SOME FACTS ABOUT SOIL MANAGEMENT IN A NEW YORK ORCHARD

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SOME FACTS ABOUT SOIL MANAGEMENT
IN A NEW YORK ORCHARD

R. C. COLLISON AND J. D. HARLAN

ABSTRACT

For the past 5 or 6 years a bearing orchard of mixed varieties on
gravelly loam soil in Ontario County has been observed with regard
to soil moisture, nitrates, temperatures, yield, and growth of the
trees.

The orchard has received consistent soil management, especially
while young, but has received no commercial fertilizer. The regular
use of red clover seeded every 2 years has built up an important
humus and nitrogen reserve in the soil, which is reflected in regular
and fairly uniform bearing.

None of the systems of sod management of the soil during 5
years has yet broken down these reserves to a point where it is
manifested in decreased yields or growth.

Nitrates are unusually abundant in the soil of the plats. Altho least
in the soil of the grass sod plat, this nutrient is still unusually high
in amount. The very abundant nitrate in the cultivated-clover plat
indicates that a superabundance of this nutrient may be formed at
the expense of soil organic matter and also may be far in excess of
the tree's requirements. Adequate provision for the growth of cover
crops to absorb this surplus should be made.

The amount of moisture removed by a cover crop growing on the
soil is comparatively unimportant, providing adequate moisture is
left for the trees. No evidence of greater moisture deficiency was
noted in this orchard on any of the plats even during the dry seasons
of 1930 and 1931.

Temperatures are higher in cultivated soil which may increase
biological reactions and consequently organic matter destruction.
This again indicates the importance of seeding a cover crop in the
cultivated orchard about the middle of June.

Shading the soil surface and prevention of free air diffusion are
factors apparently operative in reducing water loss from soil growing
a cover crop. These factors tend to compensate, in part at least, for the additional water lost thru transpiration.

Yields and terminal growth have not yet been reduced on the plats in sod and only in 1931 was there any indication, and this only on the grass plat, of any influence of the sod on foliage and fruit color.

The results of these observations indicate that the kind of soil management to follow in an orchard depends on the type, structure, and depth of soil; probably to some extent on the variety of apples; and on the previous treatment of the soil. The time to build up a reserve of humus and nitrogen is when the trees are young. This constitutes good insurance against lowered yields during the later life of the orchard.

The important point in feeding an orchard is to have sufficient available nitrogen present when needed without furnishing a super-abundance at the expense of soil organic matter reserves or at an unnecessary money outlay. The optimum of available nitrogen may be present in a soil even under grass sod receiving no commercial nitrogen, if the soil has been built up to a high level of organic matter. This level, however, is probably of short duration, depending on conditions in any particular orchard.

INTRODUCTION

In the following account there are presented some points or experiences in the soil management of a New York orchard. The orchard referred to is located in western New York, and an experimental portion is used here to illustrate some of the more fundamental considerations to be kept in mind in successful management of an orchard soil. The orchard is not "just any" orchard, but is one which has presented some rather unusual features which it is felt amply justify such a report.

The orchard first came under the authors' observation 6 years ago. Search was being made at that time for several orchards sufficiently uniform in variety and tree size and in rather starved condition to be used in an experimental comparison of six or seven forms of nitrogenous fertilizers. The description of the orchard which follows shows that it falls far short of meeting these requirements, but does possess other characteristics which arrest attention.
THE ORCHARD SITE

The orchard in question is situated in the southern edge of the famous drumlin area of western New York. These drumlins are low-lying hills of rather unusual shape running parallel to each other with undulating plains or terraces between them. Altho the drumlins themselves have probably not been modified by water, the terraces between them have been. In this region these terraces are made up of sands and gravels.

The orchard in question is located on one of these plains or terraces on a soil classified under the old Ontario County soil survey as Dunkirk gravelly loam. This soil type is a rich brown gravelly loam with a depth of 6 to 10 inches. The subsoil is also a gravelly loam in texture similar to the surface soil. This gravelly character persists for many feet below the surface and gives exceptionally good drainage. The surface drainage in the orchard is also good as the land slopes downward rather abruptly to the west and gently to the east. The surface and upper subsoil contain a large amount of small cobblestones, some of which are of limestone derivation, but many of quite different materials transported from regions much farther north. This soil grows excellent general farm crops, including alfalfa and clovers.

