New York State Agricultural Experiment Station

Geneva, N. Y.

GRAFTING AMERICAN GRAPES ON VIGOROUS STOCKS

F. E. GLADWIN

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GRAFTING AMERICAN GRAPES ON VIGOROUS STOCKS

F. E. GLADWIN

ABSTRACT

American varieties of grapes vary greatly in fruitfulness and vigor. Many varieties yield bountifully in one or possibly two successive seasons only to return low yields for some years to come. Some varieties, while of excellent quality, possess very poor cluster characters. Species of grapes exhibit wide preferences for soils. Some thrive best in the driest soils, while others prefer an excessive amount of soil water. The roots of some species are adapted to very compact soils, while those of others thrive only in a loose, open soil. For these and other reasons this experiment was prompted.

Clinton, a Riparia-Labrusca hybrid and long cultivated for wine purposes; Riparia Gloire de Montpelier; Rupestris St. George du Lot; No. 3306, a Riparia-Rupestris hybrid; and a cross between the well-known Worden and No. 3306 have been used as stocks on which to graft Catawba, Campbell, Concord, Delaware, Iona, Niagara, and Worden. A like number of own-rooted vines of each variety was planted at the same time alongside the grafted plants. Both lots have had identical care.

The experiments have been conducted on the Station grounds at Fredonia, N. Y. The grafted Concord has been growing on two soil types, viz. Dunkirk silt loam and Dunkirk gravelly loam. The other varieties have been grown only on the latter. One-year rooted stocks were bench-grafted in the spring of 1914, grown in the nursery a year, and then planted in their permanent locations in 1915.

Many vines, both grafted and own-rooted died during the first few years of the experiment. The amount of callous formation about the area where union and stock meet is indicative of the completeness of the union. Only firmly joined bench-grafts should be planted in the vineyard.

Quantity and quality of fruit, as well as vine vigor, indicated by the quantity and quality of cane growth, have been the chief criteria used in judging the effects of grafting.

The results presented in this bulletin supplement those reported in Bulletin No. 508 of this Station, entitled "The Behavior of American Grapes Grafted on Vigorous Stocks," which is now out of print.
All things considered, the data clearly indicate that Clinton has been the best stock on which to graft Catawba, Niagara, and Delaware. From a commercial standpoint the gain in quantity and quality of fruit has been highly profitable. Both Clinton and St. George have proved very satisfactory stocks for Iona, both from production and quality considerations. Riparia Gloire seems to offer most promise as a stock for Concord on gravelly loam soils, while Clinton has given almost unbelievable increases of fruit on silt loam. Clinton and Gloire have proved very conclusively superior for Campbell, with phenomenal fruit increases over vines grown on their own roots. No conclusion can be drawn at this time as to the best stock on which to work Worden. The hybrid No. 3306 and the Worden X No. 3306 stocks certainly have greatly increased cane production, and all three stocks have improved the quality of the fruit.

Fruit quality has been improved on practically all rootstocks, but as a rule that stock which has yielded the most fruit and grown the greatest amount of cane and leaf, has also given the highest quality fruit.

St. George suckers from the stock to a greater extent than either Clinton or Gloire, and the latter least of the three.

While varieties lacking in fruitfulness and vigor have been improved in both respects thru grafting, one cannot expect yields or vigor from them comparable to varieties that are inherently productive and strong.

Varieties unsuited to certain soil types may be adapted by topworking to a suitable rootstock.

The stocks have influenced the cions only in fruitfulness, vigor, and quality of fruit.

It is indicated that cions of varieties inherently lacking in vigor slow down root activity of vigorous stocks.

In these experiments, grafting did not influence the time of foliation, nor has the time of maturity been affected.

The cost of grafted American grapes is still high, and only a very few sources of supply are known. Only commercial vineyardists who have special markets for high quality fruit and the home gardener should consider the use of grafted grapes at the present time.

INTRODUCTION

The results of the investigations reported in this bulletin supplement those given in Bulletin No. 508 of this Station published in 1924.
In that bulletin the problem was quite fully discussed and in consequence will not be dealt with in detail here. There have been no radical changes in the plan of the experiments since 1924, altho one variety has been subjected to test on a different soil type.

The grafting of Old World varieties is a rather common practice in European countries, and for some years the grape growers of California planted grafted vines extensively. The practice there is now decidedly on the wane. The test vineyards on the Wilcox farm at Portland, N. Y., contained the largest number of grafted American varieties and vines known until the beginning of these experiments in 1915. However, for many years, an occasional grape grower has grafted in situ stocks of varieties that were undesirable. Since the publication of Bulletin No. 508 much interest has been aroused in the possibilities of top-working the better American sorts on vigorous rootstocks. Several experiment stations are now conducting tests, using not only the stocks of these experiments, but several others that are indigenous to their respective localities as well.

The data included in this bulletin have been recorded for 13 consecutive years from the same vines; and it is believed that they show fairly clearly the effects that may be expected under like conditions of soil when these varieties are grafted on similar stocks and planted in other localities.

PROCEDURE

STOCK VARIETIES

It is well established that certain varieties of American grapes exhibit soil preferences, i. e., a variety from the nature of its root system may be better adapted to compact or loose soil or to wet or dry soil, depending on whether the roots are fibrous or wiry and whether they extend from the base of the trunk laterally, obliquely, or tend to strike more or less in the same plane as the base of the trunk. Observation of the root systems of many varieties, representing pure species, suggests that the type of root is a species character and that varieties derived from two or more species inherit the rooting type from the parents in varying degree. Thus, two varieties derived from the same species may vary greatly in root characters.

Riparia Gloire de Montpelier and Rupestris St. George du Lot, two stocks developed by the French which have served to save French viticulture from extinction and which had been used for American varieties in some earlier Station tests were chosen. The third stock
used in these experiments is Clinton, a variety long under cultivation and supposedly a Labrusca-Vinifera hybrid.

Riparia, either growing wild or under cultivation, generally possesses a relatively shallow root system, with many fine, branched, hard divisions. This species is hence adapted to soils having the water table rather close to the surface. On the other hand, Rupestris possesses hard, wiry, strong rootlets without fine divisions, which strike deeply if the water table is not close to the surface. Clinton, probably a derivative of Labrusca and Riparia, possesses a root system intermediate between the two. It will thrive in a soil too wet for most cultivated varieties and yet it succeeds almost equally well on deep, dry, loose soils. Clinton roots are more fibrous than those of either Riparia Gloire or St. George.

Since the publication of Bulletin No. 508 another cultivated variety, Worden, has been brought under test. In a study of the rate and thoroness with which healing tissue formed over the joined parts of whip-and-tongue grafted cuttings, it was noted that Worden grafted on a stock known as No. 3306, a Riparia-Rupestris hybrid, formed callous quickly and in abundance. As a result, this stock has been utilized for top-working Worden. Furthermore, Worden was crossed with No. 3306, and the most vigorous seedling resulting from the cross has been used as a stock for Worden. Hence, these two stocks have not been discussed heretofore. It is quite evident that all the stocks are congenial to the cions of all the varieties that have been under test, which is one of the first requirements in the grafting of grapes. Further, all the stocks used root readily from cuttings and the latter are of sufficient diameter to carry good-sized cions. Rupestris St. George, however, is not the equal of Clinton and Riparia Gloire in the latter respect, requiring more stock vines to furnish a given number of sizable stock cuttings than with the other two stocks.

