RANDOM NOTES ON FRUIT TREE ROOTSTOCKS
AND PLANT PROPAGATION, III

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ABSTRACT

1. Granulated peat moss used in the tree hole at planting has resulted in increased growth of young apple trees in two out of three plantings made in successive seasons.

2. Well-rooted Malling apple rootstocks propagated by layers have given as good a stand as lining-out stock in the nursery as have good grades of branch-root seedlings. The different types vary in their performance, Malling I, XIII, and XVI giving a better stand than Malling XII.

3. The period required to produce a budded fruit tree has been shortened one year by starting the seedlings in the greenhouse, transplanting to the field in late spring, and budding in mid-summer.

4. Sour cherry trees wintered out-of-doors have made better growth than those wintered in a nursery cellar.

5. So far as growth alone of apple trees in the nursery is concerned, paper mulch has proved equal, if not superior, to intensive clean cultivation.

6. Budding of apple rootstocks at a height of 3 to 4 inches above the crown has resulted in slightly larger trees and better stand than budding at 1 to 2 inches, and much larger trees and better stand than budding either at the crown or below the crown.

7. Storage material, in the form of starch grains, was found to be abundant in roots of vigorous young pear trees, and almost entirely lacking in those of weak trees.

8. A 6-year-old orchard of Early McIntosh trees propagated on a good grade of French Crab seedlings has shown uniformity in growth and conformation, in spite of the fact that the rootstocks were of seedling origin.

9. Altho Malus hupehensis suggests the possibility of being valuable as uniform rootstock material because the seeds have apogamic embryos, the low number of viable seed and the poor germination make it unsuited for general use.

10. Peat moss has proved helpful when used as a surface coverage on seed beds for fruit tree seeds and as a complete cover over seed planted under unfavorable conditions.
NOTES are recorded on the following topics:
1. Use of peat moss in planting fruit trees.
2. Behavior of Malling apple rootstocks as lining-out stock.
3. Shortening the period required to produce budded fruit trees in the nursery.
4. Comparison of wintering cherry trees out-of-doors and in a nursery cellar.
5. Paper mulch for apple trees in the nursery.
6. Height of budding and growth of apple trees in the nursery.
7. Microscopic examination of the roots of vigorous and weak pear trees.
8. Variability of apple trees on seedling rootstocks.
9. Malus hupehensis as a rootstock material for the apple.
10. Coverage of fruit tree seed with peat moss.

1. USE OF PEAT MOSS IN PLANTING FRUIT TREES

It is not uncommon for shoot and leaf development of fruit trees to be delayed as much as 30 days following planting. In dry and unfavorable seasons the losses and replacement demands are often large, and, in any event, the trees commonly do no more than become established during the first growing season. The problem is thus presented of increasing the vigor of nursery stock so that newly set orchard trees may show an early and vigorous growth.

PREVIOUS METHODS OF ATTACK

Among various factors considered in tests being made at the Station to meet this problem has been that of nutrition of the young.
trees. It was suggested that fertilizing the trees in the nursery row prior to digging in the fall might result in the trees storing up an extra supply of nutrients which would result in more vigorous growth in the spring when the trees were set in the orchard. However, trees so treated, either by applying fertilizers to the soil or injecting fertilizers into the dug trees, failed to produce any superior growth.\(^1\)

In another trial concentrated fertilizers were placed in the tree hole at planting in close proximity to the roots. Not only was this treatment not helpful, but frequently it has resulted in serious injury or death to the tree.\(^2\)

The tests indicated that well-grown nursery stock which has been kept under good growing conditions throughout its life in the nursery, has stored within it the materials necessary for the initiation of growth the first year, and that some factors other than nutrient requirements are responsible for delayed starting and poor growth.

The work of Goff\(^3\) in Wisconsin in 1896 has suggested that the establishment of water movement into the plant is an important factor in the starting of trees. He injected water into the roots of newly planted apple trees by means of rubber tubing attached to the roots, the water being supplied from inverted flasks held at the height of the trees. Seven days after the test was begun, the leaves of water-injected trees were opening. By 55 days after planting, the water-injected trees had made good foliage development, while the non-injected trees were still without foliage.

**TESTS WITH GRANULATED PEAT MOSS**

*Planting of 1935.*—Following the suggestion of the importance of water in the establishment of the tree, a test was conducted in 1935 using damp granulated peat moss in the tree hole at planting. Sixty 2-year-old Newfane apple trees were used. They were planted 5 feet apart in rows 10 feet apart on a level, uniform piece of clay loam.

With one row, a 12-quart pail of moist, granulated peat moss was mixed with the soil and used to fill the tree hole in planting each

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tree. With the other row, the trees were planted as usual, with no application of granulated peat moss.

Rainfall was ample and growing conditions were favorable. Both the peat-treated and the untreated trees began shoot growth at the same time, altho there were more growing points on the peat-treated trees. By mid-summer, shoot growth on the peat-treated trees was noticeably greater. At the completion of the growing season the peat-treated trees had made an average terminal growth of 82.77 inches, as shown in Table 1, as compared with 14.10 inches for the check trees. Furthermore, they continued their superiority during the 1936–37 season, and were still the larger trees at the end of that season.

