Citrus Irrigation Water Survey

runoff water from diseased groves, carried in canals, can contaminate other land with infective Phytophthora spores

L. J. Klotz, Po-Ping Wong, and T. A. DeWolfe

Twelve irrigation canals, sampled repeatedly for one year, all harbored one or more of the species of *Phytophthora* that cause citrus diseases. The species that were prevalent varied with the seasonal temperature of the water. The fungus was found in only one of the three reservoirs tested.

Phytophthora citrophthora (Sm. & Sm.) Leonian, *P. parasitica* Dast., *P. syringae* Kleb., *P. hibernalis* Carne, and *P. megasperma* Drech. cause brown rot or other diseases—either above or below ground—in commercial citrus groves in California. Some are widespread in soils of the major citrus producing areas of the world.

Water-testing work was initiated in the fall of 1957 to determine the prevalence and the origin of infestation of *Phytophthora* spp., pathogenic to citrus, in irrigation water of open canals and reservoirs in five southern California counties: Riverside, San Bernardino, Los Angeles, San Diego, and Orange.

Lemon-Trap Method

To test for the presence of *Phytophthora* spp., 5–20 lemons at the silver stage were suspended—in a perforated plastic bag—in a canal or reservoir. Two weeks were allowed, during which any fungus spores present in the water could infect the fruit and cause brown rot. The bags of fruits were then brought to the laboratory, where those with brown rot lesions were cultured. Boiled hempseeds were added in each trap to increase the probability of trapping any *Phytophthora* spp. Lemons were the most satisfactory trapping agent for *P. citrophthora, P. parasitica* and *P. syringae* in water. Oranges were used as a trap for *P. hibernalis.*

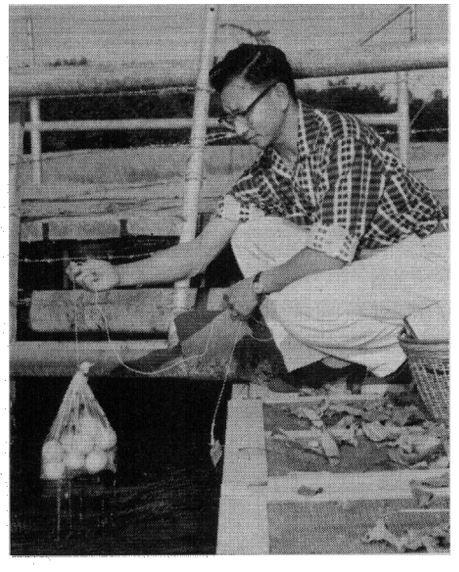
A trap was placed at or near the source of the canal water, if possible, and two to five traps were placed at intervals along each canal. The locations were usually sampled every two weeks.

Occurrence of Spores

Of the 12 canals tested from September 1957 to September 1958, all yielded *Phytophthora* spp. at one time or another, some more consistently than others. The most commonly distributed and frequently recovered species was *P. citrophthora*—11 canals; less frequently, *P. parasitica*—five canals; and least frequently, *P. syringae*—two canals. *P. hibernalis* and *P. megasperma* were not found. Four of the canals yielded *P. citrophthora* only, and four yielded both *P. citrophthora* and *P. parasitica.* Two canals yielded both *P. citrophthora* and *P. syringae.* One canal yielded *P. citrophthora, P. parasitica,* and *P. syringae.* One canal yielded an unidentified *Phytophthora* sp., which tolerated an exceptionally high temperature, up to 113°F incubation. Under greenhouse conditions it was capable of producing gummosis lesions both in the bark and on the cambium layer of the trunk of one-year-old seedlings of Cleopatra mandarin, Standard sour orange, Jameson sweet orange, and Sampson tangelo.

Where more than one species of *Phytophthora* was found in the canal during the several samplings, the species isolated seemed to be related to the prevailing water temperature. During winter and spring months, when the water temperature was between 43°F and 63°F, *P. syringae* was isolated. During the warm summer and early fall months, when the water temperature ranged from 63°F to 88°F, *P. parasitica* was isolated. However, *P. citrophthora* was recovered all through the year, with the water temperature ranging from 43°F to 88°F. These temperatures are close to the range at which the fungi grow in laboratory cultures.

