

A HASS OPEN-POLLINATED PROGENY SET

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The superior qualities of the **Hass** avocado have resulted in planting and top-working to it on a sufficiently large scale that it is now challenging the Fuerte for varietal supremacy in Southern California. These same superior qualities make it a most useful parent in a breeding; program (1,3,4,5).

Early development at the South Coast Field Station, south-east of Tustin, showed that a series of recurring windbreaks would be highly desirable. The University avocado breeding program was fortunate in being able to supply the trees for many of these windbreaks.

Self-pollinated or hybridized seedlings would have been preferable from a plant breeding point of view, but there was not sufficient time to develop such. Also, open-pollinated seedlings average somewhat more vigorous than selfed seedlings—the advantage of hybrid vigor over inbreeding degeneration.

Since provision for cross-pollination has been shown to increase fruit set in Southern California (2), open-pollinated progenies will include outcrosses. The data as yet available do not make possible an estimate of the proportion of outcrossing to be expected.

The Hass was chosen as parent for the windbreak trees.

One section of the S.C.F.S. is to be developed into an avocado varietal plot. For this purpose, alternate rows of Hass and Duke seedlings were planted. Both of these varieties are—for very different reasons— of unusual interest from the point of view of commercial avocado breeding. Therefore, it was decided to give most of these rootstocks an opportunity to fruit, before they were top-worked.

The windbreak and rootstock plantings jointly provided about 630 Hass seedlings derived from open-pollination. A few of these have died. Many of those along the south-east fence are too crowded by the alternating trees of another species to have any chance of setting fruit. The windbreak avocados near the S.C.F.S. buildings were, unfortunately, removed. Fruiting of many of the remainder has been delayed by the need for severe pruning of the windbreak trees; the avocado is not really adapted to strong air movement, and tree breakage and bending has had to be controlled by extensive pruning. Still others, in the rootstock section, have failed to set any fruit in spite of apparently ideal circumstances.

Some of them have been fruiting for several years. But in the 1965-66 season, fruit-set was general enough to justify a detailed study of the entire group. Fruit was present on 221 of these Hass seedlings.

The present paper illustrates some of the variability present. This is discussed in terms of the qualities desirable in a commercial fruit.

The illustrations are all at the same magnification, so that direct comparisons of all seedlings can be made.

LITERATURE CITED

1. Bergh, B. O. 1961. Breeding avocados at C.R.C. Calif. Avocado Soc. Yearbook (45): 67-74.
2. ----- and M. J. Garber. 1964. Avocado yields increased by interplanting different varieties. Calif. Avocado Soc. Yearbook (48): 78-85.
3. Lammerts, W. E. 1945. The avocado breeding project. Calif. Avocado Soc. Yearbook (30): 74-80.
4. Schroeder, C. A. 1948. Progress report on avocado breeding. Calif. Avocado Soc. Yearbook (33): 71-73.
5. ----- . 1960. Progress report on the avocado breeding program at UCLA. Calif. Avocado Soc. Yearbook (44): 121-124.

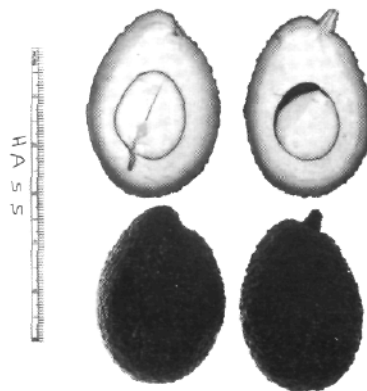


Figure 1. **The Hass variety, a standard of excellence.** As was generally practiced for these illustrations, two fruits have been cut open and placed so that the inside view is directly above the outside view of each fruit. All fruits illustrated in this paper were harvested at the South Coast Field Station in July, by which time a few Hass fruits were beginning to have roots develop from the embryo and grow down into the flesh (see upper left). The Hass moderately thick, rough skin, and purple color at maturity, are evident in the photograph. The fruit to the left has a seed that is slightly larger than the proportionate average for this variety. In the fruit to the right, the seed cracked obliquely to the cut, and so part of the inside of the seed coat is exposed.

