California Avocado Society 1962 Yearbook 46: 55-62

A POSSIBLE DWARFING ROOTSTOCK FOR AVOCADOS

B. O. Bergh and R. H. Whitsell
Assistant Geneticist and Laboratory Technician II, Citrus Research Center and Agricultural Experiment Station, Riverside.

Hodgson (10) suggested many years ago that "a semi-dwarfing rootstock might be advantageous for vigorous (avocado) varieties." The major California variety, Fuerte, is slow to come into bearing; also it commonly sets too little fruit, while showing great vegetative vigor. Apart from possible advantages of earlier and better fruit set, growers have pointed out that shorter trees would reduce picking costs—an important consideration in the present period of very small profit margins.

MATERIALS AND METHODS

A tree of unknown parentage, growing in a seedling block at the Citrus Research Center, University of California at Riverside, was observed to have the short internodes and thick stems that frequently distinguish genetic dwarfs in the plant kingdom. The tree is designated as "Mt 4."

In January of 1957, a lumite screen cage was placed around the tree and a hive of bees was placed inside. The screen would exclude large flying insects, chiefly honey bees, that might bring in pollen from surrounding avocado trees. The bees are necessary since experiments at this Center and elsewhere have repeatedly shown that pollinating insects are essential for appreciable fruit set.

We wished to be certain that the seedlings were self-pollinated since outcrossing would be expected to weaken or even mask completely any dwarfing effect present in the heredity make-up of Mt 4. Also, most avocado lines have highly diverse genetic constitutions, so that even self-pollination results in very variable seedlings; with cross-pollination the variation may be so great as to make valid conclusions impossible.

Twenty self-pollinated fruits were thus obtained from the Mt 4 tree. This is about all that could be expected considering that the tree is small and shaded by more vigorous trees around it. These 20 fruits were harvested in the late fall of 1957. Each seed was then dissected into four parts, each part containing a portion of the embryo. This was done in order to obtain four plants with an identical genetic make-up from each seed. However, in only 7 of the 20 cases did all four of the sections produce a plant; four seeds produced three identical plants each, six produced two, and from each of the remaining three seeds, only one section proved viable. Of the seven groups of four identical plans each, one group consisted of plants that were very chlorotic and weak; eventually all four died.

Such quartered seeds produce plants that are much slower growing. Not until January of 1959 were the seedlings considered generally ready for grafting, although they had been continuously in a greenhouse.

Groups with four genetically identical plants available were treated as follows: three were grafted, one each to the Bacon, the Hass, and the Fuerte varieties; the fourth was left to grow, on its own roots. By leaving one tree ungrafted, we would be able to propagate readily any of the Mt 4 seedlings that appeared, from the scions grafted to it, to have special promise as a dwarfing rootstock. Also, it would be of interest to compare any difference in dwarfing or other growth characteristic of the grafts with any differences that the seedlings themselves might show.

In cases where only three identical seedlings of a group were available, the graft to Fuerte was omitted; when only two grew, the Hass graft was also omitted; when there was only one seedling alive in a group, it was grafted, in order to obtain a measure of its performance as a possibly dwarfing rootstock—any especially promising rootstock can probably be propagated as root cuttings. Bacon was chosen as the variety to be grafted when only one seedling in the group was available for grafting, since results with other fruit trees have indicated that rootstocks with dwarfing effects sometimes have a concomitant influence on the shape of tree produced by the scion: the tree may grow lower and more spreading (6, 15). Such an effect would be desirable in the case of Bacon, since it usually grows too slender and upright.

In groups where less than four seedlings survived, an attempt was made to bring the number of up to four by the rootings of cuttings through the etiolation method. The attempt did not prove very successful. A few cuttings were induced to root, but only about enough to compensate for seedlings that died after grafting, or field planting.

Most of the trees, both the grafts and the corresponding own-root seedlings, were planted in Field 6 at the South Coast Field Station on August 5, 1959. Exceptions were trees resulting from rooted cuttings; these were not ready for planting until the spring of 1960.

