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The search for resistance to Phytophthora root rot in Latin America

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SYNOPSIS
Indigenous avocados and related species of Persea *in Latin America provide a rich source of possible resistance to Phytophthora root rot, and collections have been made in 18 countries in that area over the past 35 years. Collections include 15 species of Persea and species of other genera in the Lauraceae, totalling over 1 800. Sources of resistance have been found, particularly in some Mexican race avocados and in* Persea schiedeana*.*

INTRODUCTION

The search for rootstocks resistant to *Phytophthora cinnamomi* began in 1952 with a trip to native avocado areas in Mexico, Guatemala, Honduras, El Salvador, and Costa Rica (Zentmyer, 1952). Three principal approaches were undertaken in this project: (a) to make collections from the native home of the avocado (*Persea americana)* in Mexico, Central and South America and the Caribbean, with emphasis on trees growing in wet areas and if possible, in the presence of the pathogen *Phytophthora cinnamomi;* (b) to collect as many of the related species of the genus *Persea* as possible - approximately 80 species have been described from the Americas - (Kopp, 1966); and (c) to search for resistant avocado trees in Latin America and in California, in areas where Phytophthora root rot has been present for many years.

To begin the programme, a number of herbaria in various botanical gardens or institutions in this country were visited, and their collections of dried specimens of species of *Persea* were examined. Locations were obtained for species of *Persea* growing in various areas in Latin America. These data were used as the basis for the first explorations, which were then expanded on the basis of contacts made in many countries. Many people and many organisations provided excellent co-operation in these explorations over the years, including the Rockefeller Foundation, the Ministries of Agriculture in many Latin American countries., the US Department of Agriculture, the Escuela Agricola Panamericana in Honduras, the University of Costa Rica and CATIE in Turrialba, Costa Rica. The authors would like to express particular appreciation to the late Dr Wilson Popenoe, who was very helpful for many years in providing locations for collections and discussions of the avocado and its many forms and related species in Latin America.

Herbaria visited were: Chicago Natural History Museum, Missouri Botanical Garden, New York Botanical Garden, the Gray Herbarium, the National Herbarium in Washington, DC, the Smithsonian Institution, the University of California Herbarium at Berkeley, the California Academy of Science Herbarium, the Paul Standley Herbarium at the Esquela Agricola Pan-americana in Honduras, the University of Costa Rica Herbarium, the Herbarium at the Museo Nacional in San Jose, Costa Rica and the Kew Herbarium in England. Appreciation is expressed to the curators of these herbaria for their fine co-operation.

Countries in the Americas where collections have been made are: Mexico, Central America - Costa Rica, El Salvador, Guatemala, Honduras, and Nicaragua: South America - Brazil, Chile, Columbia, Ecuador, Peru, and Venezuela; Caribbean - Cuba, Haiti, Jamaica, Puerto Rico, St. Croix and Trinidad. Collections were also made in Florida and materials of various related plants were received from Guyana, Hawaii, Asia (the genus *Machilus)* and New Zealand (the genera *Alseodaphne* and *Beilschmedia).*

RESULTS

Collections include the following species of *Persea: P. alba, P. americana* var *americana* and *P. americana* var *guatemalensis* (Mexico and Guatemala, and non-indigenous introductions from Central and South America, the Caribbean, California, Florida and Hawaii), *P. borbonia* (southern US), *P. caerulea* (Honduras, Costa Rica and Venezuela), *P, chrysophylla* (Colombia), *P. donnell-smithii* (Guatemala and Honduras), *P. haenkeana* (Peru), *P. indica* (Canary Islands and from cultivated trees in California), *P. lingue* (Chile), *P. nubigena* (Guatemala, Honduras, Mexico and Nicaragua), *P. drymifolia* (Mexico, Central and South America, as well as California), *P. schiedeana* (Costa Rica, El Salvador, Guatemala and Mexico), *P. steyermarkii* (Guatemala), *P. vesticula* (Honduras and Costa Rica), *Persea primatogena* 'Guaslipe' (Nicaragua), very recently a new species of *Persea* from Guatemala and several species of the related genera in the Lauraceae, *Aiouea, Beilschmedia, Nectandra, Octoea*, and *Phoebe.*

The collecting programme was expanded at the University of California, Riverside, in 1971 and the second author began his extensive collections. Since that time collections have been concentrated in Middle America, especially in Guatemala. Over the past 35 years individual collections number over 1 800.

Resistance to *P. cinnamomi* in these collections from various areas has been tested in a nutrient solution test (Zentmyer& Mircetich, 1965), in pot tests in infested soil, in tests in beds of infested soil (4 ft by 15 ft in the lathhouse). and ultimately in field tests in avocado areas in California.

