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THE CAUSE AND PERMANENCE OF SIZE DIFFERENCES IN APPLE TREES

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BULLETIN 310

THE CAUSE AND PERMANENCE OF SIZE DIFFERENCES IN APPLE TREES[1]

KARL SAX AND JOHN W. GOWEN.

SUMMARY

Apple trees of the same age and grown under similar conditions may vary greatly in size. The early size differences are relatively permanent in subsequent years. The evidence indicates that the larger grades of nursery stock will usually result in larger and therefor more productive trees than the smaller grades OF THE SAME AGE.

Variability in size of apple trees may be due to many factors, but in case of the "stock and scion" orchard at Highmoor Farm the only known factor which might cause permanent differences in size was the variability of the seedling root systems.

The best grade of one year old nursery stock is recommended because the size differences will depend in part at least on inherent differences in the trees and not to differences in age. The one-year whips can also be transplanted with less shock than can an older tree.

INTRODUCTION

It is well known that apple trees of the same age and variety may vary greatly in size and productivity. In the Ben Davis orchard at Highmoor Farm certain trees have yielded less than a bushel of fruit per year while adjacent trees of the same age and under apparently identical conditions have produced an average yield of more than 5 bushels per year In fact almost one-third of the 881 Ben Davis trees have been so unproductive that they were unprofitable. In a previous paper it has been shown that these differences in productivity cannot be attributed entirely to the environmental effects of soil, exposure, weather conditions,

[1]Papers from the biological laboratory of the Maine Agricultural Experiment Station. No. 159.

etc., but are to a considerable extent due to the inherent differences in the individual trees. These inherent differences may be caused by the stock or the scion.

There is also much variation in size of nursery trees of the same age and variety. The nursery trees are graded according to size and are priced accordingly. For instance one nursery company advertises their first grade one year old apple trees, 5 to 6 feet tall, at $30.00 per hundred while the fifth grade, consisting of trees 18 to 24 inches tall, is quoted at $6.00 per hundred. If size differences of nursery trees are not due entirely to environmental conditions, but are relatively permanent in later years, there is a good reason to use only the best grades of nursery stock. If large grades of nursery stock produce larger and more productive trees than smaller grades of nursery stock then the grower is justified in paying the increased price for the best grades. On the other hand, if there is no relation between size of nursery tree and ultimate performance, the grower is paying a big price for wood. Strange as it may seem there is no available experimental evidence to show the differences in ultimate growth and yield of different grades of nursery stock.

The inherent differences in size of apple trees of the same age and variety can be attributed either to differences in the buds or scions, or to variability of the root systems. All horticultural varieties of apples are propagated by grafting buds or scions on seedling stocks. By budding or grafting, a given variety is perpetuated generation after generation with practically no change. Every tree of a given variety is like the original parental tree in color, size and shape of fruit produced, and in hardiness and productivity, with practically no exceptions. Occasionally a change may occur in a certain bud which results in some change in fruit or leaf such as color or shape. Such bud mutations are, however, very rare in apple varieties and there is no critical evidence that differences in productivity are caused by bud mutation in any clonal variety. (3)[2]

On the other hand the root systems of apple trees are extremely variable due to the use of seedling stocks. Most apple trees are grafted or budded on French Crab seedling stocks. The French Crab apple seeds are from "natural" or seedling trees grown in France, the fruit of which is used for making cider.

[2]References to "Literature Cited."

The seedlings for stocks are grown either in France or the United States. Cider mill pomace from Vermont is also used to some extent as a source of seed but usually such pomace contains some seeds of horticultural varieties. The seeds from horticultural varieties are considered inferior to seeds from "natural" trees for growing stocks.

Seedling apple trees are extremely variable even if they are from a single horticultural variety. In a seedling orchard at Highmoor Farm the trees varied in trunk girth from 2 to 18 cm. in 1921, even though they were the same age. One has only to observe the "Natural" trees so abundant in New England, to realize the great variability that exists in size, vigor, type of growth, season of maturity and adaptability to certain types of soil. It is only reasonable to suppose that buds or scions grafted on such seedlings would also vary greatly in subsequent growth and yield.

