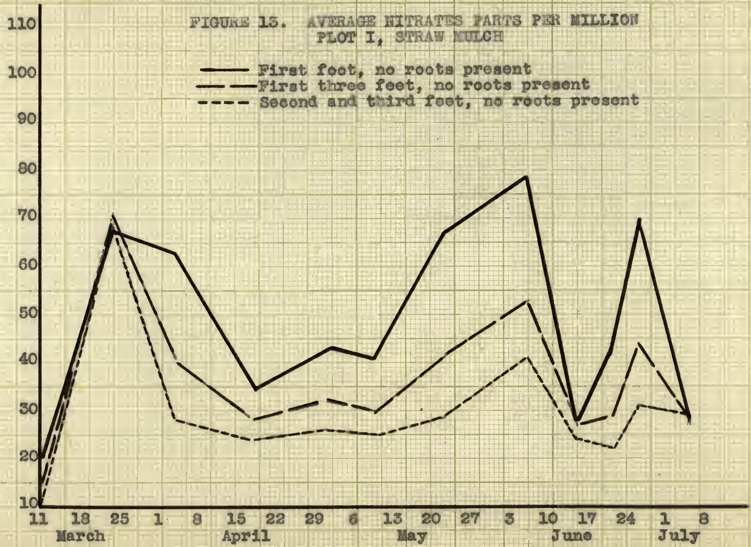


FIGURE 13. AVERAGE NITRATES PARTS PER MILLION
PLOT I, STRAW MULCH

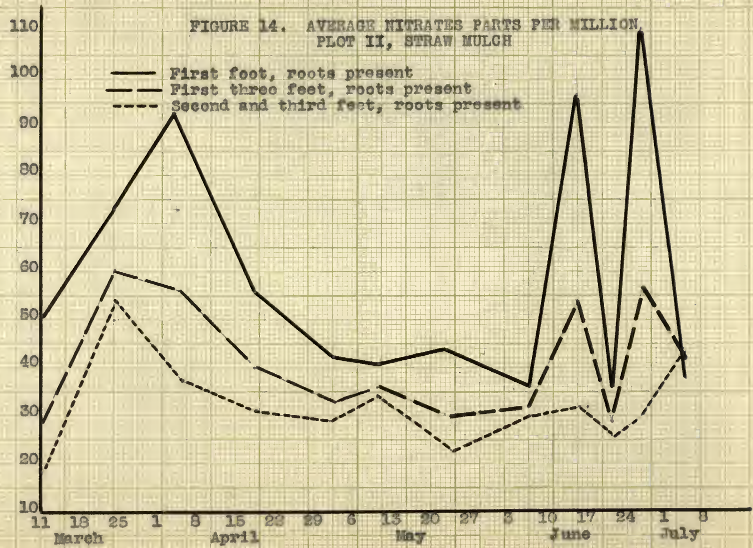


FIGURE 14. AVERAGE NITRATES PARTS PER MILLION, PLOT II, STRAW MULCH

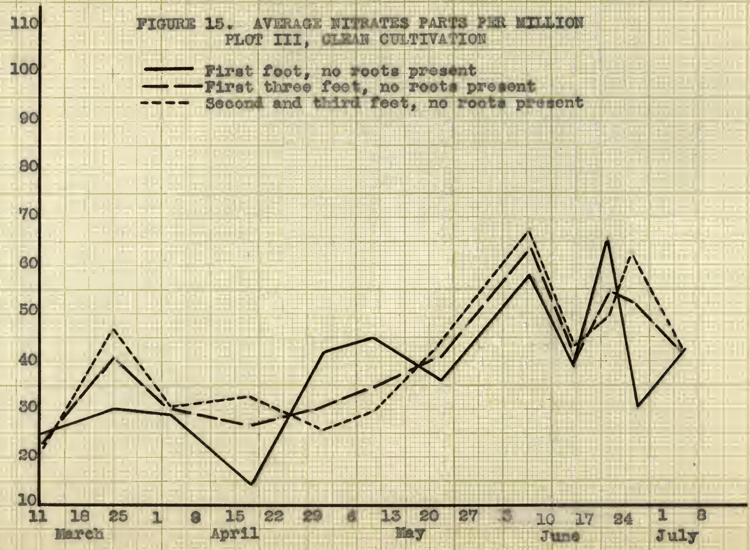
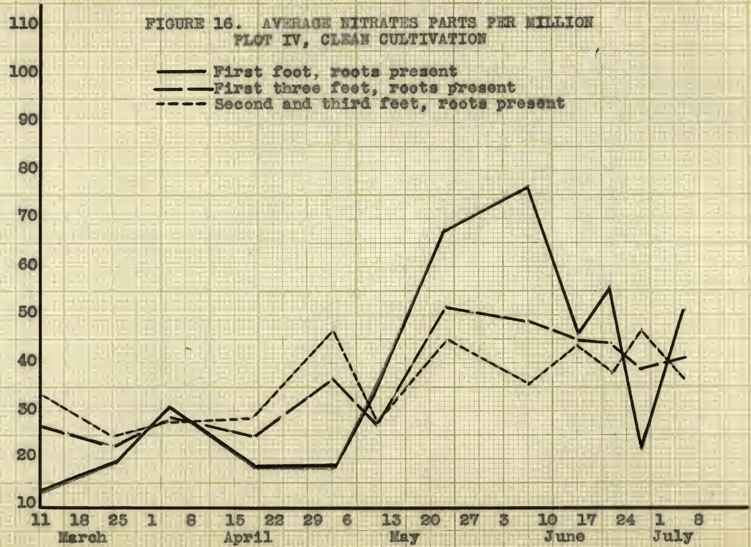


