FIVE YEARS' RESULTS WITH FERTILIZERS IN THREE HUDSON RIVER VALLEY APPLE ORCHARDS

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FIVE YEARS' RESULTS WITH FERTILIZERS
IN THREE HUDSON RIVER VALLEY
APPLE ORCHARDS

H. B. TUKEY AND L. C. ANDERSON

ABSTRACT

The results of five years of fertilizer applications in three Hudson River Valley apple orchards are reported. The orchards represent three periods in the life of an orchard, and are located on the three soil types representative of the major apple interests of the Valley, namely, (a) young McIntosh orchard at Kinderhook on unfertile Hoosic sandy loam, (b) a young bearing McIntosh orchard at Upper Red Hook on relatively unfertile Dutchess slate loam, and (c) a mature bearing Yellow Newtown orchard at Viewmont on moderately fertile Dutchess silt loam.

Applications consisted of liberal amounts of nitrate of soda, super phosphate, and muriate of potash, alone and in combination, according to the diagrams given for each orchard, applied in early spring just as the first green of the buds was showing.

The young orchard at Kinderhook was kept thoroly tilled and was sown regularly to a cover crop. The bearing orchards at Upper Red Hook and at Viewmont were cultivated to the degree that practical orchardists often call "clean cultivated" but which would not satisfy the requirements of an experimental clean-cultivated orchard. The weed growth served as cover crop.

The results of the applications were as follows:

1. No appreciable gain in growth from fertilizers was observed in the clean-cultivated young orchard at Kinderhook, altho an increasing improvement in the cover crop was noted on each plat receiving nitrogen.

The authors wish to express their appreciation of the splendid cooperation of Gordon Mead and Dewitt C. Moore and the many helpful courtesies extended by their families.
2. A slight increase in size of tree in the poorly cultivated young bearing orchard at Upper Red Hook followed nitrogen applications, together with darker green foliage, a slightly greater set of fruit in the "on" year and a corresponding decrease in the "off" year, a small increase in total yield, no effect upon size or color of fruit, and a questionable value to the orchardist.

3. An increase in size of tree in the poorly cultivated mature bearing orchard at Viewmont was obtained from nitrogen applications, accompanied by darker green foliage, greater terminal growth, very heavy set of fruit resulting in small size and poor color, increased set in the "on" year and corresponding decline in the "off" year, and a financial loss to the orchardist.

No effects were noted from super phosphate or muriate of potash, either alone or in combination, in any of the orchards.

The outstanding effect of fertilizers has been the greatly increased set of fruit when nitrogen has been applied, and the subsequent effect of heavy cropping upon the trees and upon future crops.

The small increase in size of tree and improvement in the cover crop on nitrogen fertilized plats offers the potential possibility, however, for larger crops in future years.

The cleaner cultivated the orchard, the less response to nitrogen fertilizers; while the less cultivated the orchard, the greater the response.

The difference in results depending upon the age and the condition of the orchard indicates the inadvisability of making any blanket recommendations in regard to fertilizer applications.

Fertilizer applications by themselves are not shown to be the panacea of orchard ills in the Hudson River Valley that they have often been considered.

Fertilizers are shown to be one of a number of considerations in working out a system of orchard management.
INTRODUCTION

It has long been recognized that soils of the Hudson River Valley are quite different from those of western New York. They are acid soils, they are not limestone soils, and they belong to those soils which are commonly called "light", referring not to color so much as to physical characteristics and fertility. Practically all of the fertilizer experiments with apple trees in New York, however, have been made on the heavy soils of the western part of the state, characteristically high in fertility, and for these reasons the fertilizer work here reported was undertaken in 1923. The first five years having been completed, the records are reported, which altho preliminary and more or less in the nature of a progress report, are of sufficient significance to justify their presentation.

As a preliminary step, it may not be out of place to review the soils of eastern New York so that the principles which have guided in planning the work and the significance of responses on different soil types may be fully appreciated. For a more detailed discussion of this interesting subject the reader is referred to Bulletin No. 563 of this Station¹ from which the following information is taken in part.

THE FORMATION OF HUDSON RIVER VALLEY SOILS

Altho at first glance the soils of the Hudson River Valley appear complex and disorganized, a little attention to their origin and organization will show that the fruit soils belong largely to a few main classes and that they follow an organized scheme. First of all, the fruit soils are formed for the most part from the decomposition of underlying rocks, so that the underlying material represents the type from which the surface soils have been formed. Since there are relatively few limestone formations and since the rock formations of the region are largely slates and shales, with some granite, gneiss, and schist, it can be understood why the soils are generally acid and why they are not high in fertility.

Beginning at the southern extremity of the middle Hudson River Valley, near the Highlands, are to be found some of the oldest rocks known which are designated as having been formed during the pre-Cambrian period. Like those of similar type in the Adirondack Mountains far to the north, they are hard materials—mostly granite, gneiss, and schist. The soils that have resulted from the breaking down and

disintegration of these rocks are known as the Gloucester series, characterized by yellowish-brown to brown surface soil and a brownish-yellow to yellow subsoil. They are found at good altitude with rolling to rough topography so that drainage is good. Furthermore, they are not fertile soils and are likely to be shallow at the higher elevations.

Materials from this old rock formation which have been carried down by water and deposited in benches, bars, and terraces are known as belonging to the Merrimac series. They, too, must in consequence be low in fertility. Fortunately, the soils of these two series are not extensive in this region, comprising only 3.7 per cent of Dutchess County and 4.4 per cent of Orange County, and appearing for the most part at the higher altitudes back from the river near the granite-flanked Fishkill Mountains on the east side of the river and near the Highlands on the west side, tho some spots will be found near the New England line. It will be recalled that soils of these types are typical of New England.

The main floor of the valley is made up of shale soils formed from the decomposition of the underlying shales and slates, known as the Dutchess series. Far below this mantle of shale and slate materials are the old hard rocks that have been forced to the surface in the Adirondack Mountain regions and in the Highlands. Covered deeply as they are by shale and slate-forming materials deposited during the Ordovician age at a much later time, they play no part in the soil building of the main valley floor.