RESULTS

In the spring of 1961, one-and-one-half years after planting, a considerable number of the grafts set fruit. Of 16 Bacon grafts, 10 set fruit, with two of them having 20 or more fruits each. Five of the nine Hass grafts also set. One of six grafted Fuertes set a single fruit. Thus the Bacon grafts especially appeared to be unusually precocious on the Mt 4 seedlings; Bacon trees usually require three or four years before they begin to set appreciable fruit. The Hass trees on Mt 4 also set an unusual amount of fruit for trees of that age.

Figures 1 to 3 are photographs taken in the fall of 1961. Figures 1 and 2 are of the Bacon variety grafted to Mt 4 seedling "F"; a short spreading tree has developed with precocious fruit set. Figure 3 shows how Mt 4 seedling "I" has a severely stunted Bacon scion only six to eight inches tall after two years' growth from planting.

Figures 4 to 6 are photographs taken on July 27, 1962. Figure 4 shows the typical dwarf growth and chlorosis that mark many, but not all, of the Mt 4 seedlings. Figure 5 is the Bacon tree grafted to the Mt 4 "A" seedling; without any pruning, the tree is moderately spreading. Figure 6 is the Hass graft on Mt 4 "B" seedling; it is very stunted.

FIGURE 1. *Bacon grafted on Mt 4,* two years after planting. Note the spreading tree habit. Twenty fruits set.

FIGURE 2. *Close-up of the Bacon* tree in Figure 1, showing set fruit.

FIGURE 3. Bacon tree on a different Mt 4 rootstock, exhibiting severe dwarfing two years after planting.

FIGURE 4. Mt 4 seedling 3 years after planting. Note the compact, dense growth, also the leaf chlorosis.

FIGURE 5. Bacon tree grafted to the rootstock shown in Figure 4, 3 years after planting, carrying 44 fruits.

FIGURE 6. Hass tree much dwarfed by the Mt 4 "B" rootstock; it had set 26 fruits.

DISCUSSION

Results to date indicate then that commercial avocado varieties are more precocious on Mt 4 seedlings than they are on the rootstocks commonly used by nurserymen for commercial propagation. Moreover, the grafted trees appear to be sturdy and healthy. But it is much too early in the experiment to draw definite conclusions as to the usefulness of Mt 4 rootstocks.

With apples, the effect of the most dwarfing rootstocks on tree size became conspicuous only after about seven years from planting (3). It is quite possible that our grafts on Mt 4 will eventually prove to be too weak or short-lived. This means also that some of the rootstock seedlings that have the most striking effects on precocity in the short run, may prove less desirable than other Mt 4 seedlings that have less apparent effect during the first few years.

We have propagated the parent Mt 4 in order to obtain selfed seeds of it in large numbers. This will make it possible to test it not only on a larger scale, but also with respect to a much larger sample of its genetic constitution. The results already indicate considerable differences in degree of dwarfing, from a sample size of less than 20. It is reasonable to expect that a much larger sample will show a greater range of effect. Possibly different degrees of dwarfing will be desirable for different scions, especially in terms of degree of vigor of the avocado varieties grown in California.

Our results indicated that the Hass tends to be more strikingly dwarfed than either Bacon or Fuerte. This is in agreement with results reported for apples (3), where the most dwarfing stock tested, EM VII, had a much more marked effect on the weaker-growing of the two commercial scions used. The indication is that the Hass variety may need a much less dwarfing rootstock than is desirable for such vigorous growers as Bacon, Zutano, or Fuerte. Presumably varieties like Rincon, Corona, or Wurtz need an extra-vigorous rather than a dwarfing rootstock.

Certainly more experimentation is needed with different varieties in different locations and over a much longer period of time. In fact, variety, soil, and time have all been reported in other tree fruits to interact in complex fashion with dwarfing rootstock effect (3, 7, 9). It is even possible that Mt 4 rootstocks will, for at least some varieties, prove in the long run to be invigorating rather than dwarfing, to decrease rather than to enhance fruit set.