The effect of the stock on tree growth may vary somewhat with different methods of grafting. There are three general methods of grafting used by nurserymen. Apple varieties may be budded on seedling stocks or may be grafted either on whole seedling roots or on piece roots. In the first method buds are inserted in the seedling several inches from the ground. This is done in August or September. The following spring the top of the seedling tree is removed and the grafted bud makes a growth of 2 to 6 feet. This one year old whip may be sold to be planted the following year or may be retained in the nursery another year. This method is commonly used by the eastern nurseries.

Whole root grafts are made by grafting a scion about 6 inches long on a whole seedling root. The union is made at the crown or collar of the seedling tree. Often the root is trimmed or shortened to facilitate handling.

The piece root grafts are made by grafting a scion 6 to 12 inches long on a piece of seedling root several inches long. Tap rooted seedlings are usually used for this purpose, as such a seedling will make several piece roots. The graft is often planted deep so that about 6 inches or more of the scion is under ground. This practice is claimed to cause roots to develop from the scion so that ultimately the variety is on its own roots and the function of the seedling root system is simply to act as a nurse root for several years. However, it is questionable whether this method does produce enough scion roots to be of any practical value in

many cases (1) and some varieties will not produce sufficient scion roots to be of value under the most favorable conditions. (5)

Shaw (5) does find, however, that some varieties when worked on a piece root and set deep will develop a good root system from the scion in a large percentage of cases. By removing the seedling root after several years the tree is established on its own roots. It is believed that certain vigorous, hardy varieties such as McIntosh will do better on their own roots than on the average seedling root. This method promises to be of much value for such varieties.

Unless nursery trees are made to grow on their own roots (and this is impossible or undesirable for some varieties) there will be great variability in root systems due to the use of seedling stocks. It is then simply a matter of chance whether a tree has a weak or vigorous root system in most cases. What is the effect of the variable stocks on ultimate tree growth and productivity?

EXPERIMENTAL METHODS AND RESULTS.

In 1911 the horticulturist of the Maine Agricultural Experiment Station outlined an experiment to test the value of different varieties of apples on two kinds of stocks. The varieties used were Gravenstein, Rolfe, Milding, Wealthy, Stark, McIntosh, Baldwin, Spy, Larue, and Tolman Sweet. The stocks selected were French Crab and Tolman Sweet. The Tolman Sweet was obtained by budding on French Crab and setting the whip deep enough to permit it to root. The French Crab root was not removed. In view of Shaw's (5) work it is improbable that the Tolman ever went onto its own roots as this variety was found to strike roots from the scion in very few cases. The different varieties were budded on the two classes of stocks in 1912 and 1913. The trees were set in the orchard in the spring of 1914. Forty trees of each variety were used—20 on French Crab and 20 on Tolman Sweet roots,--and were set in rows of 20 trees each. The trees on each kind of stock were planted in alternate rows. The problem as originally outlined is of little value due to the fact that both of the stocks can probably be properly classed as French Crab although those designated as Tolman Sweet are double worked. However, the work is of value from