Method for trapping zoospores of *Phytophthora* spp. that attack citrus. Perforated polyethylene bag containing citrus fruits immersed in water source for two weeks. Zoospores infect fruit, causing *Phytophthora* brown rot.



In the five canals where it was possible to set the lemon traps at the source of water supply, no *Phytophthora* spp. were recovered there. However, as the canals passed through citrus areas where excess irrigation water or rain could drain into the canals, the fungi were readily isolated from the water thus contaminated. Soil samples collected and cultured from four separate paths of runoff water which drained into irrigation canals also yielded the fungi. All the soil samples yielded *P. citrophthora,* indicating that runoff water can introduce *Phytophthora* zoospores from infested citrus groves into canals.

In six of the 12 canals tested, copper sulfate was used for control of moss and algae. One canal received paint thinner—a petroleum distillate. Commercial aquatic weed killer was added to one, and another was given aquatic weed killer plus copper sulfate. Two received no treatment. Most of the chemical treatments were applied during the warm summer months when ecological factors are conducive to the growth of algae and moss. The frequency and amount of application were governed by the quantity of aquatic weeds developing in the canals. No correlation between presence or absence of *Phytophthora* spp. and the time or kind of chemical application was found.

Only one of three reservoirs tested during the year was infested with *P. parasitica.* However, following monthly applications of copper sulfate to the infested water, repeated testing failed to recover any *Phytophthora* spp. Apparently copper sulfate is effective against *Phytophthora* fungi under the static condition of the water in a reservoir. Preliminary experiments have indicated that chlorination may be an effective means for disinfesting water of *Phytophthora* spp. Two parts per million of chlorine maintained in water for two minutes kill the infective zoospores.

The 12 canals tested are capable of infesting with pathogenic species of *Phy-*

Concluded on page 16

NEW PUBLICATIONS

–now ready for distribution–

Single copies of these publications—except Manuals and books—or a catalog of Agricultural Publications may be obtained without charge from the local office of the Farm Advisor or by addressing a request to: Agricultural Publications, 207 University Hall, University of California, Berkeley 4, California. Make checks payable to The Regents of the University of California.

MICRONUTRIENT DEFICIENCIES OF CITRUS, by Robert G. Platt, Leaf. 115.

CALIFORNIA MARKETING ORDERS, by Sidney Hoos and Kenneth R. Farrell, Leaf. 117.

A PLASTIC-ROOF SHEEP SHELTER, by Thayer Cleaver, Donald Torell, and Ralph Parks, Leaf. 118.

SUPPORTS FOR GRAPEVINES, by A. J. Winkler and A. N. Kasimatis, Leaf. 119.

Penalty for private use to avoid payment of postage, $300

University of California College of Agriculture, Agricultural Experiment Station, Berkeley 4, California

Paul J. Sharp
Director

Free—Annual Report or Bulletin or Report of Progress
Permit No. 1127

IRRIGATION WATER

Continued from page 3

tophthora all the 40,000 acres of orchards using those sources of water, and any new citrus plantings will become infested with *Phytophthora* spp. when irrigated with water from those canals. Moreover, *Phytophthora*-free irrigation water can become infested when runoff water from infested citrus groves is permitted to drain into a canal, and irrigation with *Phytophthora*-infested water rapidly distributes the fungi in a grove.

L. J. Klotz is Plant Pathologist, University of California, Riverside.

Po-Ping Wong is Junior Specialist in Plant Pathology, University of California, Riverside.