The orchard thus meets the most fundamental requirement of an orchard soil, namely, a soil with good surface drainage, a texture which insures good root aeration, and a subsoil which allows excess water to drain away from the tree roots. Since the soil is one containing a large proportion of sand and gravel, that is a light loam, soil organic matter, always a problem in fertility maintenance, is of even greater importance on account of this light texture. The following account shows how this humus problem has been met.

SOIL MANAGEMENT IN EARLY YEARS

After the young trees were set, the land was intercropped for several years with various farm crops. It was recognized, however, that this practise should not be continued too long if the soil was to be built up for future high fruit production. So after several years a cover crop or green manure system was established which seems to have been particularly effective on this soil.

Red clover was the green manure crop used and has been continued practically up to the present time. It has been handled in the following manner: In early spring the soil is disked up and a good seed-bed established. In June or July red clover is seeded. This crop is
left on the land the remainder of the current year and all the next season. The second spring following seeding the crop is turned under and the land cultivated and reseeded to red clover. This system has been followed systematically, the clover crop being mowed when necessary and left on the surface during the growing season. In the early years some poultry manure was spread in the orchard, but not a great deal and for only a few years.

It will be seen that this system is not the orthodox method of handling orchard cover crops which was used for many years in western New York. Legume crops as a rule make comparatively small growth the first season, especially when they are not seeded until July or August as has been the usual practise in the past. It has further been considered essential to get the crop under in early spring, so that very little organic matter has been added to the soil. Even when the tops show considerable growth, root development has not reached its full extent, and one of the chief values of legumes lies in their root development which may amount to as much as one-third the total weight of the plant. In early spring when top growth is still small this ratio of roots to tops in well established plants may be much nearer one to one. This method of handling red clover in this orchard allows full development of the root system, so that a maximum amount of organic matter is left in the soil. The reseeding after plowing down prevents the winter leaching of plant nutrients from the soil and the winter cover helps to hold the snow. Furthermore, red clover residues, with their narrow ratio of nitrogen to carbon, decompose readily when plowed down and their nitrogen is made available to the trees without the factor of bacterial competition which might deplete the soil of available nitrogen if non-leguminous crops were incorporated with soil at the beginning of tree growth in the spring.

PLAN OF PRESENT EXPERIMENT

When this orchard first came under observation in 1926 its exceptional character caught the attention of the writers. At that time its unusually fine foliage and its new growth were especially marked. Inquiries of the owner concerning its performance brought out the fact that, altho the orchard had been a fair producer, it was felt that it should do considerably better.

This fact, together with the profusion of foliage, good growth, and rather poor fruit color, seemed to indicate overfeeding in spite of the
fact that the orchard had never received any commercial fertilizers. The trees in the orchard are not all of equal age. Some of them are about 20 years old and the remainder 25 or 26 years old. In the older portion the trees are crowding rather badly at present which is reducing their production. Even in the younger portion some of the trees are practically touching.

Ten rows in the younger portion of the orchard were selected in 1927 for some experimental work. It seemed of practical value to determine what factors were responsible for the unusual character of the orchard and perhaps at the same time to find means of increasing its production somewhat.

The following plan gives the “layout” of the plats and the varieties.

<table>
<thead>
<tr>
<th>Plat No.</th>
<th>Varieties*</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>B R R R B X S H Sw M G B B W G</td>
</tr>
<tr>
<td></td>
<td>X R R B X S X S H G M X W G W</td>
</tr>
<tr>
<td>5</td>
<td>B R B R B X S X G M X M B W G</td>
</tr>
<tr>
<td></td>
<td>R B R B X S X S X G M B W G W</td>
</tr>
<tr>
<td>4</td>
<td>B G B R B X S H G M G M B W G</td>
</tr>
<tr>
<td></td>
<td>R B R B X S X S H G M B W G X</td>
</tr>
<tr>
<td>3</td>
<td>B R B R B X S H G M G M B W G</td>
</tr>
<tr>
<td></td>
<td>A B R B G S X S H G M B X G W</td>
</tr>
<tr>
<td>2</td>
<td>B R B R B X S H G M G M B W G</td>
</tr>
<tr>
<td></td>
<td>A B R B R X X S H G M B X G W</td>
</tr>
<tr>
<td>1</td>
<td>B R B R B X S G X M G M B W G</td>
</tr>
<tr>
<td></td>
<td>A B R B X B X S H G M B W G W</td>
</tr>
</tbody>
</table>

*The letters indicate as follows:
A = Alexander  G = Greening  M = McIntosh  S = Spy  Sw = Sweet
B = Baldwin  H = Hubbardston  R = Rome  W = Wealthy  X = Missing

This plan shows a comparatively small block of orchard which nevertheless contains nine different varieties. Much might be said here about pollination conditions in such an orchard, since besides these nine varieties in this portion of the orchard there are also Twenty Ounce trees in quantity a little farther north, but this report deals with soil factors so that the subject of pollination is left with only a reference.
The Alexander trees blighted badly for several years so that they were finally removed in 1928 and 1929. The spaces for the most part were filled in with young trees.