The slate and shale soils of the Dutchess series are extensive, constituting 51.4 per cent of the area of Dutchess County and 48.5 per cent of the area of Orange County. They are light yellowish-brown and the subsoils yellow to grayish-yellow, usually with slate and shale fragments and with outcroppings of rock. Occurring mostly several hundred feet or more above the river, they provide good air drainage as well as water drainage. The higher portions will be found to be shallow and with frequent slate or shale outcroppings, giving rise to phases known as Dutchess stony loam and Dutchess slate loam. These are the typical upland apple soils, usually found 3 to 15 miles back from the river and seldom close to it.

At slightly lower elevations, but still several hundred feet above the river, are found the heavier phases of the Dutchess series, such as the Dutchess silt loam. These constitute some of the better soils of eastern New York, and tho not of high fertility, they are relatively strong soils and are well adapted to fruit production. It is the higher proportion
of this type soil that gives the lower section of the middle Hudson River Valley region the reputation of consisting of heavy soils, whereas the soils are no different than those of the same type found in other sections, tho to be sure in smaller areas.

Where the Dutchess series of soils have been carried by water and deposited in benches, bars, and terraces they are designated as belonging to the Hoosic series. Their fertility is not high, and since they often contain a high proportion of coarse gravel and sand, they are frequently drouthy. This type is early, quick, and very easily handled. The preponderance of this type in the upper section of the middle Hudson River Valley region has given rise to the statement that soils of this section are "light" and quite unlike those of the rest of the valley, while as a matter of fact the same type may be found in all sections of the valley, tho usually in less extensive areas. In the vicinity of Kinderhook and north to Albany a type known as the Hoosic sandy loam has been used extensively for fruit growing, primarily apples.

A closely related series of similar nature, except that it contains limestone fragments, is the Dover series, of small extent, constituting only 7.3 per cent of Dutchess County. Tho excellently adapted to fruit, the Dover soils are too small in area and often too far from fruit centers to be of any great concern.

A third main series of soils, relatively small in extent but important as fruit soils, are those belonging to the Hudson series, which are for the most part heavy clays found close to the Hudson River and comprising 4.3 per cent of Dutchess County. At a more recent time, either when the glaciers were retreating or when a tongue of the sea invaded the land, the present water course of the Hudson River was an inland lake. Into this lake flowed the sediment-carrying streams from surrounding regions. Further back from the lake were deposited the gravels and the coarse sands as the streams slowed up in their course, until finally, when the more quiet waters of the lake were reached, the finer particles of silt and clay settled out. In consequence the clays of the Hudson series are found close to the present water course and at low elevation, usually under 200 feet above sea level because the level of the lake was not above this point.

Because they are heavy and in low positions, the Hudson clays are inclined to be poorly drained and difficult to work. The surface soil is yellowish-brown to brownish-drab, clearly separated from a yellowish-drab subsoil, becoming mottled at greater depths and finally dark blue. They contain a small amount of lime material, mostly in the
subsoil. These clays are the ones used in the brick industry along the Hudson River.

To take a cross sectional view from west to east, beginning at the Hudson River, the soils close to the river are frequently a heavy clay or a clay loam belonging to the Hudson series, with occasional appearances of fine sand. Back from the river at higher altitudes appear ridges of the Dutchess series with heavier soils in the lower places between the ridges. Along old water courses are the Hoosic soils, consisting of coarser materials as the distance becomes greater away from the present Hudson River. Above the 200-foot line no Hudson clays will be found, the Dutchess series gradually dominating the bulk of the area.

**LOCATING THE ORCHARDS**

With these fundamental facts in mind, three orchards were located on the three representative soil types, namely, the Hoosic sandy loam at Kinderhook, the Dutchess silt loam at Viewmont, and the Dutchess slate loam at Upper Red Hook; the first representing the water-laid level benches of more sandy soil found in various places thruout the valley; the second, the heavier, better apple land at lower elevation; and the last, the upland apple soil well back from the river.

In addition the orchards selected represented three stages in the life of an orchard, the one at Kinderhook being newly planted, the one at Upper Red Hook just coming into bearing, and the one at Viewmont being in full bearing.

**REPORTS FROM OTHER SOURCES**

Without going into detail, it may not be out of place to mention the general trend of orchard fertilizer experiments in America. In the main, fertilizers are held to be of value on thin or wornout land, or in orchards which are making weak growth. At the same time well-cared-for orchards on good land under proper methods of clean cultivation and cover cropping seldom show favorable responses to fertilizer applications. If sod orchards were to be considered in this connection, it would be apparent at once, however, that there is hardly a single exception to the general rule that sod orchards respond markedly to nitrogen fertilizers.

The results of 25 years in an apple orchard at Geneva,\(^3\) have led to the conclusion that, under the particular set of conditions that prevail there, the application of fertilizers has been a waste of time and money.

The orchard is located on strong fertile land, the trees are not crowded, the orchard has been thoroly cultivated, a cover crop has been sown annually, and the trees have had the best of care. After 25 years the small differences that do exist between various treatments, small tho they are, are observed to have been present in somewhat the same degree even before any fertilizer applications had been made.

From the discussion of the formation of Hudson River Valley soils and their nature, it can be seen that dissimilar results might be secured without conflicting with the general principles of orchard fertilization.

INVESTIGATION
YOUNG McINTOSH ORCHARD AT KINDERHOOK
LOCATION AND METHOD OF HANDLING

As has already been indicated, the site selected for a young orchard at Kinderhook was chosen for its recognized low fertility. It lies just off the New York-Albany Post Road some 5 miles east of the Hudson River within the corporate limits of Kinderhook. The land is as level as a floor and is ideally suited to an orchard experiment. The soil is very uniform. Lying fallow, it grows no strong sod, a sparse stand

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**Fig. 1.—Site of Young Mcintosh Orchard at Kinderhook.**
Note the general low fertility of the soil and the sparseness of vegetation on fallow land.
of goldenrod and a variety of other weeds being characteristic of the soil type, as shown in Fig. 1. It is designated as Hoosic sandy loam. Without cultivation, crops do very poorly. On the other hand, with continuous and frequent cultivation, many good crops can be grown. This is one of the odd and interesting features of this soil type, so that it has been studied with reference to the micro-organisms\(^4\) growing in it and with reference to humus, moisture, and temperatures thru the season. Aside from presenting some interesting correlations, however, no complete explanation has been made.

