

***Persea* and *Phytophthora* in Latin America**

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Abstract. A search in Latin America for rootstock resistance to *Phytophthora* root rot of avocado was begun in the early 1950's, and surveys were also made for the occurrence of the root rot pathogen, *Phytophthora cinnamomi*, in the same area. Over the four-decade period unique, varied, and valuable germplasm collections were made of 18 species of *Persea* and of species in six other genera in the Lauraceae in 18 countries in Latin America (including Mexico, Central and South America, and the Caribbean Islands). Some of these have resistance to *P. cinnamomi*. In the fungus survey cultures were made from roots of native species of *Persea*, including many variants of the avocado (*Persea americana* Mill.), representative of other genera in the family Lauraceae, and from cultivated avocado trees. Data indicate that the root rot pathogen is not a native inhabitant of the soil in Latin America, and was probably introduced into the area from some other region (possibly southeast Asia), as we believe has also occurred in California.

This paper concerns the 40- year search in California and in Latin America for avocado rootstocks resistant to *Phytophthora cinnamomi*, the cause of *Phytophthora* root rot. The genus *Persea* (avocado is *Persea americana* Mill) is primarily a New World genus, with over 80 species indigenous to Mexico, Central and South America. Thus the region is a rich source of germplasm in the search for disease resistance.

Coincidental with the collection of avocado and other species of *Persea*, a survey was made for the occurrence of *Phytophthora cinnamomi* in the same area. This fungus causes the most serious problem on avocado in most of the countries where that crop is grown (Zentmyer, 1980); it causes a rot primarily of the feeder roots, often with rapid decline and death of the trees. Trees on thousands of acres in California have been killed or rendered unproductive by the depredations of *P. cinnamomi*, particularly over the past 40 years.

Materials and Methods

The search for resistant rootstocks was begun by the senior author by visiting eleven of the major herbaria in the United States and others in England, Honduras, and Costa Rica. At these herbaria, collections of species of *Persea* were examined and notes taken of locations of *Persea americana* and its varieties, and other species of the genus

in Mexico, Central and South America, and the Caribbean. Where feasible, these locations were visited in the field and specimens (fruit and/or budwood) were collected and sent to California for propagation and testing for disease resistance (Zentmyer, 1952, 1961). Quarantine permits were obtained from the U.S. Department of Agriculture's quarantine office for these importations.

Other locations for collections were obtained from Kopp's useful monograph of the genus *Persea* (Kopp, 1966), from other literature, and from visits and contacts in many countries. Particularly helpful in this regard were scientists with the Rockefeller Foundation, the U.S. Department of Agriculture, the Ministries of Agriculture in many Latin American countries, the Escuela Agricola Panamericana in Honduras (Dr. Wilson Popenoe, especially), the University of Costa Rica, and CATIE in Turrialba, Costa Rica.

In addition to the collections from Latin America, a search was made in avocado groves in California where root rot had been present for many years for trees that appeared to have resistance, and attempts were made to recover the rootstocks.

Plant material from the various collections was propagated at the University of California, Riverside, and tests were made in the search for the resistant material. One method used extensively to test material was the nutrient solution tank method in which seedlings or rooted cuttings were grown in a modified Hoagland's solution in temperature controlled tanks (approximately 1.2 m² x 0.76 m deep) (Zentmyer and Mircetich, 1965). Some, less severe, tests were also conducted using large beds (1.2 m x 3.7 m x 0.45 m deep) containing soil infested with *P. cinnamomi*.

Promising material was propagated further in the glasshouse, then in the lathhouse, and eventually in root-rot areas in the field in southern California avocado groves. Uniform clonal propagation material was developed using the method of Frolich and Platt (1965). In the past 20 years our collections have been propagated by Fred Guillemet, Department of Plant Pathology, University of California, Riverside.

Results

Many thousands of seeds and budwood samples have been collected from 18 species of *Persea* and species of six other genera in the Lauraceae in 18 Latin American countries over the past 40 years (Table 1). These collections have been tested for resistance or tolerance to *P. cinnamomi*. High resistance was reported early in the program in several non-edible small-fruited species of *Persea* (i.e., *P. borbonia*), based on tests in the glasshouse and in preliminary field trials (Zentmyer and Schroeder, 1954). Since the early reports we have made additional collections of small-fruited species from Latin America that have good resistance.

Tests with these resistant species unfortunately showed (Frolich *et al.*, 1958) that they were not graft-compatible with *P. americana*, thus they could not be used directly as rootstocks. Attempts to hybridize these species with *P. americana* have also not been successful. Nor has any species been found that could serve as an interstock between

these groups of species. The genus *Persea* (Kopp, 1966) is divided into two subgenera, *Persea* and *Eriodaphne*. Avocado is in the subgenus *Persea*, and all of the highly resistant species are in *Eriodaphne*. Attempts are being made with some of the new techniques of molecular biology to transfer the resistant genes to *P. americana*.

The first indications of resistance in graft-compatible types were reported by Zentmyer and Thorn (1956) with the Duke variety of avocado that originated in Oroville, California from Mexican seed imported in 1912. In our early lathhouse tests in the 1950's and 1960's, two outstanding Duke seedlings were selected and propagated by cuttings and were named Duke 6 and Duke 7. Many field tests showed at least moderate resistance, and Duke 7 especially was propagated extensively in California and also in several other countries.

The Latin American collecting program was expanded at the University of California, Riverside in 1971 when the second author was added to the project from his base in Guatemala. Thus, in the past 20 years we have been able to collect a number of additional species of *Persea*, and large numbers of collections from the *P. americana* group (Schieber and Zentmyer, 1973; Zentmyer and Schieber, 1987).

