California Avocado Society 1973-74 Yearbook 57: 167-169

AVOCADO ROOT ROT INVESTIGATIONS

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During the past year, the greatly expanded program for control of Phytophthora root rot of avocado has continued, with a number of new developments that will be summarized in this article. Fifteen scientists in the Departments of Plant Pathology, Plant Science, and Soils and Agricultural Engineering are working on the project, primarily at the University of California at Riverside, but also on the Berkeley and Los Angeles campuses of the University. Also assisting on the research are ten staff research associates. Farm Advisors in San Diego, Riverside, Orange, Ventura and Santa Barbara counties have been involved in some of the field aspects of the work.

The research on root rot is divided into five phases: resistance, other phases of control, fungus studies, irrigation, and incompatibility.

I. Resistance

Under this heading are all of the studies relating to the discovery or development of a resistant rootstock. One important aspect of this is the collecting program in Latin America, which has continued this year with assistance from Dr. E. Schieber and several others including Dr. B. H. Waite, Laura Jefferson, E. L. V. Johnson, and the senior author of this article. Over the past year nearly 250 collections were made in Mexico, Guatemala, El Salvador, Nicaragua and Costa Rica. The emphasis has been on collecting new species of *Persea,* new types of avocado, and re-collecting materials that showed some resistance in previous collections. Seeds of *Machilus,* a genus of plants closely related to the avocado, were also obtained from a Botanical Garden in Asia.

Also work is continuing on propagating rootstocks of trees in California that show indication of resistance; rootstocks from two trees of this type are being propagated.

Many avocado seedlings and cuttings were tested for resistance at Riverside, in the nutrient solution tank test and in soil infested with *Phytophthora cinnamomi.* Only a few showed any resistance, including a Mexican type from Guatemala, cuttings of Duke 7, G22, and M21 and a native avocado type from Nicaragua.

The propagation phase of the root rot resistance project was continued at UCLA, with E. F. Frolich rooting many more cuttings for field tests for resistance. Over 1,100 trees were planted in field plots during the year, in Riverside, San Diego, Santa Barbara and

Ventura counties, with cooperation of a number of growers and Farm Advisors Don Gustafson, Len Francis, B. W. Lee, and George Goodall.

A very significant aspect of the research during the year was the isolation of a pre-formed toxic chemical from resistant species of *Persea* especially *P. borbonia* and *P. caerulea.* Using special instrumentation including a mass spectrometer with gas chromatograph, the chemical was isolated and identified as a long chain hydrocarbon ($C_{19}H_{32}O_3$) and named "borbonyl acetate". This is an exciting development in relation to the nature of disease resistance; if the chemical can be synthesized it could be used in disease control. There is also the possibility that the presence of the chemical could be used as a test for resistance. This research is being done by Drs. A. Zaki, N. T. Keen and J. Sims, in the Department of Plant Pathology.

II. Chemical, Biological and Cultural Control

A number of approaches to control besides resistance are included in this part of the project. In additional tests of soil fungicides, Terrazole was effective in frequent low-dosage applications, for possible use in a drip irrigation system. Further tests are being run, and residue samples are being analyzed to determine if Terrazole accumulates in avocado fruit, preparatory to possible registration of the chemical for use on avocados. A new systemic fungicide was toxic to avocado seedlings; different formulations are being evaluated.

Several forms of cultural control are being studied including severe cutting back, fertilization, and increased levels of calcium and potassium. Varying the type of nitrogen, in cooperative tests with Dr. T. Embleton, increased growth of avocado seedlings in diseased soil and is being studied further. In one comparative test with seedlings, root rot has developed less rapidly under drip irrigation than under sprinkler irrigation.

Biological control and antagonistic organisms in the soil are being studied by Dr. P. H. Tsao. Several organic amendments reduced *P*. *cinnamomi* populations in the soil and inhibited release of zoospores from sporangia.

In research by Dr. D. E. Munnecke on soil fumigation in relation to root rot, dosage responses of methyl bromide were accurately determined to mycelium of the fungus in culture, to the fungus in avocado roots, and to chlamydospores. Fumigation tests will be conducted in the field, with gas concentrations to be measured at different depths and under different conditions.

