

Evidence for Strains of *Phytophthora cinnamomi*

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ABSTRACT

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An A¹ mating type isolate of *Phytophthora cinnamomi* from camellia (*Camellia japonica*) in California was pathogenic to avocado (*Persea americana*) and to camellia when plants were grown in naturally or artificially infested soil. The A² isolate from avocado in California was pathogenic to avocado but not to camellia. This provides additional evidence for the presence of strains or biotypes of varying pathogenicity among isolates of *P. cinnamomi*.

Phytophthora cinnamomi Rands is a widespread and destructive pathogen, primarily causing root rots on more than 900 woody plant species (12). Most isolates are of the A² mating type; the A¹ type has a very limited distribution in terms of geography and hosts (11). In our collection of 376 *P. cinnamomi* isolates, 346 are type A² and 30 are type A¹.

There is little detailed information on strains or biotypes of the pathogen, but in 1922, Rands (8) noted two "strains" of *P. cinnamomi*, one more virulent on cinnamon than the other. Crandall et al (2) concluded that there were probably a number of slightly different "physiological strains" of *P. cinnamomi*, and Torgeson (9) identified four "physiological races" based on differential pathogenicity to different species. Manning and Crossan (4) reported evidence of biotypes based on differential pathogenicity on similar and different host plants; differences in disease ratings, however, were generally small. Others have reported differences in the pathogenicity of *P. cinnamomi* isolates to various hosts, including pineapple (3,5), blueberry (6), Monterey pine (7), and Nothofagus (10).

We recently examined the pathogenic capabilities of *P. cinnamomi* isolates from camellia (*Camellia japonica* L.) and avocado (*Persea americana* Mill.) in cross inoculations of these two hosts. The common mating type from camellia is A¹, and the A² type is predominant in avocado. This paper reports the results of this comparison of virulence of isolates from the two host species.

MATERIALS AND METHODS

Avocado seedlings (cultivar Topa Topa) and camellia cuttings (cultivar Debutante) were grown in small peat pots, then transplanted either into pots of

sterile U.C. mix (1) or into soil naturally infested with either the camellia or the avocado isolate of *P. cinnamomi*, and maintained in a greenhouse with air temperatures of 20-28 C.

Natural infestation. Soil was collected from the root zone of an avocado tree affected with root rot in southern California and from diseased camellia

