

AVOCADO ROOTSTOCK EXPERIMENTS - A 10-YEAR REPORT



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SUMMARY

Avocado rootstock experiments and related problems are discussed.

Fifty-three field plots, averaging more than 100 trees each, have been established during the period between 1943 and 1953. Two-thirds of the plots are now in satisfactory condition; the rest are doubtful or have been lost.

Thirty-seven rootstock varieties and five scion varieties are included.

The most valuable information so far obtained is that Guatemalan varieties are or seem to be more susceptible to chlorosis, Verticillium wilt, and Dothiorella canker than Mexican varieties.

This report covers the period between 1943 and 1953. Information already published will be summarized to make the report as complete as possible. For details, the reader is referred to the original article.

The chief objective of this experiment is to test the effects of various rootstock varieties on scion productivity and economic longevity. Obviously this is a long term project requiring many grower cooperative test plots in order to minimize, as much as possible, the effects on plant growth of such factors as soil and rootstock seedling variability and orchard practices. It also requires the use of several scion varieties because inter-action between stock and scion may vary.

Although over 50 plots, totaling more than 6,000 trees, have been planted, losses have been greater than anticipated. These were caused mainly by severe freezes, diseases, and neglect mainly as a result of change in ownership of the property on which the plots were located. These and other problems will be mentioned again in appropriate places.

The most valuable information obtained so far pertains to differences in susceptibility between Mexican and Guatemalan rootstocks to three diseases: chlorosis, Verticillium wilt, and Dothiorella, which will be discussed later.

ROOTSTOCKS

A fairly extensive orchard survey made in 1942 and 1943 revealed very little reliable information regarding rootstock varieties used in the past. It confirmed the generally held belief that the great majority of the trees were on Mexican stocks, presumably of unknown origin. However, three Fuerte orchards were found in which about 90% of the trees were on Guatemalan and probably so-called hybrids, and 10% on Mexican stocks. There was no noticeable consistent difference in tree size and production, which suggested the inclusion of Guatemalan stocks in the field trials.

Seedlings of 37 varieties—22 Guatemalan, 13 Mexican, and 2 West Indian—were used. West Indian are considered too tender for California conditions, but they were included to a very limited extent to test their alleged resistance to root rot (disproved later) and greater tolerance to saline soil conditions.

Following is the list of varieties used during the ten year period, not all of them being available every year. Those represented in five or more plots are starred (*).

<i>Guatemalan</i>	<i>Mexican</i>
*Anaheim	*Blake
*Cabnal	*Duke
*Carlsbad	*Ganter
"Challenge	*Gherkin
*Dickinson	*Mexicola
*Edranol	*Northrop
*Hass	Puebla
*Itzamna	*Topa Topa
*Lyon	*Zutano
*MacArthur	4 unnamed seedlings
*Mayapan	
*Nabal Panchoy	
Queen	<i>West Indian</i>
Ryan	*Waldin
*Sharpless	*Lula
Spinks	
•Taft	
4 unnamed seedlings	

Lula is considered to be a Guatemalan-Mexican hybrid, but seems to fit better into the West Indian group.

In this connection the reader is reminded that avocados do not come true from seed; hence, in effect, every seedling is a different variety, although some of the progeny may resemble the parent in leaf and fruit characters and growth habit. Therefore, when rootstocks such as Topa Topa or Nabal, for example, are listed as varieties, what is actually meant is that they are seedlings of these varieties. Only progenies obtained by asexual means, such as cuttings, are genetically the same as the parent tree.

SEEDS

Seeds were necessarily obtained from many sources. Most of the Guatemalan came from cull fruit donated by the Calavo packing house, Los Angeles. Some lots came from single trees growing in the U.C.L.A. orchard and commercial orchards.

The greater part of the Mexican seeds came from single trees in the U.C.L.A. orchard, the rest from the Citrus Experiment Station, Riverside, and commercial orchards. The West Indian seeds were obtained from Florida through F. B. Lincoln, University of Florida Subtropical Experiment Station, Homestead. All seeds, except West Indian, were obtained in the fruit in order to be certain of the variety.

Until a satisfactory storage method was discovered¹, it was necessary to plant the seeds as they became available. This resulted in a nursery in which seedlings of spring and summer varieties (Guatemalan) often reached budding size before seeds of the fall varieties (Mexican) were mature.

Another problem was delayed and/or uneven germination of most varieties, especially Guatemalan, which resulted in considerable variation in seedling size. The most practical method of minimizing this factor was found to consist of cutting off parts of the top and bottom of the seed before planting.¹

SCION VARIETIES

Five scion varieties were included to observe their reaction with various rootstocks. They were Fuerte, MacArthur, Hass, Anaheim, and Rincon. Through the courtesy of R. Hass and H. H. Brokaw, the Hass variety was propagated free of charge beginning in 1949. So-called Fuerte strains included Newman, Cole, Culbertson, and McDonald.