CION VARIETIES

The cion varieties were selected because at the time the experiment was begun they represented the leading American grape varieties for the several purposes for which grapes are grown. At the present time the varieties are Campbell Early, Catawba, Concord, Delaware, Iona, Niagara, and Worden. All of these, with the exception of Iona, are cultivated more or less extensively in the various grape districts of New York. Since they have been described rather minutely many times, it is not considered necessary at this time to
go into the details of their fruit and vine characters. In practically all sections of New York, Campbell and Iona are weak in vine, while Catawba, Concord, Niagara, and Worden are very vigorous. Delaware is intermediate between the two groups. All the varieties, with the exception of Campbell, normally set fairly compact clusters. Campbell, while it has the term early attached, is not in reality an early sort. The fact that it colors early suggests early maturity. With the exception of Catawba and Iona, the others are considered as mid-season in fruit maturity. These two ordinarily mature their fruit well in southwestern New York in about three out of five seasons. All the other varieties are fully described in The Grapes of New York.

THE VINEYARD

LOCATION

The test vineyard is located on the grounds of the Station Vineyard Laboratory at Fredonia. This tract has been under the direction of the Station since 1909. The soils of the region are largely of glacial origin and, hence are quite variable even over small areas. Fortunately, the acreage allotted to this test possesses greater uniformity of soil and topography than any other plat of like size on the farm. The area had been growing Concord for 25 years previous to the beginning of the experiment, and because of scant manuring or fertilizing the soil was badly worn. Locally the soil of this plat is termed gravel, but in reality it is a gravelly loam with a rather high percentage of loam and silt. It is well drained, very deep, and fairly retentive of moisture. Before the plat was replanted to the grafted vines it was summer fallowed one season, and then green manure crops were turned down for two successive seasons.

PLANTING PLAN

The general arrangement of the experimental planting is shown in Fig. 1. The area was divided so that four adjacent rows of 35 vines of each variety could be planted. The four rows of Campbell and Delaware, however include but 18 vines each. The remainder of the Delaware rows are planted with Worden on Clinton, on No. 3306, on own roots, and on the Worden X No. 3306 stock. There are thus 17 vines of Worden in each row.

All the vines are spaced 8 feet apart in the row, with the rows 8 feet apart. The entire block of vines has received like treatment
*Last 17 vines in these four rows from West to East, respectively. Worden on Clinton. Worden on No. 3306. Worden on own roots, and Worden on Worden x No. 3306.

**FIG. 1.—PLAN OF GRAPE GRAFTING EXPERIMENTS, FREDONIA, N. Y., SHOWING LOCATION OF VARIETY ON STOCK WITH THE NUMBER OF VINES PER PLAT.**
throughout the period of the test. The grafted plants were not the equal of the own-rooted vines when planted, but probably would have been had they been grown in the nursery another year.

PROPAGATION OF THE GRAFTED VINES

As bench-grafting had been found to be the more satisfactory method of fitting grape varieties to other stocks in earlier experiments, it was used in this instance. The cion varieties were grafted on 1-year rooted stocks according to the English whip-and-tongue method, two bud cions being used. For the purposes of this experiment it was deemed best to do the grafting in March. The 1-year stocks were cut back to about 8 inches in length, while the roots were trimmed to within 2 or 3 inches of the base of the trunk. Later it was found that grafting unrooted grape cuttings was a very satisfactory method for making grafted vines. Details concerning the process, including the taking of the cion and stock wood, the cutting, the callousing, and the planting are fully discussed in Circular No. 97 of this Station, which may be obtained on request.

The grafted and own-rooted vines were planted in their permanent locations in the spring of 1915. The grafted vines were placed so that the area of the union would stand about 2 inches below the level of the soil when the hole was filled and the soil settled. For the first few years after planting the soil was removed from about the union and if any cion roots had started they were cleanly cut away. The time for this cutting was usually about midsummer. For the past 5 years no attention has been given to this phase of the growing. The Rupestris St. George stock is quite inclined to sucker, Clinton somewhat so, while Riparia Gloire rarely suckers. In any event, all suckers should be removed as fast as they appear. The grafted plants for the first 2 or 3 years grew more slowly than the own-rooted vines. Also the fatalities were a little more numerous with the grafted plants, some that appeared well healed evidently not being thoroughly joined.

CRITERIA

Four years after setting out the vines, it was felt that the plants had become sufficiently established so that record taking was worth while. Hence, beginning with 1919 and each succeeding year up to and including 1931, fruit yields and the amount of cane produced was recorded for each individual vine in the experiment. For the first 5
years of this period, trunk diameters were also measured. Owing to the variations in loose bark ordinarily covering the trunk, it is now believed that these measurements are subject to considerable error, hence they have been discontinued. However for the past 13 years individual vine records have been taken of both fruit and cane yields, and many observations have been made relative to the comparative quality of fruit and cane. The possible effects of rootstocks on maturity of fruit and cane have been watched, and resistance to low winter temperatures studied. Since two of the rootstocks ordinarily come to leaf in the spring earlier than some of the cion varieties in the experiment, the possible influences these stocks might have on the foliation of their cions received attention.

It is believed, however, that the most important criteria, are fruit yields, the quality of the fruit, and the amount and quality of the annual cane growth. The commercial vineyardist is as much concerned with the amount and quality of cane production from year to year as with the fruit. An abundance of well-ripened cane at the close of the growing season augurs well for the fruit crop the following year. Hence, any influence that results in more and better cane becomes a decided asset in the production of good grapes.

In Bulletin No. 508 the probable errors were computed for the data of the 5-year period covered by that publication and there was appended the individual vine records for the benefit of workers interested in statistical analyses. The data for the past 8 years have not been thus treated, but for the benefit of statistical workers individual vine performance will be furnished on request.

In the discussion which follows frequent reference will be made to the various tables. The yields of fruit reported in the tables are given in tons per acre. These figures have been obtained by adding the number of pounds produced by each vine under like treatment and then finding the mean production for each variety on each stock and on its own roots. The means were multiplied by 680, the number of vines planted to the acre in this experiment, and the product converted into tons.

During the first 2 years of the experiment, the pruned canes were weighed for the entire row, but for the past 11 years the cane growth has been recorded for each vine, as in the case of the fruit. The mean yield of cane thus obtained for each variety on each stock has been multiplied by 680, the number of vines per acre, and the cane growth expressed in pounds per acre.
DISCUSSION OF DATA
FRUIT AND CANE YIELDS

The data have been collected into a series of tables, giving the yields of fruit and cane for each of 13 years for each variety on the different stocks and on its own roots, together with the mean for the period.

CATAWBA

A reference to Table 1 shows that in each of the 13 years Catawba grafted on Clinton has outyielded the own-rooted vines growing close by. The minimum increase, 0.30 ton, was obtained in 1929, while the maximum gain from the use of this stock was 2.5 tons, in 1931. The difference between the means of the 13 years shows an annual gain from the Clinton stock of nearly 1.1 tons per acre, or 51 per cent.

Comparing the yields of Catawba grafted on St. George with own-rooted Catawba, it is seen that in 5 of the 13 years, own-rooted vines have outyielded the grafted vines, but that increased gains for the other 8 years have been sufficient to give an annual increase for the entire period of 0.38 ton per acre, or about 18 per cent. Catawba grafted on St. George yielded 1.9 tons more per acre in 1931 than the own-rooted.

In 4 of the 13 years Catawba grafted on Gloire yielded less than the own-rooted vines, but the higher yields on this stock for 9 other seasons gave an average annual increase for the 13 years of 0.66 ton per acre, or 31 per cent. Again, the greatest gain for any one year was 1.9 tons per acre in 1931. It is quite probable, that had St. George and Gloire vines been pruned to their approximate capabilities in the 5 and 4 years, respectively, that their yields fell below the own-rooted vines, the results would have been different. The data for 1921 mean very little, since a late spring freeze killed all buds to about the same extent. However, an average annual increase of 31 per cent on the Gloire stocks for the 13 years would indicate a decided effect from the stock, while that of 51 per cent from Catawba grafted on Clinton is very conclusive.

