

## ANOTHER SPECIES OF PHYTOPHTHORA ON AVOCADO IN CALIFORNIA

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The avocado root rot fungus, *Phytophthora cinnamomi*, is the most common fungus attacking avocado trees in California, as well as in most other areas of avocado production. This fungus was first identified in California in 1942 (6) although the disease had been present for many years before that. *Phytophthora* root rot is the most serious disease of avocado in California and in other avocado-producing countries.

Other species of *Phytophthora* have been reported only occasionally on avocado, primarily as the cause of cankers on avocado trunks. Fawcett reported *P. citrophthora* on avocado trunks in California in 1916 (2). In 1934 Horne indicated that the fungus from avocado trunks was *P. cactorum* instead of *P. citrophthora* (5). G. A. Zentmyer isolated a fungus that appeared to be *P. cactorum* from avocado trunks in California (8, 13), and also has isolated *P. cinnamomi* from trunk cankers in California and in Latin America (9). Another species of *Phytophthora*, *P. palmivora*, has been reported as causing a seedling blight of avocados in nurseries in Florida (1) and in Honduras (9).

In the past few years we have found a different species of *Phytophthora* in cultures from avocado roots and trunks in southern California. This report concerns the identity of this new species of the fungus, and presents information regarding its significance in relation to avocado culture in California.

As a result of cooperative studies between our laboratory at Riverside and one of the authors of this article, Dr. C. J. Hickman, a *Phytophthora* specialist at the University of Western Ontario, London, Ontario, Canada, we have identified this new fungus on avocado as *Phytophthora citricola*. This species was originally described in 1927 on citrus in Formosa by Sawada (5), and has since that time been found on a number of other plants (7), including lilac, hops, rhododendron, and walnut. On these plants *P. citricola* causes a root rot and/or a crown canker.

### SOURCE OF ISOLATES

In 1967 some unusual cultures of *Phytophthora* were called to our attention by R. T. Matson, agricultural advisor in Vista. The same fungus was recovered from cankers on trunks of avocado trees in Vista, in cultures made by Matson and by us. Recently we have made additional isolations of this *Phytophthora* from avocado roots in two groves

in Fallbrook. In 1963, Mexican plant pathologist, Ing. L. Fucikovsky, provided a similar culture which he obtained from an avocado fruit in Villa Guerrero, Mexico, but which he tentatively identified as *P. cactorum* (3).

In addition, for comparison, we obtained cultures of *P. citricola* from culture collections in England and Holland, and from several pathologists who have studied the fungus on other hosts. The original type culture from Citrus was obtained from the Commonwealth Mycological Institute.

## THE FUNGUS

The new fungus from avocado and the known *Phytophthora citricola* cultures from other sources were grown in our laboratory on V8 and cornmeal agar, and comparisons were made of the mycelial growth, the production and morphology of spores, and of the growth at different temperatures. The avocado fungus was similar to *P. citricola* in all of these aspects.

Sporangia are produced by this new fungus only occasionally on solid media, commonly in sterile demineralized water or sterile pond water, and abundantly in non-sterile soil extract. The cultures from avocado produce many irregularly-shaped sporangia, often with more than one apex. The fungus is homothallic, producing the sexual stage (antheridia, oogonia, and oospores) readily on V8 agar. The temperature range of the avocado isolates is similar to that previously described for *P. citricola* (7), although in our tests *P. citricola* cultures from other plants grew faster at 30°C than did the avocado isolates.

## PATHOGENICITY STUDIES

Greenhouse experiments were conducted to determine the disease potential of *P. citricola* on avocado in comparison with *P. cinnamomi*. These involved inoculation of roots, stems, and fruit.

*Root Inoculations.* — Avocado seedlings growing in 3 gallon jars containing nutrient solution were inoculated, using the method described by Zentmyer and Mircetich (10, 11). Cultures of *P. citricola* and of *P. cinnamomi* were compared in these tests. In this severe test, *P. citricola* usually caused less than 10 per cent root rot, whereas *P. cinnamomi* rotted 95 to 100 per cent of the feeder roots within one week. The following table gives some of these results.

<i>Fungus Isolate</i>		<i>Ave. Per Cent of Feeder Roots Rotted</i>
<i>P. citricola</i> from avocado	P475 P602	2.6 10.5
<i>P. citricola</i> from citrus		7.0
<i>P. cinnamomi</i>		99.6

Some preliminary tests have also been made of the pathogenicity of *P. citricola* to avocado seedlings in soil in the greenhouse. These show the same relationship as those in nutrient solution, but the per cent of root rot caused by *P. citricola* was higher in this soil test than in nutrient solution.

*Stem Inoculations.* — Stems of Mexican (Topa Topa variety) avocado seedlings growing in the greenhouse were inoculated with cultures of *P. citricola*, and *P. cinnamomi*. Disks from cultures of the two fungi were placed in cuts on avocado stems, the cuts were wrapped with scotch tape and the cankers allowed to develop for two to three weeks in the greenhouse. Lesions developing on the stems were then measured. In general, the *P. citricola* isolates were more pathogenic to stems than they were to roots. In some tests lesions produced by one of the avocado isolates were significantly larger than those produced by *P. cinnamomi*. Also there were significant differences in the size of the stem cankers produced by the various isolates of *P. citricola*. Isolates from avocado produced significantly larger lesions than isolates from other plants.

