California Avocado Society 1987 Yearbook 71: 173-179

Avocado Rootstocks

M.D. Coffey and Fred Guillemet
Department of Plant Pathology, University of California, Riverside, CA 92521-0122.

Introduction

Many tree crops are raised on specific rootstocks selected for their particular usefulness in combating the various pests and diseases or other serious problems prevalent in soils of the region. Good examples where this is now a common practice are apple and pear. Rootstocks may also be selected for other special reasons, such as their ability to confer useful dwarfing properties on the tree.

In the case of avocado in California, the major economic factor determining the choice of rootstock is resistance to *Phytophthora cinnamomi.* No other avocado disease or pest causes the same amount of root damage. *Phytophthora cinnamomi* has the ability to destroy the root system of an avocado extremely rapidly. The rate of destruction of roots is influenced by the soil environment. In soils with impeded drainage and where there is little organic matter present, the disease is especially damaging. In contrast, in deep, well-drained soils with abundant humus the problem is less severe. *Phytophthora* thrives in wet soil conditions at temperatures above 55°F, but is not active in dry soils or at lower temperatures. High organic matter favors growth and activity of antagonistic soil fungi and bacteria. In some extremely rare soils found in California, such antagonistic activity may help to suppress the ability of *Phytophthora* to parasitize avocado roots. This phenomenon is currently being studied in our biological control program at the University of California, Riverside (UCR). Eventually, we hope to discover ways of manipulating the soil-root environment by introduction of specific suppressive microorganisms in order to lessen the damage inflicted by *Phytophthora.*

The Quest for Avocado Rootstocks

The rootstock selection at UCR is unique, being the only one of its kind in the world. Initiated by Prof. George Zentmyer in the early 1950s, it finally grew in size dramatically during the 1970s, when substantial funding was provided by the California Avocado Commission. The program has only really come of age in the 1980s, since obviously avocado trees take many years to reveal their full potential. The world's most diverse collection of *Persea* germ plasm is now located at our two research sites; South Coast Field Station and UCR. The collection includes representatives of many Mexican and Guatemalan avocado types, as well as related species, such as *P. schiedeana.* In addition, there are examples of more distantly related species, such as *P. borbonia,* which possess uniform high resistance to *Phytophthora.* Recently, we embarked on an ambitious program to select from the large numbers of seedlings made available from these unique germ plasm resources. Thus, we are entering yet another exciting and expansive phase of the program capitalizing on the continuous collections made in

Central America and elsewhere over the last thirty years.

Until quite recently, the avocado industry has literally muddled through by attempting to avoid the root rot issue. The availability of virgin land for planting new avocados provided the primary mechanism for dealing with *Phytophthora,* enabling the industry to avoid its worst impact. Unfortunately, little opportunity is now left to continue this approach. As production costs, and especially water costs, increase, the critical need becomes more and more to maximize production. *Phytophthora* is ultimately the major limiting factor in avocado production. The need to deal effectively with the problem therefore becomes paramount. In our estimation, the most important answer to the problem surely lies in discovering a rootstock with high and durable resistance to root rot.

Traditionally, the Mexican rootstocks have dominated the Californian scene. The industry was founded on such types; and prolific seed-bearers, such as the Topa Topa variety, were freely available and produced healthy-looking, relatively uniform seedlings. In the 1950s, the Duke variety, a Mexican type with good cold tolerance, proved to be a useful source of some seedlings with moderate resistance. Subsequently, Duke 6 and Duke 7, which represented individual seedlings with useful field resistance, were made available to nurseries for cloning. The search for further sources of resistance among the Mexican race led to the discovery of the G6. This was a tree found growing on the slopes of the Acatenango volcano in Guatemala. However, despite its geographical location, it is a Mexican type. More recently, the rootstock Thomas has been recovered from a survivor tree in an Escondido grove ravaged by root rot. After rigorous testing, it is now emerging as a potentially useful addition to our list of Mexican resistant types.

The discovery of the Martin Grande (G755) following its collection in late 1975 opened up yet a further source of rootstock germ plasm for investigation. The Martin Grande (G755) rootstocks proved to be natural hybrids between *Persea schiedeana* and the Guatemalan race of avocado. A search for more hybrids of this type has so far proven fruitless; but among the pure *Persea schiedeana,* tree collections, several selections have now been made that seem to have useful resistance.

A vital need is to accelerate the search for new sources of resistance. The most important location of such novel resistance is Central America, and especially Guatemala, the original home of most of the current commercial avocado varieties grown in California. Here in this beautiful but troubled country are found Guatemalan, Mexican, and West Indian avocados. Hybrids between these three races of avocado are also found. Related species of *Persea americana* (Avocado), such as *Persea schiedeana* and *Persea steyermarkii,* also occur. In the remainder of this article, we will deal with some of the important facets of our rootstock program, outlining the approaches, the tests, and ultimately the final evaluations which are still needed.