![Fig. 2.—Young McIntosh Orchard at Kinderhook at Beginning of Experiment.](image)

An orchard of young McIntosh trees (Fig. 2) selected for their uniformity was planted in the spring of 1924. The trees were planted

25 feet apart in rows 50 feet apart. Between each row, serving as a buffer row, were planted alternately Rome Beauty and Cortland trees, thus providing for cross pollination as well as to separate the plats. The trees were pruned to whips so that trunk measurements could be made more easily. The season following planting was ideal from the standpoint of a young orchard, so that no trees were lost. Furthermore, it has not been necessary to replace a single tree in the subsequent five years of the test, a fact which illustrates the general care given the orchard and the uniformity which exists.

Fertilizer applications were made beginning the first season in accordance with the accompanying diagram (Fig. 3), in the excessive amounts of 5 pounds of nitrate of soda, 5 pounds of 15 per cent super phosphate, and $2\frac{1}{2}$ pounds of potassium chloride to each tree, keeping the applications well back from the trees and applying them in a circle about them. The arrangements of plats provided for three repetitions of each treatment, with seven checks so located as to be staggered across both series of plats from one end to the other in a system which has since been reported upon as highly satisfactory from both the mathematical and practical viewpoint. In subsequent years applications were made early in the season just as growth was starting, usually the first or second week in April.

The orchard was kept thoroly cultivated by disking following each heavy rain to break a crust which usually forms on this soil type and which somehow seems

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to check growth. Usually, the orchard has been cultivated from four
to six times between early spring and the time a cover crop has been
sown in early July. A mixed cover crop of buckwheat and golden mil-
let has been especially successful in this orchard, producing an abun-
dance of humus which has been knocked down by dragging in late fall,
but which has not been thoroly worked into the soil until the following
spring. No plowing has been done since the ground was broken prepa-
ratory to setting the trees.

The orchard has as yet borne no fruit, but measurements have been
made of twig growth and trunk diameters, the diameters being mea-
sured in thirty-seconds of an inch, 1 foot above the ground. Observa-
tions have been made for color differences of foliage and of cover crops
on each plat.

RESULTS OF FERTILIZER APPLICATIONS

Since there are no crop records upon which to report, discussion of
this orchard must center upon growth. Altho the lack of yield records
may seem to minimize the results, actual records of growth are perhaps
more significant in telling what a tree is doing than are records of yield
because fruit yield is dependent upon such factors as frost, pollination,
winter injury, and the like, whereas in the increase in trunk diameter
of a tree the record of its life is systematically laid down. Further-
more, it is as important to understand fertilizer effects in the orchard
before it has reached bearing age as it is to understand what the re-
sponses may be when measured in terms of yield.

The increase in trunk diameters for the five years are given in Table
1. Figured in percentage increase over the size of the trees when
planted, the trees which have received no fertilizer stand midway in
gain between those receiving a complete fertilizer, which lead, and those
receiving phosphoric acid alone, which are lowest in the series. At the
same time the plats receiving both nitrogen and phosphoric acid and
those receiving both phosphoric acid and potash are not far different
than the check plats. In short, the indications are that, altho there
are differences between the various plats, they are not correlated with
fertilizer treatment.

Perhaps more conclusive than the general average for each treatment
is the evidence presented in Table 2, where the plats are shown dia-
gramatically as they appear in the field, with the percentage increase
in trunk diameter given for each plat. Here it will be observed that
there is a uniform declining growth from Plat 11 thru Plat 6, regardless
<table>
<thead>
<tr>
<th>Plat No.</th>
<th>Treatment</th>
<th>Number of trees</th>
<th>Diameter in 32nds of an inch</th>
<th>Average percentage increase</th>
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<td></td>
<td></td>
<td>Spring, 1924</td>
<td>Spring, 1929</td>
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<td>Complete fertilizer</td>
<td>5</td>
<td>93</td>
<td>420</td>
</tr>
<tr>
<td>15</td>
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<td>92</td>
<td>435</td>
</tr>
<tr>
<td>22</td>
<td>Complete fertilizer</td>
<td>5</td>
<td>89</td>
<td>426</td>
</tr>
<tr>
<td>3</td>
<td>Nitrogen and phosphoric acid</td>
<td>5</td>
<td>97</td>
<td>421</td>
</tr>
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<td>369</td>
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<td>5</td>
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<td>416</td>
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<td>18</td>
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<td>6</td>
<td>Phosphoric acid and potash</td>
<td>5</td>
<td>93</td>
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<td>Phosphoric acid and potash</td>
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<td>101</td>
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<td>382</td>
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<td>350</td>
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<td>21</td>
<td>No fertilizer</td>
<td>5</td>
<td>64</td>
<td>322</td>
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### Table 2.—Percentage Increases in Trunk Diameters Arranged with Reference to Field Location, McIntosh Orchard, Kinderhook, 1924 to 1928.