FIGURE 15. AVERAGE NITRATES PARTS PER MILLION
PLOT III, CLEAN CULTIVATION

FIGURE 16. AVERAGE NITRATES PARTS PER MILLION
PLOT IV, CLEAN CULTIVATION



Plot VI showed a depression in nitrate content that was measurable two weeks after the straw was first applied, table V, figure 2. This is the same effect recorded by Albrecht (1) but does not serve to contradict the work of Beaumont (4) who dealt with accumulative effects, although the depression may be due to the biological factors indicated by Collison and Conn (5). As shown in table I, the moisture content showed an immediate rise as the result of adding the mulched material.

Phase II. Plot IV, around a tree under clean cultivation, had a constantly lower nitrate content than did plot III; likewise the moisture content was two to four percent lower during the period of maximum tree growth. The moisture and nitrate content of plot V was similar to that of plot III. Figures 2 to 16 inclusive show the moisture and nitrate trends for the several treatments. Figures 13 to 16 inclusive give in detail the average nitrate content in plots I to IV inclusive at the various depths.

Phase III. Ammonia determinations were made as part of the study relative to the four original plots. These were carried through the greater part of the season. At the first sampling all plots showed a high ammonia content ranging from 36 to 55 parts per million. Nearly all of this ammonia was located in the first twelve inches of soil. The weather then became favorable for nitrification with the result that the ammonia disappeared. Woodbury, etal (24) and Albrecht (1) made a similar study but did not attach very much significance to this phase because tree growth is not started until conditions for nitrification are favorable. Davis (8) using ammonium sulphate as a direct source of ammonium for seedling apple trees was unable to obtain satisfactory indications of its value in promoting growth. Waksman (23) believes that as much variation may be encountered in sampling for ammonia as is obtained from several treatments. The conditions were favorable for nitrification and no significant quantity of ammonia was measured. After a number of determinations gave similar negative results, this portion of the problem was discontinued.

Phase IV. Soil temperature is an important measure of conditions as they effect nitrification. Oskamp (16) states that less fluctuations occur under straw mulch and the results obtained in this study bear out his statement. Group A averaged 10° lower than did Group B. However the average temperature under mulch is, through a great part of the season, high enough to favor nitrification. Tables III and IV give the soil temperature for the plots as recorded and the averages for each by months and for the season.

Twig measurements show that trees under straw mulch did not make as heavy an initial growth as did those under clean cultivation; however, the average total twig growth was 6 centimeters greater in plot II. The average twig growth in plot IV was 16.53 cm. as compared with 22.55 cm. in plot II. This would indicate a more vigorous condition of the trees under straw mulch. Both plots had an adequate supply of moisture and nitrates that gave no measurable difference in the amount of girth growth.

CONCLUSIONS

1. This study, in some measure, served to verify the results of both Albrecht (1, 2) and Beaumont (4). It showed that the actual conditions surrounding an experiment must be considered in order correctly to interpret the results obtained.

2. The nitrate content under straw mulch was sufficient to maintain adequate twig growth and tree vigor.

3. Soil moisture can be best maintained by an adequate straw mulch.

4. Because of the presence of a high proportion of the tree roots under mulch in the upper soil, any neglect in maintaining the mulch will result disadvantageously to the trees.

5. Soil ammonia quickly disappears after environmental conditions favorable for nitrification appear.

6. Mulch material should be renewed during late summer or winter so it will not depress the nitrate content of the soil at the time of greatest tree growth.

