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AVOCADO ROOT ROT RESEARCH PROGRAM

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The research program on Phytophthora root rot of avocado continued in an expanded form during the past year, as a result of the increased support of the avocado industry through marketing order funds. Seventeen scientists in the Departments of Plant Pathology, Plant Science, and Soils and Agricultural Engineering are involved in the project, primarily on the Riverside campus but also on the Los Angeles and Berkeley campuses of the University. Also ten staff research associates are working on the program. Farm Advisors Don Gustafson, Len Francis, Tom Hales, B. W, Lee, George Goodall, and Jim LaRue have been involved in various field aspects of the program in San Diego, Riverside, Orange, Los Angeles, Ventura, Santa Barbara, and Tulare counties.

The research program on root rot is divided into five phases; resistance, chemical and biological control, fungus studies, irrigation and incompatibility. This paper briefly summarizes the various phases of the work.

1. Resistance

In this section are the studies relating to control of the disease by resistant rootstocks; this involves foreign explorations, propagation of California rootstocks, testing of collections and propagated material for resistance, propagation of resistant material for field tests, and chemical tests on the basis for resistance.

The collecting program has continued during the past year, at a slightly reduced scale, with the assistance primarily of Dr. Eugene Schieber, headquartered in Guatemala. Dr. Schieber has made collections during the past year in Northern Mexico, Guatemala, El Salvador, Nicaragua, Costa Rica, and Ecuador; nearly 300 collections were made, primarily of avocado types *(Persea americana),* but also including *P. schiedeana* (an interesting tree related to avocado with large leaves and fruit similar to avocado), *P. steyermarkii,* (a primitive type somewhat similar to the Guatemalan avocado), and a new species of Persea from Nicaragua, with fruit like a somewhat elongated date.

The search continued in California for avocado trees that were resisting root rot in old avocado root rot areas. Additional trees were found, and the rootstock was recovered from one of these

Many avocado seedlings and some cuttings were tested for resistance in the nutrient solution test and in soil in the greenhouse. A few showed resistance, including several Mexican types from Guatemala, *P. americana* from El Salvador and from Ecuador, Duke 6 and 7 cuttings, Huntalas cuttings, and G6 cuttings.

The propagation phase of the root rot program was continued at UCLA, with E. F. Frolich rooting many cuttings for field tests. Additional field plots were established in San Diego, Riverside, Ventura, Santa Barbara and Tulare counties. Approximately 900 trees were planted in these counties with the cooperation of many growers and of Farm Advisors Don Gustafson, Len Francis, B. W. Lee, George Goodall, and Jim LaRue. In previously established field plots, appreciable resistance is evident in Duke 6 and Duke 7 cuttings and some G22 cuttings.

Further chemical work was done during the year to definitely establish the chemical structure of the pre-formed toxic chemical present in species of *Persea* resistant to *Phytophthora cinnamomi.* This chemical was isolated last year and named "borbonol" or "borbonyl acetate" because it was first isolated from *Persea borbonia.* With the aid of special instruments the complicated chemical structure has nearly been established. If it can be synthesized the chemical may have practical use in control of the disease. This research is being done by Drs. A. I. Zaki, J. J. Sims and N. T. Keen.

2. Chemical and Biological Control

Several different approaches to control of root rot are included under this phase of the project—including fungicides, fumigants, various types of cultural control and nutrition, biological control and suppressive soils.

A number of additional soil fungicides were evaluated for root rot control, with the ethazol type (Terrazol, Truban) giving good results in greenhouses and in some fieldplots. A new organic fungicide from France showed promise in preventing root rot and also had some systemic activity. Additional residue studies are being made on fruit from trees treated with Terrazole, preparatory to application for registration of the chemical for use on avocado.

In other aspects, addition of calcium salts and some other salts has reduced root rot on avocado and *P. indica* seedlings. Further tests are being run by Drs. F. T. Bingham and G. A. Zentmyer to determine if this is an effect on the fungus, on host nutrition, or on other microorganisms in the rhizosphere, and to determine possible use for root rot control in the field. The development of root rot in drip vs. sprinkler irrigation is being studied in the field, on young trees in a planting in Santa Barbara county.