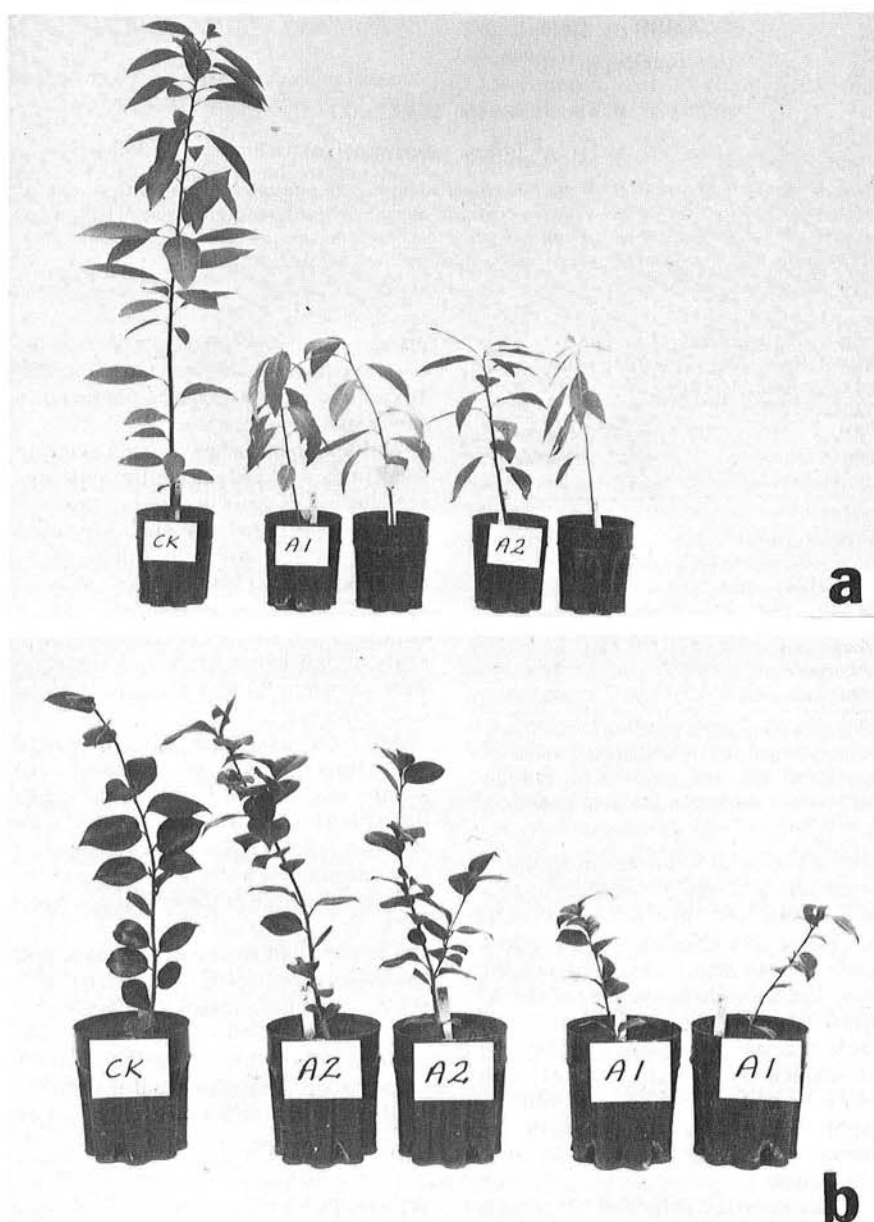


Fig. 1. Response of avocado seedlings (a) and camellia cuttings (b) when grown in uninfested soil and in soil naturally infested with the A¹ isolate of *Phytophthora cinnamomi* from camellia or with the A² isolate from avocado.

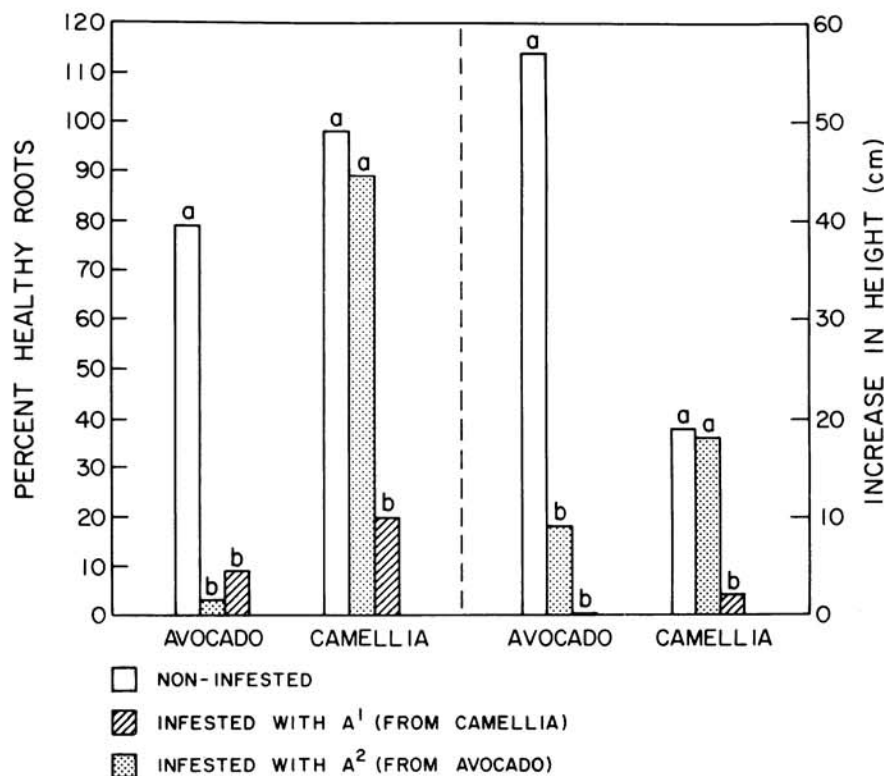


Fig. 2. Response of avocado seedlings and camellia cuttings to infestation of soil with A¹ and A² mating types of *Phytophthora cinnamomi*, in terms of percent healthy roots (left side of figure) and increase in height (right side of figure). Letters above bars indicate statistical significance of data; bars with the same letters are not statistically different at $P=0.01$.

