Protection of *Persea* species Against *Phytophthora cinnamomi* and *P. citricola* by Prior Inoculation with a Citrus Isolate of *P. parasitica*

T. E. Dolan, Y. Cohen, and M. D. Coffey

Postdoctoral fellow, visiting professor, and professor, respectively, Department of Plant Pathology, University of California, Riverside 92521.

We gratefully acknowledge the financial assistance of the California Avocado Commission. We thank Fred Guillemet for assistance with plant propagation, Greg Greer for technical assistance, and BettyAnn Merrill for typing the manuscript.

Accepted for publication 10 September 1985.

ABSTRACT

Dolan, T. E., Cohen, Y., and Coffey, M. D. 1986. Protection of *Persea* species against *Phytophthora cinnamomi* and *P. citricola* by prior inoculation with a citrus isolate of *P. parasitica*. Phytopathology 76:194-198.

Stems of seedlings of *Persea indica* were inoculated with zoospores of *Phytophthora parasitica*, a pathogen of citrus but not of *Persea*, and challenged 0, 2, and 48 hr later with zoospores of the pathogenic species, *P. citricola* or *P. cinnamomi*. Severe lesions developed due to challenge by either pathogen within 3 days on stems receiving simultaneous inoculations of nonpathogen and challenge zoospores. However, lesion development was significantly reduced at a site of nonpathogen inoculation if stems were challenge-inoculated with *P. citricola* or *P. cinnamomi* following a delay of 2 or 48 hr. Seedlings of *P. indica* previously root-inoculated with the nonpathogenic *P. parasitica* were systemically protected from the development of stem lesions when stem-challenged 4 days later with zoospores of either *P. citricola* or *P. cinnamomi*. Plants of *P. indica* and *P. americana* grown in soil infested with *P. parasitica* were protected against root rot caused by either *P. cinnamomi* or *P. citricola* when transplanted after 6 wk into infested soil. Recovery of *P. cinnamomi* and *P. citricola* from feeder roots of protected plants was reduced by 60–85% relative to unprotected plants. The nonpathogen *P. parasitica* was recovered from less than 5% of the feeder roots of protected plants. Evidence suggests that this induced protection may be operating systemically.

Root rot of *Persea americana* Mill., caused by *Phytophthora cinnamomi* Rands, is responsible for crop losses amounting to in excess of one million dollars in the avocado production areas of southern California (14,19). Our research program is principally concerned with the development of an integrated approach to disease control involving nursery practice, cultural practice, chemical control, biological control, and tolerant rootstocks. Recently our attention was drawn to a novel cultural practice involving the interplanting of citrus trees, usually limes, in orchards heavily infested with *P. cinnamomi*. Planting limes next to root rot-infested avocado trees apparently improved the appearance and production of these trees. No data exists to support the implementation of this strategy for root rot control. However, the faith placed in this practice by local growers compelled us to examine this "citrus barrier" phenomenon further.

It was observed (M. D. Coffey, *unpublished*) that, in laboratory experiments, zoospores of *Phytophthora parasitica* Dastur, the citrus root rot fungus, are capable of initiating infections on, but causing little apparent damage to, the roots of *Persea indica* L., the small-fruited avocado relative commonly used to trap *P. cinnamomi* from field soils. It is probable that citrus interplanting would favor the introduction of *P. parasitica* into avocado orchard

The publication costs of this article were defrayed in part by page charge payment. This article must therefore be hereby marked "*advertisement*" in accordance with 18 U.S.C. § 1734 solely to indicate this fact.

soils and this fungus might play a role in the induction of resistance in avocado.

Examples of both local and systemic protection of plants against foliar disease induced by either pathogens or nonpathogens are well documented in the literature (16). However, less evidence exists for protection against soilborne fungal pathogens (2,6,10,13,15). In the present study, we wanted to determine if cultivar Topa Topa of *P. americana* or *P. indica* could be protected from root rots incited by *Phytophthora citricola* Sawada (20) or *P. cinnamomi* by prior inoculation with *P. parasitica*. Protection of *P. indica* was examined in the laboratory by inoculating bare-rooted seedlings. Protection of *P. indica* and *P. americana* was investigated in greenhouse experiments by using soil amended with *P. parasitica* followed by challenge with a pathogen-infested soil. Root-plating techniques were employed to quantitate the level of both pathogen and nonpathogen in protected and unprotected plants. Preliminary reports on protection of *Persea* spp. from root rot have been published already (4,7).

MATERIALS AND METHODS

Inoculum of *Phytophthora* spp. All *Phytophthora* spp. used were from the collection of *Phytophthora* at the University of California, Riverside. Three avocado isolates of *P. citricola* (P1273, P1287, and P1346) and one avocado isolate of *P. cinnamomi* (Pc444) were used for challenge inoculation. The inducer fungus used was *P. parasitica* (P1155) isolated as M134 from citrus in Brazil by J. A. Menge. Fungi were grown on cleared V8C (V8C, 10% V-8 juice, 1% $CaCO_3$, clarified by centrifugation) in 9-cm-diameter petri dishes at 24 C.