The Screening Process

The need to continue to screen for new germ plasm with resistance potential should be self-evident to most growers who have to deal with root rot on a day-to-day basis. The Guatemalan connection has become the most important life-line in this lengthy and difficult process. On a month-to-month basis, Dr. Eugenio Schieber and his assistants, Martincito and Daniel, scour the Guatemalan jungles and visit the marketplaces in

remote Mayan villages in the Highlands, making collections of avocados. The journeys are difficult and sometimes very dangerous in this troubled part of the world. In December 1987, I (M.C.) visited Dr. Schieber to discuss the program. Despite current difficulties, he is more enthusiastic than ever at the prospect of collecting avocado germ plasm. We took time to visit the small cemetery in Santa Catarina Palopa where Martin Grande is buried. It is a remote and beautiful place overlooking Lake Atitlan and its magnificent volcanoes. Martin Grande was killed in 1981, an innocent victim of a troubled situation, while making collections of avocados for us. It was Martin who collected the now famous G755 fruit in September 1975 in Coban.

The collected germ plasm is subjected to a screen where individuals with potentially significant resistance to *Phytophthora* are selected out. Currently, this involves planting seedlings in a vermiculite growing medium which is subsequently flooded with an aqueous suspension of *Phytophthora* zoospores. The majority of seedlings rapidly succumb to root rot. Occasionally, individual seedlings survive this treatment. These are then stepped up to larger containers with *Phytophthora-infested* soil, and are eventually cloned to produce upwards of 5 copy trees to provide a source of budwood for further evaluations.

The process with seedlings takes approximately five to six years. Three years are needed to run the seedling through the 3-stage test to where it is seen to survive and prosper in severe root rot conditions. A further 2-3 years are needed to clone sufficient material for planting out in the field to provide germ plasm for rootstock evaluation. Finally, the trees have to have a period to grow in the absence of root rot in order to raise sufficient budwood. In total then, it can take from seven to nine years to reach the stage where field evolutions can proceed on a large scale.

The Duke 7 rootstock was discovered in the 1950s but did not see commercial release until the mid-1970s. The G6 rootstock, located in 1971, did not see release for large-scale field testing until about 1978. The Martin Grande, collected in late 1975, was available for limited field evaluation from 1982-3. In fact, large-scale plantings and evaluations were not initiated until 1984 and are still continuing.

The Discovery Phase of the Program

Unfortunately, over 90 percent of selections which show early promise do not meet the required standards in the final tests. In order to improve the chances of bringing only good products to the final test phase of the program, we believe it is necessary to learn much more about the reasons for good rootstock performance. To this end, we have embarked on an ambitious program to learn more about rootstock growth dynamics and mechanisms of *Phytophthora* suppression. In essence, rootstocks are grown under precise conditions, and different components of their growth are measured. In addition, the progress of *Phytophthora* is quantified. These more precise data should eventually allow us to select out rootstocks for superior performance prior to critical testing under field conditions.

The second part of the discovery phase involves planting the rootstock selections under professionally managed growing conditions in a severe root rot test at our South Coast Field Station. Here the trees receive careful individual care under the watchful eye of Dave Lillard. Members of our research group make frequent trips to the site to take

measurements of tree growth and performance. At the two year stage, Thomas and Martin Grande (G755c) have shown superior performance. No differences have been observed so far in the performances of G755a, G755b, and G755c. Ban-Duke, a seedling of Duke 6, appears to have some semi-dwarfing properties in addition to its moderate resistance to *Phytophthora.* The most critical evaluation phase for this test program will be from 1990 onwards, when the trees are expected to come into production.

The Experimental Release Phase

Perhaps there is no greater confusion about rootstocks than when they first become available to growers under an experimental agreement. Currently, we have the following rootstocks under experimental agreements with some nurserymen: Thomas, Barr Duke, and G1033, and several newer selections: UCR 2001, UCR 2002, UCR 2009, UCR 2011, and UCR 2014. This limited release process allows the nurserymen to assist our program by producing more trees than we could otherwise do, and thus hopefully permitting an earlier readout on potential rootstock performance. The nurseryman is required to report his findings to our program on a regular basis, typically once a year. Growers can also cooperate in this scheme.

Two other agreements are between the California Avocado Society and the University of California. They cover the release and propagation of G6 and Martin Grande (G755a, G755b, and G755c) and reflect the desperate needs of the avocado industry to obtain potentially useful germ plasm at an early stage in the discovery process. With the signing of such agreements, the nurseryman is able to sell these rootstocks to growers. A useful component of these agreements is that a small portion of the money paid by growers is returned to the university as a fee. For each G6 sold, the university receives 50c; and for a Martin Grande, $1. Since 1982, we have received vital financial help from these agreements.