*Fruit Inoculations.* — Fuerte avocado fruit were inoculated with several isolates of *P. citricola* and *P. cinnamomi*, both with and without wounding. The *P. citricola* isolates produced a rot on the avocado fruit similar to that produced by *P. cinnamomi*.

## FIELD OBSERVATIONS

We have isolated *Phytophthora citricola* from the roots of only a few avocado trees in southern California. Generally these trees do not show any disease symptoms; they look the same as completely healthy trees. In one case, a tree from which we isolated *P. citricola* did show symptoms of decline, with restricted growth of the top, thin foliage and some die-back but it is doubtful that this condition was caused by the presence of the fungus. The cankered trees in a grove in Vista were unthrifty; the cankers had invaded a considerable portion of the lower trunk but had not girdled the trees.

## DISTINGUISHING *P. CITRICOLA* FROM *P. CINNAMOMI*

It is important that avocado growers and individuals involved in testing for the presence of the avocado root rot fungus, *P. cinnamomi*, be aware of the occurrence of this new species of *Phytophthora* in California. *P. citricola* causes spots on avocado fruit similar to those produced by *P. cinnamomi* (12) so that it is impossible to distinguish between the two species by using avocado fruit traps alone. It is necessary to observe the mycelium and/or the spore stages of the fungus in agar culture.

In many cases when avocado roots are cultured on agar, the distinction between the two species can be made by a trained observer, but it may be necessary to subculture the fungus and induce the formation of sporangia and oospores. If only fruit traps are used, small pieces may be removed from the margin of the rotted spots and cultured on cornmeal agar for microscopic observation of the mycelium.

Several characters readily distinguish *P. cinnamomi* from *P. citricola* in agar culture. Hyphae (mycelial stage) of *P. cinnamomi* are coralloid and produce abundant spherical hyphal swellings, whereas the hyphae of *P. citricola* are smooth. Occasionally

sporangia are produced by *P. citricola* in agar cultures from avocado roots, in contrast to *P. cinnamomi* which does not normally produce sporangia in agar culture. Also, the sporangia of the two species differ considerably in appearance: *P. citricola* sporangia are very variable in shape and have broad, shallow apical thickenings; *P. cinnamomi* sporangia are ellipsoid or ovoid and are non-papillate. On agar such as V8 agar, another important distinction may be observed; *P. citricola* produces thick-walled oospores abundantly in single culture, while *P. cinnamomi* produces oospores only if paired with another culture of the opposite mating type or if grown under special conditions.

*P. citricola* and *P. cinnamomi* can also be distinguished by the appearance of the colony when grown on potato dextrose agar. *P. cinnamomi* typically has a rosette or camellioid type of growth, while *P. citricola* has more of a radiating type of growth (Figure 1). This difference is obvious only on potato dextrose agar; on other types of agar it is difficult to distinguish the two species.

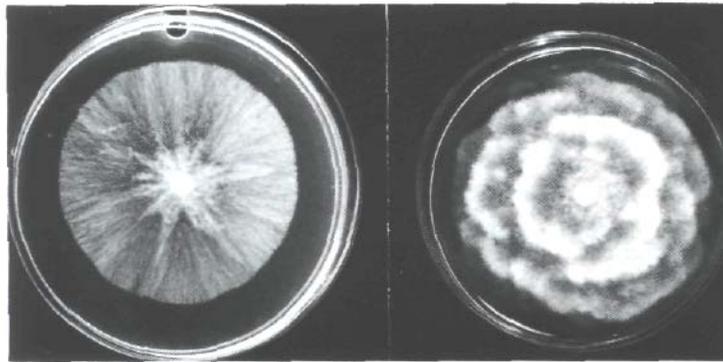


Figure 1. Cultures of *Phytophthora citricola* (left) and *P. cinnamomi* (right) growing on potato dextrose agar.

## SUMMARY AND CONCLUSIONS

This paper reports the occurrence of a new species of *Phytophthora*, *P. citricola*, on avocado trees in California; the fungus has been isolated from feeder roots and from cankers on trunks. Inoculation tests indicate that this fungus has very limited pathogenicity on avocado roots, is appreciably pathogenic to avocado stems or trunks, and can also invade avocado fruit and cause a fruit rot.

Inoculation data and field observations to date indicate that *P. citricola*, has limited potential as a pathogen of avocado roots. It could cause some damage on avocado trunks if inoculum were present and wounds occurred on the lower trunk. Based on current knowledge the distribution of the fungus appears to be quite limited in southern California.

This additional species of *Phytophthora* provides a complication in testing for the presence of the avocado root rot fungus if the avocado fruit trap test alone is used, as *P. citricola* forms spots on fruit similar to those produced by *P. cinnamomi*. *P. citricola* is sufficiently distinct from *P. cinnamomi* so that additional culture tests and microscopic

observations will enable the two species to be separated.

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