One of the interesting collections with moderate resistance was a Mexican type tree growing on the slopes of the volcano Acatenango in Guatemala, which we labeled G6. This collection in 1971 has been propagated in large numbers in California. Another very interesting Guatemalan collection is G755, collected by the second author and his Mayan helper Martin Grande from the Coban area. G755 (now known as Martin Grande) is apparently a hybrid between *P. americana* var. *guatemalensis* and *P. schiedeana* (Schieber and Zentmyer, 1977; Ellstrand *et al.*, 1986). It is a very vigorous rootstock and has significant resistance. It has been erratic in some of the California tests, possibly because G755 is sensitive to low temperature and apparently to high pH.

A number of other recent collections, primarily from Guatemala, appear promising in early glasshouse tests and are being propagated further for field trials. These are Mexican types (known as "Matul-oj" in Guatemala) and typical Guatemalan "criollos". Some of our other indigenous collections from Central America in the subgenus *Persea* include *P. nubigena*, *P. steyermarkii*, and *P. tolimanensis* (Zentmyer and Schieber, 1990). Additional collections involving many seeds are needed for further tests of these species.

In the 1950's and 1960's especially, Zentmyer collected root and soil samples at the same time that he collected seed and budwood from the various collections in Mexico, Central and South America and the Caribbean. Roots from these samples were cultured on agar favorable for growth of *Phytophthora cinnamomi*. If the fungus were found on the roots of some of these native trees without causing disease symptoms that area would be of great interest for possible resistance or tolerance to the fungus.

In the course of these tests over 400 samples were collected from roots of species of *Persea* in native, non-cultivated situations: in rain forests, montane forests, and

swamps. Samples were collected from Argentina, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Jamaica, Mexico, Peru, Puerto Rico, St. Croix (Virgin Islands), Trinidad, and Venezuela. *Phytophthora cinnamomi* was not recovered from any trees in native, undisturbed sites, indicating that it is not a native inhabitant of these soils (Zentmyer, 1977).

In addition to the samples from native trees, cultures were also made from avocado trees in cultivation that were showing symptoms from root rot: in Argentina, Brazil, Chile, Costa Rica, Cuba, El Salvador, Haiti, Honduras, Mexico, Peru, Puerto Rico, St. Croix, and Trinidad. *P. cinnamomi* was readily recovered from many trees in all of those countries.

We believe that these and other data indicate that *P. cinnamomi* was probably introduced into Latin America from some other region--possibly from southeast Asia (Zentmyer, 1977; Zentmyer, 1988).

Collections have also been made from tropical trees in several other genera in the family Lauraceae: *Aiouea*, *Beilschmedia*, *Nectandra*, *Ocotea*, and *Phoebe*. One species collected in Nicaragua had been originally identified as *Persea rigens*, then was changed to *P. primatogenia*; this has recently been identified by H. van der Werff at the Missouri Botanical Gardens as a species of *Beilschmedia* (personal communication).

Discussion

This collecting and testing program is continuing in Latin America, an extremely fertile area for collections, with the large number of species of the genus *Persea*, and with the great variety of seedlings of the three races of avocado, Mexican, Guatemalan, and West Indian that occur widely especially in Central America and Mexico. Possibilities are almost limitless, and attempts will be made to sample new species as well as explore further the species and varieties of avocado that have already shown some indications of resistance. Continuing collections are also planned in established groves in California to detect and propagate the rootstocks from individual surviving trees that may have resistance. The *Phytophthora* root rot program, including the rootstock resistance program, is continuing at UCR under the direction of John Menge.

These unique germplasm materials from Latin America and California, as well as material exchanged with other countries, form the basis for the valuable UCR *Persea* collections. This germplasm could be valuable in breaking the compatibility barrier between species of *Persea* resistant to *P. cinnamomi* and the susceptible species. Techniques of molecular genetics may be useful here.

In addition to providing sources of root rot resistance, these collections may prove valuable for a variety of approaches to other pathological or horticultural problems with the avocado. They have already provided a useful working collection for a number of studies of the molecular genetics and taxonomy of the genus *Persea*, and of the origins and phylogeny of members of the genus *Persea*.

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Table 1. Species of *Persea* and other species in the Lauraceae collected in Latin America.

Species	Country
<i>Persea alba</i>	Brazil
<i>P. americana</i> incl. vars. <i>guatemalensis</i> , <i>americana</i> , and <i>drymifolia</i>	Mexico, Guatemala, Honduras, Costa Rica, Venezuela, Colombia, Ecuador, Trinidad, Puerto Rico
<i>P. borbonia</i>	Southern U.S.
<i>P. caerulea</i>	Costa Rica, Honduras, Venezuela
<i>P. chrysophylla</i>	Venezuela
<i>P. cinerascens</i>	Mexico
<i>P. donnell-smithii</i>	Guatemala, Honduras
<i>P. haenkeana</i>	Peru
<i>P. lingue</i>	Chile
<i>P. nubigena</i>	Guatemala, Honduras, Nicaragua
<i>P. pachypoda</i>	Mexico
<i>P. primatogenia</i> (now identified as <i>Beilschmedia</i>)	Nicaragua
<i>P. schiedeana</i>	Mexico, Guatemala, Honduras, Costa Rica
<i>P. steyermarkii</i>	Guatemala, El Salvador
<i>P. tolimanensis</i> (Aguacate de Mico)	Guatemala, El Salvador
<i>P. veraguasensis</i>	Costa Rica
<i>P. vesticula</i>	Honduras
<i>P. zentmyerii</i>	Guatemala
<i>Aouea</i> sp.	Guatemala
<i>Beilschmedia anay</i>	Guatemala
<i>Beilschmedia miersii</i>	Chile
<i>Nectandra sinuata</i>	Honduras
<i>Ocotea</i> sp.	Peru
<i>Phoebe mexicana</i>	Costa Rica