Current Rootstocks—Facts and Factors

Although Duke 7 was available for commercial release in the mid-1970s, it did not immediately gain universal acceptance as a rootstock. Since there was no good method available until 1981 for controlling root rot in order to allow establishment of such moderately-resistant selections, this is quite understandable. The registration of Ridomil® in 1981 was the deciding factor. Our first long-term experience with this fungicide was in 1983, when a 4-acre planting of Duke 7/Hass was established at Rancho California. We used either Ridomil® or Aliette® as fungicides. While some trees have subsequently died and others have suffered significantly from root rot decline, others still appear quite healthy. However, more observations will be necessary to measure the relative degree of success of this planting. A crucial evaluation involves estimating the level of fruit production that can be sustained over many years.

Early results in the field with the Martin Grande and Thomas selections indicate that their resistance to root rot is significantly higher than that of Duke 7. Our two most successful plantings with these newer rootstocks have been at Embarcadero Ranch, in Goleta, and at the Spaulding Ranch, in Carpinteria. At Embarcadero, over 7 acres of trees have been under test since 1984 under the expert management of John Hunt. At Carpinteria, Bob Branstetter looks after the ranch for Betty Spaulding. The outstanding

contributions of all these dedicated growers to our program cannot be overstated.

The hard facts are that there are still no good data on the long-term performance of Duke 7, G6, Martin Grande, or Thomas. It will take 4-5 years to obtain a good data base on fruit production. Growers should be made aware that the early promise may not necessarily translate into stable and economically-acceptable levels of production in the years ahead. The earliest useful planting of Duke 7 in root rot conditions was made in 1983. The other rootstocks were first planted in significant amounts in1984. The most useful information on rootstock performance will become available in the period from 1989 onward. Investment of much time and effort will be required to obtain these crucial facts.

Selection and Breeding

The germ plasm collection at UC, and the ongoing collecting activities taking place in Central America, represent the future life blood of the avocado industry. From among these remarkably diverse collections of avocado germ plasm will emerge the new rootstocks so necessary for the ultimate survival of a crop currently under threat.

As we discover useful selections, they are passed over to Bob Bergh's program, where he attempts to hybridize them. Progeny from this program are then returned to us where they are tested for resistance. Large numbers of seed from this breeding program should become available in about two to three years. Already included in this program are over twelve different lines identified as possessing useful characters for breeding.

The Holistic Approach

The ultimate objectives of our rootstock program are to discover and develop useful germ plasm for the different soil, climatic, salinity, and cultural conditions prevailing in California. Since root rot is potentially the major limiting factor in production, and given its high incidence throughout the industry, it is paramount that the number one objective should be selection of high resistance to *Phytophthora.* In the final and most crucial stages of testing, these rootstocks are grafted with commercial scions, such as Hass, and planted throughout the avocado growing regions in southern California. The final verdict on rootstock performance must be based on sustained avocado production figures obtained over many years from diverse locations. Our approach is holistic, all-embracing in that it tests all the inputs from the environment, and their influence on production. Some factors which are being tested include ability to grow in:

1. Different soil types (sandy, clay, etc.) and pHs.
2. Soils with impeded drainage.
3. High salinity situations.
4. Different climatic conditions in California (from Escondido to San Luis Obispo).
5. Other prevalent pest or disease situations.
6. Different grove management conditions (irrigation methods, etc.).
7. Different soil nutrient conditions.

The ultimate aim is to produce different *Phytophthora*-resistant rootstocks well suited to

the wide range of growing conditions found in California.

A Glimpse into the Future

The early successes of our program indicate that diverse rootstock types will emerge. Mexican, Guatemalan, and *Persea schiedeana* hybrid rootstocks are already in the program. Further intensive collecting, propagating, and selecting will produce an enormous stockpile from which to select the ultimate rootstocks designed to satisfy the various environmental and cultural conditions prevalent in California. Plant breeding may be expected to introduce a further dimension. Useful hybrids between different selections may be found.

The needs of the moment are to accelerate the complex research processes involved in screening for rootstocks. The threat of root rot still looms over the industry. We have the richest and most diverse avocado germ plasm collection in the world of types adapted to our conditions. The potential to develop superior rootstocks can hardly be better. Just as only twenty years ago the emergence of rootstocks such as Martin Grande and Thomas would have been thought unlikely, now the future prospects are surely exciting. The reality of rootstocks that will deal a final death blow to *Phytophthora* is no longer just a dream. However, that reality depends very heavily on the wisdom and courage of industry leaders to invest heavily in such vital rootstock research.