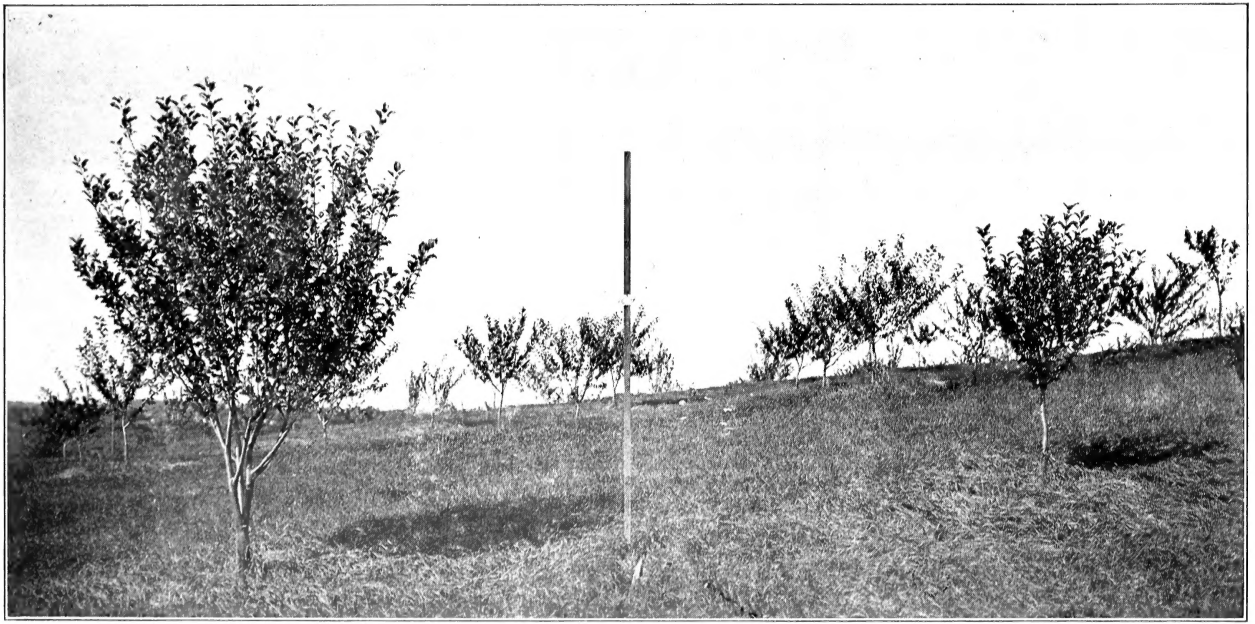

FIG. 1. The two trees in the foreground were both budded on French Crab roots in 1913. Although the two trees have received the same treatment the one at the left is more than twice as large as the one at the right. Part of the variation in size is attributed to the effect of the variation in vigor of the seedling stocks on which the trees were budded.

another standpoint,—i. e., the variation and permanence of early size differences in apple trees.

No data were taken on these trees in 1914 and 1915 but in 1916 the trunk girth was measured and since then the trunk circumference has been obtained each fall. Although about 400 trees were set in the orchard many of them died and were reset or were seriously injured so that in 1922 there were left 208 trees for which records are complete and which are free from injury. Thus the number of trees of each variety is too small for a satisfactory comparison of the growth of different varieties.

The buds of each variety were selected from a single tree in each case, thus practically eliminating any possible variation due to bud mutation or to disease transmitted by grafting. The soil in the orchard was found to be uniform when tested for soil heterogeneity. There was no difference in size of trees whether on the so-called Tolman roots or French Crab roots. There was some variability due to differences in growth rate of different varieties but the variability within each variety was so great that varietal differences have little effect on the permanent size differences of individual trees. It has been shown in a more technical paper that the only known factor which may cause the permanent differences in yield is the variable root stocks. (4) All other known factors are under control or are of minor importance.

Although the only known variable factor of importance in causing tree variability in the stock and scion orchard is the effect of root stocks, yet great differences are found in the size of the trees. In 1916 some trees had a trunk circumference of less than 2 cm. while others had a trunk girth of over 7 cm. In 1922 the size differences, as indicated by trunk circumference, ranged from 7 to 27 cm. The size differences in the stock and scion orchard are well illustrated in figure 1. The two Spy trees in the foreground were both budded on French Crab stocks in 1913. The buds came from the same tree. The trees are on apparently uniform soil. Yet in 1922 the tree at the right had a trunk girth of 11.5 cm. while the tree at the left had a trunk girth of 26.1 cm.

Not only are the trees extremely variable in size but the size differences are relatively permanent. Trees which were small in 1916 were relatively small in 1922 and the large trees in 1916

