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A Comparison of Hass Selections on Four Rootstocks

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Summary

Our H670 "Hass" failed to show better production than standard Hass. Trees were larger on *Persea nubigena* rootstock, about the same size on three *P. americana* stocks of the Mexican horticultural race. Production averaged highest on Duke 7 clonals, somewhat the lowest on G6 seedlings, intermediate on seedlings of *P. nubigena* and the Topa Topa standard; but the differences were intermittent and small. There was strong year-to-year yield alternation, even of group averages from up to 80 trees. Tree growth showed strong negative correlation with fruit set.

As far as we know, no one has demonstrated a Hass mutant (sport) with superior productivity. Such a Hass selection could be of considerable economic importance. Two major Hass weaknesses are large tree size and per acre yields well below that of some selections from our breeding program. A heavier-bearing Hass would be obviously valuable, and heavier production would of itself be expected to reduce tree size (Wolstenholme 1981, 1987).

California avocado rootstocks have been tested for resistance to root rot, to salinity, to chlorosis, and differences in grafted tree size have been noted. However, the more difficult comparisons of commercial fruit yields as influenced by rootstock has not been made in a valid experiment.

Materials and Methods

Our clone H670, selected from a field of Hass seedlings at the South Coast Field Station, is more like variety Hass in both tree and fruit than any seedling we have ever seen. It has sometimes shown small differences from nearby grafted Hass—but standard Hass trees and fruits sometimes differ just as much, because of micro-environments, or rootstocks, or possibly mutation. Even in electrophoresis isozymes Hass and H670 have so far been identical.

H670 is different in one respect: it has repeatedly tested free from viruses. Is it a Hass graft that somehow (a) got mixed in with the seedling group, and (b) shed its viruses? Or is it a seedling that segregated out astonishingly like its Hass parent? We can see no bud union; we have been unable to stimulate root suckers by girdling, either the roots or low on the trunk.

Regardless of its origin, a virus-free "Hass" could be commercially useful. Harm from avocado viruses has not been shown—but no real comparison has been made in avocados; and virus injury is well known in other tree fruits. Moreover, in three different locations, a handful of H670 trees averaged slightly more fruit than a similar small number of Hass trees. And in two of those locations, there was enough frost damage for comparative ratings; in both, H670 averaged slightly more hardy than regular Hass.

We therefore designed a replicated experiment with enough trees of each clone to provide a statistically meaningful comparison. Also, Avarham Ben-Ya'acov (1987) of Israel has shown that different rootstocks can give strikingly different performances of the same scion-clone grafted on them, so we tested several stocks. Actually, a comparison of rootstocks under the Hass standard would be of interest in its own right: as our industry moves from a reliance on Mexican seedling stocks to clonally-propagated stocks with resistance to *Phytophthora cinnamomi* root rot (and perhaps other desirable traits), testing the horticultural performance of promising new stocks becomes increasingly important. We chose the following:

Topa Topa. The long-time standard, seedling stock.

Duke 7. The leading root rot resistant stock at the time. Clonally propagated to match the industry practice.

G6. Another stock with root rot resistance; of special interest to us because of its precocious and heavy fruiting, suggesting that (1) it might yield useful levels of seedling resistance at a rootstock cost well below that of the (non-sexual) clonals, and (2) it conceivably could impart some of that precocity to its grafted top. We obtained our seeds from isolated trees that would be largely self-pollinated, for maximum root rot resistance, and some reduction in vigor for possible top dwarfing and thereby also possible yield enhancement (Wolstenholme, 1987).

Persea nubigena. This primitive wild avocado may be an ancestor of the Guatemalan race. It is therefore quite different from the other three, which are largely (Duke 7) or entirely (the remaining two stocks) of the Mexican race. It was included because of small-scale, good experience in Israel with this unusual stock. Grown as open-pollinated seedlings.

There were two scion varieties and four rootstocks, in five replication blocks, with eight trees in each plot, of 320 trees in all. The plots were randomized in each block. Guard avocado trees were planted between the experimental blocks and an avocado windbreak around the perimeter.

The trees were planted in the spring of 1981 on Corona Foothill Company's Wild Rose Ranch Block 50-2, south of Corona, California. There was a sprinkling of set spring 1983; we made fruit counts on each tree that year and the four subsequent years, until the trees were removed in 1988 for subdivision.