The study of suppressive soils was continued by Dr. K. F. Baker at Berkeley, and with some cooperative research at Riverside by a visiting scientist from Australia, Miss Pat Broadbent. Biological control of *Phytophthora* in the soil in Australia apparently involves inhibition of formation of zoospores and lysis of mycelium of the fungus. Indications were found of suppressiveness in a southern California soil with extensive lysis of mycelium occurring. Factors involved in sporangium production are also being studied further.

III. Irrigation and Aeration

Studies of drip irrigation on avocado groves in Ventura and Santa Barbara counties have provided information on water distribution, root development, and salt accumulation.

Studies are underway to develop information on the progress of root rot under various aeration and moisture regimes in the greenhouse, using avocado soils typical of two different areas where the disease is present. Studies of root porosities of several varieties of avocado and one resistant species of *Persea* show correlation in the initial stages with susceptibility to root rot, with the most susceptible variety having the lowest root porosity. Porosity readings were: Topa Topa 4.2%, Mexicola 4.3%, Ganter 5.0%, Vista 5.5%, Duke 9.5%, and *Persea cinerascens* 10.3%. This project is under the direction of Dr. L. H. Stolzy and T. Suszkiewicz, Dept. of Soils and Agricultural Engineering.

IV. Studies of the Fungus, Phytophthora Cinnamomi

This aspect of the research has continued and is being expanded, with the emphasis on developing more information on the life cycle of the pathogen that can be used in finding efficient control measures.

Under Drs. J. V. Leary and G. A. Zentmyer these studies are contributing additional data on development of mutants, ribosome studies, variability in the fungus in relation to growth type, resistance to antibiotics, and variation in pathogenicity.

Attempts were continued to obtain stable mutants of *P. cinnamomi,* using a variety of mutagens. Some presumed morphological mutants were isolated and are being characterized. The events in RNA and protein synthesis received major emphasis. An in vitro protein synthesis system was developed for *Phytophthora,* so that the capacity for protein synthesis in various spore forms can be assayed.

Preliminary results indicate that normal cellular organelles are not present in the dormant oospore, and that ribosomal proteins are dispersed throughout the cytoplasm. A significant aspect is the confirmation of the absence of ribosomes in the dormant oospore.

Isolates of the root rot fungus from avocado, camellia, pine, cinnamon, eucalyptus, and heather, from various parts of the United States and from Australia, Germany and Sumatra were inoculated onto pine, camellia, and avocado during the year. There was considerable variation in pathogenicity, indicating the probable presence of races of the fungus; one of the camellia isolates, for example, was not pathogenic to avocado.

V. Incompatibility Studies

These studies are being carried out by Dr. T. Murashige, R. Makino, and Dr. B. O. Berg, Dept. of Plant Science. During the past year these have included research on interspecific hybridization through test-tube pollination, radiation experiments, and graft incompatibility.

In the test tube pollination studies, ovaries of *P. americana* and *P. skutchii* were cultured and pollinated in the laboratory, using several different techniques. These exploratory tests have been confined to homospecific pollinations. Under these conditions many of the ovary cultures remained alive from several weeks to several months in culture. Also attempts were made to implant interspecifically pollinated ovules of Perseas into tomato or pepper fruit in vitro, hoping that the *Persea* embryo will develop in this borrowed ovary.

Scion wood of Duke variety was irradiated with fast neutrons at the Oak Ridge National Laboratory, with 100 scions irradiated with each of several dosages. Successful grafts from the highest treatment were retained for further culture and are being grown at the Brokaw Nursery in Saticoy. Seedlings of *Persea Donnell-Smithii* and *P. skutchii* will be grown and used for rootstocks for irradiated scion-wood of these two species.

Other studies are aimed at determining the anatomical or biochemical basis for graft incompatibility. Grafts between *P. americana* and *P*. *borbonia* and *P. Donnell-Smithii* are being examined. A substance has been seen consistently and invariably in the region of contact in incompatible grafts; its identify is not yet known.

Investigations in all of the above five areas are being continued during the present year, with some changes in emphasis as new developments appear. Progress has been substantial, with the great increase in personnel at the University working on avocado root rot, and significant developments appear to be imminent in several of the areas.