Examination of the root systems showed that the roots of the peat-treated trees, instead of being massed in the peat close to the tree, had spread outward so as to give a much larger and much more extensive root system. The larger top growth, larger trunk diameter, and greater root development and spread has continued thru three growing seasons as shown in Fig. 1.

*Planting of 1936.*—In 1936 the experiment was repeated, using 60 trees of the varieties Kendall, Cortland, and Macoun. In this test, however, dry peat moss was used, and instead of being carefully mixed with the soil was shaken into the tree hole as it was being filled with soil. Unlike the preceding season, a drouth prevailed from the time of planting until August 15, so that total growth was less than in the planting made the preceding year. Differences between treatments were not large. With two varieties, Kendall and Macoun, both shoot growth and number of growing points were larger for peat-treated trees, but with the Cortland variety they were less.

The second growing season the untreated trees made a greater total shoot growth, particularly the Macoun variety, as shown in Table 1, but the number of spur growths was greater with all three varieties where peat was used. Since there are more leaves per inch of spur growth than terminal growth, the importance of the greater number of spurs must not be overlooked. Combining the number of shoots and the number of spurs, the data show that a greater number of buds developed on the peat-treated trees. Examination of the roots at the end of the second growing season showed a definitely greater root development of the peat-treated trees.

*Planting of 1937.*—In 1937, the experiment was repeated a third time, using trees of Medina and Young America. A further variation
<table>
<thead>
<tr>
<th>Variety</th>
<th>Growing season</th>
<th>Mean number of spurs*</th>
<th>Mean shoot growth, inches</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Moist peat</td>
<td>Dry peat</td>
<td>Check</td>
</tr>
<tr>
<td>Newfane</td>
<td>1935</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>1936</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Cortland</td>
<td>1936</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>1937</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Kendall</td>
<td>1936</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>1937</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Macoun</td>
<td>1936</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>1937</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Young America</td>
<td>1937</td>
<td>25.69±1.54</td>
<td>24.99±1.81</td>
</tr>
<tr>
<td>Medina</td>
<td>1937</td>
<td>32.54±2.71</td>
<td>38.77±2.31</td>
</tr>
</tbody>
</table>

*Growth 1 inch or less in length.
†Probable error of the mean.
Fig. 1.—Newfane Apple Trees During Third Growing Season, Planted With and Without Peat Moss.

Left, granulated peat moss used in tree hole when tree was planted. Right, check, planted in usual manner. Note the strong development and extensive spread of roots of peat-treated trees.

in the trial was made, using dry peat moss in comparison with moist peat moss, besides the check treatment. Rainfall during this season was ample in early spring, followed by a dry period in late summer. All trees began growth at the same time. It was soon apparent that there were more growing points in the rows of peat-treated trees than on the check trees. By mid-summer greater shoot growth, as well, could be seen on the peat-treated trees; and further, the trees treated with moist peat were superior to those treated with dry peat. Nevertheless, the differences were not as great as in the season of 1935.
An analysis of the data of shoot and spur growth is given in Table 1 where it is seen that both the total shoot growth and the number of spurs are greater for the peat-treated trees. There is some difference between varieties, Medina responding more to treatment than Young America. Further, the trees around which moist peat moss was used show a greater response than those which received dry peat moss. The increase in the total number of buds which developed is consistently greater for the peat-treated trees. Examination of the roots showed clearly a larger and better development from the peat-treatments, whether the treatment was with dry or with moist peat moss.

DISCUSSION

Of the three plantings in successive seasons, two plantings were definitely benefited by the peat treatment as shown by the greater number of growing points and the greater spread and growth of roots. In the most favorable season peat produced a marked effect which continued for three seasons. In the next most favorable season it was helpful but not strikingly superior. In the third planting season peat-treated trees did not produce a greater shoot growth but again showed a greater number of growing points and better root development.

Rainfall may be a contributing factor in producing these differences. In the season of no response from the use of peat moss the rainfall was inadequate; whereas, in the seasons of response rainfall was adequate, particularly in the early part of the season.

If the value of peat lies in its water-holding capacity, it might be thought that the roots would be found close to the tree in the peat moss. Not only were the roots not numerous in the peat, but they extended outward and away from it.

This distribution of the roots suggests the possibility of aeration as the principal factor involved. It is well known that the supply of oxygen is a limiting factor in root development. In a wet season the movement of air would be restricted, particularly in a heavy soil such as was used for these tests. The incorporation of peat in the soil would tend to form a chimney or column for air movement downward into the soil around the tree and thence outward into the soil.

Other experiences point to the beneficial effect of peat moss upon root formation. In the rooting of layered apple rootstocks on this
soil, which is a clay loam, peat moss incorporated in the surface area of the soil and drawn up around the plants in mounding operations has improved rooting markedly.4 With an application of 50 bales per acre the number of well-rooted plants has been increased from 38.1 to 67.4 per cent. The improvement in rooting has been so marked over a period of 8 years that the use of peat moss in the stool beds has become standard practice. Here again, whether it is a matter of moisture supply, aeration, or some other factor, such as some material in peat moss which favors root formation, is a question for further investigation. All that can be said is that peat moss definitely favors root formation.