An examination of Table 2 discloses that the Catawba vines grafted to Clinton have pruned away each year of the 13 much more cane than similarly grown own-rooted Catawba vines. The greatest difference was in 1919 when 950 pounds were cut away and the
<table>
<thead>
<tr>
<th>Stock</th>
<th>1919</th>
<th>1920</th>
<th>1921</th>
<th>1922</th>
<th>1923</th>
<th>1924</th>
<th>1925</th>
<th>1926</th>
<th>1927</th>
<th>1928</th>
<th>1929</th>
<th>1930</th>
<th>1931</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinton</td>
<td>3.30</td>
<td>2.65</td>
<td>1.88</td>
<td>4.90</td>
<td>2.34</td>
<td>1.36</td>
<td>2.40</td>
<td>4.04</td>
<td>2.03</td>
<td>3.19</td>
<td>3.60</td>
<td>3.50</td>
<td>6.60</td>
<td>3.21</td>
</tr>
<tr>
<td>St. George</td>
<td>1.87</td>
<td>2.67</td>
<td>0.93</td>
<td>4.10</td>
<td>1.49</td>
<td>0.91</td>
<td>1.90</td>
<td>3.09</td>
<td>0.98</td>
<td>2.40</td>
<td>2.90</td>
<td>3.40</td>
<td>5.80</td>
<td>2.50</td>
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<td>Own roots</td>
<td>0.99</td>
<td>2.27</td>
<td>1.12</td>
<td>2.70</td>
<td>0.68</td>
<td>0.54</td>
<td>1.60</td>
<td>3.36</td>
<td>1.15</td>
<td>2.70</td>
<td>3.30</td>
<td>3.00</td>
<td>4.10</td>
<td>2.12</td>
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<tr>
<td>Gloire</td>
<td>2.01</td>
<td>1.90</td>
<td>0.96</td>
<td>5.30</td>
<td>1.36</td>
<td>1.36</td>
<td>2.04</td>
<td>4.82</td>
<td>1.46</td>
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<td>3.10</td>
<td>2.80</td>
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</table>

**Table 2.—Cane Growth of Catawba in Pounds per Acre.**

<table>
<thead>
<tr>
<th>Stock</th>
<th>1919</th>
<th>1920</th>
<th>1921</th>
<th>1922</th>
<th>1923</th>
<th>1924</th>
<th>1925</th>
<th>1926</th>
<th>1927</th>
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<tbody>
<tr>
<td>Clinton</td>
<td>1,360</td>
<td>1,122</td>
<td>1,564</td>
<td>775</td>
<td>639</td>
<td>735</td>
<td>1,190</td>
<td>782</td>
<td>612</td>
<td>1,183</td>
<td>931</td>
<td>1,203</td>
<td>1,666</td>
<td>1,058</td>
</tr>
<tr>
<td>St. George</td>
<td>816</td>
<td>482</td>
<td>884</td>
<td>490</td>
<td>292</td>
<td>367</td>
<td>660</td>
<td>517</td>
<td>252</td>
<td>931</td>
<td>782</td>
<td>1,020</td>
<td>1,503</td>
<td>696</td>
</tr>
<tr>
<td>Own roots</td>
<td>406</td>
<td>549</td>
<td>884</td>
<td>190</td>
<td>129</td>
<td>238</td>
<td>490</td>
<td>394</td>
<td>820</td>
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<td>571</td>
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<td>850</td>
<td>482</td>
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<tr>
<td>Gloire</td>
<td>517</td>
<td>523</td>
<td>1,020</td>
<td>435</td>
<td>245</td>
<td>442</td>
<td>673</td>
<td>578</td>
<td>415</td>
<td>1,047</td>
<td>931</td>
<td>1,332</td>
<td>1,632</td>
<td>753</td>
</tr>
</tbody>
</table>
smallest difference in 1929 when the excess was but 200 pounds per acre. For the entire period Catawba grafted to Clinton has annually yielded over 500 pounds more wood per acre than on its own roots.

In 2 of the 13 years the amount of cane from Catawba vines on their own roots has exceeded that of Catawba grafted to St. George, but the latter have annually yielded an excess of 200 pounds per acre for the time under discussion. In 1 year of the 13, the own-rooted Catawba vines have pruned away more cane than those top-worked on Gloire, the average annual increase for the latter over the own-rooted vines being 271 pounds per acre.

A consideration of fruit and wood yields from the four rows would strongly indicate that Clinton has had a very pronounced beneficial effect as a rootstock for Catawba, that Gloire stock has brought about a favorable response, and that of the three stocks, St. George has been least effective.

IONA

The first thing that impresses one as he studies Table 3 is the smaller yields of Iona as compared with Catawba, irrespective of the different types of plants involved. This variety, at least in southwestern New York, is decidedly lacking in fruitfulness and vigor. In 1 year of the 13, own-rooted Iona has produced more fruit than Iona top-worked on Clinton, yet this stock has brought about an average annual increase of fruit for the 13 years of 72 per cent.

While own-rooted Iona has outyielded the vines worked on St. George in 2 of the 13 years, the average annual gain for the stock has been a little higher than 72 per cent. In no year of the period has Iona grafted on Gloire yielded less than the own-rooted plants, while the average annual increase of fruit for the period has been 67 per cent. Thus, it will be seen that all three stocks have very materially increased the yields of Iona.

Reference to Table 4 shows that in each year of the 13 Iona grafted to Clinton and St. George has pruned away more cane than vines on their own roots, and that in only 2 of the 13 years have the own-rooted vines outyielded those on Gloire stocks. It should be noted that in 1931, Iona on St. George, pruned away over 900 pounds more cane per acre than the own-rooted vines. Iona grafted to Clinton has annually pruned away nearly 90 per cent more cane than has been cut from the vines growing on their own roots. Iona on St. George has produced an annual excess of 85 per cent, while the increase in cane for the Gloire stock has been nearly 50 per cent.
Table 3.—Fruit Yields of Iona in Tons per Acre.

<table>
<thead>
<tr>
<th>Stock</th>
<th>1919</th>
<th>1920</th>
<th>1921</th>
<th>1922</th>
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<th>1924</th>
<th>1925</th>
<th>1926</th>
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<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinton</td>
<td>1.32</td>
<td>1.15</td>
<td>1.59</td>
<td>2.60</td>
<td>1.63</td>
<td>1.36</td>
<td>0.83</td>
<td>3.50</td>
<td>0.83</td>
<td>2.50</td>
<td>2.30</td>
<td>2.27</td>
<td>2.00</td>
<td>1.83</td>
</tr>
<tr>
<td>St. George</td>
<td>1.05</td>
<td>1.19</td>
<td>1.68</td>
<td>2.70</td>
<td>1.39</td>
<td>1.12</td>
<td>0.45</td>
<td>2.80</td>
<td>0.73</td>
<td>2.00</td>
<td>2.70</td>
<td>2.70</td>
<td>3.50</td>
<td>1.84</td>
</tr>
<tr>
<td>Own roots</td>
<td>0.78</td>
<td>0.98</td>
<td>1.29</td>
<td>1.30</td>
<td>0.34</td>
<td>0.37</td>
<td>1.40</td>
<td>1.50</td>
<td>0.78</td>
<td>1.50</td>
<td>1.40</td>
<td>1.10</td>
<td>1.10</td>
<td>1.06</td>
</tr>
<tr>
<td>Gloire</td>
<td>1.02</td>
<td>1.15</td>
<td>1.29</td>
<td>2.20</td>
<td>1.70</td>
<td>1.22</td>
<td>1.74</td>
<td>2.30</td>
<td>0.98</td>
<td>1.80</td>
<td>2.70</td>
<td>2.30</td>
<td>2.60</td>
<td>1.77</td>
</tr>
</tbody>
</table>

Table 4.—Cane Growth of Iona in Pounds per Acre.