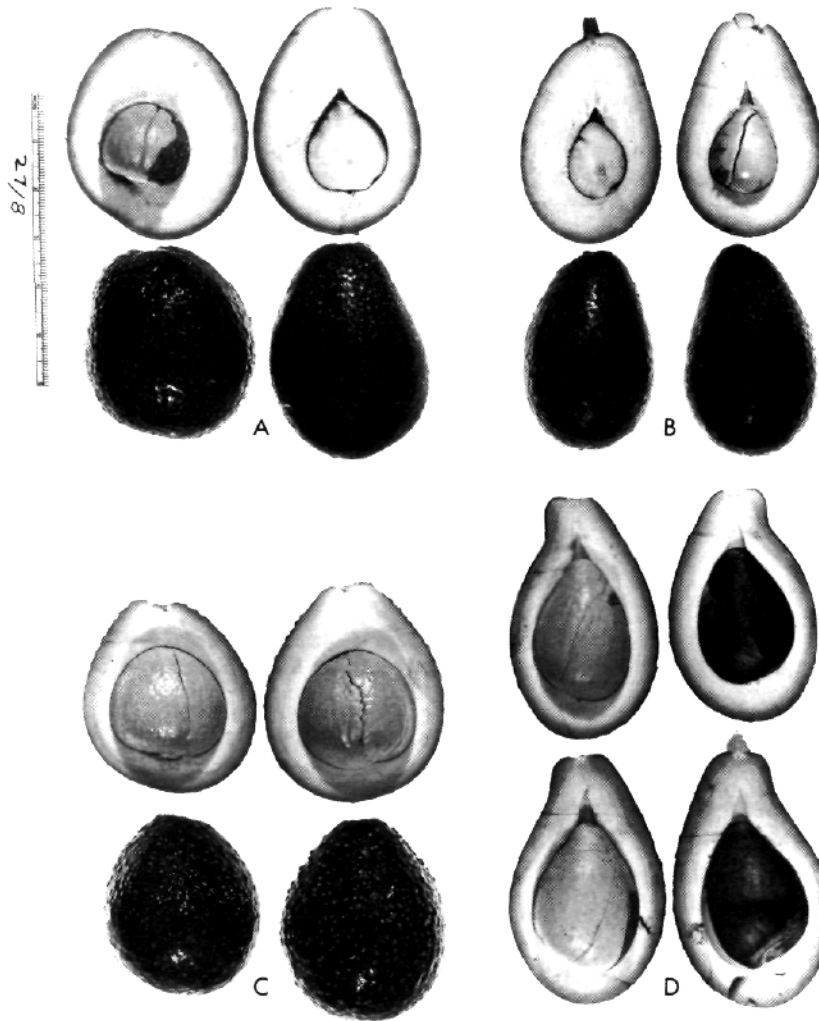


Figure 2. Seed size variation. A and B are from seedlings that have a smaller proportionate seed size than the Hass, while C and D represent seedlings that are worthless because of their huge seeds. The seedling illustrated in D would also be objectionable because of its tendency to have a crooked neck. Still another bad feature is the fact that the seed cavity extends up beyond the seed coat. This is likewise true to a lesser degree of seedling B, and there is a hint of it in A.

A and B are two of the more promising seedlings in this set. While it is not evident from Figure 2, A and B have green skins at maturity and the skins of C and D are purple. There is no clear association of skin color with relative seed size, but the latter is fairly closely associated with skin thickness. Thus, A and B have fairly smooth but thick skins, while D has a much thinner skin; C is one of many exceptions, although its skin is more rough than thick. This association is presumably due to the linkages of many genes, each of which has a small effect on the character.