Quite aside from any benefit to root formation is the relation to the planting operation itself. In general, the use of peat moss has resulted in a firmer packing of the tree in place as well as easier planting. The peat helps if the soil is too wet, preventing it from puddling when stamped around the roots; and in a dry season or when the soil is lumpy, it tends to make the soil lighter and more springy so that the tree can be set more easily.

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2. BEHAVIOR OF MALLING APPLE ROOTSTOCKS
AS LINING-OUT STOCK

BECAUSE of the interest in the vegetatively propagated types of apple rootstocks and the desire to evaluate them as rapidly as possible for American conditions, records of their behavior have been given as rapidly as possible. Reports have already been made concerning methods of propagation, hardness, and yield of rooted plants of the so-called Malling rootstocks, which are selections of material propagated easily by layers. The performance of this material as lining-out stock is of next concern.

GENERAL OBSERVATIONS

Plantings, involving several thousand rootstocks a year, have been made from 1930 to 1937, mostly of Malling I, Malling II, Malling IX, Malling XII, Malling XIII, and Malling XVI. They have all been propagated on the Station grounds at Geneva, N. Y. For purposes of comparison, seedling rootstocks have been lined-out similarly.

In general, it seems that well-rooted Malling rootstocks give as good a stand of lining-out stock as a good grade of branch-rooted seedlings. Compared with straight-root seedlings, they have been superior.

Three seasons records of the stands of plants of Malling I, Malling II, Malling IX, Malling XII, Malling XIII, and Malling XVI are given in Table 2. The plants, altho limited in number, are comparable, all having been No. 1, well-rooted plants. The figures are based on the number of plants lined-out and the number of plants sufficiently large and vigorously growing in mid-summer to be budded. The factors of congeniality and varietal preference do not, therefore, enter into consideration.

The percentage stands as given in Table 2 would be considered "very good" by nurserymen. For comparison with seedling rootstocks, an exceptionally good stand of 96.2 per cent was secured in 1931 from 752 French Crab seedlings. In commercial nurseries and

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in most seasons the stand is not so high, and 85 to 90 per cent would be considered satisfactory.

Referring again to Table 2, the differences in stands between the different rootstocks are of interest. Malling XIII and Malling XVI

<table>
<thead>
<tr>
<th>Material</th>
<th>1929 Number planted</th>
<th>1929 Percentage stand</th>
<th>1931 Number planted</th>
<th>1931 Percentage stand</th>
<th>1937 Number planted</th>
<th>1937 Percentage stand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malling I</td>
<td>112</td>
<td>90.1</td>
<td>204</td>
<td>88.7</td>
<td>111</td>
<td>87.3</td>
</tr>
<tr>
<td>Malling II</td>
<td>57</td>
<td>82.4</td>
<td>20</td>
<td>95.0</td>
<td>111</td>
<td>83.7</td>
</tr>
<tr>
<td>Malling IX</td>
<td>67</td>
<td>89.5</td>
<td>204</td>
<td>93.5</td>
<td>444</td>
<td>86.0</td>
</tr>
<tr>
<td>Malling XII</td>
<td>71</td>
<td>92.9</td>
<td>194</td>
<td>94.3</td>
<td>444</td>
<td>86.0</td>
</tr>
<tr>
<td>Malling XIII</td>
<td>147</td>
<td>97.1</td>
<td>306</td>
<td>96.3</td>
<td>666</td>
<td>99.5</td>
</tr>
<tr>
<td>Malling XVI</td>
<td>60</td>
<td>95.0</td>
<td>87</td>
<td>96.5</td>
<td>222</td>
<td>95.0</td>
</tr>
<tr>
<td>French crab seedlings</td>
<td>——</td>
<td>——</td>
<td>752</td>
<td>96.2</td>
<td>——</td>
<td>——</td>
</tr>
</tbody>
</table>

stand consistently higher than the others listed. Furthermore, these two propagate and form roots more easily than the others, so that the greater ease of rooting may be the factor involved in the better stand in the nursery row. Malling XII, which roots with more difficulty than Malling XIII, also gives a lower stand of plants in the

Fig. 2.—Block of Yearling Apple Trees on Malling I Rootstocks in a Commercial Nursery in Western New York.
nursery row, thus agreeing with the general opinion expressed abroad that Malling XIII is better suited to the nursery than is Malling XII.

**BEHAVIOR IN COMMERCIAL NURSERIES**

The behavior of Malling rootstocks in commercial nurseries over a period of 6 years has also been thoroughly satisfactory. During that time 16,350 layered quince roots and 14,155 layered apple roots have been supplied to nurseries in different parts of the country. In all instances, complete satisfaction has been expressed.