<table>
<thead>
<tr>
<th>Stock</th>
<th>1919</th>
<th>1920</th>
<th>1921</th>
<th>1922</th>
<th>1923</th>
<th>1924</th>
<th>1925</th>
<th>1926</th>
<th>1927</th>
<th>1928</th>
<th>1929</th>
<th>1930</th>
<th>1931</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinton</td>
<td>690</td>
<td>328</td>
<td>680</td>
<td>408</td>
<td>231</td>
<td>211</td>
<td>401</td>
<td>251</td>
<td>150</td>
<td>571</td>
<td>367</td>
<td>409</td>
<td>979</td>
<td>436</td>
</tr>
<tr>
<td>St. George</td>
<td>595</td>
<td>233</td>
<td>612</td>
<td>415</td>
<td>156</td>
<td>177</td>
<td>408</td>
<td>326</td>
<td>190</td>
<td>714</td>
<td>490</td>
<td>748</td>
<td>1,462</td>
<td>425</td>
</tr>
<tr>
<td>Own roots</td>
<td>586</td>
<td>206</td>
<td>476</td>
<td>122</td>
<td>64</td>
<td>54</td>
<td>170</td>
<td>88</td>
<td>116</td>
<td>272</td>
<td>156</td>
<td>190</td>
<td>493</td>
<td>230</td>
</tr>
<tr>
<td>Gloire</td>
<td>483</td>
<td>156</td>
<td>632</td>
<td>354</td>
<td>231</td>
<td>156</td>
<td>292</td>
<td>204</td>
<td>163</td>
<td>456</td>
<td>347</td>
<td>421</td>
<td>734</td>
<td>340</td>
</tr>
</tbody>
</table>
Taking fruit and wood yields into consideration, it would seem that Clinton and St. George have been of about equal value as stocks for Iona, with Gloire ranking but a little below. All three stocks have greatly influenced the cion variety.

NIAGARA

A study of Table 5 discloses that in each year of the 13 Niagara grafted to Clinton has out-yielded the own-rooted vines from 0.43 to 2.6 tons per acre, and that the average annual increase per acre for the entire period for the Clinton stock has been 83 per cent.

In 1 year of the 13, own-rooted Niagara gave a slightly larger tonnage than Niagara on St. George, but the latter has produced an average annual increase over the own-rooted vines of 62 per cent. Likewise, in 2 of the 13 years, own-rooted Niagara has yielded higher than vines grafted on Gloire, but when the whole period is considered, there has been an average annual increase in fruit from grafting on this stock of 36 per cent.

An examination of Table 6 shows that Niagara grafted to both Clinton and St. George has pruned away each year more cane than has been cut from the own-rooted vines, while in only one year of the period has Niagara top-worked on Gloire failed to exceed the own-rooted vines in the amount of prunings. The average annual increase per acre is 33 per cent for Clinton, 48 per cent for St. George, and 48 per cent for Gloire.

Of the three stocks, it is at once apparent that Clinton outranks the others for Niagara and that St. George is second, yet all have yielded substantial fruit increases. St. George and Gloire have grown more cane each year than Clinton, but the amount developed with the latter has been sufficient to bring to maturity larger quantities of fruit than any other stock.

CONCORD

It was noted in Bulletin No. 508 that Concord had been affected by top-working least of all of the varieties studied, and a like statement is just as pertinent at this time. It would seem from an examination of Table 7 that grafting this variety had been harmful with at least two of the stocks; and had we not had earlier evidence that Concord top-worked on St. George had been made very fruitful, a general assumption to this effect would seem justified. Data that will follow shortly, however, show very conclusively that when one stock is
Table 5.—Fruit Yields of Niagara in Tons per Acre.

<table>
<thead>
<tr>
<th>Stock</th>
<th>1919</th>
<th>1920</th>
<th>1921</th>
<th>1922</th>
<th>1923</th>
<th>1924</th>
<th>1925</th>
<th>1926</th>
<th>1927</th>
<th>1928</th>
<th>1929</th>
<th>1930</th>
<th>1931</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinton</td>
<td>3.10</td>
<td>3.64</td>
<td>0.62</td>
<td>5.50</td>
<td>3.50</td>
<td>2.38</td>
<td>2.17</td>
<td>4.30</td>
<td>1.97</td>
<td>4.00</td>
<td>2.90</td>
<td>3.70</td>
<td>4.60</td>
<td>3.26</td>
</tr>
<tr>
<td>St. George</td>
<td>2.10</td>
<td>1.97</td>
<td>0.18</td>
<td>5.80</td>
<td>3.33</td>
<td>2.48</td>
<td>1.76</td>
<td>3.70</td>
<td>1.56</td>
<td>3.50</td>
<td>2.80</td>
<td>3.50</td>
<td>4.90</td>
<td>2.89</td>
</tr>
<tr>
<td>Own roots</td>
<td>1.05</td>
<td>1.13</td>
<td>0.19</td>
<td>3.70</td>
<td>2.20</td>
<td>1.15</td>
<td>1.36</td>
<td>2.30</td>
<td>1.50</td>
<td>2.10</td>
<td>2.10</td>
<td>2.40</td>
<td>2.00</td>
<td>1.78</td>
</tr>
<tr>
<td>Gloire</td>
<td>2.10</td>
<td>2.16</td>
<td>0.26</td>
<td>4.10</td>
<td>2.44</td>
<td>2.41</td>
<td>1.23</td>
<td>3.90</td>
<td>1.25</td>
<td>2.90</td>
<td>2.50</td>
<td>3.10</td>
<td>3.30</td>
<td>2.43</td>
</tr>
</tbody>
</table>

Table 6.—Cane Growth of Niagara in Pounds per Acre.

<table>
<thead>
<tr>
<th>Stock</th>
<th>1919</th>
<th>1920</th>
<th>1921</th>
<th>1922</th>
<th>1923</th>
<th>1924</th>
<th>1925</th>
<th>1926</th>
<th>1927</th>
<th>1928</th>
<th>1929</th>
<th>1930</th>
<th>1931</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinton</td>
<td>1,210</td>
<td>720</td>
<td>1,292</td>
<td>768</td>
<td>619</td>
<td>911</td>
<td>1,326</td>
<td>707</td>
<td>576</td>
<td>1,088</td>
<td>802</td>
<td>1,033</td>
<td>1,455</td>
<td>962</td>
</tr>
<tr>
<td>St. George</td>
<td>863</td>
<td>616</td>
<td>1,428</td>
<td>925</td>
<td>680</td>
<td>1,204</td>
<td>1,428</td>
<td>931</td>
<td>724</td>
<td>1,305</td>
<td>911</td>
<td>1,060</td>
<td>1,836</td>
<td>1,070</td>
</tr>
<tr>
<td>Own roots</td>
<td>761</td>
<td>447</td>
<td>857</td>
<td>387</td>
<td>319</td>
<td>653</td>
<td>1,040</td>
<td>632</td>
<td>510</td>
<td>993</td>
<td>680</td>
<td>748</td>
<td>1,333</td>
<td>720</td>
</tr>
<tr>
<td>Gloire</td>
<td>744</td>
<td>552</td>
<td>1,183</td>
<td>775</td>
<td>816</td>
<td>1,006</td>
<td>1,258</td>
<td>863</td>
<td>700</td>
<td>1,414</td>
<td>1,169</td>
<td>1,360</td>
<td>2,040</td>
<td>1,067</td>
</tr>
</tbody>
</table>
### Table 7.—Fruit Yields of Concord in Tons per Acre.