Each tree was also measured, with circumference 3 inches above the graft union as a criterion of tree size. Measurements were made in autumn of both 1986 and 1987, to pick up any significant late trends that a final (1987) overall measurement by itself might miss.

Results and Discussion

All data are summarized in Table 1.

Table 1. Average fruit number and tree size (circumference in inches).

		Fruit numbers						Rootstock means	
Rootstock	Variety	1983	1984	1985	1986	1987	Means	Ft. #	Tree size
Topa Topa	Hass	9	21	88	129	116	69	**69**	**20.8"**
	H670	12	11	81	75	177	69		
G6	Hass	3	7	62	133	91	54	**57**	**20.9"**
	H670	4	9	62	114	125	59		
Duke 7	Hass	10	18	107	84	219	86	**90**	**21.0"**
	H670	10	9	115	83	252	93		
P. nubigena	Hass	8	12	89	146	116	72	**69**	**22.4"**
	H670	7	16	85	193	44	66		
Variety means:	Hass	7	15	88	121	139	**74**		**21.3"**
	H670	8	11	88	114	154	**75**		**21.4"**

I. FRUIT SET. Rounded to the nearest whole number, the averages in Table 1 show that set was very light in 1983 and 1984, moderate in 1985, and generally good in the spring of both 1986 and 1987. There are some sizeable differences between both varietal and rootstock means. Perhaps the most evident general trend is for higher and lower sets to oscillate from one year to the next.

a. Varietal differences. In the first year with meaningful set, 1985, the two were dead even averaged over the four stocks. In 1986, Hass had slightly more fruits; in 1987, H670 had a larger but still small advantage. The overall averages at 74 and 75 fruits are practically identical. Moreover, because of yield oscillation, we think that Hass would have had the higher mean yield in 1988, and that the two would probably alternate in yield advantage thereafter. There is no evidence that H670 is more productive than standard Hass.

Nevertheless, if the two are really genetically different, one might be more productive on one rootstock and the other equalize the overall mean by being more productive on a different stock. Examination of Table 1 shows them dead even on Topa Topa, H670, with small advantages on G6 and Duke 7, and Hass ahead on *P. nubigena* stock. All three differences are much too small to be of significance in light of the great variability of the raw data. There is simply no evidence that H670 is different from Hass. Therefore, the two "varieties" can be combined for each rootstock to give the more stable averages in the final two columns of Table 1 (headed "Rootstock means").

It is always possible that H670 failed to demonstrate yield superiority in this experiment because all four chosen rootstocks happened to have viruses that contaminated the H670 scion tops and so canceled the potential H670 performance advantage. Such an interpretation is unverified speculation.

b. Rootstock differences. Unlike the two grafted tops, the four rootstocks appear to represent real yield differences.

But these differences tend to be obscured by the year-to-year set oscillations noted above. For example, for each rootstock we can compare yields of the two "varieties" over the last two years of good set. In 1986, only on Duke 7 did the two scion-tops set about the same number of fruits (Table 1); on the other three stocks, one top had a clear advantage over the other, and, in all three cases, 1987 set sharply *reversed* the direction of yield advantage. Similarly, we can compare overall yields on the four rootstocks, combining the two "variety" counts. For 1986, the fruit set ranking (Table 1) was *P. nubigena* > G6 > Topa Topa > Duke 7; for 1987, the ranking was exactly *reversed.* This consistent yield oscillation casts doubt on the significance of the relative Rootstock means in the second-last column of Table 1. Indeed, if data could have been obtained in 1988, one would then expect Duke 7 to again have the lowest yield and G6 the highest of the three Mexican-race rootstocks (the Guatemalan-type *P. nubigena* produced larger trees—see below—which are therefore not really yielding comparable).

Nevertheless, we think that the four rootstock means fruit number averages in the second-last column of Table 1 reflect with some accuracy the relative rootstock yielding abilities under the conditions of this experiment. In fact, excluding the 1987 data, when the oscillation favors Duke 7 and disfavors G6, the totals through 1986 actually show exactly the same relative yield order: Duke 7 > Topa Topa > G6. But we would suggest that the second-last column of Table 1 exaggerates the inherent differences in yielding ability of the rootstocks under these conditions.