In 1934, 2,500 rootstocks of Malling I (Fig. 2) and Malling IX were supplied to a commercial nursery in the western New York area. The following summer was one of drouth and generally unfavorable growing conditions; nevertheless, the stand and growth of the rootstocks was satisfactory and was better than that of adjoining rows of seedling rootstocks.
3. SHORTENING THE PERIOD REQUIRED TO PRODUCE BUDDED FRUIT TREES IN THE NURSERY

A SHORTAGE of various lines of young fruit trees prevailed in New York State nurseries during the seasons of 1934, 1935, 1936, and 1937. This was brought about, in part, by the severe winter of 1933–34 which killed thousands of orchard trees, reduced the normal supply of nursery stock, and at the same time increased the demand for replacement stock. In addition, a shortage resulted of seedling rootstocks, upon which nurserymen commonly bud fruit trees. Accordingly, various more or less hastily conceived methods were tried, both to build up a supply of nursery stock and to provide a source of rootstocks. (See Fig. 3.)

Normally, three growing seasons are required in New York State

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**Fig. 3.—Propagation of Apple Trees from Seed in Two Years.**

A, stand of seedling apple rootstocks in mid-summer from seed the same year. B, seedlings being budded on September 11. C, close-up to show relative size of seedlings with buds in place, September 11. D, yearling apple trees the following season.
to produce a yearling tree of apple, pear, cherry, and plum. Seed planted one season develops into so-called seedling rootstocks which are dug in the fall of the year and lined out and budded the second season. The third season the top of the rootstock is cut off just above the bud and the bud forced into growth to produce a yearling tree by fall. In the case of the peach, however, seedlings from seed planted directly in the nursery row attain sufficient size during the first year to be budded in late summer. Thus, only two growing seasons are required to produce a yearling peach.

In warmer regions which favor larger and more rapid plant growth, however, seedlings of both the plum and the Mazzard cherry may grow too large to be sold as lining-out stock, so that occasionally they are budded in the seedling row and grown into nursery trees. In fact, McClintock\(^7\) has pointed out that in Tennessee it is possible to space seed sufficiently far apart so that seedlings of Mazzard and Mahaleb cherry, Myrobalan plum, and apple may be budded the first year from seed.

**TRANSPANTING TESTS**

At Geneva, N. Y., during the seasons of 1927, 1928, and 1929 a study was made in transplanting fruit tree seedlings in order to produce branch-root seedlings.\(^8\) Seeds of Myrobalan plum and Mazzard and Mahaleb cherry were started in the greenhouse, and the resulting seedlings, after transplanting to the field, reached sufficient size by late summer to be budded. In 1927, seed was sown April 12 and transplanted to the field on May 8; in 1928, seed was sown March 27 and transplanted May 1; and in 1929, seed was sown April 5 and transplanted April 25.

At this time it was suggested that this method might be applied to nursery practice, the transplants being set in permanent rows spaced sufficiently far apart to be budded and left to produce nursery trees.

**COMMERCIAL APPLICATION**

Commercial application of this method to apple seedlings was made during the seasons of 1933 and 1934 by the Maloney Brothers


Nursery Company of Dansville, New York.\(^9\) Apple seed was stratified for after-ripening the middle of January in 1934. By the first week in March it was ready to germinate and was planted in the greenhouse (a) in 2-inch paper cups, three seeds to a cup, and (b) sown broadcast in flats. The stand of seedlings was somewhat variable. Even with three seeds to a cup, no seedlings developed in some cups. Accordingly, the method of starting the seedlings in flats and later prickling them off into paper cups was deemed the more practical.

The plants were pricked off into paper cups between April 15 and May 1, depending upon the size of the plants. Some damping off resulted the first week in April from too close planting and from keeping the houses too poorly ventilated. On May 25 the seedlings in paper cups were transplanted to the field, and planted in rows as for lining-out stock. The soil was a river-bottom clay loam, high in fertility, and considered especially good nursery soil.

By July 6 the seedlings had reached a height of 2 to 4 inches and the stand of plants approached 100 per cent. By September 10 and 11 the plants had reached a caliper of 3/16 to 1/4 inch at the crown and a height of 26 inches, at which time they were budded. Some plants were 7/16 inch in caliper. Of 1,200 plants in a row, 1,075 were budded. This is a higher stand of budded seedlings than is commonly secured from lined-out 1-year-old seedlings. A total of 13,200 seedlings were grown in this manner.

The planting was subsequently handled according to regular nursery practice in which the tops were cut off just above the bud in early spring of the next year. The growth of the buds was satisfactory, so that by October 8 the yearling whips were 4 to 5 feet high. The root systems, altho 1 year younger than those of yearling apple trees raised by regular nursery methods, were vigorous, and the trees were in every way satisfactory to meet the nursery and orchard demands for 1-year-old trees.

In 1935 the practice was repeated with essentially the same results.

\(^9\)The authors wish to acknowledge their appreciation to Maloney Brothers Nursery Company for making the data available.
4. COMPARISON OF WINTERING CHERRY TREES OUT-OF-DOORS AND IN A NURSERY CELLAR

Undoubtedly the best method known at the present time for over-wintering nursery stock is to leave it in the ground, except for tender plants which will not stand winter cold. In early days of fruit growing in America when the nursery industry was small and demand for stock was limited, it was possible for a grower to secure his stock delivered fresh dug from a nearby nursery. Today, with production of nursery stock on an extensive scale and with thousands of orders being shipped in a limited period of time, it has become impossible to handle orders in so intimate a manner. This means that the nurseryman is forced to dig nursery stock in the fall of the year, grade it, store it, and pack it for early spring delivery.