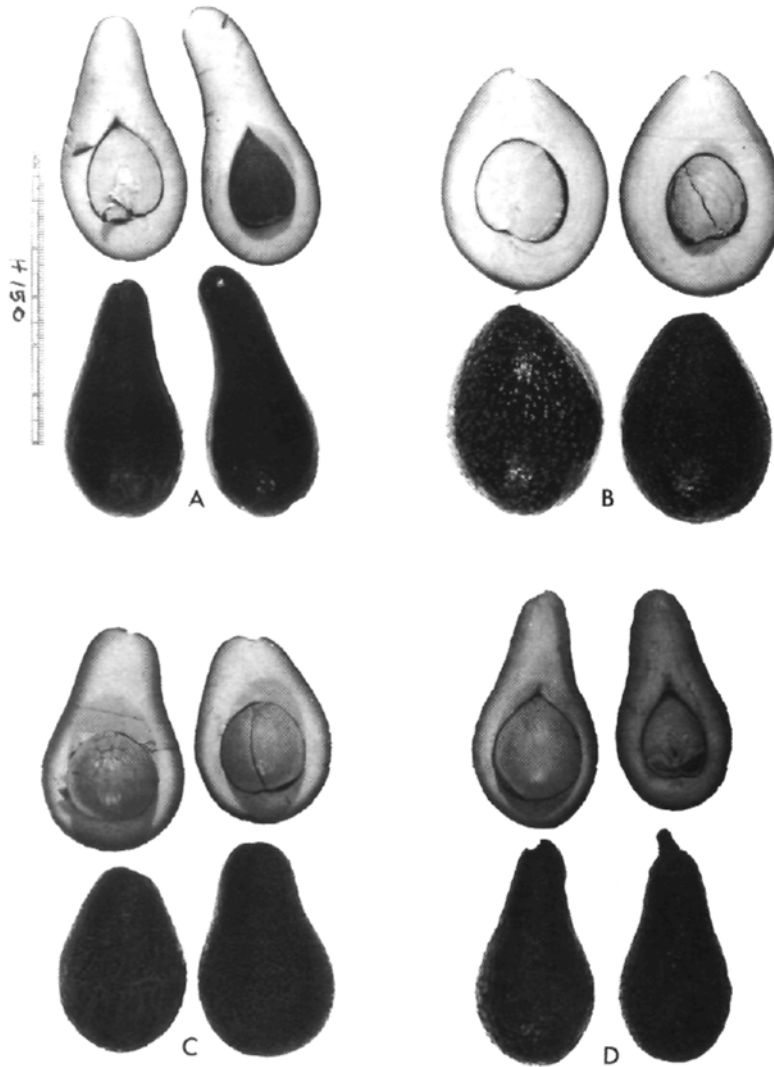


Figure 3. **Russeting and end-spotting.** One of the major advantages of the Hass is an absence of surface blemishes. Many of its offspring do not inherit this virtue, especially those with a less-thick skin.

Seedling **B** has moderate russet, and many good qualities; it is also a good fruit-setter. While **B** has a shape comparable to that of Hass, **A** is indicative of the very different, and, as in this case, objectionable shapes that emerged in its progenies. **C** exemplifies many of the qualities that we are **not** looking for: severe russet and end-corking, large seed, poor skin peeling, pale flesh color, some flesh fibres, off flavor. **D** has most of these vices, except for peeling and flavor; its flesh color is pale greenish throughout, which is equally objectionable. The embryo in the **D** fruit to the right has germinated and shows considerable root development.