We had expected that trees and fruit set on the uniform clonal stocks (Duke 7) would be less variable than the trees on the genetically variable seedlings of the other three sources. Unfortunately, the soil in these blocks proved exceptionally variable, resulting in a disconcerting degree of tree variability that overwhelmed the postulated rootstock differences. Our randomized replications balanced out soil effects sufficiently to give us some confidence in the mean yield differences, but the huge error variance prevented statistical significance of those differences.

A final comment on the distinct year-to-year-yield reversals: their size seems surprising, considering that they are based on the averages of up to 80 trees each. One might expect a better balancing out of individual tree phases. The contrary result reflects two realities. First, avocado fruit set is usually variable tree-to-tree, compared with citrus and tree fruits generally. Second, the Hass trees must be producing near the upper limit of their physiological potential in this experiment.

In such circumstances, increased fruit set would reasonably result in slightly smaller average fruit size. Therefore, the mean fruit number differences in Table 1 would reasonably have their magnitude reduced a bit further, in terms of total fruit weight. However, repeated commercial (size) picking in this grove proved incompatible with any accurate experimental fruit size comparison. We think that sampled differences would likely have been insignificantly small.

II. TREE SIZE. This was conveniently determined by measuring each circumference at a height of about one foot above soil level.

a. Varietal differences. Table 1 shows that the two were practically identical, at means of 21.3 and 21.4 inches, respectively. Again, there is no evidence that H670 is anything other than standard Hass. This supports the earlier decision to combine the two data sets for each rootstock.

b. Rootstock differences. The three Mexican types produced trees that averaged practically the same size: 20.8, 20.9, and 21.0 inches in circumference. *P. nubigena* produced larger trees, averaging 22.4 inches. The difference may seem small, but the truer measurer of tree size, cross- sectional area, increases the proportional difference by squaring it. This makes the trees on Guatemalan-type rootstock larger than the largest on Mexican race (Duke 7) by 15.8%.

The larger, wider spreading trees on *P. nubigena* will have to be planted at a little wider spacing or else thinned sooner. Hence, their fruit production in Table 1 should be discounted relative to the three Mexican stocks. These rootstock-race results agree with our extensive data (unpublished) showing that avocado varieties are usually larger on Guatemalan than on Mexican rootstocks.

Similar size measurements were made a year earlier, autumn 1986, to try to uncover changing tree size trends. However, any such were apparently overwhelmed by the effects of crop size. For the three Mexicans, tree growth from fall 1986 to fall 1987 was in exactly inverse proportion to set, spring 1986. Set was G6 > Topa Topa > Duke 7, and the respective increases in circumference were 0.6, 1.0, and 1.7 inches.

The more vigorous trees on *P. nubigena* were an exception to the above pattern. They had set the heaviest of all four rootstocks in 1986 and yet made a mean growth increase of 1.2 inches.

Analysis of variance compared *P. nubigena* tree size with that of the largest Mexican group, Duke 7. The fall 1987 mean circumference difference of 1.4 inches (Table 1) is sharply smaller because of the preceding rapid growth on Duke 7 (due to their low spring 1986 fruit set). Combining this with the unexpectedly high tree-to-tree variability in the experiment, the 1.4" difference was not statistically significant: the probability of such a difference due to chance alone is just over 1 in 20. The size comparison the previous year, fall 1986, is comparable to what we would expect if the trees could have been retained another year; the *P. nubigena* trees averaged 2.1 inches larger than those on Duke 7, and the difference is highly significant (probability is 1 in 200). We can safely assume that the trees on Guatemalan-type rootstock are indeed larger than those on Mexican type.

In conclusion, our results were disappointing on two counts. First, H670 did not prove to be more productive than regular Hass. Second, no rootstock proved to be strikingly more productive than any other. Still, it is encouraging for California's avocado future that the top-performing rootstock, Duke 7, is the one conferring resistance to root rot. Other findings were primarily of research interest. Certainly, 61/2 years is too short a time for a rootstock experiment. Data should be collected at least past tree maturity, 10 or 12 years, and preferably much longer to pick up any differences that appear only in the long run.

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