Altho nursery stock so handled has given a good record of performance when planted out, there are many problems in handling and storage in the modern manner which, if solved, would benefit both the nursery industry thru fewer losses and would benefit the planter by providing him with even more vigorous growing plants.

MATERIALS AND METHODS

In connection with a series of tests to determine the best methods for handling nursery stock, a comparison was made between fall-dug nursery stock which was heeled-in out-of-doors immediately after digging and fall-dug nursery stock which was stored in a nursery cellar.

Two-year-old Montmorency sour cherry trees on Mazzard roots grown on the Station grounds were used. The trees were dug when properly mature late in the fall (the middle of November). Forty were immediately trenched in soil adjacent to where they were grown, the trees being slanted in a trench at an angle parallel with the prevailing wind and the roots being well covered with soil. One hundred trees of the same lot were taken to the nursery cellar and placed horizontally in bins, with dampened moss on the roots, according to the accepted nursery practice of the region. The nursery cellar in question is considered equal, if not superior, to most commercial cellars.

RESULTS AND DISCUSSION

The following spring the trees were planted in adjacent rows. The trees which were over-wintered out-of-doors began growth a few days earlier than those stored in the cellar and were noticeably larger and more vigorous by fall.
This superiority in growth has been maintained for 4 years in the orchard as shown by the measurements of trunk diameter given in Table 3 and as indicated by Fig. 4. No trees from either treatment died during the course of the tests and the growth of all trees would be considered satisfactory.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Number of trees planted</th>
<th>Number living after 4 years</th>
<th>Trunk diameter 30 cms above ground, av. cms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trenched in out-of-doors</td>
<td>40</td>
<td>40</td>
<td>3.56</td>
</tr>
<tr>
<td>Stored in nursery cellar over winter</td>
<td>100</td>
<td>100</td>
<td>2.95</td>
</tr>
</tbody>
</table>

These findings agree with those already presented by Upshall\textsuperscript{10} in which fall-planted sweet cherry trees made over 30 per cent more growth than trees dug and planted in spring, and in which the latter in turn made 20 per cent more growth than trees dug in the fall and over-wintered in a nursery cellar.

5. PAPER MULCH FOR APPLE TREES IN THE NURSERY

Paper mulch has been used successfully with many crops. It is a heavy paper, similar to a building paper, and is placed close to and around the plants in the treated area so that the entire soil surface is covered. No cultivation is possible. With some crops, holes are made in the paper and the plants set thru them.

In regular nursery practice, fruit trees are an intensively cultivated crop. There is a saying in nursery circles that trees will not grow unless "the dirt is moved". Cultivations are frequent thruout the life of the crop beginning the first season with the lined-out seedlings and continuing until the end of the third season when trees are 2 years old. In an average season, with a cultivation after each rain, the trees are cultivated five or six times.

MATERIALS AND METHODS

To compare paper coverage with clean cultivation, eight rows of nursery stock were used in a test, four of the rows being covered with paper and four being cultivated. The rootstocks were French Crab seedlings imported from France lined out 8 inches apart in rows 42 inches apart, according to regular nursery practice and later budded to Early McIntosh. There were 144 plants in a row.

The paper was placed the middle of May a month after the rootstocks were lined out. The strips were 36 inches wide and left a narrow band of uncovered soil 3 inches wide adjacent to the trees. In practical operation this width seems good. Heat injury to trees in the nursery at the ground line is not uncommon so that black paper too close to the trunks might increase the possibilities of injury. The edges of the paper were held with soil and loose stones.

Altho the paper rotted away at the edges somewhat, it persisted satisfactorily for the first and second years and lasted until the middle of the third growing season when it began to disintegrate and could not be kept in place. By that time, however, the trees had completed their growth as 2-year-old nursery trees, so that the paper covering was no longer required.

RESULTS AND DISCUSSION

The comparative sizing of the 2-year-old trees is shown in Table 4 which gives the average diameter of the trees 2 inches above the bud for two representative rows.

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Table 4.—Comparative Effect of Paper Mulch and Clean Cultivation on the Growth of Apple Trees in the Nursery.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Number of trees</th>
<th>Average Diameter of 2-Year-Old Trees, 32nds of an Inch</th>
<th>Average Height of 2-Year-Old Trees, Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper mulch</td>
<td>49</td>
<td>23.4</td>
<td>66–70</td>
</tr>
<tr>
<td>Cultivation</td>
<td>55</td>
<td>22.8</td>
<td>66–70</td>
</tr>
</tbody>
</table>

All the trees in the block, totaling 870, made good growth. The growth appeared slightly more vigorous where the paper mulch was used, as shown also by the figures in the table, yet the differences were not great. The important fact is, however, that the paper mulch accomplished fully as much, so far as the growth is concerned, as did intensive clean cultivation.

Altho paper mulch is thus seen to be favorable to tree growth in the nursery, there are practical limitations to its use since the paper must be walked upon several times in the performance of such nursery operations as budding the first season, cutting the tops and sprouting the stock the second season, heading the trees the third season, and spraying several times each season.
6. HEIGHT OF BUDDING AND GROWTH OF APPLE TREES IN THE NURSERY

In nursery practice, fruit trees are budded slightly above the crown of the seedling. The soil is cleared away from around the plant, the stock wiped off, and the bud inserted as near the ground line as possible.