The following treatments were laid out in this block:
Plat 1. Original plan of red clover seeded in summer, left over the succeeding year and incorporated with the soil the second spring; then reseeded.
Plat 2. Red clover.
Plat 3. Alfalfa.
Plat 4. Grass sod.
Plat 5. Sweet clover.

The plan was to compare these legumes in permanent seedings with the regular procedure which had been followed in the orchard for a period of years. The grass sod plat was used as a means of checking too luxuriant growth with a view of greater fruitfulness. The seeding mixture per plat consisted of timothy, 10 pounds; Kentucky blue grass, 5 pounds; and red top, 8 pounds. All seedings were made in the spring of 1927. They came along well so that in 1928 they all covered the ground. The crops were mowed when necessary, but no material was removed.

In 1929, the red clover was still an excellent stand and the grass sod was also excellent. The alfalfa was only fair so some reseeding was done. The sweet clover was good for the first two years, but in 1929 it had to be completely reseeded. Very little natural reseeding took place which was contrary to what was hoped for. In fact sweet clover has been the least satisfactory of the legumes in this particular orchard. Altho this land is very excellent alfalfa land, the sweet clover seeding in 1929 was practically a failure. This may have been partly due to mowing the crop too closely during dry weather. Red clover and alfalfa maintained themselves exceptionally well for several years. At this date, after 5 years the stand of alfalfa is still quite good, while the red clover has almost disappeared. Sweet clover practically disappeared in 1929, while the grass sod is still very good.

Alfalfa, therefore, has been the most satisfactory of the three legumes when handled in the way described and has required the least attention.

Aside from these seedings and an occasional mowing in spring and summer, no other treatment has been given the soil. No manure or fertilizer has been used on the plats.
EFFECT OF MANAGEMENT ON SOIL NITRATES

The vigor with which nitrification goes on in a soil as measured by its content of nitrates during the growing season is a measure of the soil's organic matter or humus content, the available character of this organic matter, and the supply of nitrates available for tree growth.

During the summer of 1929 nitrate analyses were made on soil samples taken from some of the plats in order to determine the relative abundance of this nutrient under the different soil conditions. The results are shown in Table 1.

The cultivated soil contained the most nitrate throughout the season, except on September 9 which date for the other three plats may have marked the beginning of a secondary rise which is often true of seasonal nitrate fluctuations. There may have been a lag of this secondary maximum in the cultivated soil. Nitrates were surprisingly abundant in all these plats, reaching rather unusual figures for the mid-July maximum.

The nitrates under grass sod were exceptional, this nutrient usually being almost absent under sod during the growing season when the grass is active. This fact shows that material for nitrification was unusually abundant in this soil, furnishing an ample nitrate supply for both grass and trees. The nitrate present in these soils to a considerable extent represented a surplus over the amount necessary for growth. This surplus was very high over practically the whole growing season, especially in the clean-cultivated soil. Thus, on July 17, there was present in this plat nitrate equivalent to over 500 pounds of nitrate of soda per acre 7 inches. A week later this amount had dropped to a little over 200 pounds, probably due to a fall of 1.4 inches of rain on July 24. Some of this nitrate which must have leached out of the surface 7 inches was probably still available to the roots of the trees, but some of it was undoubtedly beyond the reach of absorbing roots which are comparatively near the surface. In the case of the plats with the cover crops, this July maximum was not very apparent, nitrate production being much more uniform, and the reduction after the hard rain of July 24 was comparatively slight.

When a cover crop occupies the soil, two effects become apparent. The absorbing roots of the crop keep soil nitrates at a much lower and more uniform level and the presence of these roots helps to prevent the loss of nitrates from leaching after heavy rains. Therefore, altho
### Table 1.—Nitrates in Parts per Million of Dry Soil in Orchard Soil Under Various Covers in 1929.