Table 1. Pathogenicity of A¹ and A² mating types of *Phytophthora cinnamomi* to avocado and to camellia in artificially infested soil^a

Plant	Soil infested with	Percent healthy roots
Avocado	Sterile control	95 a
	Avocado isolate (A ²)	3 c
	Camellia isolate (A ¹)	39 b
Camellia	Sterile control	96 x
	Avocado isolate (A ²)	92 x
	Camellia isolate (A ¹)	47 y

^aPlants grown in infested soil for 7 months.

^bNumbers followed by different letters are significantly different at $P=0.01$; camellia and avocado results were analyzed separately.

plants growing in a nursery in southern California. Soil was screened through a 7-mm mesh screen. In each case, isolations were made from the diseased plants and *P. cinnamomi* was recovered from the roots. The avocado isolate was of the A² mating type and the camellia isolate of the A¹ mating type. Mating types were determined by pairing isolates with known A¹ and A² mating type cultures, established by comparison with the original A¹ and A² mating type cultures of *P. infestans*.

Ten avocado seedlings and 10 camellia cuttings were planted singly into 3.78-L cans containing infested soil from the avocado grove. Similarly, 10 avocado seedlings and 10 camellia cuttings were

planted singly into infested soil from the camellia nursery. Ten avocado plants and 10 camellia plants were also planted into cans containing sterilized soil.

Artificial infestation. Twenty avocado seedlings and 20 camellia cuttings growing in U.C. mix in 3.78-L containers were used for the artificial infestation experiment. An avocado isolate of *P. cinnamomi* (Pc40 from avocado roots in Santa Barbara County, California) and a camellia isolate (Pc97 from camellia roots in San Diego County, California) were grown in 90-mm plates containing clear V-8 agar.

After the agar had become covered with fungal growth, one plate of each isolate was blended in 200 ml of sterile demineralized water for 15 sec. Ten milliliters of this suspension was pipetted into each of two holes 10 cm deep in the soil on either side of the seedling midway to the edge of the container.

Ten plants of each type (avocado and camellia) were grown in soil infested with the avocado isolate and 10 of each were grown in soil infested with the camellia isolate. Ten plants of each type were grown in steam sterilized soil as controls. Soil moisture was maintained at an adequate level for plant growth.

RESULTS

Natural infestation. All of the avocado seedlings in soil infested with either isolate developed severe root rot and corresponding top symptoms and had

made very little growth after 9 mo (Fig. 1a). The camellias, however, developed root rot and grew poorly only in soil infested with the A¹ mating type from camellia (Fig. 1b). Camellias grew as well and had as high a percentage of healthy roots in soil infested with the A² mating type as they did in steamed soil.

Artificial infestation. Results were similar in the soils artificially infested with isolates of the two mating types of the pathogen (Fig. 2, Table 1). Avocado seedlings were severely affected by both mating types of *P. cinnamomi*, but camellias were susceptible only to the A¹ type.

In each case, the original pathogen used in the inoculations or present in the naturally infested soil was isolated from the plants that became diseased in that soil. No disease symptoms appeared on control plants.

In another small-scale test in the greenhouse, similar results were obtained with camellia. Five plants of the Covina cultivar were planted in soil taken from an area where avocado trees were severely affected with *Phytophthora* root rot. These plants were grown for 2 yr in this soil without developing symptoms of root rot; the camellia roots were healthy when the experiment was terminated, and *P. cinnamomi* was not recovered from them.

DISCUSSION

These data confirm the presence of strains or races of *P. cinnamomi* in relation to pathogenicity. The avocado isolate used affected avocado but did not affect camellia. The camellia isolate was pathogenic to both camellia and avocado.

These results indicate clearly the danger of bringing the camellia isolate into an avocado grove from ornamental landscape plantings. The camellia isolate could spread to the avocado trees and cause substantial damage. Such occurrences of the A¹ mating type on avocado, however, are extremely uncommon. Only one of hundreds of isolates from avocado groves in southern California has been of the A¹ mating type. Other ornamental plants in southern California nurseries, however, have been affected with the A² mating type of *P. cinnamomi*. The A² type may in some cases have been introduced into the avocado grove by such infected ornamental plants.

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