The tentative indication that Bacon trees on the dwarfing rootstocks are more spreading than normal agrees with observations made by workers on cherries (6). In apples also (15), a dwarfing rootstock has been associated with both higher yields and a more low and spreading tree habit. Actually, the fruit-harvesting problem with varieties like Bacon, Zutano and Elsie results from their vigor in combination with their upright habit; rootstocks that merely reduce their vigor would keep the trees from reaching such great height that picking becomes difficult.

With prospects of reduced labor supply and sharply increased labor costs, the California avocado grower may eventually have to turn to mechanical harvesters. It appears likely that new varieties would be desirable to meet the needs of mechanical harvesting, as has been found with other crops such as tomatoes. On the other hand, such harvesters work more efficiently on trees that are of reasonably large size; too great a degree of dwarfing would therefore be objectionable. Optimum tree size is as yet unknown and will have to await the actual development of feasible mechanical harvesters. Rootstocks with differing degrees of dwarfing effect would seem desirable to help fit varietal tops of differing size and shape to the needed optimum.

Increased fruit set per unit leaf surface has sometimes been found to be associated with dwarfing rootstocks in other tree fruits (6, 13). This may supplement greater precocity (2, 3, 4, 6, 12) to produce greatly increased yields (15), at least when the trees are spaced closer together to compensate for their smaller size.

However, dwarfing rootstocks may have important disadvantages. Their roots may be shallower, as is reported of the trifoliate rootstock for citrus, resulting in a smaller soil reservoir of nutrients, and a need for more frequent irrigation (12). Or their roots may be more brittle as appears to be the case with true-dwarfing apple rootstocks, making it necessary to provide additional staking during the first several years (2, 3, 7). The major dwarfing apple stock, EM IX, is reported in England to also be more scantily and shallowly rooted (13); Macer Wright (ibid) concluded that "The dwarf tree, in particular, will not tolerate mismanagement." The avocado in California is already growing in a somewhat more rigorous environment than it prefers.

Other effects sometimes associated with degree of rootstock dwarfing may be desirable or undesirable depending upon the circumstances. In the olive (9), differences in tree-dwarfing effect were accompanied by differences in fruit size and in flesh/pit ratio. A few California avocado varieties, for example the Mexicola and perhaps the Hass, would profit from larger fruit size; several California varieties: Nabal, Anaheim, Mundo, and others could be more readily marketed if they were of smaller average size. Smaller proportional seed size would of course be desirable in any variety.

Dwarfing rootstocks have been shown to affect fruit quality and season of maturity in other tree fruits (2, 4, 5). For citrus, the trifoliate stock may hasten maturity and enhance quality. Both effects may be associated with the increased carbohydrate supply that has been postulated (5) to account for observed greater precocity. Heavier fruit set might have a similar explanation. For the avocado, hastened maturity in the earlier Fuerte districts would be a distinct market advantage. But the effect of rootstock on fruit quality is largely unpredictable and sometimes prohibitively detrimental (4). Tests of eating, keeping, shipping qualities would have to be made before a new avocado rootstock could be recommended for commercial use. Limited taste panel tests carried out last season on the fruits from trees with Mt 4 stocks did not indicate any perceptible taste differences; neither were there any obvious differences in fruit appearance or ripening qualities.

Other possible rootstock effects are varied. Dwarfing stocks have been reported to change the time of blooming (2). This might have important effects on yields of a variety like the Fuerte in which fruit set appears to vary with spring blossoming temperature (11). Rootstock differences have been associated in other tree fruits with various other differences of possible importance to the avocado industry, such as in injury from uptake of chlorine (1) and boron (8). This all emphasizes the need for testing as many varieties, soils, climates, and years as is practicable before a new rootstock can be recommended.