<table>
<thead>
<tr>
<th>Plat and Cover</th>
<th>May 31</th>
<th>June 10</th>
<th>June 21</th>
<th>July 1</th>
<th>July 9</th>
<th>July 17</th>
<th>July 25</th>
<th>Aug. 2</th>
<th>Aug. 12</th>
<th>Aug. 20</th>
<th>Aug. 31</th>
<th>Sept. 9</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, cultivated*</td>
<td>38.0</td>
<td>86.0</td>
<td>132.0</td>
<td>120.0</td>
<td>200.0</td>
<td>192.0</td>
<td>79.0</td>
<td>96.0</td>
<td>100.0</td>
<td>83.0</td>
<td>73.0</td>
<td>70.0</td>
<td>105</td>
</tr>
<tr>
<td>2, red clover</td>
<td>6.0</td>
<td>46.0</td>
<td>33.0</td>
<td>57.0</td>
<td>60.0</td>
<td>46.0</td>
<td>53.0</td>
<td>24.0</td>
<td>37.0</td>
<td>41.0</td>
<td>48.0</td>
<td>105.0</td>
<td>46</td>
</tr>
<tr>
<td>3, alfalfa</td>
<td>6.2</td>
<td>41.0</td>
<td>23.0</td>
<td>70.0</td>
<td>84.0</td>
<td>69.0</td>
<td>52.0</td>
<td>24.0</td>
<td>41.0</td>
<td>48.0</td>
<td>73.0</td>
<td>104.0</td>
<td>53</td>
</tr>
<tr>
<td>4, grass sod</td>
<td>6.0</td>
<td>20.0</td>
<td>18.0</td>
<td>34.0</td>
<td>48.0</td>
<td>35.0</td>
<td>26.0</td>
<td>12.0</td>
<td>25.0</td>
<td>20.0</td>
<td>36.0</td>
<td>53.0</td>
<td>28</td>
</tr>
</tbody>
</table>

*This is plowed up and reseeded to red clover every two years, and therefore differs from the ordinary cultivated orchard which is cultivated each spring and early summer after which some cover crop is sown or weeds allowed to grow.
cultivation results in an abundant supply of nitrates, they are produced at the expense of soil organic matter and may be formed in amounts much in excess of plant needs. High nitrates in the cultivated plat were in part due no doubt to a nitrification of the red clover residues incorporated in early spring which fact also shows the importance of working an orchard soil early and of getting the soil covered again as soon as possible with a growing crop to utilize this nitrate surplus. If the crop is seeded June 10 to 20, it may make sufficient growth to be an important factor in absorbing and conserving this nitrate surplus which is at its maximum in mid-July.

The unusual nitrate supply in these soils furnishes an adequate explanation why there has been such excellent wood and foliage growth in these trees and also why there has been for 5 years almost no apparent diminution in foliage growth and even some increase in yield of the trees in grass sod. The high humus level of this soil has withstood the nitrate drain on it due to sod and the sod in turn has reduced the supply of available nitrates to a level more conducive to fruitfulness.

If plat 1 had been cultivated during successive years as is customary under this system of management instead of every other year, even more nitrate might have been formed and also more lost from the soil. During the alternate years when red clover occupies the land, nitrogen is being conserved, both by fixation of atmospheric nitrogen and prevention of losses by absorption of the surplus by the plants. Lysimeter investigations at this Station have shown that, altho legumes increase the nitrogen of soil by fixation, they as well as non-legumes, use large quantities in growth, thus temporarily depleting the soil of its nitrates.

**EFFECT OF MANAGEMENT ON SOIL MOISTURE**

/ It is always a question as to what extent any growing crop in an orchard competes with the trees for moisture. Has the soil supplied enough water for both trees and cover crop, is an important question, especially during a season when rainfall is below normal. It might be expected that, altho a growing cover crop removes more soil moisture than would be lost from bare soil, this might be partially compensated for by less evaporation from the soil due to shading and lowering of soil temperature and by the cover crop furnishing an obstruction to the drying action of wind. The relation of moisture to nitrate formation is also important.
Table 2.—Percentage Moisture Content of Soil Under Various Covers on Oven-dry Basis, 7-inch Depth, 1929.