The reasons for this height having been selected are not entirely apparent. No doubt, one reason is the fact that the bark of the seedling is more tender and will cut and "slip" more readily where it has been covered lightly with soil and hence may be budded over a longer period of time. Another factor may be that raffia, with which buds have been tied largely until recent years, loosens when it becomes dry and fails to hold the bud tightly in place, so that soil is thrown onto the tied bud as soon as possible after the budding operation in order to keep the raffia moist and tight. Low budding would favor these operations. Furthermore, with small seedlings, low budding would permit a greater number to be budded, since the largest caliper of the seedling is at the crown; and with tender plants, as roses, winter protection to the bud would be a factor.

On the other hand, with the relatively recent adoption of rubber budding strips as ties for the bud, and with the more common usage of spray materials to protect the foliage from premature defoliation and to extend the budding season, the necessity for low budding is not so great.

TESTS OF HEIGHT OF BUDDING

To determine the effect of budding at different heights, four rows of French Crab seedling rootstocks were budded in four positions as follows: (A) 3 to 4 inches above the crown, called "high budding"; (B) 1 to 2 inches above the crown, called "normal budding"; (C) at the crown, called "low budding"; and (D) below the crown, called "very low budding".

Following budding to Early McIntosh, all rows were similarly treated as regards cultivation, spraying, and general management. Nevertheless, it should be pointed out that because of the low position of the buds in treatments B, C, and D they were covered lightly with soil as the rootstocks were cultivated, and the soil was thrown towards them following budding. On the other hand, the high posi-
tion of the buds in treatment A placed them above the soil at all times.

The spring following budding it was noticeable that the buds of treatment A, being all above the soil, began growth earlier in the season and more evenly. The buds of B, C, and D being frequently covered entirely or partially with soil were delayed and variable in the time in starting.

The results in Table 5 show the average diameter of the trunk and the average height of the trees as 2-year-old trees. The highest budding, namely, 3 to 4 inches above the crown, resulted in the tallest trees and those of the greatest caliper. Budding at normal height, as well as low and very low budding, resulted in shorter trees with trunks of smaller caliper, the height and caliper being in descending order for each successively lower budding.

Table 5.—Effect of Height of Budding on Growth of Apple Trees in the Nursery.

<table>
<thead>
<tr>
<th>Height of Budding</th>
<th>Number of Trees</th>
<th>Average Diameter of 2-Year-Old Trees, 32nds of an Inch</th>
<th>Average Height of 2-Year-Old Trees, Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, 3 to 4 inches above the crown (high).</td>
<td>104</td>
<td>23.4</td>
<td>66–70</td>
</tr>
<tr>
<td>B, 1 to 2 inches above the crown (normal height)</td>
<td>110</td>
<td>21.7</td>
<td>65–69</td>
</tr>
<tr>
<td>C, at the crown (low)</td>
<td>85</td>
<td>21.1</td>
<td>64–68</td>
</tr>
<tr>
<td>D, below the crown (very low)</td>
<td>108</td>
<td>20.7</td>
<td>64–68</td>
</tr>
</tbody>
</table>

Additional Results

In addition to these figures, observations have been made each year for several years on the effect of height of budding on the growth of the resulting tree. These observations are in entire agreement with the figures given above, indicating that low budding of apple trees is inferior to budding at 3 to 4 inches above the crown. The inferior growth from low budding seems to be associated with the soil temperature, as buds which are partially or entirely covered by soil in early spring are delayed in starting by the relatively lower temperature of the soil as compared with that of the air. The time of bud start is controlled by the temperature of the bud and not that of the entire plant, so that buds placed higher on the rootstock and entirely above the soil start earlier and more uniformly.
RELATION TO DWARF TREES

These figures and observations are of particular interest at this time when there is a revival of interest in dwarf rootstocks. In order to prevent scion-rooting and thus destroy the dwarfing influence of the rootstock, it has been proposed to bud such rootstocks at a slightly higher position than usual with standard rootstocks. These facts indicate that such a practice, quite aside from its value for dwarf rootstocks, results in a better growth of trees and a more uniform stand.
7. MICROSCOPIC EXAMINATION OF THE ROOTS OF VIGOROUS AND OF WEAK PEAR TREES

In the spring of 1935 attention was called to a 1-year-old planting of pear trees in Orleans County which had made a weak growth during the preceding season and about which there was some question as to whether it should be left in the orchard or replaced by new trees. The statement of the fruit grower, which examination of the trees verified, was that the trees were of good size and apparently vigorous when received from the nursery company and when planted.

The trees were dug and examined. No new root growth could be found and shoot growth was confined to terminal elongation of 1 to 4 inches, together with short spur growths. New wood growth was small and the color of the bark was yellowish.