<table>
<thead>
<tr>
<th>Stock</th>
<th>1919</th>
<th>1920</th>
<th>1921</th>
<th>1922</th>
<th>1923</th>
<th>1924</th>
<th>1925</th>
<th>1926</th>
<th>1927</th>
<th>1928</th>
<th>1929</th>
<th>1930</th>
<th>1931</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinton</td>
<td>2.50</td>
<td>3.33</td>
<td>0.62</td>
<td>4.90</td>
<td>3.33</td>
<td>2.41</td>
<td>1.44</td>
<td>3.70</td>
<td>2.07</td>
<td>3.20</td>
<td>2.38</td>
<td>3.18</td>
<td>5.10</td>
<td>2.93</td>
</tr>
<tr>
<td>St. George</td>
<td>1.93</td>
<td>2.65</td>
<td>0.36</td>
<td>4.10</td>
<td>3.70</td>
<td>1.97</td>
<td>1.33</td>
<td>2.38</td>
<td>1.17</td>
<td>2.38</td>
<td>1.70</td>
<td>2.97</td>
<td>5.50</td>
<td>2.47</td>
</tr>
<tr>
<td>Own roots</td>
<td>2.58</td>
<td>3.67</td>
<td>0.65</td>
<td>5.50</td>
<td>3.10</td>
<td>2.21</td>
<td>1.84</td>
<td>4.42</td>
<td>2.50</td>
<td>2.78</td>
<td>2.60</td>
<td>3.07</td>
<td>4.20</td>
<td>3.01</td>
</tr>
<tr>
<td>Gloire</td>
<td>3.19</td>
<td>4.04</td>
<td>0.65</td>
<td>5.40</td>
<td>3.36</td>
<td>3.02</td>
<td>1.56</td>
<td>4.04</td>
<td>2.21</td>
<td>3.36</td>
<td>2.38</td>
<td>3.60</td>
<td>5.60</td>
<td>3.26</td>
</tr>
</tbody>
</table>

### Table 8.—Cane Growth of Concord in Pounds per Acre.

<table>
<thead>
<tr>
<th>Stock</th>
<th>1919</th>
<th>1920</th>
<th>1921</th>
<th>1922</th>
<th>1923</th>
<th>1924</th>
<th>1925</th>
<th>1926</th>
<th>1927</th>
<th>1928</th>
<th>1929</th>
<th>1930</th>
<th>1931</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinton</td>
<td>1,360</td>
<td>1,016</td>
<td>1,496</td>
<td>911</td>
<td>843</td>
<td>1,156</td>
<td>1,532</td>
<td>1,224</td>
<td>816</td>
<td>1,530</td>
<td>1,124</td>
<td>1,292</td>
<td>2,067</td>
<td>1,259</td>
</tr>
<tr>
<td>St. George</td>
<td>1,183</td>
<td>1,047</td>
<td>1,564</td>
<td>1,183</td>
<td>999</td>
<td>1,224</td>
<td>1,768</td>
<td>1,496</td>
<td>884</td>
<td>1,863</td>
<td>1,428</td>
<td>1,870</td>
<td>2,584</td>
<td>1,468</td>
</tr>
<tr>
<td>Own roots</td>
<td>986</td>
<td>911</td>
<td>1,224</td>
<td>592</td>
<td>442</td>
<td>748</td>
<td>1,088</td>
<td>816</td>
<td>476</td>
<td>884</td>
<td>700</td>
<td>768</td>
<td>1,224</td>
<td>835</td>
</tr>
<tr>
<td>Gloire</td>
<td>1,258</td>
<td>1,142</td>
<td>1,564</td>
<td>1,204</td>
<td>1,156</td>
<td>1,292</td>
<td>1,666</td>
<td>1,428</td>
<td>748</td>
<td>1,659</td>
<td>1,366</td>
<td>1,720</td>
<td>2,228</td>
<td>1,417</td>
</tr>
</tbody>
</table>
grown on another soil type fruit and cane production in Concord are greatly superior to own-rooted Concord. The average annual increase for Concord grafted on Gloire is only 8 per cent, altogether too small to be considered significant. Much fruit has been lost on the grafted vines each spring because of the fact that they developed their shoots so fast that they were easily broken by the wind. The spacing in the rows would not allow enough additional canes that normally would check rampant growth and hence breakage, and possibly this may explain the poor showing of Clinton and Gloire.

An examination of Table 8 indicates the greatly increased cane growths that have been produced on the grafted vines. It should be noted that in each year of the 13 each stock has grown much more cane per acre than that produced on the own-rooted vines. The increases have been 50 per cent for Clinton, 75 per cent for St. George, and 70 per cent for Gloire for the entire period. Thus it would seem that if some of this excess cane could be utilized for fruiting purposes to a greater degree, the yields of fruit would be materially changed from the figures of Table 7.

Before leaving the discussion of Concord, attention should be directed to the figures in Table 9. A few years ago the Station had a

<table>
<thead>
<tr>
<th>Stock</th>
<th>1930</th>
<th>1931</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Own roots</td>
<td>1.67</td>
<td>3.16</td>
<td>2.42</td>
</tr>
<tr>
<td>Clinton</td>
<td>3.40</td>
<td>6.35</td>
<td>4.88</td>
</tr>
<tr>
<td>Own roots</td>
<td>2.10</td>
<td>2.30</td>
<td>2.20</td>
</tr>
<tr>
<td>Clinton</td>
<td>3.67</td>
<td>6.00</td>
<td>4.84</td>
</tr>
</tbody>
</table>

number of Concord vines top-worked on Clinton in excess of its normal requirements, and these were planted in two rows alternating with two rows of own-rooted Concord on a heavier soil, which was mapped as Dunkirk silt loam and which was quite well supplied with soil moisture. The planting record was mislaid and not until the summer of 1930 was it located. In the fall of that year and subsequently, vine records of fruit and cane were taken. Table 9 reveals that in 1930 Concord top-worked on Clinton yielded 87 per cent more fruit than the adjacent own-rooted vines and that the increase for 1931 amounted to 126 per cent. Table 10, which gives the weights of the canes pruned away, clearly shows that increased production of fruit from the grafted vines was not at the expense of the vitality of
the plants, since 1,500 pounds more cane per acre were pruned from the grafted vines in 1930 than from the own-rooted vines and yet 126 per cent more fruit was produced on the same vines in 1931. Although a heavy crop was borne in 1931, the grafted plants have again pruned 1,600 pounds of cane over and above the prunings from the own-rooted vines.

Table 10.—Cane Growth of Concord in Pounds per Acre on Dunkirk Silt Loam.

<table>
<thead>
<tr>
<th>Stock</th>
<th>1930</th>
<th>1931</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Own roots</td>
<td>381</td>
<td>904</td>
<td>643</td>
</tr>
<tr>
<td>Clinton</td>
<td>1,536</td>
<td>2,040</td>
<td>1,788</td>
</tr>
<tr>
<td>Own roots</td>
<td>374</td>
<td>904</td>
<td>639</td>
</tr>
<tr>
<td>Clinton</td>
<td>2,230</td>
<td>3,060</td>
<td>2,645</td>
</tr>
</tbody>
</table>

In view of these data it would seem that Concord may be greatly increased in its fruitfulness thru grafting. Neither Clinton nor Gloire roots are so well adapted to gravelly soils as to the wetter ones.

