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AVOCADO ROOT ROT RESEARCH

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The accelerated research program on Phytophthora root rot of avocado continued during the past year, with the increased support provided by the avocado industry through the marketing order funds. The research is being carried out by scientists in the Departments of Plant Pathology, Plant Science, and Soils and Agricultural Engineering of the Riverside campus, and in the Department of Plant Pathology on the Los Angeles and Berkeley campuses. Farm Advisors in the University's Extension Service are also involved in various field aspects of the root rot program; these include Len Francis, George Goodall, Don Gustafson, Tom Hales, B. W. Lee, and J. H. LaRue, in Riverside, Santa Barbara, San Diego, Orange, Los Angeles, Ventura and Tulare counties. Studies were divided into four phases this past year: resistance, chemical and biological control, fungus studies, and irrigation.

1. Resistance

This phase covers all aspects of the studies involved in control of root rot by the possible use of resistant rootstocks, including foreign explorations for new, resistant germplasm, propagation of possibly resistant rootstocks from trees in California, various tests of the collected materials for resistance in the greenhouse, propagation of root-stocks for further field testing, and studies of the chemical basis for resistance.

The collecting program in Latin America continued actively again this year. Our collector, Dr. Eugene Schieber, made 362 collections during the year, in Guatemala, El Salvador, Costa Rica, and Ecuador; and several collections were made by other cooperators. One collection was obtained from Guyana.

Collections included many different avocado types *(Persea americana and P. americana drymifolia*—Mexican type) a primitive type known as "Aguacate mico" from El Salvador; a large-fruited avocado relative, "coyo" *(P. schiedeana)*; a primitive Guatemalan type *(P. nubigena),* and several unidentified collections.

Several additional trees were found in California that either have some resistance or are "escapes." Attempts are being made to recover the rootstocks and test them to determine if some resistance is present.

Over 2,000 seedlings and cuttings were tested for resistance in the nutrient solution. No outstanding resistance was found, but several Mexican types showed moderate resistance. 324 surviving seedlings from the tank tests were transplanted into soil

infested with the root rot fungus, for additional tests for resistance. An additional Duke seedling was selected for the secondary screening program in soil, for propagation for further root rot resistance tests in the field. Some of the cuttings, especially Duke 6, Duke 7, G6, and Huntalas showed appreciable resistance in soil tests.

In further tests to study the effect of a scion on the susceptibility of the rootstock to *Phytophthora cinnamomi,* grafted seedlings and cuttings (Topa Topa, Duke seedling, and Duke 7 cutting) had less root rot than ungrafted seedlings or cuttings; this was in a greenhouse test in heavily infested soil.

E. F. Frolich at UCLA rooted many more cuttings for field tests of resistance. Approximately 1,200 of these trees, on several rootstocks, were planted in the field this year in additional plots established in San Diego, Riverside, Los Angeles, Ventura, Santa Barbara, and Tulare counties, with the cooperation of Farm Advisors Don Gustafson, Len Francis, Tom Hales, B. W. Lee, George Goodall, and Jim LaRue. This year the first sizeable plantings of some newer selections, such as Huntalas and G6, were made in the field. In previously-established plots, trees on Duke 6 and Duke 7 rootstocks are still holding up well after 4 to 5 years. Further information is needed on the effect of the scion on the resistance of the rootstock; results to date have been variable in the field. The UCLA phase of the program was terminated in July 1975 and E. F. Frolich retired after many years of excellent contribution to California agriculture and recently particularly to the avocado root-stock program. Propagation work was transferred in July to the Riverside campus.

Further studies were made of the chemical structure of borbonol, the preformed antifungal substance found in *Persea borbonia* and other highly resistant species of *Persea.* The final chemical structure is nearly completely determined; it appears that the chemical exists in the trees in several closely-related forms. Research on this phase is being done by Drs. A. I. Zaki, J. J. Sims and J. Pettus.

2. Chemical and Biological Control

This phase includes all other aspects of control, not including resistance. One of the significant aspects, which may be of use in controlling root rot on established trees, is the use of soil fungicides. During this past year 15 chemicals were tested for their effect on the root rot fungus. The ethazol type (Terrazole) was effective in increasing growth and condition of trees in several plots, and in some cases in reducing the amount of root rot fungus in the soil. Residue tests have been negative for the presence of the chemical in avocado fruit from treated trees. There is a possibility that Terrazole may be available for use on avocado trees in California early in 1976.