Sections for microscopic study were made from the roots, and, for comparison, similar sections were made from roots of 2-year-old pear trees in storage in the nursery cellar. Fig. 5 shows the marked difference between the condition of these two lots of trees. In the poorly growing trees, altho the cell size was large indicating vigor-

![Fig. 5.—Photomicrographs of Roots of Young Pear Trees.](image)

A, stored food almost entirely exhausted, trees subsequently dying. B, abundance of stored food in form of starch grains, trees subsequently making vigorous growth.
ous growth and development of the trees in the nursery, yet the food materials stored in the cells had become almost entirely exhausted. On the other hand, the cells of the nursery trees in storage were seen to be filled with storage material in the form of starch grains. The weak trees died in the orchard during the subsequent growing season.

Examination of trees by microscope sections is suggested as a means of determining their condition as regards potentialities for further growth and development.
8. VARIABILITY OF APPLE TREES ON SEEDLING ROOTSTOCKS

APPLE trees growing in the orchards of New York State have been propagated almost entirely upon rootstocks raised from seed. Theoretically, such rootstocks might be expected to show considerable variation, which, in turn, might be responsible for some of the variation seen in orchard trees. Accordingly, fruit growers and nurserymen have often asked, "Do large seedling rootstocks produce the larger orchard trees?" And, "Is the genetic make-up of the rootstock responsible for the growth and behavior of orchard trees?"

In an earlier publication special attention was paid to the effect of size of rootstock on the growth of the budling and of the 2-year-old tree in the nursery. It was shown that in a population of 18,000 individuals there was, first, a very high correlation between the size of the 1-year nursery tree and the size of the 2-year nursery tree; second, a smaller yet significant correlation between the after-budding size of the seedling and the size of 1-year and 2-year nursery trees; and lastly, no relation between the size of the seedling at planting and the size of 1-year and 2-year nursery trees.

MATERIALS AND METHODS

As a continuation of that work, and to present data on the influence of size of the rootstock and of the nursery tree on the growth of an orchard tree when planted out, 270 2-year-old Early McIntosh trees, comprising two nursery rows, were selected for experiment. These had been budded on imported French crab seedlings and grown on the Station grounds. The seedling rootstocks when received were well graded as to size, and the subsequent growth in the nursery of both rootstocks and budded trees was fully equal, if not superior, to blocks of apple trees in adjacent commercial nurseries.

Before digging, each tree was tagged with a number corresponding to the original nursery number. No sorting or grading was done and no undesirable trees eliminated, each tree being planted in the

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orchard according to its numerical order in the nursery row, the entire plan of the experiment being to emphasize any variability that might be present in the trees. In accepted nursery practice the smaller size trees would have been separated, if not discarded, in grading.

The trees were planted 6 feet apart in the row, in rows 8 feet apart, on a uniform piece of Ontario stony loam, a soil considered high in fertility. Such close planting did not interfere with the experiment, since a re-transplanting of every other tree after 3 years in the orchard was contemplated and later carried out.

The planting was kept in clean cultivation for 3 years, after which a legume cover crop was grown between the rows. No pruning was done except for a light thinning out during the sixth year in the orchard. Proper disease and pest control was practiced throughout the period, and the trees, with the exception of those re-transplanted a second time after they had been growing for 3 years in the orchard, made very vigorous growth. All in all, the conditions under which the trees were grown were such as would be considered satisfactory from both the nursery and orchard standpoint, and such as would provide opportunity for both genetic and environmental factors to assert themselves. (See Fig 3.)

Trunk diameter was used as a measure of tree growth. Measure-
ments were taken by caliper to the nearest millimeter exactly 12 inches above the union each year during the dormant period. The figures obtained for each tree were entered on cards and the figures studied statistically.

RESULTS AND DISCUSSION

The results may be summarized as follows:

1. There is no relationship between the size of the rootstocks when they were planted and the future growth of the budded trees, either in the nursery row or in the orchard. The largest seedlings failed to produce the largest trees and the small seedlings failed to produce the smallest trees. Similarly, small seedlings sometimes produced large trees and vice versa. In other words, small size differences among closely graded seedlings are due largely to environmental conditions such as spacing in the row, trimming, and planting, and may be easily changed by the new environment coincident with planting in the nursery.

2. There is a fairly strong relationship between the total growth made by the rootstock during its first growing season in the nursery and the size of the budling (1-year whip) obtained. Further, this correlation persists, altho in steadily decreasing degree, to the 2-year-old nursery tree and for several years in the orchard. In other words, seedlings which make the best growth in the nursery the first year will make the larger trees. The importance of the first growing season in the nursery to the production of vigorous nursery stock is thus emphasized.

3. There is a strong correlation between the size of the budling (1-year whip) and the size of the 2-year-old nursery tree. Further, this correlation persists for the next 3 years, after which it declines to a low but fairly steady figure. In other words, the factor of larger size of the budling due to better growth of the seedling rootstock the preceding year is carried over into the tree growth for several years.

4. There is a strong correlation between the size of the 2-year nursery tree and the size of the tree in successive years in the orchard. Altho similar to the correlation mentioned in the preceding paragraph for the budling, it is still greater. The largest 2-year trees from the nursery are still the largest after 6 years in the orchard.

5. There is a very high correlation between the size of the tree after the first year in the orchard and the size of the tree thereafter. In other words, as with the first year of seedling growth in the nurs-
ery, the local environment of an individual tree in its new location plays a very great part in its future behavior.