CAMPBELL

It should be stated at the outset that Campbell is most particular in its soil requirements and that perhaps climate is the second most important factor in its growing. At any rate we have never seen anywhere in New York vigorous, productive vines of this variety growing on their own roots. The soil on which the variety is growing on the Station grounds at Fredonia is not at all congenial to it. As a result of unfavorable conditions, many vines of Campbell growing on its own roots have died during the life of the experiment and have been replaced by others. Consequently, very few of the own-rooted vines are as old as the grafted plants. Probably the vigor and fruitfulness of the re-sets have been lessened because of the better established vines on either side. In short, the competition of the root systems has been mostly in favor of the grafted vines immediately adjacent. However, an examination of Table 11 shows that even in the first years of the experiment, before some of the original, own-rooted vines succumbed, the grafted plants were more fruitful than the own-rooted. The table reveals that in each of the 13 years Campbell grafted on Clinton has outyielded the own-rooted vines by very substantial increases, while Campbell top-worked on Gloire has yielded annually a little less than Campbell on Clinton. The average annual increase for the entire period is 158 per cent for Clinton and
127 per cent for Gloire. Campbell on St. George has averaged 74 per cent more fruit annually than the own-rooted vines.

Table 12 shows that each of the three stocks in each of the 13 years has pruned away more cane than the own-rooted plants. In terms of percentages, Campbell grafted on Clinton has annually grown over 360 per cent more than the own-rooted plants, on St. George 344 per cent, and on Gloire 330 per cent.

Tables 11 and 12 show conclusively that, under the soil conditions in this vineyard, the use of any one of the three stocks has greatly influenced for the better both the fruit and cane production of Campbell. Certainly it has been unprofitable to grow this variety on its own roots in this experiment.

DELAWARE

A reference to Table 13 discloses that Delaware grafted on Clinton has failed in only 1 of the 13 years to yield more fruit than the own-rooted vines. In one other year the yields from the two lots were identical. For the entire period, the Clinton stocks have annually returned 30 per cent more fruit than was produced by the own-rooted vines.

With the St. George and Gloire stocks the comparative yields have fluctuated first in one direction and then in another. However, viewing the data for the entire period, it is seen that Delaware grafted on St. George has given an average increase annually of 16 per cent, while for Gloire the gain amounts to 22 per cent.

An examination of Table 14 shows that, with the exception of the first year, Delaware grafted to Clinton has each season pruned away considerably more cane than the vines on their own roots. In each of the 13 years the St. George and Gloire stocks have produced much larger amounts of cane than the own-rooted plants. The computations show that Delaware on Clinton roots has annually pruned away 55 per cent more cane than the own-rooted vines, while the increase each year for both St. George and Gloire amounts to 86 per cent.

Since Delaware grafted to Clinton has yielded 30 per cent more fruit and was at the same time vigorous enough to prune away 55 per cent more cane than the own-rooted vines, it would seem that grafting is a very desirable practice for this variety. The second choice of stocks for Delaware would seem to lie with Gloire, while St. George, with an average increase of 16 per cent in fruit production, would seem to rank third.
Table 11.—Fruit Yields of Campbell in Tons per Acre.

<table>
<thead>
<tr>
<th>Stock</th>
<th>1919</th>
<th>1920</th>
<th>1921</th>
<th>1922</th>
<th>1923</th>
<th>1924</th>
<th>1925</th>
<th>1926</th>
<th>1927</th>
<th>1928</th>
<th>1929</th>
<th>1930</th>
<th>1931</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinton</td>
<td>1.90</td>
<td>3.16</td>
<td>0.77</td>
<td>3.70</td>
<td>5.40</td>
<td>2.89</td>
<td>1.87</td>
<td>5.80</td>
<td>2.10</td>
<td>4.70</td>
<td>4.00</td>
<td>4.80</td>
<td>6.70</td>
<td>3.67</td>
</tr>
<tr>
<td>St. George</td>
<td>1.40</td>
<td>2.04</td>
<td>0.18</td>
<td>2.90</td>
<td>4.25</td>
<td>1.70</td>
<td>0.85</td>
<td>3.00</td>
<td>1.22</td>
<td>3.00</td>
<td>3.00</td>
<td>3.90</td>
<td>4.90</td>
<td>2.48</td>
</tr>
<tr>
<td>Own roots</td>
<td>0.48</td>
<td>1.77</td>
<td>0.17</td>
<td>2.30</td>
<td>2.50</td>
<td>0.98</td>
<td>0.88</td>
<td>2.10</td>
<td>1.07</td>
<td>1.80</td>
<td>1.50</td>
<td>0.90</td>
<td>2.00</td>
<td>1.42</td>
</tr>
<tr>
<td>Gloire</td>
<td>2.00</td>
<td>3.15</td>
<td>0.17</td>
<td>4.40</td>
<td>5.44</td>
<td>2.48</td>
<td>1.30</td>
<td>3.00</td>
<td>2.89</td>
<td>3.00</td>
<td>3.90</td>
<td>5.37</td>
<td>5.00</td>
<td>3.23</td>
</tr>
</tbody>
</table>

Table 12.—Cane Growth of Campbell in Pounds per Acre.

<table>
<thead>
<tr>
<th>Stock</th>
<th>1919</th>
<th>1920</th>
<th>1921</th>
<th>1922</th>
<th>1923</th>
<th>1924</th>
<th>1925</th>
<th>1926</th>
<th>1927</th>
<th>1928</th>
<th>1929</th>
<th>1930</th>
<th>1931</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinton</td>
<td>394</td>
<td>418</td>
<td>884</td>
<td>816</td>
<td>659</td>
<td>660</td>
<td>884</td>
<td>748</td>
<td>496</td>
<td>850</td>
<td>660</td>
<td>1,190</td>
<td>1,747</td>
<td>800</td>
</tr>
<tr>
<td>St. George</td>
<td>394</td>
<td>428</td>
<td>748</td>
<td>802</td>
<td>748</td>
<td>544</td>
<td>571</td>
<td>602</td>
<td>442</td>
<td>952</td>
<td>816</td>
<td>1,156</td>
<td>1,747</td>
<td>765</td>
</tr>
<tr>
<td>Own roots</td>
<td>224</td>
<td>216</td>
<td>381</td>
<td>235</td>
<td>143</td>
<td>157</td>
<td>150</td>
<td>129</td>
<td>88</td>
<td>136</td>
<td>116</td>
<td>88</td>
<td>177</td>
<td>172</td>
</tr>
<tr>
<td>Gloire</td>
<td>510</td>
<td>360</td>
<td>659</td>
<td>782</td>
<td>625</td>
<td>716</td>
<td>680</td>
<td>578</td>
<td>550</td>
<td>782</td>
<td>680</td>
<td>1,020</td>
<td>1,706</td>
<td>742</td>
</tr>
</tbody>
</table>
Table 13.—Fruit Yields of Delaware in Tons per Acre.