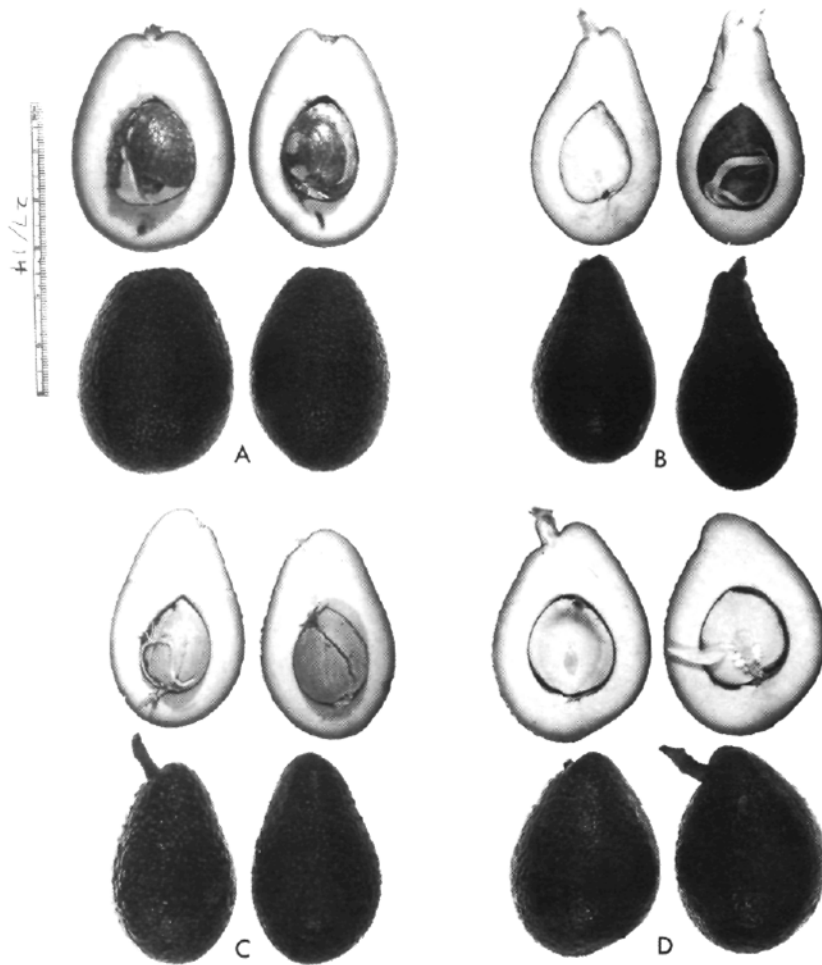


Figure 4. **Embryo germination.** While a few of the seedlings in this progeny set were later maturing than the Hass parent, the great majority were earlier maturing. Hence, embryo development was general. Many roots had grown right out through the skin.

There were two different kinds of root development. In the first, the roots grew out into the flesh; this is exemplified by the left Hass fruit in Figure 1, and by Figure 4A, in which both fruits had a root growing to the fruit surface but the plane of the section was oblique to that of the root in both cases. The second kind is illustrated by B right (see also Figure 5A); the root may develop extensively but does not leave the seed cavity chamber.

In D, the left seed broke in half to expose an embryo with almost no development, while the right embryo has seed cavity root growth and unusual leaf development (shown folded out from the cavity).

Each of these four seedlings shows promise. The A has an attractive surface; it is green at maturity, turning purple as it ripens; its size, shape, skin thickness, peelability, and flavor are all good to very good. The B seedling has some of the same virtues; it has better interior color and a huge fruit set this year, but also has more of a neck than is desirable and it is light purple. The seedling illustrated by C has most of both the strengths and weaknesses of A; fibres are less visible, but there is surface corking. Seedling D also has some russet, but it is a good, green fruit, and has set a very heavy crop for the coming season.

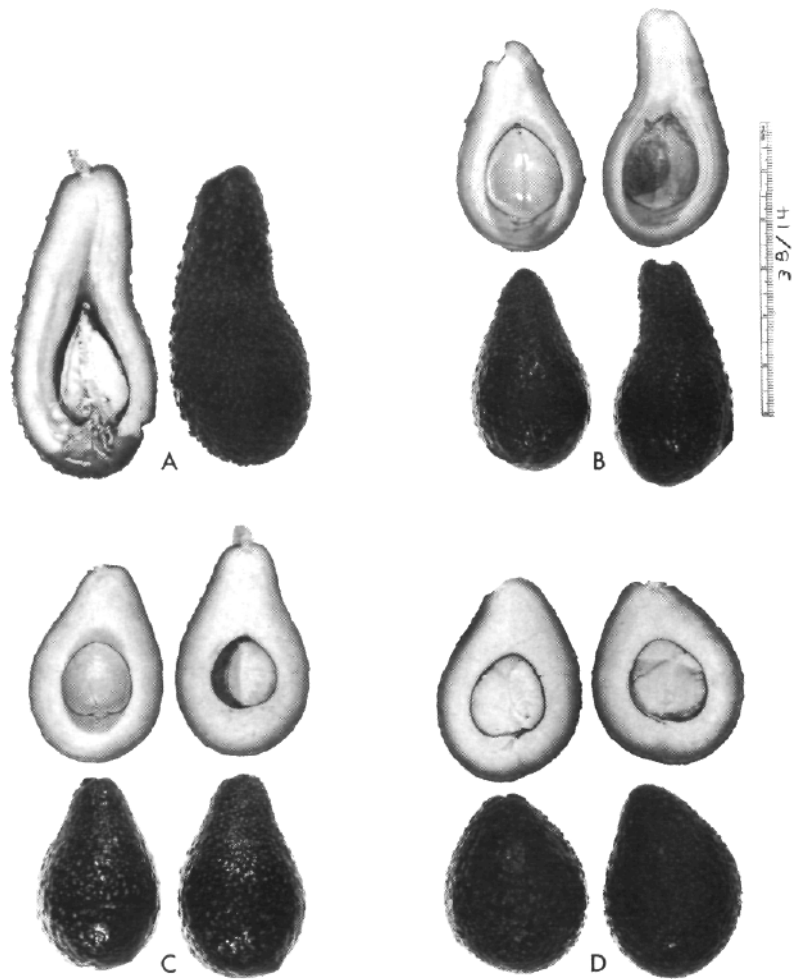


Figure 5. **Rough skins.** The warty (see Figure 1) skin of the Hass parent was present in surprisingly few of these seedlings. The four with the roughest skins are shown, and only in A is it really pronounced.