The question arises of how possibly beneficial dwarfing effects arc to be combined with the future Phytophthora-resistant rootstock that the California avocado industry so greatly needs. Mt 4 has not yet been tested for resistance to root rot, since all the seeds so far produced have gone toward experimentation on its possible dwarfing potentialities; inasmuch as it appears to be a typical **Persea americana**, the probability that it is root rot resistant is extremely small. One possibility is to hybridize Mt 4 selections with Phytophthora-resistant rootstocks as the latter are developed. Unless both dwarfness and disease resistance prove to have a simple genetic basis, this approach would be difficult and time-consuming. Another possibility is to have the nurserymen produce three-part trees (14): the rootstock resistant to root rot; the interstock dwarfing; the top of the desired commercial variety. This would make the trees more expensive, but the advantages might more than compensate for the added cost. The interstock length could be varied to achieve the degree of dwarfing desired. Or bark insertions from a dwarfing stock may prove to be practicable (2).

Dwarfing rootstocks are especially advantageous to the average amateur or back-yard grower (13) because of his limitations of both space and equipment. But Erase and Way

(2) have recently pointed out how greatly North American professional pomology is changing from the earlier extensive businesses based on cheap land and labor; "More and more, a trend towards fully mechanized operations makes it necessary to have fruit trees that not only can be restricted in size to reduce maintenance cost in orchard care, but also to have trees that produce fruit at a younger age." With the possibility of earlier and heavier bearing added to savings in space and greater ease of pruning, harvesting, and spraying when needed, dwarfing rootstocks for avocados appear to merit further study.

LITERATURE CITED

1. Bernstein, L., J. W. Brown, and H. E. Hayward. 1956. The influence of rootstock on growth and salt accumulation in stone-fruit trees and almonds. Proc. Amer. Soc. Hort. Sci. 68:86-95.
2. Erase, D. K., and R. D. Way. 1959. Rootstocks and methods used for dwarfing fruit trees. New York Agr. Exp. Sta. Bull. 783, 50 p.
3. Carlson, R. F., and H. B. Tukey. 1959. Fourteen-year orchard performance of several apple varieties on East Mailing rootstocks in Michigan (Second Report). Proc. Amer. Soc. Hort. Sci. 74:47-53.
4. Chandler, W. H. 1957. Deciduous orchards. 3rd ed. Lea & Febiger, Philadelphia. 492 p.
5. Chandler, W. H. 1958. Evergreen orchards. 2nd ed. Lea & Febiger, Philadelphia. 535 p.
6. Gardner V. R. 1942. Basic horticulture. The MacMillan Co., NewYork 441 p.
7. Gourley, J. H., and F. S. Howlett. 1941. Modern fruit production. The MacMillan Co., New York. 579 p.
8. Hansen, C. J. 1955. Influence of the rootstock on injury from excess boron in Nonpareil almond and Elberta peach. Proc. Amer. Soc. Hort. Sci. 65:128-132.
9. Hartmann, H. T. 1958. Rootstock effects in the olive. Proc. Amer. Soc. Hort. Sci. 72:242-251.
10. Hodgson, R. W. 1947. The California avocado industry. Univ. Calif. Agr. Ext. Ser. Circ. 43. 93 p.
11. Hodgson, R. W., and S. H. Cameron. 1934. On the bearing behavior of the Fuerte avocado variety in Southern California. Proc. Amer. Soc. Hort. Sci. 32:200-203.
12. Jeffers, Joyce. 1958. A big future for dwarf trees? Western Fruit Grower 12(9):21-22.
13. Macer Wright, D. 1953. Dwarf fruit trees. Faber and Faber, London. 111 p.
14. Sax, K. 1953. Interstock effects in dwarfing fruit trees. Proc. Amer. Soc. Hort. Sci. 62:201-204.
15. Tukey, R. B., R. L. Klackie, and J. A. McClintock. 1954. Twelve years performance of East Mailing rootstcks at Lafayette, Indiana. Proc. Amer. Soc. Hort. Sci. 64:146-150.