<table>
<thead>
<tr>
<th>Plat No.</th>
<th>1</th>
<th>2</th>
<th>3 Nitrogen and phosphorus</th>
<th>4 None</th>
<th>5 Complete</th>
<th>6 Phosphorus and potash</th>
<th>7 Phosphorus</th>
<th>8 None</th>
<th>9 Nitrogen and phosphorus</th>
<th>10 None</th>
<th>11 None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilizer</td>
<td>None</td>
<td>Nitrogen</td>
<td>None</td>
<td>Complete</td>
<td>Phosphorus and potash</td>
<td>Phosphorus</td>
<td>None</td>
<td>Nitrogen</td>
<td>Nitrogen and phosphorus</td>
<td>None</td>
<td></td>
</tr>
<tr>
<td>Percentage increase in trunk diameter</td>
<td>305</td>
<td>321</td>
<td>336</td>
<td>341</td>
<td>351</td>
<td>276</td>
<td>312</td>
<td>343</td>
<td>352</td>
<td>355</td>
<td>372</td>
</tr>
<tr>
<td>Percentage increase in trunk diameter</td>
<td>315</td>
<td>298</td>
<td>343</td>
<td>372</td>
<td>305</td>
<td>279</td>
<td>270</td>
<td>285</td>
<td>361</td>
<td>403</td>
<td>378</td>
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<tr>
<td>Fertilizer</td>
<td>Phosphorus</td>
<td>None</td>
<td>Phosphorus and potash</td>
<td>Complete</td>
<td>Nitrogen and phosphorus</td>
<td>None</td>
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<td>Phosphorus and potash</td>
<td>None</td>
<td>Complete</td>
<td></td>
</tr>
<tr>
<td>Plat No.</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
<td>19</td>
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<td>21</td>
<td>22</td>
</tr>
</tbody>
</table>
of fertilizer treatment. At this point there is a sudden increase and then a uniform decline thru Plat 1. The differences thus seem again more clearly correlated with soil variation than with any fertilizer applications.

**DISCUSSION**

One of the conclusions that anyone who has studied this orchard must be forced to admit is the lack of uniformity in what seems to be as ideally uniform land as could be desired. The senior author, in planting the trees, helped in digging the holes and noted any soil differences. In Plat 21 the soil in which one tree was set appeared to have more humus and better physical texture. This point was noted, and subsequent measurements show that this tree has made a greater growth than any other tree in the orchard, save one. It is possible to think of a dozen factors which might be responsible for this situation, such as the presence of a haystack many years previous, yet the land has lain idle for many years and there are no records of uniform treatments. The fact remains that there is variability in what appears to be an exceptionally uniform piece of land.

Thruout the five-year period the trees have made very good growth on all plats, increasing over 300 per cent in trunk diameter, and have been thoroly satisfactoyr from the orchardist's viewpoint, so that it would not be thought of as necessary to improve upon. Observation during the five years has shown no color improvement of the foliage where nitrogen has been applied, such as is often seen in orchards where a response is found, nor has there been any noticeable effect from any of the other fertilizers.

The only differences that have been seen have been in the color and amount of the cover crops on the various plats. Where nitrogen has been applied, there has been a general improved growth and a darker green color each succeeding year, being hardly appreciable the first year and quite prominent the fifth. Incidentally, millet makes an admirable crop by which to measure color differences, the color changes extending over a wide range and being quite striking.

For those who care to carry the discussion further, it may be remarked that differences in growth have been compared with a calculated check for each plat and the differences thereby become smaller rather than greater, still further showing the lack of response to fertilizer applications.

What the future of this orchard may be must wait for later years
to tell. So far as the early life of the orchard is concerned, however, the trees would have been just as well off had no fertilizer been applied. Yet from the increased growth of the cover crop and since the soils of the Hoosic series are noticeably low in humus, it may be that as time goes on the plats which have received fertilizers may respond indirectly to the benefits from increased humus supply. Or, when the trees begin to fruit, the fertilizers may affect the crop thru the set of fruit, or by altering the nutritional balance just enough to give significant differences. It must be admitted, however, that up to this point fertilizer applications have been a waste of time and money.

MATURE BEARING YELLOW NEWTON ORCHARD AT VIEWMONT
LOCATION AND METHOD OF HANDLING

The second orchard, at Viewmont, is located just west of the church and along the lane in rear of the farm buildings on the Dewitt C. Moore place, a mile east of the Hudson River, on Dutchess silt loam.

![Image: Mature Yellow Newtown Orchard at Viewmont](image_url)

Fig. 4.—Mature Yellow Newtown Orchard at Viewmont.

That the soil type selected is thoroly representative of this heavier and more fertile phase of the Dutchess series is evidenced by the fact that soil samples from this orchard are permanent record in the vaults
of the Bureau of Soils at Washington, D. C. The trees, about 25 years of age (Fig. 4) when the fertilizer experiment was begun, are 35 feet apart each way, and do not touch as yet. No fertilizer applications had been made since the orchard was planted. Altho somewhat un-uniform in soil from the standpoint of an ideal fertilizer experiment, the situation is surprisingly good in comparison with most Hudson Valley orchards on this soil type, the uniformity of the trees indicating the general uniformity of conditions.

Fertilizer applications were made at the rate of 8 pounds of nitrate of soda, 8 pounds of 16 per cent super phosphate, and 4 pounds of potassium chloride, according to the plat arrangement shown on the diagram (Fig. 5), each treatment repeated twice. Buffer rows divided the plats and received half-tree fertilizer applications equivalent to the adjacent plats, thus eliminating any possibility of variations due to competition from neighboring trees. Applications were made in a circle about the tree and well out from the trunk at a time in spring when the buds were just starting to break, usually the first week in April, and since fertilizers were also applied to adjacent guard rows, the applications approximated coverage of the space between trees on all sides.

The orchard was kept clean cultivated after the manner followed by many orchardists, but not in a manner that would satisfy clean cultivation in experimental work. In

Fig. 5.—Diagram of Experiment at Viewmont.
actual operation the orchard was plowed about the last week in May, working both ways with a harrow two weeks later, and working again both ways with a harrow about the last of June. Weed growth was strong so that there was a heavy cover crop in the orchard by the end of the season. Therefore, no cover crop as such was sown.

Records of growth were made by calipering the trunk diameter in inches at 1 foot and at 3 feet above the ground. Yield was secured in bushel baskets for each tree at harvest time, and altho, because of the size of the crop, it was found impossible to grade the fruit from each tree, grade records were made from representative samples of fruit from each plat.