7. The effect of using a small quantity of a readily available nitrogenous fertilizer at the time of the addition of the mulch would be a problem worth study.

8. Frequent sampling is necessary both to secure an adequate quantity of data and to secure data less affected by abnormal weather conditions.

9. The summer of 1928 has been an unusually wet season thus reducing the need of moisture conservation.

10. Many distinct and significant trends may be entirely covered up when averages of soil nitrates are made the bases of conclusions.

11. The results of one season should not be interpreted as conclusive in regard to any method of soil treatment.

BIBLIOGRAPHY

1. Albrecht, W. A.
1922. Nitrate Accumulation under Straw Mulches. Soil Sci., 14:299-305.

2. Albrecht, W. A. and Uhland, R. C.
1925. Nitrate Accumulation under Straw Mulch. Soil Sci., 20:253-265.

3. Ballou, F. H. and Lewis, I. P.
1920. Orchard Rejuvenation in Southeastern Ohio. Ohio Agr. Exp. Sta. Bul., 399:26-32.

4. Beaumont, A. B., Sessions, A. C. and Kelly, O. W.
1927. Nitrate Accumulation under a Mulch. Soil Sci., 24:177-185.

5. Collison, R. C. and Conn, H. J.
1925. The Effect of Straw on Plant Growth. N. Y. Agr. Exp. Sta. Tech. Bul. 114.

6. Cullinan, F. P.
1921. Root Development of the Apple as Affected by Cultural Practices. Proc. Am. Soc. Hort. Sci., 1921:197-203.

7. Cullinan, F. P. and Baker, C. E.
1927. Orchard Soil Management Studies. Purdue Univ. Agr. Exp. Sta. Bul. 315.

8. Davis, M. B.
1927. The Influence of Ammonium Sulphate as a Direct Source of Nitrogen for Apple Trees. Scientific Agriculture, Sept., 1927, VIII:41-55.

9. Emerson, Paul.
1925. Soil Characteristics. McGraw Hill Book Co., N. Y., p. 99.

10. Harper, Horace J.
1925. The Ammonia Content of Soil and Its Relation to Total Nitrogen, Nitrates and Soil Reaction. U. S. D. A. Jour. Agr. Res., 31:549-555.

11. Hootman, H. D. and Wells, H. M.
    1927. A Comparison of Soil Management Methods in a Young Apple Orchard. Mich. Agr. Exp. Sta. Quarterly Bul., 9:133-137.

12. Karraker, P. E.
    1927. Variable Occurrence of Nitrates in Soils. Soil Sci., 24:259-262.

13. Lohnis, F.
    1924. Influence of Time of Year on Nitrate Formation. E. S. R., 50:17.

14. Martin, T. L.
    1925. Effect of Straw on Accumulation of Nitrates and Crop Growth. Soil Sci., 20:159-164.

15. Murray, T. J.
    1921. The Effect of Straw on the Biological Soil Process. Soil Sci., 12:233-260.

16. Oskamp, J.
    1915. Soil Temperatures as Influenced by Cultural Methods. Jour. Agr. Res., V:173-177.

17. Prince, Arthur.
    1918. Variability of Nitrate and Total Nitrogen in Soils. Soil Sci., 15:395-405.

18. Sachs, Ward H.
    1926. Effect of Cultivation on Moisture and Nitrates of Field Soil. Ark. Exp. Sta. Bul. 205.

19. Scott, H.
    1921. The Influence of Wheat Straw on Accumulation of Nitrates in Soil. Jour. Amer. Soc. Agron., 13:233-258.

20. Sievers, F. J. and Holtz, H. F.
    1926. The Significance of Nitrogen in Soil Organic Matter Relationships. Wash. Agr. Exp. Sta. Bul. 206:1-43.

21. Stewart, J. P.
1915. Experimental Results in Young Orchards in Pennsylvania. Pa. Sta. Bul. 134:20.

22. Tozzer, C. W.
1927. The Moisture and Nitrate Content of Orchard Soils as Influenced by Straw Mulches, Clean Cultivation, and Cover Crops Plowed under at Different Times. Unpublished Master's Thesis, Kansas State Agricultural College Library.

23. Waksman, Selman.
1923. Microbiological Analysis of Soil as an Index of Soil Fertility. Soil Sci., 14:49-65.

24. Woodbury, C. G., Noyes, H. A. and Oskamp, Joseph.
1917. Soil Management Investigations in Young Apple Orchards. Purdue Agr. Exp. Sta. Bul. 205.