C was green-skinned at early maturity, but this was rare for seedlings with any degree of skin roughness—"polygenic" linkage is again indicated.

A shows that skins do not have to be thick in order to be rough. **A** illustrates again extensive within-cavity embryo root development.

B is perhaps the latest of the entire group, and was not quite mature in July. It had a glossy, greenish surface.

C is one of the better seedlings. Size, shape, appearance, skin thickness, seed size, and interior color were all favorable.

D also merits watching.



Figure 6. **Thick, smooth skins.** Figure 5A showed that skins do not have to be thick to be rough. Figure 6 illustrates that the inverse is also true; each has the Nabal type of skin: thick but without appreciable roughness. Very rarely in these progenies is a skin of this type associated with elongate fruit shape—genetic linkage is again indicated.

A represents a shape that has packing and shipping advantages, although it "does not look like an avocado." This particular seedling is purple-skinned.

B is a green-skinned fruit that is attractive both inside and out.

C has a light purple skin, and paler interior color with a pronounced green rim.

D is green-skinned even when ripe. Its seed size is excellent, and the interior color very good. But it has a rather flat flavor, and fruit size averages larger than what has been considered desirable. An unusual characteristic of this fruit is a tendency for the flesh to recede from the skin, beginning at the blossom end, as it ripens.



Figure 7. **Thin skins.** A surprisingly large proportion of these progenies had fruit skins that rated of only medium thickness or less. Evidently the Hass possesses recessive genes for a much thinner skin. Also, an unknown proportion of such progenies derived from open-pollination would be outcrosses.

It is interesting to find such thin skins on fruits that remain on the tree a year or so before achieving maturity. Unfortunately, the reverse was very rare—medium or thicker skins on fruits that matured much earlier than Hass. The latter would be far more commercially useful.

The skins of the first three of the seedlings illustrated in Figure 7 were too membranous to peel. However, **D** peeled fairly well in spite of its thin skin.

B holds its green skin color through ripening. It has attractive interior color, and also good flavor. The skin is objectionably thin.

C has even better flavor and a similarly appetizing flesh color (with more of a green rim). Its skin is equally thin and in addition is a light purple with considerable russet. It produces many "cukes."