RESULTS OF FERTILIZER APPLICATIONS

Within 28 days after the first season application of fertilizers in 1924, it was possible to pick out the various plats which had received nitrogen as indicated by the growth of grass under the trees. By May 19, the darker green foliage of the trees on nitrogen plats was easily discernable. From then on thruout the season, differences in color of foliage became more pronounced, and each succeeding year of the five years reported showed the same significant color differences.

Effect upon growth.—Discussing first the responses in tree growth shown in Table 3, nitrogen either alone or in combination, has given a significant gain in trunk diameter, while plats which received phosphorus and potash without nitrogen are lower and quite similar to the plats receiving no fertilizer. The figures agree quite closely, the average percentage increase in trunk diameter being 19.6 per cent for the five-year period where nitrogen, phosphorus, and potash were applied; 19.0 per cent where nitrogen and phosphorus were applied; and 21.0 per cent where nitrogen alone was applied; as compared with 14.4 per cent where phosphorus and potash were used and 14.0 per cent where no fertilizer treatment was given. There is no mistaking the general trend towards increased growth, altho not great, wherever nitrogen has been applied, and the lack of response from any of the other fertilizers applied.

Altho no complete records were made of leaf size or twig growth, general observation shows clearly a greater twig growth and larger leaf size on plats receiving nitrogen.

Effect upon yield of fruit.—The records of yield are shown in Table 4. There is a slight increase in average yield noticeable in plats that
Table 3.—Effect of Fertilizers Upon Increase in Trunk Diameters, Newtown Orchard. Viewmont, 1924 to 1928.

<table>
<thead>
<tr>
<th>Plat No.</th>
<th>Treatment</th>
<th>Number of trees</th>
<th>Diameter in inches</th>
<th>Average Percentage Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Spring, 1924</td>
<td>Fall, 1928</td>
</tr>
<tr>
<td>1</td>
<td>Complete fertilizer</td>
<td>5</td>
<td>46.7</td>
<td>55.3</td>
</tr>
<tr>
<td>7</td>
<td>Complete fertilizer</td>
<td>5</td>
<td>37.5</td>
<td>45.3</td>
</tr>
<tr>
<td>3</td>
<td>Nitrogen and phosphoric acid</td>
<td>6</td>
<td>46.7</td>
<td>56.2</td>
</tr>
<tr>
<td>8</td>
<td>Nitrogen and phosphoric acid</td>
<td>5</td>
<td>41.8</td>
<td>49.2</td>
</tr>
<tr>
<td>4</td>
<td>Nitrogen</td>
<td>7</td>
<td>57.2</td>
<td>71.5</td>
</tr>
<tr>
<td>9</td>
<td>Nitrogen</td>
<td>5</td>
<td>44.6</td>
<td>52.3</td>
</tr>
<tr>
<td>5</td>
<td>Phosphoric acid and potash</td>
<td>5</td>
<td>45.2</td>
<td>50.0</td>
</tr>
<tr>
<td>11</td>
<td>Phosphoric acid and potash</td>
<td>5</td>
<td>47.5</td>
<td>41.4</td>
</tr>
<tr>
<td>2</td>
<td>No fertilizer</td>
<td>6</td>
<td>47.5</td>
<td>54.7</td>
</tr>
<tr>
<td>6</td>
<td>No fertilizer</td>
<td>6</td>
<td>52.2</td>
<td>58.4</td>
</tr>
<tr>
<td>10</td>
<td>No fertilizer</td>
<td>6</td>
<td>46.9</td>
<td>54.0</td>
</tr>
<tr>
<td>Plat No.</td>
<td>Treatment</td>
<td>Number of Trees</td>
<td>Yield in Bushels</td>
<td>Average Yield</td>
</tr>
<tr>
<td>---------</td>
<td>----------------------------------------</td>
<td>-----------------</td>
<td>------------------</td>
<td>---------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1924</td>
<td>1925</td>
<td>1926</td>
</tr>
<tr>
<td>1</td>
<td>Complete fertilizer</td>
<td>5</td>
<td>3.5</td>
<td>85.6</td>
</tr>
<tr>
<td>7</td>
<td>Complete fertilizer</td>
<td>5</td>
<td>0.6</td>
<td>71.7</td>
</tr>
<tr>
<td>3</td>
<td>Nitrogen and phosphoric acid</td>
<td>6</td>
<td>0.3</td>
<td>89.0</td>
</tr>
<tr>
<td>8</td>
<td>Nitrogen and phosphoric acid</td>
<td>5</td>
<td>0.3</td>
<td>83.9</td>
</tr>
<tr>
<td>4</td>
<td>Nitrogen</td>
<td>7</td>
<td>4.5</td>
<td>118.3</td>
</tr>
<tr>
<td>9</td>
<td>Nitrogen</td>
<td>5</td>
<td>1.1</td>
<td>91.2</td>
</tr>
<tr>
<td>5</td>
<td>Phosphoric acid and potash</td>
<td>5</td>
<td>0.6</td>
<td>78.7</td>
</tr>
<tr>
<td>11</td>
<td>Phosphoric acid and potash</td>
<td>5</td>
<td>0.1</td>
<td>71.3</td>
</tr>
<tr>
<td>2</td>
<td>No fertilizer</td>
<td>6</td>
<td>5.5</td>
<td>70.8</td>
</tr>
<tr>
<td>6</td>
<td>No fertilizer</td>
<td>6</td>
<td>3.7</td>
<td>85.8</td>
</tr>
<tr>
<td>10</td>
<td>No fertilizer</td>
<td>6</td>
<td>0.0</td>
<td>86.0</td>
</tr>
</tbody>
</table>
have received nitrogen in comparison with those receiving no treatment, but the total is not great, and certainly not sufficient to justify fertilizer applications. Analyzed further, however, the records of yield bring out some interesting facts.

