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Pathogenicity of Different California Isolates of *Phytophthora cinnamomi* to Avocado

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All evidence to date indicates that *Phytophthora cinnamomi,* the avocado root rot fungus, is not native to California (2), but the fungus is now widely distributed in many counties, especially in southern California. The fungus has been found on avocado in all counties with significant commercial avocado acreage, and also occurs on ornamental plants in these same areas. *Phytophthora cinnamomi* causes root rot and stem cankers in over 900 different species or varieties of plants (3), thus it is important to know whether isolates of the fungus from other plants can also cause root rot of avocado. There is no definite evidence yet of "strains" or "races" of the fungus, though there are some indications of differences in pathogenicity. This article compares the pathogenicity to avocado of different isolates of *P. cinnamomi* from avocado and from nursery stock in various parts of California.

Comparisons of Isolates from Avocado

Seedlings of the susceptible rootstock Topa Topa were inoculated in hydroponic culture with eleven isolates of *P. cinnamomi* from avocado groves in four counties: Los Angeles, San Diego, Santa Barbara, and Ventura. In this method, the seedlings are placed bare-root in half-strength Hoagland's nutrient solution, the solution is aerated, the pH is maintained at 6.5, and inoculum of the fungus is added from laboratory cultures. Under these conditions, root rot develops very rapidly in a susceptible variety such as Topa Topa; a high percentage of the roots are usually rotted in a two-week incubation period.

In this test all eleven isolates caused root rot, varying from 55 percent of the roots rotted (an isolate from San Diego county) to 92 percent of the roots rotted (a different isolate from San Diego county). Root rot caused by most of the isolates averaged from 70 to 90 percent in the 18-day infection period (Table 1).

In a different type of test of virulence of *P. cinnamomi* isolates, stems of Topa Topa seedlings growing in the greenhouse were inoculated with eight avocado isolates from San Diego, Santa Barbara, and Ventura counties. Seven of the isolates were also used in the hydroponic test; one new Santa Barbara county isolate was added. In this test, all of the isolates caused stem cankers on the Topa Topa seedlings (Table 1); the cankers ranged from 36 to 99 mm in length in a three-week period. However, the results in the canker test did not correlate with the results of the root inoculation test. For example, isolate 185 from San Diego county caused relatively small cankers (average length 49

mm), but caused severe root rot (average 87 percent). The results of the root inoculation tests would seem more likely to be correlated with possible root rot hazard for avocado trees in the field.

TABLE 1. Severity of root rot and canker on Topa-Topa seedlings inoculated with *Phytophthora cinnamomi* A^2 isolates from avocado, from various locations in California.

Isolate	Source (County)	Average % Root Rot	Average Canker Length (mm)
Pc 192	San Diego	92	—*
139	Los Angeles	91	—
154	Santa Barbara	89	—
185	San Diego	87	49
130	San Diego	87	99
94	Santa Barbara	86	98
215	San Diego	81	77
79	Ventura	77	36
40	Santa Barbara	74	60
138	Santa Barbara	68	77
128	San Diego	55	—
93	Santa Barbara	—	120

*= not tested

Comparison of Isolates from Ornamental Plants

In another test, with 6-month-old Topa-Topa seedlings, UC mix was artificially infested with blended mycelia of five *P. cinnamomi* isolates from ornamental plants. The isolates were from *Myrtus communis* (myrtle), Orange County; *Cupressus semperuirens* (Italian cypress), San Diego County; *Protea* sp., San Diego County; *Pinus radiata* (Monterey pine), Los Angeles County; and *Rhododendron* sp. (azalea), Riverside County.

All five isolates produced some disease symptoms on Topa Topa seedlings, with varying degrees of virulence. The isolates from Italian cypress, Monterey pine, and azalea produced severe root rot, as did an isolate from avocado, while isolates from myrtle and *Protea* caused relatively little damage. Table 2 gives the percentages of healthy roots, and also the weight of the roots of the seedlings. This provides indication of some possible differences between isolates; this should be examined in additional tests.