Both budwood and seeds have been collected from the various areas involved in the programme, with appropriate quarantine permits necessary for the importations. Until very recently seeds had to be sent to California via El Paso, Texas, where the seeds were fumigated with methyl bromide to assure that the avocado seed weevil was not imported along with the seeds. Fumigation is at present done at the Los Angeles quarantine facility. Budwood is sent directly to Los Angeles where it is inspected and

treated with an insecticide if necessary. Plants propagated from the budwood are subject to a two-year inspection period.

In the first few years of the collecting programme, high resistance was apparent in several non-edible., small-fruited species of *Persea*. These included *P. alba, P. borbonia, P. caerulea, P. chrysophylla, P. donnell-smithii* and *P. skutchii.* Tests with these resistant species (Frolich *et al,* 1958) showed that they were not graft-compatible with *P. americana,* thus they could not be used as rootstocks. Attempts to hybridise these resistant species with *P. americana* have also been unsuccessful. No species has yet been found that would provide an interstock between the two groups of *Persea.* Two distinct groups are described in the genus *Persea* (Kopp. 1966): the subgenus Eriodaphane containing the small-fruited species resistant to *Phytophthora cinnamomi* and the subgenus *Persea* containing the species with larger, edible fruit that are generally susceptible to *P. cinnamomi.*

In the early years of the resistance programme some indications of resistance were found in seedlings of some Mexican varieties of the avocado, notably in the Duke variety. This variety originated from some seeds sent from Mexico to Oroville, California, in 1912. One of these seedlings was selected because of some promising fruit characteristics and was named Duke. As an indication of at least moderate resistance in some Duke seedlings, 110 Duke seeds were planted in a bed of soil naturally infested with *P. cinnamomi,* in comparison with 110 seeds of the Topa Topa Mexican variety. After three years, 45 per cent of the Duke seedlings were apparently healthy, based on top symptoms compared with 0,9 per cent of healthy seedlings in the Topa Topa planting.

During tests in lathhouse beds of infested soil, two seedlings showed the best resistance; these were designated Duke 6 and Duke 7 and were propagated further as clonal rootstocks. Field tests in the 1960s showed that these clones had appreciable resistance, thus they were propagated more widely, especially the Duke 7 because of superior growth and vigour. Duke 7 has been propagated extensively as a clonal rootstock by Californian nurserymen in the past 10 years.

Field trials in southern Californian avocado groves provided evidence of at least some resistance or tolerance in trees grafted on Duke 7 or Duke 6 clonal rootstocks. Under very severe disease conditions, however, these clonal rootstocks have been severely affected.

The Duke 7 rootstock has been propagated extensively as a clonal rootstock by avocado nurserymen in southern California and has proven to be a moderately vigorous rootstock, producing uniform trees. Many hundreds of thousands of trees on Duke 7 clonal rootstock have been planted in southern California. In the 1970s and early 1980s several additional graft compatible rootstocks showed some promise in the resistance programme. One of these, G6, which is also of Mexican seedling origin, was collected from the slopes of the volcano Acatenango in Guatemala and was first found in 1971 by the second author. The first seeds and budwood of G6 were collected in July, 1971.

Trees on G6 clonal stock grew better on the usual susceptible rootstocks in early field trials in disease situations, and this clone was also propagated by southern Californian nurserymen, although not as much as Duke 7.

An apparent ancestor of the Guatemalan avocado, *P. americana* var *guatemalensis,* was first found in the 1950s in El Salvador and in Guatemala, and has more recently been collected more extensively in Guatemala and Nicaragua. This interesting tree has small oval fruit, about 1½ to 2 inches in diameter with thick skin and a minimum of flesh, which is quite bitter. It appears to be a primitive form of the Guatemalan avocado and has shown some indication of resistance to root rot. It is known as 'Aguacate de Mico' by the natives.

There have also been some indications of resistance in other graft-compatible species of *Persea.* This is true of some of the collections of *P. steyermarkii* and also of *P. schiedeana.* Early collections of *P. schiedeana* gave quite variable results in resistance tests in the 1950s and 1 960s, but one 1975 collection from the Coban area, G755, is one of the most promising rootstock resistant collections made. This was a market collection made by the second author and his Mayan helper, Martin Grande, and appears to be a hybrid between *P. americana* var *guatemalensis* and *P. schiedeana.* It is a very vigorous rootstock and has grown well in a number of field plots in infested soil. Evaluation on large numbers of trees is continuing.

Most of the species of *Persea* and varieties of avocado grow in Middle America between 4 500 and 8 500 feet above sea level, as well as in the rainforests of the volcanic slopes. All of these grow in areas of relatively cool temperatures, with a few exceptions. *Persea schiedeana* and *P. donnell-smithii* are found in warmer regions of Middle America.

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