First of all, there has been a striking effect of nitrogen upon the resultant behavior of subsequent crops. For example, the yield of apples for the two "on" years, namely, 1925 and 1927, is noticeably greater on the plats receiving nitrogen; while the yield in the "off" years has been greater on the plats receiving no nitrogen. In other words, the effect of fertilizers has been to increase the set of fruit during the "on" year, and because the set has been heavier on nitrogen plats the crops in the following "off" years have been correspondingly reduced. On the other hand, trees receiving no nitrogen have set a lighter crop on the "on" years and have borne some fruit in the "off" years. Totalling the figures for the "off" and the "on" years, therefore, does not show so clearly what is going on in this orchard as a study of the crops in the "off" and "on" years.

Effect upon size of fruit.—It was impossible in harvesting a crop of this size to secure accurate figures on the number of apples or the grades from each individual tree. Records were made, however, of representative lots from individual plats, the differences being so striking as to call for no more accurate determinations. For example, in 1925, the yield was so heavy on trees receiving nitrogen that the size of the fruit was reduced to a point where it graded only 18.7 per cent "2½ inches and up" and 71.3 per cent "below 2½ inches," as shown in Table 5. On the other hand, unnitRate nitrate trees graded 63.6 per cent "2½ inches and up" and 36.3 per cent "below 2½ inches".

In addition, the trees receiving nitrate held their fruit much later in the season so that the color was very poor at picking time, while the fruit on the unnitrate trees matured properly and developed good color for Newtowns. "Drops" under nitrate trees were only half what they were under unnitrate trees.

DISCUSSION

There is no mistaking the response of the trees in this orchard to nitrogen fertilizers, especially the setting of the fruit, but their value is a question for discussion. In other words, the applications of nitrogenous fertilizers in this particular orchard under this set of conditions has been to upset a normally profitable system of orchard management, an overload of undersized fruit, and a financial loss to the orchardist.
### Table 5.—Effect of Fertilizers Upon Size and Color of Fruit, Newtown Orchard, Viewmont, 1924 to 1928.

<table>
<thead>
<tr>
<th>Plat No.</th>
<th>Treatment</th>
<th>Number of Trees</th>
<th>Color</th>
<th>Size</th>
<th>Grade, per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Complete fertilizer</td>
<td>5</td>
<td>Poor</td>
<td>Small</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Complete fertilizer</td>
<td>5</td>
<td>Poor</td>
<td>Small</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Nitrogen and phosphoric acid</td>
<td>6</td>
<td>Poor</td>
<td>Small</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Nitrogen and phosphoric acid</td>
<td>5</td>
<td>Poor</td>
<td>Small</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Nitrogen</td>
<td>7</td>
<td>Poor</td>
<td>Small</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Nitrogen</td>
<td>5</td>
<td>Poor</td>
<td>Small</td>
<td>18.7</td>
</tr>
<tr>
<td>5</td>
<td>Phosphoric acid and potash</td>
<td>5</td>
<td>Good</td>
<td>Medium</td>
<td>71.3</td>
</tr>
<tr>
<td>11</td>
<td>Phosphoric acid and potash</td>
<td>5</td>
<td>Good</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>No fertilizer</td>
<td>6</td>
<td>Good</td>
<td>Medium</td>
<td>63.6</td>
</tr>
<tr>
<td>6</td>
<td>No fertilizer</td>
<td>6</td>
<td>Good</td>
<td>Medium</td>
<td>36.3</td>
</tr>
<tr>
<td>10</td>
<td>No fertilizer</td>
<td>6</td>
<td>Good</td>
<td>Medium</td>
<td></td>
</tr>
</tbody>
</table>
It may be that eventually, or by altering the entire system of management by pruning and thinning, a better system may be evolved, but this experience indicates strikingly the necessity for caution in making any blanket recommendations in regard to any sudden change in a successful system of orchard management. The significant fact has been the increased set of fruit, the behavior of the orchard seeming more nearly correlated with the set of fruit than any other one factor.

YOUNG BEARING MCIINTOSH ORCHARD AT UPPER RED HOOK
LOCATION AND METHOD OF HANDLING

The orchard at Upper Red Hook (Fig. 6) on Dutchess slate loam, characteristic of upland orchard soils located further back from the main course of the river, was six years of age and just beginning to bear when the experiment was begun. It is located one-fourth mile west of the Albany Post Road, on the road to Tivoli, and at the end of the lane north from the farm buildings on the Gordon Mead place.

The trees, set 30 feet apart each way, were small enough in size so that no guard rows were left between plats as had been done in the other experiments. Furthermore, the variability of orchards and soils located on Dutchess slate loam is so great that it is impossible to find an orchard of any great size which can be used in a fertilizer experiment, the greater distance between plats merely increasing the difficulties. Not only is the Dutchess slate loam found at high altitude and

![Fig. 6.—Young Bearing Mcintosh Orchard at Upper Red Hook. This is a typical upland apple orchard of the Hudson River Valley.](image-url)
relatively far back from the river, but it is rolling and has slate and stone outcrops at frequent intervals, all adding to the difficulty from the standpoint of orchard fertilizer work. Altho the variability in this particular orchard is greater than one should like, the orchard is quite uniform in comparison with others on similar soil type.

Fertilizers were applied at the rate of 4 pounds of sodium nitrate, 4 pounds of superphosphate, and 2 pounds of potassium chloride, according to the plan indicated in Fig. 7. The treatments were repeated twice. The fertilizer was spread in a circle about the trees well back from the trunk, application being made in early spring, usually about the first week in April, just as soon as the buds began to break.