A new French fungicide and a systematic material from the Dow Chemical Company showed some promising results in greenhouse tests and are being investigated further.

In other phases of control, indications were obtained, in cooperative work with Drs. T. W. Embleton and G. A. Zentmyer, that nitrogen added in various forms to infested soil may give some disease reduction. This appears to have most promise when the nitrogen is present in combination with the chemical N-SERVE that keeps nitrogen in the ammonium form. This is being studied further. Salt and osmotic effects are being

studied in relation to the root rot fungus in the laboratory, and will be expanded to soil tests. Sodium chloride and potassium chloride inhibit growth of the fungus at osmotic pressure of -10 atms or less, which is within the range of osmotic pressures tolerated by plants.

The relationship of endotrophic mycorrhizae to avocado trees and to root rot is being studied by Dr. J. A. Menge. A survey indicates that these beneficial mycorrhizal fungi are present in essentially all California avocado groves. Nine species of mycorrhizae have been found in association with avocado roots in California, including several species of *Glomus, Sclerocystis, Gigaspora,* and *Acaulospora.* The role of mycorrhizae in development of root rot is not yet understood.

In field plots further information was obtained on effectiveness and penetration of soil by methyl bromide. Two microorganisms antagonistic to *Phytophthora cinnamomi* were established in the soil following fumigation and their populations were maintained at significant levels for nearly one year. This research is being done by Dr. D. E. Munnecke.

Dr. P. H. Tsao has continued the study of survival and activity of the avocado root rot fungus in soil, in soil extracts, and of production of sporangia. Several types of organic matter, including chicken manure, alfalfa meal, seaweed extract, and a commercial high protein product reduced the infection of *Persea indica* by the root rot fungus in greenhouse experiments. These materials increase the population of bacteria and actinomycetes in the soil greatly. Methods were improved for producing sporangia under sterile conditions in the laboratory, which will facilitate research on inhibition of this spore stage.

Research continued at Berkeley on microorganisms that stimulate *P. cinnamomi* to produce sporangia, and the possible mechanisms of this stimulation. Several microbial stimulators were isolated and used in combination to stimulate production of sporangia in culture. Axenic production of sporangia was further refined, with indications of the need for removal of nutrients as thoroughly as possible, and for uniform light conditions. These studies are being conducted by Drs. K. F. Baker and C. Schoulties on the Berkeley campus of the University of California.

3. Studies of the Fungus, Phytophthora cinnamomi

Under this phase of the project Dr. J. V. Leary is studying development of mutants resistant to antibiotics and fungicides, so that these could be used in developing further information on the life cycle of the root rot fungus. Other research along this line concerns oospore dormancy, synthesis of ribonucleic acid, effects of antibiotics on mitochondria of the fungus, and variation in response of many isolates of *P. cinnamomi* to several antibiotics.

Other fungus studies by Dr. G. A. Zentmyer include work on the response to temperature of many isolates of the root rot fungus, and on the time required to kill the fungus at different temperatures; for example, exposure to 110°F for 1 to 2 hours killed the fungus in laboratory studies. The new method of isolating *P. cinnamomi* from soil, using small seedlings of the avocado relative *Persea indica,* looks very promising and

sensitive; as few as 100 zoospores in solution will cause canker development on *P. indica.* Several other species of *Phytophthora* will also infect *P. indica.* Additional cultures added to the *P. cinnamomi* collection will permit more study of variation in the species and the possible presence of different races of the fungus.

4. Irrigation

Drs. J. D. Kirkpatrick and L. H. Stolzy are continuing studies on various aspects of drip irrigation in regard to emitter rate, volume of water, frequency of application, nitrogen fertilizer application, and soluble salt relations.

Soil moisture and aeration conditions in regard to growth of young Hass avocado scions grafted onto Topa Topa and Duke seedlings are being studied by Dr. L. H. Stolzy and T. Szuszkiewicz of the Department of Soils and Agricultural Engineering in cooperation with Dr. G. A. Zentmyer. When suitable conditions are defined, studies will be made of the relation of moisture and aeration to root rot development on the avocado trees on the two rootstocks. Dr. C. K. Labanauskas of the Department of Plant Science also has cooperated in research on the effect of root rot infection on accumulation of various nutrients in the roots and tops of seedlings.

In a field study in which George Goodall, Santa Barbara County, and G. A. Zentmyer are cooperating, young avocado trees are declining from root rot more slowly under drip irrigation than under comparable sprinkler irrigation. More information on this effect is needed, and additional studies are planned.