T. A. DeWolfe is Associate Specialist in Plant Pathology, University of California, Riverside.

DONATIONS FOR AGRICULTURAL RESEARCH

Contributions to the University of California, Division of Agricultural Sciences

BERKELEY

California Spray Chemical Corp. ..... 2 gals. Systox
For melon insect investigations

Chemagro Corporation
For walnut insect investigations ..... 5 gals. ethyl Guthion SC
5 gals. Guthion emulsion
For experimental work on pests of ornamentals .. 10 lbs. Dylox 80% SP

Cottage Gardens Co., Inc. ..... 92 grafted rhododendron plants
For research in plant pathology

Food Machinery & Chemical Corp.
For melon insect investigations ..... 300 lbs. 2½% Tedion dust
5 gals. Ethion emulsion
For tomato insect investigations ..... 8 gals. Thiodan emulsion
For walnut insect investigations ..... 110 lbs. Tedion 25% WP

Furniture Manufacturers Association of California $500.00
For forest products research

Greenbelt Aviation
3 airplane applications of insecticides to 15 acres of experimental plots
For tomato insect investigations

Hercules Powder Company ..... 1,000 lbs. 10% Toxaphene dust
For tomato insect investigations

Rohm & Haas Co. ..... 4 gals. Kelthane emulsion
12 gals. Kelthane EC
For walnut insect investigations

Shell Chemical Corp. ..... 8 gals. Endrin emulsion
For tomato insect investigations

Stauffer Chemical Co. ..... 100 lbs. Thuricide WP
50 lbs. 25% methyl Trithion WP
10 gals. Trithion emulsion
For melon insect investigations

Union Carbide Chemicals Company
For melon insect investigations ..... 450 lbs. 5% Sevin dust
For tomato insect investigations
1,000 lbs. 5% Sevin + 75% sulfur dust
For walnut insect investigations ..... 150 lbs. 50% Sevin WP

Vero Beach Laboratories, Inc. ..... 5 lbs. Bayer 30686 50% WP
For experimental work on pests of ornamentals

DAVIS

American Cyanamid Co.
For studies of infectious diseases of poultry $2,500.00
For studies of laryngotracheitis vaccine $1,000.00

American Scientific Laboratories, Inc. $1,500.00
For research on laryngotracheitis

Beet Sugar Development Foundation $2,500.00
For research on nematode-plant relationships on sugar beets

California Committee on the Relation of Electricity to Agriculture $6,750.00
For research on the use of electricity in agriculture

California Spray-Chemical Corp. $3,000.00
For research on fertility: moisture utilization relationships

California Strawberry Nurserymen's Assn. $1,450.00
For research on the plant parasitic nematodes affecting strawberry production

Foremost Dairies, Inc. $1,000.00
For work on tomato powders and concentrates

Frosted Fruit Products $750.00
For research on brown rot in peaches

Lodi Grape Growers Assoc. $500.00
For breeding studies of new seedless grape varieties

Malting Barley Improvement Association $5,000.00
For malting barley research

National Plant Food Institute $3,000.00
For studies on soil-moisture-fertility

National Science Foundation $2,500.00
For study of *Allium*

Sacramento Frosted Foods Co. $750.00
For research on brown rot in peaches

Southern Pacific Railroad ..... 1,003 used railroad ties
To repair fences, for research projects in veterinary medicine

Syntex Animal Products Company ..... Teco Tilting Squeeze
For studies on the influence of hormones on reproduction in beef heifers

U. S. Public Health Service
For research on bacteria in poultry products $5,278.00
For studies on the biosynthesis of aromatic compounds in higher plants $5,988.00
For study of the flight range of *Culex tarsalis* $10,803.00
For research on nucleic acid metabolism and protein synthesis $2,258.00
For research on the submicroscopic structure in gels of starch and casein $575.00

RIVERSIDE

California Fertilizer Association $1,500.00
For vegetable fertility studies in southern California

Chemagro Corporation ..... 10 lbs. Bayer 22555
For avocado root rot research

Fruit Growers Supply Company $490.00
For use of DK-2 spectrophotometer for one month

Shell Development Company ..... 1 gal. SD 4741
For avocado root rot research

Union Carbide Chemicals Company $500.00
For research on cotton insects in the Imperial Valley

Willits & Newcomb Nursery ..... 65 Rough Lemon seedlings
75 Cleopatra Mandarin
To investigate the cause of an unknown disease of citrus trees in the Coachella Valley

STATEWIDE

Stauffer Chemical Co. ..... 800 lbs. Eptam 5% granular
For experimental control of Medusa-head on rangeland