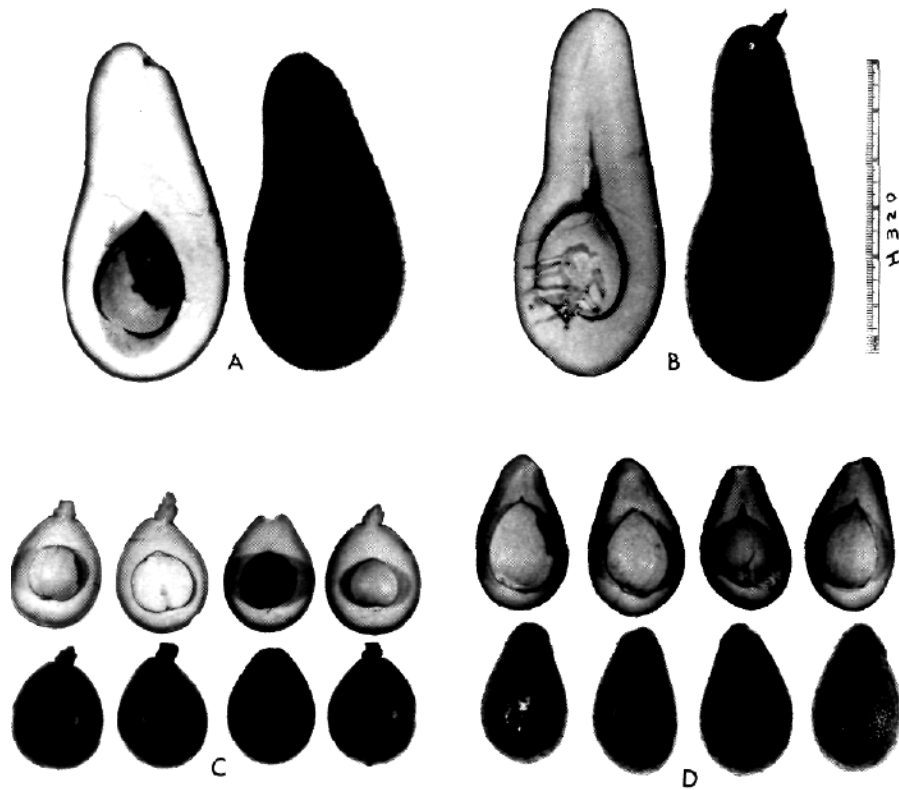


Figure 8. Size variation. A and B illustrate two of the largest-fruited of these progenies, and C and D two of the smallest-fruited. There were some interesting and unexpected character associations among these progenies (based on many more seedlings than those illustrated): the larger fruits tended to be more elongated (for an exception see Figure 6D); more purple; and thicker-skinned. The correlation named last is especially surprising since, of the Mexican and Guatemalan races represented in California avocados, the former race brings in jointly smaller size and thinner skin, as compared with the latter race. The smaller fruits also tended to have proportionately larger seeds, as Figure 6 indicates, but this could be a mechanical consequence of fruit size per se.

Seedlings C and D are worthless. A and B are too large, but this size might be useful in a breeding program. It might even be of immediate commercial value, if the sale of avocados in the form of a guacamole-like product assumes sufficient importance.

A has an even smaller seed. Its green skin is even more russeted. The flesh is paler than is preferable.

B is remarkable for the apparent development of roots from the upper part of the embryo.

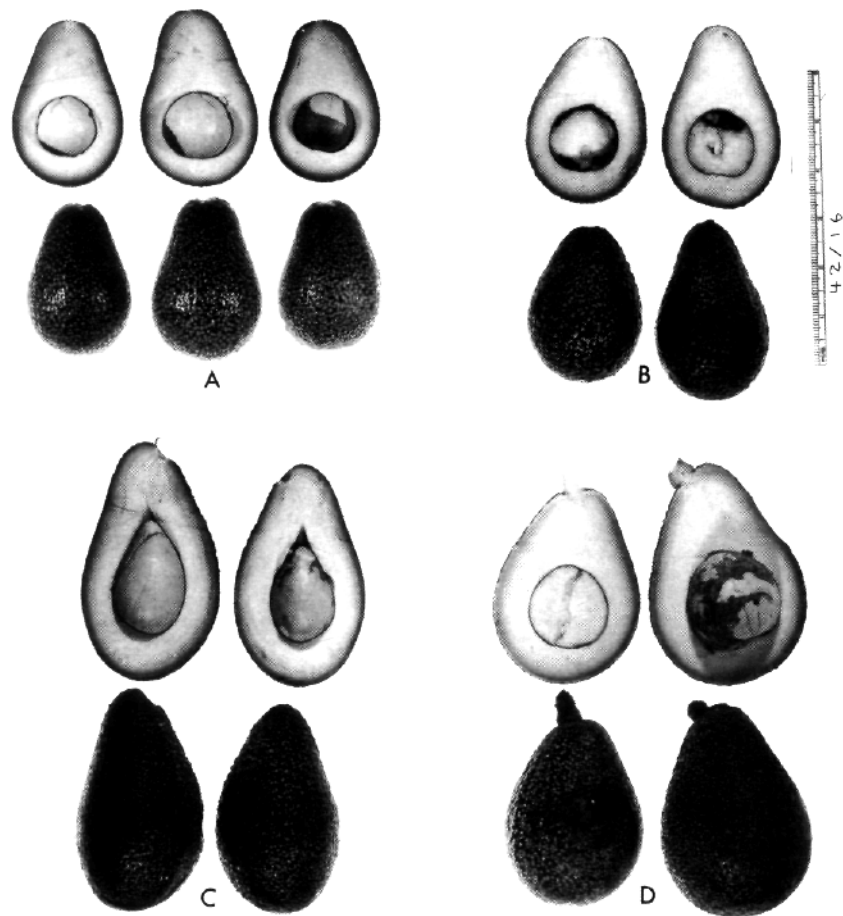


Figure 9. **Yellow-green skins.** A purple or black skin has a disadvantage in certain markets. It is of interest, then, that approximately half of the seedlings in these Hass progeny sets had green fruits at maturity. Some of them did turn dark as they ripened. Some others began and remained green with a large admixture of raised yellow flecks—such were often highly attractive. As Figure 9 exemplifies, for some reason these were usually of below-average size.

My field note on A comments: "If only it were twice the size."

B when russeting occurs, it begins in the raised "islands" or "warts" on the fruit surface.

C has good size and very little russeting. Flesh color is also favorable, a rich yellow. The flavor is pleasant and mild—some might consider it not rich enough. Its chief drawback is the upward extension of the seed cavity.