NURSERIES

The trees were propagated in six nurseries as follows:

1. Subtropical area, U.C.L.A. Budlings and tip-grafts for general distribution.
2. Shepard's Mesa, Carpinteria. Through the courtesy and hearty cooperation of Stanley and John Shepard, all the MacArthur trees for the Santa Bar bara County plots were propagated.
3. Rancho Sespe, Fillmore. Fuerte and Hass grown exclusively for plots on this ranch.
4. E. R. Eggers' nursery, Fallbrook. Fuerte and Hass trees for San Diego County and for one plot each in Riverside and Orange Counties.

5. E. Borchard, Oxnard. Dickinson for one plot on this ranch.
6. La Patera Ranch, Goleta. MacArthur and Hass for two plots on this ranch.
7. Santa Barbara County Hospital. Many seedlings were grown and distributed in the County by the late Arnold White, then farm advisor of Santa Barbara County. Some of the seedlings were later top-worked to different scion varieties.

NURSERY OBSERVATIONS

Difficulties and losses such as are often experienced by nurserymen were encountered. Frost injuries and bud failures were most common. One entire nursery of about 400 trees was killed by frost, and partial losses and injuries were suffered in several nurseries.

Bud failures were especially bothersome with MacArthur and Hass varieties, although at times the "take" was very good. Tip grafting was generally satisfactory when done during the winter months, but the results were irregular at other times. The condition of the scion wood seemed to be the underlying reason, but this problem was not investigated.

No consistent trend was observed as to "bud take" in relation to root-stock variety except on the West Indian variety Waldin, in which case the percentage of budlings obtained was generally below average. Observations did not indicate that seedlings from a single tree vary less than seedlings from mixed lots of the same variety.

Guatemalan varieties, as a group, grew more rapidly than Mexican, but this difference in growth was not noticeably reflected in yearling budlings.

Most of the trees planted were standard budlings and so-called "tied-up buds", that *is*, partly grown scions tied to the stock stub. Others were either side or tip grafts grown in 4-inch paper pots or 3-gallon cans.

In 1952 and 1953 a small number of cuttings were planted for comparison with budlings. These were propagated by a somewhat involved but very successful method.⁵

FIELD PLOTS

Locating a plot site presented a problem because the combination of reasonably well drained and uniform soil, relative freedom from severe freezes, and assurance of reasonably good care was practically impossible to find.

Very little progress was made during the war years, but since 1945 over 6,000 trees were grown and distributed. Omitting a number of very small plantings, 53 plots averaging over 100 trees each have been established, over 70% of them during the past 6 years.

The layout of the plots varied according to the size and shape of the area. Generally, trees on the same rootstock variety were planted in twos or threes and replicated.

The number of trees on each rootstock variety often varied considerably. This was unavoidable since differences in "bud take" and sometimes frost injury frequently

resulted in more trees on some stocks than on others. Wherever possible a minimum of 8 trees on a given stock were planted in the larger plots. Of course, not all rootstock varieties are represented in any one plot. Unfortunately replants were necessary in practically all plots; in several this amounted to 10%. Often trees on the same stock were not available, and substitutions had to be made.

Table I gives a summary of the plots planted and their condition and usefulness as of December 1953.

Scion Variety	No. of Plots Planted	Good or Fair	Of Doubtful Value	Lost
Fuerte	19	11	6	2
Hass	17	14	—	3
MacArthur	12	6	3	3
Rincon	3	3	—	—
Anaheim	2	1	—	1
Total	53	35	9	9

One additional Hass plot will be planted in Spring 1954, and this will terminate the plantings except possibly for some cuttings.

As already mentioned, Arnold White, former farm advisor of Santa Barbara County, planted seedlings. He established 12 plots (not included in Table I), totaling about 1,700 trees, with the intention of grafting them later. Unfortunately practically all of them have been abandoned for various reasons without obtaining any information of value.

It will be noted in Table I that, as of December 1953, only 66% of the plots were in good or fair condition. In view of the fact that 74% of these plots are only 6 years old or younger, additional plots may be expected to lose their usefulness.

COLD HARDINESS

As has been mentioned, freezes have been responsible for considerable losses. Although avocado varieties of the Mexican race are inherently more cold-hardy than Guatemalan varieties, observations indicate that this difference does not manifest itself when the trees are in a succulent condition at the time of a freeze. Details of these observations and results with grafting cold-injured trees were given in two reports.^{2,3}

ROOTSTOCK EFFECT ON SCION AND BUD UNION

No detailed study has been made to determine the effect of various root-stocks on scion growth. General observations indicate differences in size of trees on Guatemalan as well as on Mexican rootstocks, but any specific statement at this stage may be misleading, especially in view of the fact that most of the plots are very young.

As to type of bud union, limited observations suggest a greater tendency toward scion overgrowth when on Mexican than when on Guatemalan. But there are also indications that this may not hold for all scion-rootstock combinations.

YIELD

The records, so far, are too limited or too variable to justify even a tentative statement. From one to three yields have been obtained from 4 Fuerte, 4 MacArthur, and one Anaheim plot.