<table>
<thead>
<tr>
<th>Stock</th>
<th>1919</th>
<th>1920</th>
<th>1921</th>
<th>1922</th>
<th>1923</th>
<th>1924</th>
<th>1925</th>
<th>1926</th>
<th>1927</th>
<th>1928</th>
<th>1929</th>
<th>1930</th>
<th>1931</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinton</td>
<td>2.04</td>
<td>1.29</td>
<td>1.15</td>
<td>2.70</td>
<td>2.99</td>
<td>2.55</td>
<td>2.70</td>
<td>4.10</td>
<td>2.17</td>
<td>2.70</td>
<td>2.60</td>
<td>2.17</td>
<td>4.80</td>
<td>2.60</td>
</tr>
<tr>
<td>St. George</td>
<td>1.42</td>
<td>1.02</td>
<td>0.64</td>
<td>2.70</td>
<td>3.26</td>
<td>2.55</td>
<td>2.24</td>
<td>3.70</td>
<td>1.30</td>
<td>2.40</td>
<td>2.30</td>
<td>2.50</td>
<td>4.20</td>
<td>2.33</td>
</tr>
<tr>
<td>Own roots</td>
<td>0.31</td>
<td>1.76</td>
<td>0.81</td>
<td>2.00</td>
<td>2.00</td>
<td>1.46</td>
<td>1.36</td>
<td>3.10</td>
<td>1.50</td>
<td>2.70</td>
<td>2.40</td>
<td>3.00</td>
<td>3.80</td>
<td>2.00</td>
</tr>
<tr>
<td>Gloire</td>
<td>1.15</td>
<td>1.38</td>
<td>0.78</td>
<td>2.90</td>
<td>4.25</td>
<td>2.44</td>
<td>2.24</td>
<td>3.60</td>
<td>1.40</td>
<td>2.38</td>
<td>2.20</td>
<td>2.90</td>
<td>4.00</td>
<td>2.44</td>
</tr>
</tbody>
</table>

Table 14.—Cane Growth of Delaware in Pounds per Acre.

<table>
<thead>
<tr>
<th>Stock</th>
<th>1919</th>
<th>1920</th>
<th>1921</th>
<th>1922</th>
<th>1923</th>
<th>1924</th>
<th>1925</th>
<th>1926</th>
<th>1927</th>
<th>1928</th>
<th>1929</th>
<th>1930</th>
<th>1931</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinton</td>
<td>313</td>
<td>382</td>
<td>442</td>
<td>490</td>
<td>517</td>
<td>748</td>
<td>952</td>
<td>639</td>
<td>503</td>
<td>816</td>
<td>768</td>
<td>904</td>
<td>1,570</td>
<td>696</td>
</tr>
<tr>
<td>St. George</td>
<td>367</td>
<td>467</td>
<td>544</td>
<td>483</td>
<td>748</td>
<td>884</td>
<td>1,156</td>
<td>680</td>
<td>564</td>
<td>1,020</td>
<td>986</td>
<td>1,224</td>
<td>1,700</td>
<td>832</td>
</tr>
<tr>
<td>Own roots</td>
<td>340</td>
<td>272</td>
<td>387</td>
<td>251</td>
<td>245</td>
<td>238</td>
<td>489</td>
<td>380</td>
<td>326</td>
<td>544</td>
<td>639</td>
<td>551</td>
<td>1,156</td>
<td>447</td>
</tr>
<tr>
<td>Gloire</td>
<td>476</td>
<td>815</td>
<td>489</td>
<td>591</td>
<td>646</td>
<td>816</td>
<td>1,020</td>
<td>666</td>
<td>612</td>
<td>952</td>
<td>1,088</td>
<td>1,067</td>
<td>1,577</td>
<td>832</td>
</tr>
</tbody>
</table>
WORDEN

In Table 15 are presented the Worden data for each of the 6 years this variety has been a part of the experiment. It is to be noted that only in 1931 have the Worden vines top-worked on Clinton yielded more fruit than the own-rooted plants. In the other 5 years the latter have outyielded the Clinton stock. In 3 of the 6 years, Worden grafted on stock No. 3306 has produced more fruit than the own-rooted vines. In the remaining 3 years the reverse is true. In 2 of the 6 years, Worden grafted on the Worden X No. 3306 stock has yielded higher than the own-rooted plants. In the other 4 years the own-rooted vines produced more grapes. The means for the entire period have no significance pro or con, but the yields for 1930 and 1931 indicate that in future years the rootstocks are going to prove effective in the production of fruit in this experiment.

**Table 15.—Fruit Yields of Worden in Tons per Acre.**

<table>
<thead>
<tr>
<th>Stock</th>
<th>1926</th>
<th>1927</th>
<th>1928</th>
<th>1929</th>
<th>1930</th>
<th>1931</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinton</td>
<td>2.95</td>
<td>1.70</td>
<td>2.99</td>
<td>2.30</td>
<td>2.20</td>
<td>4.30</td>
<td>2.74</td>
</tr>
<tr>
<td>No. 3306</td>
<td>3.36</td>
<td>1.88</td>
<td>3.40</td>
<td>3.00</td>
<td>2.80</td>
<td>5.80</td>
<td>3.37</td>
</tr>
<tr>
<td>Own roots</td>
<td>4.00</td>
<td>2.50</td>
<td>3.90</td>
<td>2.70</td>
<td>2.40</td>
<td>4.00</td>
<td>3.25</td>
</tr>
<tr>
<td>Worden X No. 3306</td>
<td>3.60</td>
<td>1.80</td>
<td>2.99</td>
<td>2.50</td>
<td>3.20</td>
<td>4.70</td>
<td>3.13</td>
</tr>
</tbody>
</table>

An examination of Table 16 shows that for the first 2 or 3 years of the experiment the own-rooted vines each season pruned approximately the same amount of cane as vines on the different stocks. It is to be noted further that during the last 2 years all the stocks have greatly exceeded the own-rooted vines in cane production. The last column in Table 16 gives the means for the 6 years. These indicate clearly that the grafted vines have without exception been the most vigorous.

**Table 16.—Cane Growth of Worden in Pounds per Acre.**

<table>
<thead>
<tr>
<th>Stock</th>
<th>1926</th>
<th>1927</th>
<th>1928</th>
<th>1929</th>
<th>1930</th>
<th>1931</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinton</td>
<td>612</td>
<td>544</td>
<td>924</td>
<td>666</td>
<td>721</td>
<td>1,577</td>
<td>841</td>
</tr>
<tr>
<td>No. 3306</td>
<td>548</td>
<td>625</td>
<td>1,020</td>
<td>925</td>
<td>1,228</td>
<td>2,339</td>
<td>1,114</td>
</tr>
<tr>
<td>Own roots</td>
<td>548</td>
<td>394</td>
<td>455</td>
<td>422</td>
<td>299</td>
<td>775</td>
<td>482</td>
</tr>
<tr>
<td>Worden X No. 3306</td>
<td>476</td>
<td>408</td>
<td>693</td>
<td>850</td>
<td>1,020</td>
<td>2,198</td>
<td>941</td>
</tr>
</tbody>
</table>

If the data for 1930 and 1931 both for fruit and cane yield are at all indicative of what may be the future trend of this variety, they point to stock No. 3306 or its diluted form, Worden X No. 3306, as offering greater possibilities than the Clinton.
EFFECTS OF GRAFTING ON QUALITY OF FRUIT

CATAWBA

Catawba fruit from Clinton stock has been far superior to that from the other stocks and from the own-rooted vines in size and compactness of cluster, size of berry, and in general appearance. The fruit has colored more evenly in spite of the larger crop borne. The fruit from the St. George and Gloire stocks has also been somewhat superior to that from the own-rooted plants in the same respects. One would not hesitate, if given the choice, to select the fruit from the grafted vines.

Many factors influence ripening, not the least of which is the quantity of fruit carried by the vine. All the stocks seem to have overcome to a large degree delayed maturity, which ordinarily is coordinated with high yields. Other conditions being equal, the own-rooted vines should mature their fruit earlier and to a higher degree than the grafted plants which carry heavier yields, but the reverse was true with Catawba in this experiment.

IONA

In Bulletin No. 508 the statement was made that the fruit of Iona had been unaffected by grafting up to 1924. However, during the past 8 years, it is very evident that all the stocks have exerted a favorable influence upon the fruit of this variety. Of the three stocks St. George has been the most effective and Gloire the least. Year after year the fruit from the own-rooted vines has been the poorest colored and the clusters have been the most straggly of the lot.