![Diagram of Experiment at Upper Red Hook](image)

Altho this orchard was supposed to be a "clean cultivated orchard" from the standpoint of the practical grower, it was only in fairly good tilth from the standpoint of an experimental clean cultivated orchard. It was plowed in early spring, usually some time in May, and disked twice during the season, tho because of the stony nature of the soil the work could not be done as thoroly as would otherwise have been the case. A cover crop of buckwheat and millet was sown whenever
<table>
<thead>
<tr>
<th>Plat No.</th>
<th>Treatment</th>
<th>Number of Trees</th>
<th>Trunk Diameter in Inches</th>
<th>Average Percentage Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Spring, 1924</td>
<td>Fall, 1928</td>
</tr>
<tr>
<td>1</td>
<td>Complete fertilizer</td>
<td>10</td>
<td>31.2</td>
<td>70.5</td>
</tr>
<tr>
<td>6</td>
<td>Complete fertilizer</td>
<td>10</td>
<td>31.0</td>
<td>70.5</td>
</tr>
<tr>
<td>2</td>
<td>Nitrogen and phosphoric acid</td>
<td>10</td>
<td>32.5</td>
<td>72.8</td>
</tr>
<tr>
<td>7</td>
<td>Nitrogen and phosphoric acid</td>
<td>9</td>
<td>30.6</td>
<td>69.4</td>
</tr>
<tr>
<td>4</td>
<td>Nitrogen alone</td>
<td>8</td>
<td>28.5</td>
<td>61.9</td>
</tr>
<tr>
<td>9</td>
<td>Nitrogen alone</td>
<td>9</td>
<td>28.0</td>
<td>66.1</td>
</tr>
<tr>
<td>5</td>
<td>Phosphoric acid and potash</td>
<td>10</td>
<td>32.9</td>
<td>69.3</td>
</tr>
<tr>
<td>10</td>
<td>Phosphoric acid and potash</td>
<td>9</td>
<td>30.2</td>
<td>65.5</td>
</tr>
<tr>
<td>3</td>
<td>No fertilizer</td>
<td>9</td>
<td>30.6</td>
<td>64.3</td>
</tr>
<tr>
<td>8</td>
<td>No fertilizer</td>
<td>8</td>
<td>26.5</td>
<td>57.0</td>
</tr>
</tbody>
</table>
conditions favored its growth, but usually the catch was not equal to
the growth of weeds so that for all practical purposes the cover crop
was a sparse growth of weeds.

From this description it will be seen that the orchard does not meet
the requirements of an experimental clean cultivated orchard, but it
does represent quite closely the general cultural treatments of the
region, and may be all the more valuable for that reason.

Eight trees have had to be omitted from the calculations because of
mouse injury, untruthness to name, or some other irregularity, namely,
tree 9 in plat 3; trees 1 and 5 in plat 4; tree 1 in plat 7; trees 7 and 9
in plat 8; tree 6 in plat 9; and tree 7 in plat 10.

RESULTS OF FERTILIZER APPLICATIONS

Effect upon growth.—The effect of fertilizers upon tree growth is
shown in Table 6 by the measurements of trunk diameter for the five-
year period, the caliper being taken at a point 12 inches above the
ground. In spite of the variability that exists, there is unmistakable
evidence of greater growth wherever nitrogen has been applied, either
alone or in combination, and curiously enough when the two series of
plats are averaged, the percentage increase in growth is almost identical
for all nitrogen treatments and identical, yet lower, for treatments
containing no nitrogen. That is, the increase from nitrogen, super-
phosphate, and potash is 126 per cent; for nitrogen and phosphorus,
124 per cent; for nitrogen alone 126 per cent; whereas where phos-
phorus and potash have been applied, the increase is only 113 per
cent; and where no application has been made it is likewise 113 per
cent.

Very shortly after the fertilizers were applied to this orchard, differ-
ences could be seen in the color of foliage on plats receiving nitrogen.
This has been characteristic throughout the five-year period, the trees
receiving nitrogen having a darker green appearance and one of gen-
erally improved vigor.

Effect upon yield.—As for the effect of fertilizer upon the yield, the
figures (Table 7), are not so conclusive. It will be remembered that
the orchard was just beginning to bear when the experiment was begun.
Under such conditions one or two trees beginning to bear somewhat
earlier than others tend to overbalance the results of fertilizer appli-
cations. Nevertheless, there is a slight trend towards increased yield
<table>
<thead>
<tr>
<th>TREATMENT</th>
<th>1924</th>
<th>1925</th>
<th>1926</th>
<th>1927</th>
<th>1928</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete fertilizer</td>
<td>7.2</td>
<td>43.0</td>
<td>17.8</td>
<td>62.2</td>
<td>27.5</td>
<td>157.7</td>
</tr>
<tr>
<td>Complete fertilizer</td>
<td>11.0</td>
<td>46.7</td>
<td>34.0</td>
<td>40.3</td>
<td>34.6</td>
<td>166.5</td>
</tr>
<tr>
<td>Nitrogen and phosphoric acid</td>
<td>10.0</td>
<td>59.1</td>
<td>21.6</td>
<td>54.5</td>
<td>37.5</td>
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<td>9.1</td>
<td>55.9</td>
<td>17.2</td>
<td>39.8</td>
<td>24.5</td>
<td>146.5</td>
</tr>
<tr>
<td>Nitrogen alone</td>
<td>12.7</td>
<td>41.9</td>
<td>28.2</td>
<td>41.1</td>
<td>38.8</td>
<td>162.7</td>
</tr>
<tr>
<td>Nitrogen alone</td>
<td>7.7</td>
<td>42.4</td>
<td>15.5</td>
<td>31.8</td>
<td>18.8</td>
<td>116.2</td>
</tr>
<tr>
<td>Phosphoric acid and potash</td>
<td>7.6</td>
<td>47.7</td>
<td>30.6</td>
<td>43.4</td>
<td>25.2</td>
<td>154.5</td>
</tr>
<tr>
<td>Phosphoric acid and potash</td>
<td>7.5</td>
<td>41.9</td>
<td>32.1</td>
<td>34.8</td>
<td>20.8</td>
<td>115.3</td>
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<tr>
<td>No fertilizer</td>
<td>34.0</td>
<td>43.2</td>
<td>41.9</td>
<td>42.4</td>
<td>34.3</td>
<td>176.7</td>
</tr>
<tr>
<td>No fertilizer</td>
<td>24.8</td>
<td>23.1</td>
<td>21.5</td>
<td>21.5</td>
<td>16.2</td>
<td>93.1</td>
</tr>
</tbody>
</table>

**PLA T No.**

**YIELD IN BUSHELS**

<table>
<thead>
<tr>
<th>AVERAGE YIELD</th>
<th>Per-tree</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Per treatment**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
wherever nitrogen has been applied, but nothing of sufficient magnitude to justify applications up to the present time.