Zoospores were obtained by incubating 5-mm-diameter inoculum disks for 24 hr at 24 C in 20% V8C broth, washing them three times with distilled water, and incubating them in filtered 1% (w/v) nonsterile soil extract (SE) for 2 days. This procedure was used for all isolates except *P. cinnamomi* which required 6 days of incubation in SE for zoosporangium development. Chilling sporangia for 20 min at 4 C initiated zoospore release.

Sterile UC-mix (50% blow sand, 50% peat moss, plus 2.2 kg dolomite, 1.5 kg superphosphate, 148 g KNO_3, 148 g K_2SO_4 per cubic meter [1]) was amended with fungus-infested millet for greenhouse experiments. Coarsely ground millet seed (100 g in 250-ml flasks) was autoclaved for 20 min at 1 atmosphere (15.7 psi) gauge pressure, inoculated with 25 ml minced mycelium of the appropriate fungus, and incubated for 8–10 days at 24 C. Minced mycelium was prepared by blending one 5-day-old culture on V8C with 100 ml of sterile distilled water. After incubation, infested millet was mixed 1:300 (v/v) with UC-mix and colony-forming units (cfu's) were determined by dilution plating according to the method of Kellam and Coffey (12). The mix was diluted with sterile UC-mix to achieve the cfu's used for greenhouse experiments.

Plant materials. The plants of *P. indica* were grown from seed in flats containing sand in the greenhouse at about 24 C. Plants were used for experimentation 45 days after sowing, or when the stems had reached approximately 11 cm in length. Plants of cultivar Topa Topa of *P. americana* were grown from seed for 8 wk under greenhouse conditions. Individual seeds were sown in 0.5-L plastic sleeves filled with UC-mix.

Protection of *P. indica*. For local protection, bare-rooted plants were placed in 15 × 33 × 2-cm aluminum baking pans. The root systems were covered with facial tissue and saturated with distilled water. Plants were divided into three treatment groups. Some plants received a 10-µl drop of inoculum, containing ~100 zoospores of *P. parasitica* which was applied to the stem 5 cm above the cotyledons. These plants will be referred to as induced. An equal number of control plants received droplets of distilled water. At the start of the experiment, one group of induced plants was challenged simultaneously at the site of inoculation with a 10-µl drop of inoculum containing ~100 zoospores of a pathogen. The pathogen isolates used in these experiments were either *P. citricola* (P1273, P1287) or *P. cinnamomi* (Pc444). At 2 hr and 48 hr after inoculating with *P. parasitica*, the remaining control and induced plants were each challenged with pathogen zoospores.

The trays were sealed in plastic bags and maintained at ~24 C on a benchtop in the laboratory. The plants were assessed 72 hr after challenge by measuring stem lesion length. The data represent the mean of 15 plants per treatment from two experiments.

Twenty-five plants of *P. indica* were placed in 4 × 20-cm tubes filled with UC-mix infested at a rate of ~200 cfu's of *P. parasitica* and grown in the greenhouse for a 2-wk induction period. Root systems of five plants were cut into 1-cm pieces, starting at the root tips, after induction. These pieces were surface-sterilized by a 5-sec dip in 70% ethanol (EtOH), washed in distilled water, blotted dry with paper towels, and plated on PARP medium (11), modified by the substitution of 125 g of ampicillin trihydrate for 250 g of sodium ampicillin per milliliter. The degree of infection by *P. parasitica* was expressed as percent root pieces yielding colonies. The remaining induced plants were challenged by transferring the entire root mass into 6.25 × 25-cm tubes and surrounding the roots with UC-mix infested with either *P. citricola* P1346 at 200 cfu's or *P. cinnamomi* at 20 cfu's. Control plants were grown in UC-mix lacking the inducer fungus and were challenged as described above. Four weeks after challenge, plants were scored for percent wilting or death. The data represent the mean of 10 plants per treatment from two separate experiments.

The degree of systemic protection was examined by placing the root system of plants of *P. indica* in styrofoam cups containing zoospore suspensions of either *P. parasitica, P. citricola* (P1273, P1287), or *P. cinnamomi* at a concentration of ~100 zoospores per milliliter of distilled water. The plants remained in the suspension for 24 hr after which they were rinsed well in demineralized water and incubated in fresh distilled water at room temperature for 4 days. After incubation, the plants were placed in aluminum baking trays and stem-challenged with a 10-µl drop of inoculum containing zoospores of either *P. citricola* (P1273, P1287) or *P. cinnamomi* as described previously. Plants were incubated under laboratory conditions and lesion lengths were measured 72 hr after challenge. The data represent the mean of 10 plants per treatment from three separate experiments.