<table>
<thead>
<tr>
<th>Plat</th>
<th>May 31</th>
<th>June 10</th>
<th>June 21</th>
<th>July 1</th>
<th>July 9</th>
<th>July 17</th>
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<th>Aug. 20</th>
<th>Aug. 31</th>
<th>Sept. 9</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, cultivated</td>
<td>15.1</td>
<td>13.0</td>
<td>12.0</td>
<td>11.6</td>
<td>13.8</td>
<td>11.9</td>
<td>17.6</td>
<td>11.6</td>
<td>14.8</td>
<td>11.2</td>
<td>12.3</td>
<td>16.5</td>
<td>13.5</td>
</tr>
<tr>
<td>2, red clover</td>
<td>11.9</td>
<td>9.2</td>
<td>6.6</td>
<td>7.9</td>
<td>12.1</td>
<td>8.8</td>
<td>17.6</td>
<td>10.4</td>
<td>13.2</td>
<td>9.7</td>
<td>11.6</td>
<td>17.5</td>
<td>11.4</td>
</tr>
<tr>
<td>3, alfalfa</td>
<td>14.0</td>
<td>10.7</td>
<td>8.2</td>
<td>9.8</td>
<td>12.7</td>
<td>9.0</td>
<td>16.5</td>
<td>10.6</td>
<td>13.2</td>
<td>11.6</td>
<td>12.3</td>
<td>16.7</td>
<td>12.1</td>
</tr>
<tr>
<td>4, grass sod</td>
<td>12.5</td>
<td>9.1</td>
<td>6.2</td>
<td>8.5</td>
<td>12.6</td>
<td>10.1</td>
<td>16.4</td>
<td>11.5</td>
<td>14.0</td>
<td>11.6</td>
<td>11.3</td>
<td>17.4</td>
<td>11.8</td>
</tr>
</tbody>
</table>
The moisture figures given in Table 2 show that water was more abundant in the cultivated soil throughout most of the 1929 season to the extent of 1 to 2 per cent. However, if it can be shown that the cover crop plats have had sufficient water for maximum growth and production of both cover and trees, this excess moisture in the cultivated plat fails to have any practical significance, except in seasons with rainfall below normal.

Growth, foliage characters, and fruit production on these plats show that there has been no greater lack of soil moisture on one plat than on another during these 5 years. Even on the alfalfa and grass sod plats where moisture would be expected to be deficient if on any plats, no greater deficiency is apparent. Even in 1930 and 1931 when the rainfall was below normal, there was no apparent advantage of higher soil moisture ascribable to cultivation.

It is interesting that soil moisture was somewhat higher under alfalfa than under either red clover or grass sod, notwithstanding the fact that alfalfa produced a larger amount of dry matter than either of the other two crops. Alfalfa is a plant whose roots tap subsoil moisture which is beyond the reach of shallower rooted crops. This property of alfalfa conserves the water in the upper soil horizons.

It seems reasonable to assume from these results that at least under normal rainfall much of the fear that trees will suffer from moisture deficiency due to cover crop growth is ungrounded. They indicate further that deep-rooting plants, such as alfalfa, apparently conserve the moisture of the upper soil where most of the active tree roots are located.

In this connection there is another point which should be remembered. Lysimeter investigations at this Station have shown that plants which are plentifully supplied with nitrogen produce their dry matter with less water consumption than those receiving less nitrogen. This fact makes it possible that the trees on the sod plats might have suffered more than they did from lack of moisture during the dry seasons of 1930 and 1931 if they had not been so abundantly supplied with nitrogen from the soil itself.

EFFECT OF MANAGEMENT ON SOIL TEMPERATURE

The point has already been made that due to shading by the soil cover lower soil temperatures may prevent such rapid evaporation of water and thereby partially compensate for greater water absorp-
tion by the cover crop itself. No soil thermographs were available for this work so the soil temperatures of the four plats were taken just after midday with common soil thermometers. These were taken each time that soil samples were taken for moisture and nitrates. The thermometers were temporarily covered with caps to keep them from the direct rays of the sun. Ten thermometers uniformly distributed over the plat were inserted in the soil to a depth of 4 inches and left while the soil samples were being taken. They were then read and the results for the plat averaged. The readings are given in Table 3.

The mean temperature figure indicates that for the period between May 31 and August 20 the soil of the cultivated plat had the highest midday temperature and the alfalfa plat the lowest. The red clover and grass plats were intermediate and very similar to each other. The difference between the cultivated plat and the alfalfa plat was 7°. Furthermore, the alfalfa plat soil was about 3.5° cooler than the other cover crop plats. These temperatures were about in proportion to the height and density of the cover which indicates that shading of the soil by the cover is certainly a factor in determining its temperature and consequently in moisture loss from soil. This is further shown by the rise in soil temperatures which takes place after the crop has been cut. Therefore, this must be a partially compensating factor, at least in soil moisture loss.