TABLE 2. Development of root rot on Topa-Topa avocado seedlings following inoculation with different isolates of *Phytophthora cinnamomi* from ornamental plants.

Source of Isolate	Percent Healthy Roots	Weight of Roots (grams)
Non-inoculated	96 a*	185 a*
Protea	90.8 a	133 b
Myrtle	91.3 a	117 b
Avocado	40.5 b	35 c
Cypress	21.0 c	31 c
Azalea	21.0 c	29 c
Pine	15.5 c	25 c

*Weights followed by the same letter are not significantly different from each other.

Also, six isolates from ornamental plants were used to inoculate stems of Topa Topa avocado seedlings in the greenhouse. These isolates were from Italian cypress in San Diego county, and from camellias in San Diego, Riverside, and Los Angeles counties; avocado isolates from Santa Barbara and San Diego counties were used for comparison. As shown in Table 3, all of the isolates produced cankers on the avocado seedlings, and there was no statistical difference in size of cankers produced by the various isolates.

TABLE 3. Size of cankers on Topa-Topa stems caused by *Phytophthora cinnamomi* isolates from California.

Isolate	Host	Source (County)	Average* canker area (cm^2)	Mating type
Pc 102	Italian cypress	San Diego	4.8	A 2
21	Camellia	Riverside	4.2	A 1
100	Camellia	Los Angeles	3.9	A 1
40	Avocado	Santa Barbara	3.2	A 2
97	Camellía	San Diego	3.2	A 1
67	Camellia	Riverside	2.8	A 1
68	Camellia	Riverside	2.0	A 1
56	Avocado	San Diego	1.7	A 2

*No statistically significant differences in canker sizes.

In another greenhouse experiment, avocado seedlings (Topa Topa cultivar) and camellia [*Camellia japonica*] cuttings were grown in soil from an avocado grove naturally infested with *P. cinnamomi* (A^2 mating type) and from a camellia nursery also infested with *P. cinnamomi* (A^1 mating type). Avocado seedlings and camellia cuttings were also grown in soil artificially infested with the avocado and camellia isolates of the fungus. In both experiments (natural and artificial infestation of soil) root rot was produced in the avocado seedlings by both the avocado and camellia isolates of *P. cinnamomi,* but camellias were only affected by the camellia strain of the fungus (4). Table 4 gives some of these results.

Conclusions

It is obvious from the results of these several experiments that isolates of *P. cinnamomi* from ornamental plants are also pathogenic to avocado and thus pose a definite threat to avocado groves. There have been a number of field observations of the development of *Phytophthora* root rot from diseased ornamental plants used in landscaping home sites. These greenhouse tests, using isolates from a number of different ornamental plants, clearly demonstrate the potential danger and confirm the circumstantial evidence observed in avocado groves.

TABLE 4. Effect of avocado and camellia isolates of *Phytophthora cinnamomi* on avocado and camellia. Plants grown in greenhouse, in steamed soil or in soil infested with the fungus.

Plants	Soil Infested With:	Percent Healthy Roots	
Camellia	Sterile control	96	x*
Camellia	Avocado isolate (A^2 mating type)	92	x
Camellia	Camellia isolate (A^1 mating type)	47	y
Avocado	Sterile control	95	a
Avocado	Avocado isolate (A^2 mating type)	3	c
Avocado	Camellia isolate (A^1 mating type)	39	b

Plants were grown in greenhouse for 7 months.

*Numbers followed by different letters are significantly different at the 1% level; camellia and avocado results analyzed separately.

There appear to be some differences in degree of pathogenicity to avocado of some of the isolates from different plants, but all of them caused some disease. This points up the necessity of using great care in selecting ornamental plants for landscaping in an avocado grove, to avoid bringing in *P. cinnamomi* by that means. Unfortunately, the host list for *P. cinnamomi* is extensive (3), including many desirable ornamental plants commonly cultivated in California (1). These known host plants should not be planted adjacent to avocado trees, and any landscape plants should be obtained from nurseries that follow good sanitation practices. Planting clean nursery stock (both avocado and ornamentals) is one of the main practices to help avoid problems with avocado root rot.

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