Unfortunately the records from the Fuerte plots, now 7 to 11 years old, have been of little or no value. The oldest produced only one good crop before it became worthless due to several freezes and root rot. Two of the plots suffered from insufficient soil moisture at critical times, resulting in small and erratic production. The fourth Fuerte plot, now 8 years old, is in excellent condition, but unfortunately it is located in an area not especially suitable for this variety. It has furnished three yield records, all very small and variable. The average number of fruit for 36 trees on Guatemalan stocks is 15 and for 25 trees on Mexican, 16. Practically no fruit set in 1953.

The four MacArthur and one Anaheim plots have yielded one crop in 1953. Unfortunately three diseases—chlorosis, Verticillium wilt, and Dothiorella—have affected a number of MacArthur trees in varying degrees, which will make the interpretation of future yields in terms of rootstock effect difficult, if not impossible.

DISEASES

As already indicated, the most valuable information that has so far emerged from the rootstock trials pertains to differences in degree of susceptibility or tolerance of Guatemalan and Mexican rootstocks to certain diseases. These include chlorosis, Verticillium wilt, and Dothiorella canker.

Two other diseases, root rot and mottle leaf, have shown no rootstock preferences. In addition to diseases, considerable damage and losses have been caused by rodents, especially gophers, and deer. *Chlorosis*

The term chlorosis means a diseased condition manifested as yellowing of the normally green parts of the plant. In severe cases there may be leaf burn, twig dieback, and eventually death.

A type of chlorosis, probably due mainly to an excess of calcium in the soil and, in a few cases, to salinity, has occurred in several plots. Two reports^{4,7} mention that in two plots between 70 and 78% of the trees on Guatemalan stocks became chlorotic while only 1% of the trees on Mexican were affected. This difference in tolerance was also observed in several other plots, although the disorder was not as prevalent. An experimental nursery showed similar differences. Additional evidence of this was obtained in 1953.

Unquestionably Guatemalan varieties are more sensitive to the soil condition causing chlorosis than are Mexican varieties, but the interesting fact is that, in all chlorotic plots as well as in the experimental nursery, affected and healthy trees on the same variety were often found side by side. In the orchards where the trees are about 20 feet apart, this may be attributed to soil variability, but this hardly applies to the nursery where the plants are only one foot apart. A more reasonable assumption is that difference in

behavior is due to genetic differences among seedlings. *Verticillium Wilt (Verticillium albo-atrum)*

This disease, which causes sudden tree collapse, has appeared in three plots. As of December 1953, a total of 30 trees were affected. All but two of these were on Guatemalan stocks.

Detailed observations and results of inoculation experiments to further test the susceptibility of Guatemalan and Mexican varieties to the disease will be found in a separate report⁸. *Dothiorella Canker*

This fungus—*Dothiorella gregaria*; perfect stage: *Botryosphaeria ribis*—infected trunks and large branches in one plot in 1953. As of December 1953, 34 trees showed infections in varying degrees. Of interest is the observation that, so far, only Guatemalan varieties (either stock or scion) have been affected, which suggests that they are either more susceptible or that the bark is more easily penetrated by the fungus than that of Mexican varieties. A separate report giving more details has been issued⁹. *Root Rot (Phytophthora cinnamomi)*

One Fuerte plot planted in 1943 developed symptoms of this disease about 6 years later. However the plot also suffered from freezes and erratic irrigation which probably hastened tree decline. There were 113 trees, 109 of them on 6 Mexican varieties and 4 on one Guatemalan variety. No difference in susceptibility among these stocks was observed. *Mottle Leaf*

This type of chlorosis is characterized by chlorotic areas between the veins of the leaves and is caused by zinc and, probably to a lesser extent, by manganese deficiencies. Mottle leaf was observed in a two year old Hass and Fuerte plot. About 17% of 570 trees showed the disorder in varying degrees which, of course, retarded growth and thus increased the variability in tree size and vigor. Several foliar sprays corrected the disorder. No rootstock relationship was evident.

SEEDLING ROOTSTOCK VARIABILITY

The unavoidable problem of variable seedling rootstocks in this investigation has been mentioned. In order to obtain information concerning the range of variability in seedlings of different varieties, the following experiment was set up. A summary only will be given since details have been published⁶.

Seeds of each of four Guatemalan and four Mexican varieties were planted, and from the resulting seedlings as many cuttings as possible were rooted. It should be mentioned that such cuttings root readily. They were planted in 1952 in two plots, one consisting of 59 Guatemalan and 60 Mexican cuttings averaging three for each of 40 parent seedlings; the other included 71 Guatemalan and 114 Mexican averaging four for each of 36 parent seedlings. The parent seedlings which survived the frequent removal of cuttings were also planted. Eventually most of them will be grafted to observe scion growth. As would be expected, the cuttings from a given seedling are uniform as to leaf character and growth habit, but of interest is the observation that, at present, they vary in size.

ACKNOWLEDGEMENT

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