The obstruction which the cover crop offers to moist air replacement by diffusion and circulation must also be a compensating factor here. These temperature differences must have some important bearing on biological activities which may in part be responsible for differences in soil nitrates. It is also probable that the higher summer temperatures in cultivated land help in the destruction of soil organic matter to some extent.

EFFECT OF MANAGEMENT ON YIELDS

In Table 4 are presented the yields of apples on the five plats for the 5 years 1927 to 1931, inclusive. Altho there are a number of other varieties on the plats, the data are for McIntosh, Baldwin, and Greening. It will be noted that in the mean yields for the 5 years those for the cultivated-clover plat are lowest for all three varieties. This cannot be said to be due to any lack of soil nitrogen or moisture since both were uniformly higher in this plat than in any other. It is
Table 3.—Midday Soil Temperatures in Degrees Fahrenheit Under Various Covers.

<table>
<thead>
<tr>
<th>Plat</th>
<th>May 31</th>
<th>June 10</th>
<th>June 21</th>
<th>July 1</th>
<th>July 9</th>
<th>July 17</th>
<th>July 25</th>
<th>Aug. 2</th>
<th>Aug. 12</th>
<th>Aug. 20</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, cultivated</td>
<td>74.3</td>
<td>76.5</td>
<td>77.1</td>
<td>87.2</td>
<td>82.0</td>
<td>75.0</td>
<td>78.0</td>
<td>69.0</td>
<td>76.0</td>
<td>70.0</td>
<td>76.5</td>
</tr>
<tr>
<td>2, red clover</td>
<td>69.0</td>
<td>69.0</td>
<td>72.4</td>
<td>83.0</td>
<td>77.0</td>
<td>72.0</td>
<td>76.0</td>
<td>68.0</td>
<td>76.0</td>
<td>69.0</td>
<td>73.1</td>
</tr>
<tr>
<td>3, alfalfa</td>
<td>67.7</td>
<td>61.8</td>
<td>69.0</td>
<td>77.0</td>
<td>76.0</td>
<td>70.0</td>
<td>72.0</td>
<td>64.0</td>
<td>73.0</td>
<td>64.0</td>
<td>69.5</td>
</tr>
<tr>
<td>4, grass sod</td>
<td>71.0</td>
<td>72.2</td>
<td>74.5</td>
<td>76.0</td>
<td>77.0</td>
<td>72.0</td>
<td>74.0</td>
<td>69.0</td>
<td>74.0</td>
<td>68.0</td>
<td>72.8</td>
</tr>
<tr>
<td>Plat</td>
<td>McIntosh</td>
<td>Baldwin</td>
<td>McIntosh</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cultivated-clover</td>
<td>28.0</td>
<td>3</td>
<td>9.3</td>
<td>74.0</td>
<td>8</td>
<td>9.3</td>
<td>17.0</td>
<td>3</td>
<td>5.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Red clover</td>
<td>31.5</td>
<td>3</td>
<td>10.5</td>
<td>73.5</td>
<td>8</td>
<td>9.2</td>
<td>23.5</td>
<td>3</td>
<td>7.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alfalfa</td>
<td>34.3</td>
<td>3</td>
<td>11.4</td>
<td>50.5</td>
<td>8</td>
<td>6.3</td>
<td>20.5</td>
<td>3</td>
<td>6.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grass sod.</td>
<td>26.5</td>
<td>3</td>
<td>8.8</td>
<td>74.0</td>
<td>8</td>
<td>9.3</td>
<td>18.5</td>
<td>3</td>
<td>6.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweet clover</td>
<td>33.5</td>
<td>3</td>
<td>11.2</td>
<td>33.5</td>
<td>6</td>
<td>5.6</td>
<td>16.0</td>
<td>3</td>
<td>5.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Plat</th>
<th>McIntosh</th>
<th>Greening</th>
<th>McIntosh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivated-clover</td>
<td>45.0</td>
<td>3</td>
<td>15.0</td>
</tr>
<tr>
<td>Red clover</td>
<td>48.5</td>
<td>3</td>
<td>16.2</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>58.0</td>
<td>3</td>
<td>19.3</td>
</tr>
<tr>
<td>Grass sod.</td>
<td>50.5</td>
<td>3</td>
<td>16.8</td>
</tr>
<tr>
<td>Sweet clover</td>
<td>72.0</td>
<td>3</td>
<td>24.0</td>
</tr>
</tbody>
</table>

probably rather a superabundance of nitrates which has caused somewhat less yields.