NIAGARA

No great differences have been noted between the fruit of Niagara grafted either on Clinton, St. George, or Gloire, all stocks being considerably superior to own roots. Owing to the color, or rather lack of it, with this variety, no true comparisons could be made as to the effects of grafting on maturity. Such observations as were made indicated that the larger yields from the grafted vines tended to retard the development of the golden yellow color characteristic of Niagara when well matured. Niagara being normally quite compact was not appreciably affected in this regard thru grafting. The berries, especially from the Clinton stock, were larger than those from the other stocks or from the own-rooted vines.
CONCORD

All three stocks produced larger clusters of fruit of Concord, with greater compactness and a finer finish to the large berries than was obtained from the own-rooted vines. The clusters from the own-rooted plants were shorter and broader. Since the own-rooted vines made much less growth of cane and leaf, the fruit was exposed to light to a greater extent than was that on the grafted vines. This tended to equalize the color and maturity of the fruit. Gloire produced the most attractive fruit, with St. George ranking second and Clinton a close third.

The effects of grafting on fruit characters were even more pronounced on the silt loam soil than on the gravelly loam. The greatly increased amount of leaf area produced by the Clinton stock seemed to have been sufficient to color and mature the crops thoroly. Altho increases amounted to 87 and 126 per cent over the own-rooted vines in 1930 and 1931 respectively, at the same time larger and more compact clusters with larger berries were obtained.

CAMPBELL

In all the characters that go to make the fruit of this grape attractive, the rootstocks have played a part. The fruit from the own-rooted vines has been inferior in cluster and berry. Campbell grafted on Clinton and Gloire has yielded fruit superior to that from St. George. Much of the fruit from the own-rooted vines has been unsalable because of inferior quality, especially straggliness.

DELAWARE

Thruout the entire period the fruit of Delaware from all three stocks has been markedly superior to that from the own-rooted vines. Larger clusters and berries have characterized the fruit from the three stocks. No differences in time of ripening was noted that could be ascribed to stock influence. Here again the larger quantity of fruit borne could easily nullify the effect of stock. No variety is more greatly affected by the quantity of fruit carried in respect to color and maturity than is Delaware. The fruit from the grafted vines was the more marketable.

WORDEN

Both stocks No. 3306 and Worden X No. 3306 have grown fruit that is much superior to that from the own-rooted vines. Fruit pro-
duced on the Clinton stock was somewhat better than that from the own-rooted vines. The first two stocks overcame to a considerable extent the tendency of the variety to color and ripen unevenly except in a very favorable growing season, or when the vines are closely pruned. Normally, Worden produces compact clusters and large berries. The first two stocks tended to heighten these characters.

GENERAL OBSERVATIONS

No stock has in the least affected the time of foliation of any variety used in these tests, altho some of the stocks, notably Gloire, when once foliation has been initiated, cause the shoots to elongate at a much faster rate than occurs with the same variety on its own roots. This may prove objectionable if high winds are common early in the season, as much breaking of shoots may result. Gloire is a better stock on which to work if cuttings are bench-grafted, since their larger caliper permit the use of good-sized cions. The amount and rapidity with which healing tissue forms is greatly favored thru the use of rather large cuttings as stocks, and cions to match. Clinton and St. George sucker more freely in the vineyard than does Gloire, St. George more than Clinton. The expense of sucker removal with St. George might prove rather costly in commercial practise. In any event suckers should be removed each year shortly after they begin to develop.

The data for the 13 years indicate that varieties inherently low in fruitfulness and vigor cannot be brought to the production and growth of the more fruitful and vigorous sorts thru top-working on vigorous stocks. While Delaware and Iona have been markedly improved in both respects thru grafting, their yields in no wise approach those of Concord, Catawba, and Niagara. Thus, it would seem that the cion variety exerts an influence on the stock. In view of this limitation, one should not expect pronounced results thru top-working very feeble varieties on vigorous rootstocks.

The stocks have not influenced the cion varieties in any other respects than fruitfulness, quality and vigor in this experiment. Each variety has retained its inherent, individual characters, which distinguish it from every other variety.

Grape vines grown from cuttings taken from the grafted varieties are not one whit better or worse than vines propagated from any vigorous, own-rooted vine of like variety.
Top-working grapes can make varieties that are unadapted to certain soil types adaptable thru the use of the correct rootstock. Concord does not do as well planted on silt loam soils as on loams and gravelly loams, while Clinton grows vigorously on silt loam, as indicated by the data.

CONCLUSIONS

Taking into consideration fruit yield and the amount of cane produced, it is plain that Catawba grafted on Clinton has been highly profitable from the standpoint of the commercial vineyardist as well as the home gardener. The data indicate that Catawba top-worked on Gloire has not been as responsive as on the Clinton stock, and even less so on St. George.

Clinton and St. George seem to have been of approximately equal value in the growing of Iona, with Gloire ranking a little below. The experiment would indicate that under like conditions it would be folly to attempt to grow Iona without grafting.

Clinton has proved the outstanding stock for Niagara in this experiment, with St. George second and Gloire third. All three have been very effective in the production of higher yields.

Concord on a gravelly loam soil has, next to Worden, been least affected by grafting. Of the three stocks, Gloire promises the most. On Dunkirk silt loam, Concord grafted on Clinton has yielded the greater fruit increases in the two years for which data have been taken than for any other variety on any stock in the experiment.

The data show that Clinton and Gloire have been the outstanding stocks for Campbell. The fruit yields for the entire period have been greatly in excess of those harvested from the own-rooted vines. St. George has also proved very desirable as a stock for this variety. The tests clearly show that under the conditions of soil and climate prevailing, Campbell can only be grown profitably year after year by means of grafted plants.

The first choice of a stock for Delaware unquestionably falls to Clinton. Gloire would seem the second choice and St. George the least desirable. The first two stocks no doubt would prove profitable in commercial plantings.

No very definite conclusions can be drawn at present as to the value of grafting Worden on the stocks utilized in this experiment, at least so far as yield increases are concerned. Grafting has resulted, however, in the production of fruit of much higher quality.
Whether grafted grapes can be profitably utilized at present in commercial vineyards is dependent on several factors. The first consideration is the probable cost of top-worked vines. These must of necessity sell at a higher price than ordinary nursery-propagated plants. Only one nursery in the West, so far as is known to the author supplies grafted American varieties, and these must be ordered several months before delivery can be made in any considerable quantities. It is impractical for the average vineyardist to attempt to make his own grafts, because of the necessity of providing a proper place for the callousing. The details for this and other steps in bench-grafting are fully described in Circular No. 97 of this Station.

Again, the selling prices for most grape varieties, with the possible exception of Catawba, have been so low for the past few years that the initial expenditure for grafted vines would not seem warranted. Growers who own or supply roadside stands with grapes might be justified in the purchase of top-worked plants because of the superior fruit obtainable from grafted vines, especially of Delaware, Campbell, Concord, Catawba, and Worden. The commercial demand for Iona is so small that grafted vines of it would not seem justified.

The use of grafted vines of all the varieties in the experiment, and possibly others, is warranted in every home garden or private collection.

Varieties that are not adapted to specific soil types may, in many instances, be grown satisfactorily by grafting on rootstocks that are adapted to a particular soil.

American grapes should not be grafted with the idea that earlier maturity of fruit will result or that the inherent fruit characters will be changed. Each variety maintains its identity in all essentials when top-worked to any rootstock.

Grafted grapes have proved no more resistant to low temperatures than the own-rooted vines.