D develops some russet as it ripens. But this is a fruit of high quality.

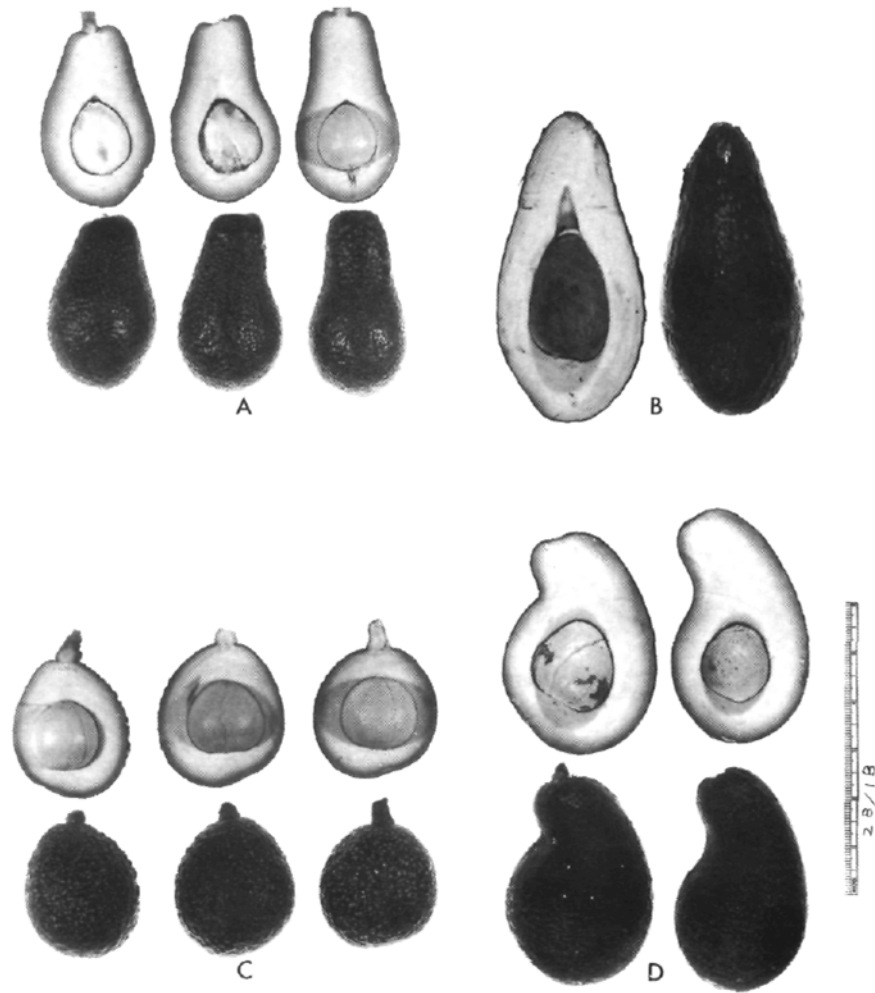


Figure 10. **Some odd ones.** None of these are commercial.

A has a meaty, Jalna-like neck, and small proportional seed size. Both its skin (green) and its flesh are very attractive. Flavor is very good. The set was extremely heavy this year.

In general appearance, and even to some extent in skin thickness, **B** is more like a fall thin-skin than it is like its Hass parent. But the fruit is large. The deep purple, undulating skin is not particularly pleasing.

If its fruits were twice as large and the seed unchanged in size, **C** might be commercial. The foliage of this seedling is chlorotic and poor.

D has a purple skin. When it is this mature, it has considerable russet. Above all, it has a crooked neck. All of which nullifies its small seed and fine interior color.