The differences are also shown between the effect of fertilizers in the "off" year and in the "on" year, following somewhat the tendency of the Newtown orchard already reported upon, tho to a lesser degree. Nitrogen has tended to increase the set. Wherever this set has been such as to give a good crop of fruit, the yield has been reduced the following year. The plats receiving no nitrogen, therefore, have tended to be more uniform in their production from year to year, whereas the plats receiving nitrogen have tended to produce a larger crop for the "on" year, and a smaller crop in the "off" year. One of the interesting points brought out is that the plats that have led in the production of fruit have lagged in growth; while the trees that did not carry such heavy crops have made greater growth.

_effect upon size of fruit._—The trees never carried such full crops that there appeared to be danger of overloading, or necessity for thinning. Accordingly, it is not surprising that the counts made of the number of apples in each bushel of apples from each tree, given in Table 8, show no significant effects from any of the fertilizer applications. Neither was there any consistent effect upon color of fruit.

_effect upon bloom._—Records of bloom have shown an interesting correlation with yield. That is to say, there has been the same fluctuation between the "off" year and the "on" year in the amount of bloom present as in the yield of fruit. The nitrate plats having set more fruit the first year of cropping, bloomed "lighter" the next year, and set less fruit, whereas the trees which received no fertilizer applications bloomed more regularly in successive years.

**DISCUSSION**

In this orchard, then, the general effect of fertilizers has been to increase the growth of trees, tho not markedly, and to increase the set of fruit slightly, tending to make the trees bear heavier crops in the "on" year. Practically, from the present financial status, the application of fertilizers has been of questionable value, excepting as it has increased the size of tree. It may be that as the trees get into full bearing, the increased size may reflect itself in increased yields so that the fertilizers that have been applied in the past may make up for their lack of adequate returns to date.
<table>
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<tr>
<th>Plat No.</th>
<th>Treatment</th>
<th>Number of trees</th>
<th>Number of apples per bushel</th>
<th>Average per tree</th>
<th>Average per treatment</th>
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<td>1925</td>
<td>1926</td>
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<tr>
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<td>10</td>
<td>107</td>
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<td>115</td>
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<tr>
<td>6</td>
<td>Complete fertilizer</td>
<td>10</td>
<td>115</td>
<td>126</td>
<td>107</td>
</tr>
<tr>
<td>2</td>
<td>Nitrogen and phosphoric acid</td>
<td>10</td>
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<td>100</td>
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<td>136</td>
<td>115</td>
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</table>
DISCUSSION AND CONCLUSIONS

The story in all three of these orchards has been nothing spectacular from the standpoint of beneficial responses to fertilizer applications. The results may be summarized as follows:

1. A young McIntosh orchard at Kinderhook, on unfertile Hoosic sandy loam, clean cultivated, sown to a cover crop, gave no appreciable increase in growth of trees from any of the commercial fertilizers applied, but an increasingly improved growth of cover crops on plats receiving nitrogen which may reflect itself in the future life of the orchard.

2. A young bearing McIntosh orchard at Upper Red Hook, on relatively unfertile Dutchess slate loam, not thoroly clean cultivated, poor weed cover crop, gave a noticeable response from nitrogen applications in color of foliage, slightly increased gain in tree size, slightly greater crop, and slight tendency to increase the set of fruit in the "on" year with consequent lessened crop in the "off" year, but not sufficient present financial return to justify the application of fertilizers, tho the increased size of trees where nitrogen has been applied offers the possibility of greater crops in future years.

3. A mature bearing Yellow Newtown orchard at Viewmont, on moderately fertile Dutchess silt loam, not thoroly clean cultivated, good weed cover crop, gave a striking response from nitrogen applications in increased growth as measured by trunk girth, increased twig growth, markedly heavier set of fruit, resulting in small size, accentuated alternate bearing, and financial loss.

The results are, therefore, not as strong a recommendation for commercial fertilizers as one might expect from the nature of the soil. The fact that even on the poorest soil type that could be found in the Hudson River Valley intense clean cultivation and cover-cropping without fertilizer applications has resulted in no striking benefit raises the question whether in the other two orchards a more thoroly system of cultivation and cover-cropping might not have produced similar results. On the other hand, had cultivation and cover-cropping been even less carefully carried on, might not the differences between treatments have been more pronounced and might not the value of fertilizers have been more accentuated?

Yet, recognizing the fact that because of the heavy nature of the land, the stony outcrops, or the shortage of labor, many orchards are no more thoroly cultivated than those in this experiment, nitrogen
fertilizers may be expected to give a favorable response in many sections of the Hudson River Valley, tho sometimes not commensurate with the cost of the fertilizers.

There is always the possibility, however, that the future may make up for the past. That is, since bearing trees under only moderately clean cultivation have made greater growth, they offer the possibility of carrying more fruit in future years and of eventually making the early year applications profitable.

Since the applications of nitrogen fertilizers have so markedly increased the set of fruit, the necessity for caution is emphasized in making any blanket recommendations regarding fertilizer applications. The application of nitrogen fertilizers in the "on" year to trees that tend to be biennial in bearing may by itself merely accentuate the biennial habit, because of the effect of an overload of fruit upon fruit-bud formation for the ensuing year's crop.

Finally, the results from these three orchards are of importance in one thing if in no other, namely, in driving home the thought that the mere application of commercial fertilizers by themselves to an apple orchard will not always solve the problem of growth and of fruiting that one is often led to believe. Other factors, such as humus and organic matter, cultivation, pruning, and the like, may be of greater practical importance. Instead of looking upon the application of commercial fertilizers as the panacea of all ills, the grower should rather look upon fertilizers as one of a number of factors that should be included in planning a well-rounded system of orchard management.