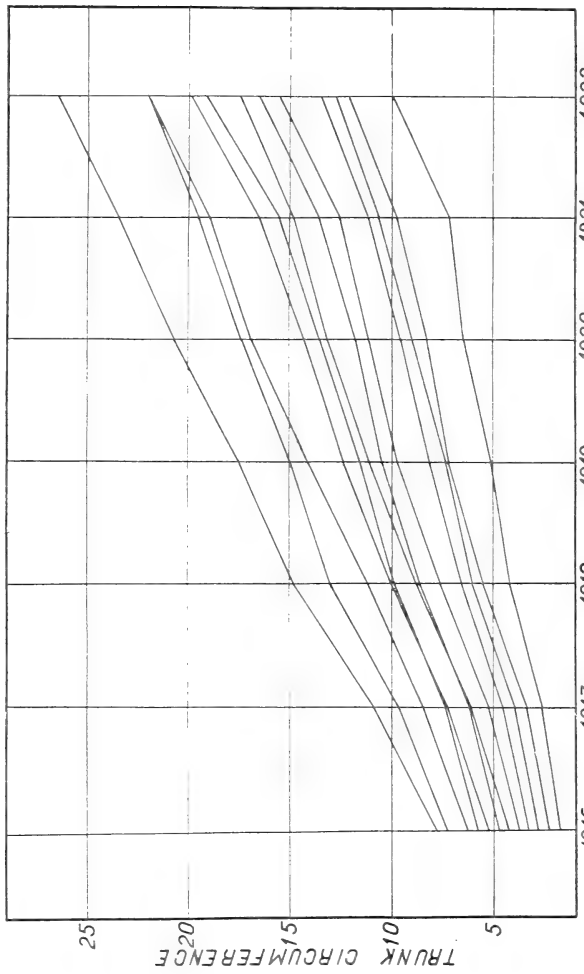

FIG. 2. Showing the permanence in size differences of 208 trees in the "stock and scion" orchard. The trees were grouped according to trunk circumference in .5 cm. classes in 1916 and the average size of each group is shown for each subsequent year. The group with an average trunk girth of 1.75 cm. in 1916 had an average trunk girth of 10.0 cm. in 1922 while the group with an average trunk girth of 7.75 cm. in 1916 had an average trunk girth of 26.6 cm. in 1922.

have in general maintained their superiority year after year. The permanence in size differences is well illustrated in figure 2. The 208 trees were divided into 13 different size groups in 1916 and the average size of each group is shown for each year up to and including 1922. For instance the trees which had an average trunk girth of 1.75 cm. in 1916 had an average trunk girth of 10.0 cm. in 1922, while the trees with greatest trunk girth in 1916 also have on the average the largest trunk girth in 1922. In a few cases the relative size differences have changed somewhat

but in general the trees which were large in 1916 are also relatively large in 1922. It seems probable that these relative size differences will also be maintained in future years.

In the analysis of the data on the stock and scion orchard the trunk girth has been considered as a measure of the value of the tree. It is generally recognized by horticulturists that trunk circumference is closely associated with productivity. This has been definitely shown for Ben Davis (2), York, Baldwin, Stayman and Jonathan. (6)

It has also been shown that the permanence in differences in yield are almost entirely due to differences in tree size as measured by trunk circumference. (4) It is evident then that relatively permanent differences in size and therefore in productivity may exist in apple trees where the only known variable factor of importance is the effect of differences in vigor or adaptability of the seedling root systems.

CONCLUSIONS

The available evidence indicates that trees which are small when set in the orchard are likely to remain small, and will therefore be relatively unproductive, in subsequent years. In the stock and scion orchard at Highmoor Farm the permanent differences in tree size are not due primarily to soil variability, varietal differences, bud mutation or to any known differential treatment. Although many unknown factors may be involved it seems probable that differences in vigor of the seedling stocks, (the only *known* variable factor of importance) are the cause of at least some of the permanent differences in size of the young trees in the orchard.

The evidence also indicates that the larger grades of nursery stock will usually result in larger and more productive trees than the small grades *of the same age*. This conclusion is in accord with Webber's (7) recommendations in regard to citrus nursery stock.

Large size in nursery trees is not always desirable, however, and large trees may actually be inferior to the smaller grades in some cases. If trees are large because they have grown in the nursery several years they may be older dwarfs which were too small to be sold as a one year whip. Even if the larger two and three year old trees made a good growth from the beginning they may be no better to set out than smaller trees because the shock

of transplanting is greater with larger trees. Although a first grade two or three year old tree is larger than first grade one year old the latter will probably make just as good growth and bear just as early as the older trees. This is the conclusion of some of the more progressive horticulturists. If the grower wishes to buy wood, however, the nurseryman is willing to sell it to him.

The best grade of one year old nursery stock is recommended because the size differences will depend in part at least on inherent differences in the trees and not to differences in age. The shock of transplanting one year whips is less than for older trees. The grower can also head and shape his tree as he wishes, if the one year whip is used. In ordering one year old nursery stock it would be advisable to pay attention to the method of grading. The size will vary somewhat according to variety and climatic conditions, but is essential to get trees which are *relatively* large. Under some conditions this might mean trees 5 feet tall and up while in other cases trees 4 ft. and up or even less may cull out the inferior stock. Some nurseries advertise only one grade of one year old nursery stock classing as XXX all trees 3 feet and up. Other companies have as many as five grades. Nursery trees are graded according to height or to caliper. The caliper is probably a better measure of the size and vigor. It is essential not only that the trees be *relatively* large for their age and for the conditions under which they are grown, but they should of course be well matured and free from disease.

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