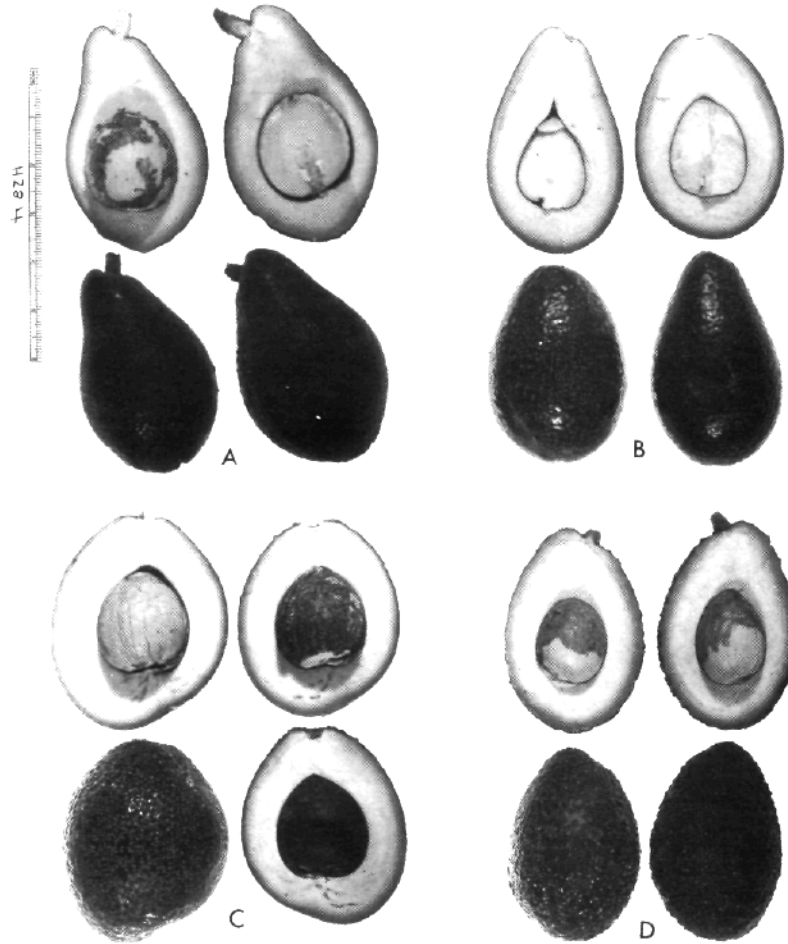


Figure 11. **Promising dark segregants.** Avocados with purple or black skins meet some consumer resistance in certain markets, but not enough to require rejection on that basis alone. As Hass production increases, more and more consumers are learning that a dark avocado skin is usually associated with superb quality.

The **A** seedling has good size, acceptable shape, attractive surface. The seed is a little large.

B has a better shape. The skin has light flecks, but is not unattractive. Seed proportion is lower. Note that the left and right fruit halves were unintentionally interchanged.

The fruits of **C** are lopsided, but I consider their shape preferable to that of a pronounced neck.

While many of the seedlings had foliage much like that of their Hass parent, **D** was the only one with set this season that had a really Hass-like fruit. Fruits from the two sources were practically indistinguishable (see Figure 1). If this seedling proves to be as good a bearer as the Hass, it will be far superior for breeding purposes. For the Hass, like most avocado lines, carries much hidden genetic variability ("heterozygosity"). So it is impossible to predict its breeding behavior. But genetic theory teaches that each selfing generation reduces heterozygosity by about half. Hence, the selfed seedling would carry only about half as many hidden bad genes as does its parent.



Figure 12. Promising late greens. A and B were about as late as the seedling illustrated in Figure 5B. Both had fruits that cut on July 7, 1966, with the crackling of immature flesh. A already had only a fair appearance, due to general russet splotches. But its good shape and mature size, its small seed, its fine flesh appearance, and its good set this past season (with an even heavier one coming up), are all in its favor.

B is a rather similar fruit in all respects.

C is similar to B, but more attractive because the yellow, raised flecks are less often russeted. Its excellent crop was mature in July, or nearly so.

Seedling D has a remarkably small seed, very little russeting, an advantageous larger size, very good interior color, and an excellent set for the coming season. It, also, was almost mature in early July. (The fruit halves were inadvertently reversed for the photograph). It peels well and has good flavor with practically no fibre. Its shelf is longer than that of most avocado lines. This may be our best Hass seedling to date.



Figure 13. Promising earlier greens. When examined in early July, these all had brown seed coats, cut easily, and embryo germination was common.

The fruits of **A** have good size, shape, and external appearance.

At full maturity, the skin of **B** has a hint of purple, which becomes more noticeable as it ripens. A round shape like this one has theoretical advantages. Seed size is small and interior color good. The leaves of this seedling are oddly deformed.

C has good size and shape. At this stage (most embryos showed root development), there was scattered russet plus a corky end-spot. The flesh is attractive. The seeds average larger than medium. Fruit-set was very good.

Sedling **D** is of interest because it approaches the (necked) shape and appearance of Fuerte fruits as grown under inland conditions. The skin is thinner than desirable for good shipping. The seed is a little larger than we would like. The flesh is attractive. Although the fruits were well past maturity, their skins remained surprisingly attractive.