

ORIGIN OF ROOT ROT RESISTANT ROOTSTOCKS

George A. Zentmyer—

Professor, Department of Plant Pathology, College of Natural and Agricultural Sciences, Citrus Research Center and Agricultural Experiment Station, University of California, Riverside.

Resistance is one of the most promising methods for control of plant diseases. The development or discovery of a resistant rootstock has been for many years our primary approach to solving the serious *Phytophthora* root rot problem on avocado. Recent research in this area in general was covered in an article in the 1977 Yearbook (4). The present article provides details of the origin of the three primary rootstocks that have shown appreciable resistance to *Phytophthora cinnamomi*, the root rot fungus, and are also graft compatible with commercial avocado scions. These rootstocks are: Duke 6, Duke 7, and G6.

Our tests for resistance at the University of California, Riverside, involve two principal methods—a severe test in tanks containing nutrient solution, and a less severe test in naturally infested soil in containers in the greenhouse or in large beds in the lathhouse. Seedlings or cuttings from material collected in California or in Latin America are tested under carefully controlled conditions by these two methods. In the tank test, seedlings are transplanted bare-root into tanks approximately 4 feet square by 30 inches deep, containing a complete nutrient solution which is aerated and maintained at a temperature of 25C and a pH of 6.5. After about two weeks of growth in these tanks, inoculum of *Phytophthora cinnamomi* is added to the tanks, in the form of agar cultures of the fungus suspended in cheesecloth bags throughout the tanks (2). After a 12-day incubation period seedlings are removed, percent of root rot assessed, and resistant seedlings are saved for future propagation. In the 12-day period usually 95 % of the roots of susceptible seedlings are rotted.

The soil test involves planting seedlings or cuttings for varying lengths of time in pots or various-sized containers with soil infested with the root rot fungus. In some of our tests, seeds, seedlings, or cuttings have been planted in infested soil in beds 15 ft. by 4 ft. by 18 inches deep.

Duke 6 and Duke 7—These are two selections that I made in the program of testing many seedlings of many California varieties or cultivars of avocado in the 1950's and 1960's. This program is still continuing as new possibilities for increased resistance become evident. In the early extensive tests (3), seedlings of the Duke cultivar consistently had higher resistance to *Phytophthora cinnamomi* than any other seedlings. For example, in one of the early tests 45 percent of 110 Duke seedlings tested showed some resistance to root rot, compared to 1.5 percent of 110 Nowels seedlings and 0.9 percent of 110 Topa Topa seedlings.

Following these initial tests, more seeds from Duke fruit were obtained from the Calavo Packing House in Los Angeles, and seedlings were planted in beds of infested soil from San Diego County in our lathhouse at Riverside. Seedlings of a number of

other cultivars were also included in these tests. In one of these test beds one Duke seedling made particularly outstanding, vigorous growth; this was designated as Duke 6, merely because of its position in the bed, as the 6th Duke seedling in that particular test. Rooted cuttings were made

from this original Duke 6 seedling, by the method developed by Frolich (1) at UCLA. The original Duke 6 seedling was transplanted into one of our experimental fields (Field 20) at UCR, where it is still growing. This tree was the source of much budwood distributed to avocado nurserymen for propagation, and for our propagation to test the resistance of rooted cuttings of this selection, with or without Hass and Fuerte scions.

The following year a second vigorous Duke seedling was selected from a similar test bed, and was designated Duke 7. Propagation material was taken from this seedling, as from Duke 6; this was distributed to avocado nurserymen and used to produce trees for our further tests for resistance in the greenhouse and in numerous field plots throughout southern California. The Duke 7 seedling was a more vigorous seedling and had greener foliage than the Duke 6 selection, although the resistance appears similar. The Duke 6 seedling and cuttings from this seedling appear somewhat chlorotic and are susceptible to tip-burn. Because of the more vigorous growth of Duke 7 it has been preferred by avocado nurserymen and thousands of commercial trees on clonal Duke 7 rootstock have been propagated and sold over the past several years. The clonal designation indicates that the rootstock has been propagated as a rooted cutting, and thus is identical to the original Duke 7 seedling selection. In the 1978-1979 season one nursery has produced approximately 100,000 trees on clonal Duke 7 rootstock.