Endotrophic mycorrhizae *(Endogone* or *Glomus* spp.) as they affect root rot are being studied by Dr. J. A. Menge at Riverside. These are beneficial fungi that aid in growth of healthy trees and have recently been found to occur on avocado; their role in root rot is not yet known.

Further information was obtained on the response of *Phytophthora cinnamomi* to methyl bromide in research by Dr. D. E. Munnecke. Field plots were established in which methyl bromide concentrations were monitored at various times after fumigation, at different depths in the soil, and the effect on the root rot fungus is being determined as

well as the effect of adding microorganisms that are antagonistic to the root rot fungus after fumigation.

Dr. P. H. Tsao is continuing studies on survival and activity of *P. cinnamomi,* including effect of various amendments on spore formation, release of zoospores from sporangia, and on infection of seedlings of *Persea indica.* Methods are being developed for optimum production of sporangia, to facilitate the research on activity of *P. cinnamomi* in soil and determine how best to reduce the activity of the fungus.

Dr. K. F. Baker at Berkeley, with assistance from Dr. C. L. Schoulties, is continuing the study of "suppressive" soils, to determine why certain soils tend to suppress the root rot. Stimulation of production of sporangia by certain bacteria in the soil is involved in activity of *P. cinnamomi;* specific aspects of this phenomenon are being studied, as the more that is known about the factors involved in production of sporangia the more chance there is of adequately controlling the fungus.

3. Studies of the Fungus, Phytophthora cinnamomi

Under this phase of the project, the effort is being made to obtain information on as many details of the life cycle as possible, in order to find and exploit weak links in the cycle. Drs. J. V. Leary and G. A. Zentmyer are involved in this phase. Mutagenic chemicals are being studied, in efforts to find stable mutants of *P. cinnamomi,* Studies of oospore dormancy are providing further information on this resistant spore structure; apparently dormancy is imposed quite early in the life of the oospore, and the dormant oospore cannot synthesize proteins. Antibiotics and metabolic poisons were found to inhibit protein synthesis in mycelium and germinating zoospores.

Further evidence was found of variation in isolates of *P. cinnamomi,* in relation to temperature and growth, and in growth in presence of several antibiotics. Most isolates of the fungus do not grow or make very little growth at 33°C (91 °F), but can survive at that temperature for at least 8 days. No cultures tested grew at 6°C (43°F); all cultures made very slight growth at 9°C. Oospore germination was better at the blue range of light than in shorter wavelengths,

A new method of isolating *P. cinnamomi* from soil, using bare-root seedlings of *Persea indica* shows considerable promise as a very sensitive method for detecting the fungus in soil samples.

4. Irrigation

Further studies of drip irrigation in avocado orchards in Ventura and Santa Barbara counties are providing information on available soil moisture and salt accumulation in relation to root development, in research by Drs. J. D. Kirkpatrick and L. H. Stolzy.

Dr. L. H. Stolzy and T. Szuszkiewicz of the Department of Soils and Agricultural Engineering are conducting tests on growth of avocado seedlings and young grafted trees in various soils in relation to oxygen and water content. Further background information is needed before additional tests can be made of the relation of soil oxygen and water to root rot development.

5. Incompatibility Studies

In these studies, by Drs. T. Murashige and R. Bergh, and R. Makino of the Department of Plant Science, various phases of the problem of incompatibility are being studied. This concerns primarily the incompatibility between species of *Persea* that are resistant to root rot and the cultivated avocado. This phase has involved studies of test tube pollination of excised ovaries and ovules, efforts to increase Phytophthora resistance in the avocado through irradiation, irradiation of species of *Persea,* histochemical studies of the graft unions, and callus cultures of avocado and other species of *Persea.*

Growth of ovaries in artificial culture has not been substantial, but the ovaries remained alive for several months and developed green coloration. Some plants have been propagated from irradiated scion sticks of Duke avocado. In the graft unions with avocado and other species of *Persea* a reddish brown substance appearing at the interface of incompatible grafts has not been definitely identified but apparently some polysaccharides are present. Callus cultures have been initiated of avocado as well as *P. Donnell-smithii* and P. *borbonia.*