Baldwin has produced better in grass sod than in any other cover crop, while the McIntosh and Greening plats in sweet clover are a little higher in yield, altho not significantly so. It should be remembered that the sweet clover remained down only during 1927 and 1928 after which the plat grew up to grass and weeds.

Altho the differences in yield among the plats are not striking, except perhaps that of Baldwin in grass sod and all three varieties in the cultivated-clover plat, it is significant that under the conditions in this orchard no material falling off in yields occurred when the soil was seeded to grass and left in sod for 5 years.

This seems to indicate that there may not only be some varietal differences in response to various methods of orchard soil management, but also that the effect of any system of management depends in great measure on the condition of the soil and previous treatment in any particular orchard. Laying down an orchard to grass sod may be a good practise if its fertilizer needs are met, and under conditions such as prevailed in this orchard additional nitrogen may be detrimental rather than beneficial to production, for some years at least.
1927 to 1931.

### 1929

<table>
<thead>
<tr>
<th>McIntosh</th>
<th>Baldwin</th>
<th>Greening</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total, bu.</strong></td>
<td><strong>No. trees</strong></td>
<td><strong>Mean, bu.</strong></td>
</tr>
<tr>
<td>29.3</td>
<td>3</td>
<td>9.7</td>
</tr>
<tr>
<td>36.3</td>
<td>3</td>
<td>12.1</td>
</tr>
<tr>
<td>31.3</td>
<td>3</td>
<td>10.4</td>
</tr>
<tr>
<td>30.3</td>
<td>3</td>
<td>10.0</td>
</tr>
<tr>
<td>31.5</td>
<td>3</td>
<td>10.5</td>
</tr>
</tbody>
</table>

### 1931

<table>
<thead>
<tr>
<th>Baldwin</th>
<th>McIntosh</th>
<th>Greening</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total, bu.</strong></td>
<td><strong>No. trees</strong></td>
<td><strong>Mean, bu.</strong></td>
</tr>
<tr>
<td>151.6</td>
<td>8</td>
<td>19.0</td>
</tr>
<tr>
<td>144.9</td>
<td>6</td>
<td>24.2</td>
</tr>
<tr>
<td>137.3</td>
<td>6</td>
<td>22.9</td>
</tr>
<tr>
<td>196.9</td>
<td>7</td>
<td>28.1</td>
</tr>
<tr>
<td>159.1</td>
<td>7</td>
<td>22.7</td>
</tr>
</tbody>
</table>

**EFFECT OF SOIL MANAGEMENT ON TREE GROWTH**

In order to gain some idea as to whether the various methods of soil management had an appreciable effect on vigor as measured by twig growth, terminal measurements were taken on McIntosh, Greening, and Baldwin at the end of the 1931 season. Three years’ growth, namely, that for 1931, 1930, and 1929, were measured separately on 25 different terminals on each of three trees of each variety. In all, therefore, 75 measurements were made on each tree, or 225 for each variety on each plat. The results are summarized in Table 5.

It was thought that terminal growth would give some measure of the general effect of soil management on the trees, especially that of the nitrate supply. It was further expected that laying down the trees to grass sod would reduce the supply of available nitrogen which would be reflected in terminal growth. Altho as may be noted in Table 1, the soil under grass contained the least amount of nitrates, the terminal growth of the trees on the grass plat was not reduced during the 3 years. In fact the longest terminal growth of all three varieties was made by the trees on the grass plat, altho if variability
Table 5.—Growth Measurements of Terminals in Inches for 1931, 1930, and 1929.