As noted in the article in the 1977 Avocado Yearbook (4), in our numerous field plots established over the past 10 years, trees on both Duke 6 and Duke 7 rootstocks are showing substantial resistance. They do not have the extremely high resistance of the non-compatible wild species of *Persea*, but where the disease situation is not excessively severe, trees on these clonal rootstocks are growing very well and are producing well.

In late 1971 Dr. Eugene Schieber who has been collecting avocados and other species of *Persea* in our Latin American program for several years, and Ed Johnson, staff research associate who worked with me at Riverside, observed an interesting tree on the slopes of the volcano Acatenango, near Antigua, Guatemala. I visited the area with Dr. Schieber in January 1972 and we collected the first fruit and budwood from this tree, which we designated as G6, for our tests in Riverside. The tree is a medium-sized (20-25 feet tall), spreading tree of the Mexican type, with typical purplish-black ovoid fruit approximately 2 to 2½ inches in length, and with strong anise odor in the leaves. We do not know the origin of this tree; the great majority of the avocado trees in Guatemala are of the thick-skinned "Guatemalan" type, although there are a number of the Mexican type (termed "Matul-oj" by the natives) in Guatemala. There is some evidence, in Dr. Schieber's collections, of the Mexican type as a native tree in northern Guatemala.

Seeds of this G6 collection were sent to Riverside in January 1972 via the usual quarantine procedures under which seeds are sent to El Paso, Texas for fumigation, using our USDA quarantine permits. The first tests with seedlings germinated from

these seeds were very encouraging; 3 of the 7 seedlings survived the initial severe nutrient solution test with less than 40 percent of the roots rotted; 6 of the 7 seedlings had less than 70 percent of their roots rotted. In other words, approximately 44 percent of these first G6 seedlings showed very significant resistance, which is much better than the usual result in such a test.

Topa Topa seedlings in the same test, for example, averaged 95 percent root rot; there were no seedlings with root rot below 70 percent.

From budwood collected in Guatemala, the G6 parent clone was established in California, but budded onto seedlings in our greenhouse at Riverside. One of the G6 seedlings that survived the original severe test in the best condition was transplanted into soil and used for propagations of this seedling. Both the G6 parent clone and the G6 seedling were propagated by making vegetative cuttings as noted above. We have established a number of field plots also testing G6 for resistance in southern California. Early indications are that this rootstock is at least as resistant as Duke 6 and Duke 7; it may be even more resistant.

The G6 material has also been distributed to avocado nurserymen in southern California for establishment and for preparation of material for future propagations and sale. An arrangement has been worked out between the California Avocado Society and the University of California, Riverside under which the University receives a fee for all material propagated and sold; this fee will be used to support research on avocado root rot at UCR.

During the past year or two we have obtained many seeds from our Duke 7, and G6 clonal trees, and a few from the Duke 6 clone, and have tested a number of open pollinated seedlings from these trees for resistance. As indicated in the report in the 1977 Yearbook (4), seedlings of Duke 7 and G6 have appreciable resistance, although they (particularly Duke 7 seedlings) are more variable in resistance than the clonal Duke 7 and G6 trees. We are investigating this aspect further, and Dr. B. O. Bergh is cooperating in this phase of the project through arranging for fruit from self-pollinated flowers this coming season; seeds from such fruit should be less variable in resistance characters.

Thus, there are three rootstocks now available that show considerable resistance to Phytophthora root rot; the two that are being propagated extensively are Duke 7 and G6.

LITERATURE CITED

1. FROLICH, E. F. and R. G. PLATT 1971-72. Use of the etiolation technique irr rooting avocado cuttings. Calif. Avocado Society Yearbook. 55:97-109.
2. ZENTMYER, G. A. and S. M. MIRCETICH. 1960. Results with new method of testing for resistance to Phytophthora root rot of avocado. Calif. Avocado Society Yearbook. 44:107-109.
3. ZENTMYER, G. A. and W. A. THORN. 1956. Resistance of the Duke variety of avocado to Phytophthora root rot. Calif. Avocado Society Yearbook. 40:169-173.
4. ZENTMYER, G. A., F. B. GUILLEMET, M. K. HARJUNG, and A. I. ZAKI. 1977. Resistance to Phytophthora root rot. Calif. Avocado Society Yearbook. 61:76-79.