6. The variability present in a closely graded lot of vigorous French crab seedlings is a less important factor in variability in the orchard than is commonly supposed, based upon theoretical grounds.

7. Such operations as digging from the nursery and planting have had a marked influence on the growth of the trees, regardless of any possible inherent vigor of the rootstock. Furthermore, the method of budding, the time of budding, and the condition of the seedling rootstock at time of budding seem to be important factors, which may be expressed in the growth of the resulting tree for a considerable time in the nursery row and for a considerable time after transplanting to the orchard.

8. Re-transplanting to a new location after the trees have been once established in an orchard seems to result in an equalization in the growth of the larger and smaller trees and tends still further to overcome or mask any possible inherent vigor of the rootstock.

9. In general the vigor and conformation of the trees in this orchard on seedling rootstocks have been surprisingly uniform. This is the more surprising when it is considered that no grading was done when the trees were dug from the nursery, and that little or no pruning or other standard operations were performed which would tend still further to have equalized the growth and conformation of the trees. (See Fig. 3.)
9. MALUS HUPEHENSIS AS A ROOTSTOCK MATERIAL FOR THE APPLE

AMERICAN apple orchards are growing almost entirely upon rootstocks raised from seed—so-called “seedling rootstocks”. The seed is collected from the wild and from various cultivated varieties of apple. Orchardists and fruit growers have suspected that some of the variability of trees often found in apple orchards may be due to variations in the rootstocks. While admitting that seedling rootstocks have given a very good account of themselves in the orchards of America, nevertheless various methods have been proposed for securing a more uniform rootstock material.

Among these has been the production of apogamic seedlings, that is, seedlings which are produced from seed which is not the result of fertilization but is the development of some somatic tissue of the plant. This condition is not uncommon among plants and has been made use of commercially in the production of citrus rootstocks. Using citrus as an example, the embryos in the seed have developed from the nucellus of the ovule by a process of “budding”, and are not the result of a fusion of gametes. Such seed will develop into plants identical to the mother plant as tho propagated from layers and cuttings, thus providing the desired uniformity of rootstock.

Horticulturists have sought similar material in the apple. Dermen has recently worked out the cytology and embryogeny of the tea crab, Malus hupehensis (Pamp.) Rehd., and has found that embryos are formed from unfertilized egg cells and that the embryo sac in the ovules develop from other cells than megaspores or megaspore mother cells. Plants raised from such seed would be identical with each other as well as with the mother plant. From the standpoint of producing uniform apple rootstock material they would be ideal.

MATERIALS AND METHODS

To test the practicability of using seed of Malus hupehensis as rootstock material, seed was secured from the Arnold Arboretum, Jamaica Plains, Mass., thru the courtesy of Dr. Donald Wyman, and from Highland Park, Rochester, N. Y., thru the courtesy of R. E.

Horsey. Many shriveled seeds were contained in the samples, which were received in the fall of the year. They were after-ripened at 41°F for 10 weeks and planted in the spring of the year, being lightly covered with peat moss to aid the emergence of the seedlings.

RESULTS AND DISCUSSION

From 20 linear feet of row in which the sample from the Arnold Arboretum was planted, only 38 plants developed, while from 60 linear feet of row in which the sample from Highland Park was sown, only 8 plants developed. Dermen has reported similar results, in which “a large number of seeds was planted from which a very small number of seedlings was obtained”. From 39 seedlings which developed, 2 plants were tetraploid, 1 had roots both triploid and hexaploid, and 36 were triploids, showing further that all of the seedlings may not be apogamic.

From the practical standpoint, therefore, the low propagation of viable seed and low germination make the use of seed of *Malus hupehensis* for the commercial production of apple rootstocks extremely doubtful. The fact that a species of apple does exist which produces seed parthenogenetically, however, suggests the advisability of continuing the quest for material of this type.
10. COVERAGE OF FRUIT TREE SEED WITH PEAT MOSS

In a previous publication the value of granulated peat moss has been demonstrated as a top-dressing for seedbeds containing fruit tree seed. In subsequent years the behavior has been similar, as shown in Fig. 7. The value has seemed to consist largely in keeping the surface soil from packing and thus preventing the emergence of the large cotyledons which are characteristic of fruit tree seed.

An additional, yet somewhat similar, use of granulated peat moss was made during the spring of 1937. The spring season was so wet that the planting of seed was impossible by usual methods. Fruit tree seed, unlike seed which may be held dry and which does not require after-ripening, such as tomato seed, is held in a cool, moist environment, which is favorable both to after-ripening and germination. The result is that fruit tree seed which has completed the after-ripening process may begin to germinate in storage and must be planted at once.

Fig. 7.—Improved Stand of Pear Seedlings in Seedbeds Covered with Peat Moss.

Three rows to left covered with peat moss; three rows to right not covered.

Seed which had thus begun to germinate in storage was spread in rows in the field and, since the soil was too wet to work, covered with 1 to 1½ inches of granulated peat moss. The seed germinated rapidly and well. Altho many reports were received from nearby nurseries of damping-off in the seedbed due to the wet weather and high humidity of the season, no damping-off was experienced in the peat moss covered beds, even tho the seedlings were crowded in the row. Strong, vigorous plants developed.