<table>
<thead>
<tr>
<th>Year</th>
<th>Cultivated-clover</th>
<th>Red clover</th>
<th>Alfalfa</th>
<th>Grass</th>
<th>Mean of 75 terminals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tree 1</td>
<td>Tree 2</td>
<td>Tree 3</td>
<td>Tree 1</td>
<td>Tree 2</td>
</tr>
<tr>
<td>1931</td>
<td>4.9</td>
<td>4.9</td>
<td>4.2</td>
<td>5.4</td>
<td>4.9</td>
</tr>
<tr>
<td>1930</td>
<td>10.1</td>
<td>10.3</td>
<td>8.2</td>
<td>9.4</td>
<td>8.4</td>
</tr>
<tr>
<td>1929</td>
<td>10.8</td>
<td>10.5</td>
<td>10.3</td>
<td>9.9</td>
<td>8.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>McIntosh</td>
<td></td>
</tr>
<tr>
<td>1931</td>
<td>5.6</td>
<td>7.0</td>
<td>4.2</td>
<td>7.1</td>
<td>6.0</td>
</tr>
<tr>
<td>1930</td>
<td>11.7</td>
<td>11.8</td>
<td>8.8</td>
<td>11.3</td>
<td>12.8</td>
</tr>
<tr>
<td>1929</td>
<td>10.1</td>
<td>9.7</td>
<td>9.7</td>
<td>11.1</td>
<td>8.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Greening</td>
<td></td>
</tr>
<tr>
<td>1931</td>
<td>5.9</td>
<td>6.0</td>
<td>6.1</td>
<td>9.3</td>
<td>9.2</td>
</tr>
<tr>
<td>1930</td>
<td>7.9</td>
<td>10.3</td>
<td>10.1</td>
<td>8.5</td>
<td>8.6</td>
</tr>
<tr>
<td>1929</td>
<td>7.5</td>
<td>10.2</td>
<td>9.6</td>
<td>9.9</td>
<td>9.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Baldwin</td>
<td></td>
</tr>
<tr>
<td>1931</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1930</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1929</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Means</td>
<td></td>
</tr>
<tr>
<td>1931</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1930</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1929</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
were considered, the differences would probably not be statistically significant. This is difficult to account for since additional nitrogen supply usually results in longer terminals.

The seasons of 1930 and 1931 were abnormally dry ones in which trees in many fruit growing sections in the East suffered badly from drought. Altho these two seasons were also dry ones in western New York, this fact is not reflected in reduced terminal growth of one plat over another in this orchard, nor did the trees apparently suffer from lack of moisture from any observational standpoint. This may be due to several causes in this particular orchard. In the first place, the soil is a gravelly loam to considerable depth, which, with its good drainage, encourages deep rooting of the trees. Further, it has been built up in its organic matter content, as has already been noted, and this has increased its water-holding capacity. Its high nitrification with consequent abundant nitrate supply favors moisture conservation. Last, and perhaps not least, this soil is filled with stones of various sizes which may serve to break capillarity with the surface layer of soil and thus conserve the moisture of lower soil depths, altho capillary moisture movement apparently does not take place thru long vertical distances.

DISCUSSION

One of the outstanding points about this orchard has been its general appearance during the past 5 years. In 1926, its unusual thrift and healthy appearance arrested the attention. Size of leaf, density of foliage, new growth, all indicated strikingly that the trees were luxuriating in a superabundance of food. This was further borne out by the size of fruit, its general lack of color, and the fact that it was not as abundant as the condition of the trees warranted. Every fruit grower is familiar with the appearance of trees in grass sod which is receiving no additions of manure or fertilizer. The scant, rather yellow foliage which is dropped early in the fall, the short stubby new growth, the frequent changes in bark color, and the rather scarce, small but highly colored fruit, are all unmistakable signs that the trees are losing out in their competition with the grass for soil nitrates. In this orchard, altho the grass sod has now been down 5 years without any additions whatsoever of fertilizers or farm manures, none of the above effects could be observed until the season of 1931. That year, for the first time, a slight falling off in foliage
characters was noted on the grass plat, while the fruit had somewhat more color.

This may be more marked during succeeding years, but of course can be taken care of by a small application of nitrogenous fertilizer. These facts serve to indicate that an orchard soil properly built up in humus content while the trees are young and when maximum green manure crops can be grown is in condition to stand severe drains on its reserves in later years.

It is also significant that the plat which has been in alfalfa for 5 years, the plat in red clover for 3 or 4 years, and even the plat which grew sweet clover successfully only 2 years are at present showing none of the signs which indicate nitrogen starvation.

It should be noted further that the lowered reserve of plant nutrients in the soil is not the only bad effect which results from neglect of orchard soils. The practises which result in lowered reserves of nutrients also deplete the soil of another valuable ingredient, namely, organic matter, which is reflected in bad physical condition, especially on the heavier soils. This in turn means soils more difficult to work, with poorer drainage, less moisture-holding power, and poorer root aeration.

The additional facts that neither growth nor fruit yields have significantly fallen off during the 5 years on the sod plats make it clear that the early soil management in the orchard has had an important effect in building up humus supply. This humus supply has meant greater nitrogen supply, more reserves, and greater moisture conservation.

The results of the experimental work in this orchard indicate not only that it is unusual in its soil and soil management features, but also the reasons why it is unusual. Many New York orchards on well-drained soil, especially if the trees are young, may be built up in their soil reserves by similar management. After the trees are large, and especially if they were too closely planted, the growing of adequate green manuring crops is a much more difficult matter.