Protection of *P. americana*. In experiments with cultivar Topa Topa of *P. americana*, 2-mo-old plants were potted with their root balls in 1-L pots containing UC-mix infested with inducer inoculum containing 500 cfu's of *P. parasitica* and plants were grown in the greenhouse for 6 wk. A parallel series of plants was grown in UC-mix amended at similar rates with inducer-free millet. Control plants were potted in UC-mix free of inducer or millet. After 6 wk, the plants were transplanted with root balls into 1.5-L pots of UC-mix infested with either ~50 cfu's of *P. citricola* (P1273) or with 200 cfu's of *P. citricola* (P1346). Different rates of infestation were used because of differences in isolate pathogenicity (5). Before roots were challenged, samples of twenty 1-cm root segments from five induced plants were plated, as described for *P. indica*, to determine the degree of infection by *P. parasitica* prior to challenge.

Plant growth was determined by measuring shoot height at 4 and 8 wk after challenge. The experiment was terminated 8 wk after challenge. Plants were removed from the pots and the bottom 1-cm layer of the root system, representing new root growth, was cut off. Soil was washed from the remaining root system and fresh and dry weights of shoot and root were determined. The excised root mat was cut into approximately 1-cm segments. Forty segments were selected at random, surface-sterilized for 5 sec in 70% EtOH, rinsed in distilled water, blotted dry, and plated on PARP medium for fungal recovery. After 2 days, the number of colonies were counted and each colony was subcultured on PARP amended with 1 g a.i. of metalaxyl per milliliter. This fungicide completely inhibits the growth of *P. parasitica*, but not *P. citricola* (3). Thus, colonies that grow on the subculture plates can be identified as *P. citricola*.

Plants of cultivar Topa Topa were challenged with *P. cinnamomi* by overlaying the soil surface of 1.5-L pots to a depth of 1 cm with 100 g of UC-mix infested with ~200 cfu's of *P. cinnamomi*. Eight weeks after challenge, the plants were removed from pots and root pieces were plated as described for plants challenged with *P. citricola*. Colonies were subcultured on PARP medium. Isolates of

P. parasitica were distinguished from *P. cinnamomi* on the basis of colony morphology. Colonies of *P. parasitica* were more compact and grew at a slower rate on PARP medium.

Protection experiments with *P. americana* were repeated three times with 20 plants per treatment. In each case, the data presented is for a representative experiment.

RESULTS

Local protection of *P. indica*. As early as 2 hr after inoculation with *P. parasitica*, stems challenged with zoospores of *P. citricola* or *P. cinnamomi* were partially protected compared to noninduced controls (Table 1). Lesion development was completely inhibited if challenge by *P. citricola* (P1273) at the site of inducer inoculation was delayed by 48 hr. A 48-hr delay between inoculation with *P. parasitica* and challenge with *P. cinnamomi* resulted in significantly better protection than that observed for challenge at 2 hr after inoculation with *P. parasitica*. Stems challenged with *P. citricola* (P1287) were equally protected at 2 and 48 hr postinduction. No protection was observed against any challenge isolate applied to stems simultaneously with zoospores of *P. parasitica*. Heat-killed zoospores or boiled homogenates of *P. parasitica* were not able to induce protection (4,7). Zoospores of *P. parasitica* produced minute lesions on the stems of some plants of *P. indica*. These were restricted to the inoculation site and were evident within 48 hr after induction.

Systemic protection of *P. indica*. Mean lesion length on stems was significantly shorter on plants whose roots were exposed to zoospores of *P. parasitica* for 24 hr before challenge (Table 2). For two isolates of *P. citricola*, average canker length was reduced by 48 and 53%, respectively, and by 23% for an isolate of *P. cinnamomi*, relative to water-treated controls. In contrast to *P. citricola* (P1273), which induced no protection, exposure of the root system to zoospores of isolate P1287 reduced mean lesion length by 20%. Similar results were obtained when mycelial homogenates of *P. parasitica* were used to treat the roots (4,7).

The root systems of plants protected by *P. parasitica* showed no evidence of necrosis. However, *P. parasitica* was recovered from 40–80% of 1-cm root pieces plated on PARP selective medium.

Greenhouse protection of *P. indica*. Plants of *P. indica* exposed to millet-infested UC-mix for 2 wk prior to challenge with *P. citricola* (P1346), or *P. cinnamomi*, showed less mortality and wilting after 4 wk than noninduced, challenged controls (Table 3). However, the protection induced against *P. cinnamomi* did not persist indefinitely. By 8 wk after challenge all protected plants showed severe wilting or death. Protection against *P. citricola* was much stronger; the percentage of diseased plants did not increase over the 8-wk period of the experiment.

Up to 80% of the root pieces from protected unchallenged plants yielded colonies of *P. parasitica* when plated on PARP selective medium. These plants were severely stunted compared to unprotected, unchallenged plants.

Protecting *P. americana* cultivar Topa Topa. Two isolates of *P. citricola* reduced plant shoot height (Fig. 1A), shoot dry weight, and root dry weight (Fig. 1B) of unprotected plants. Unchallenged plants grown in the presence of *P. parasitica* showed significant increases in shoot development, on both a height and dry weight basis, compared with unprotected plants. Protected challenged plants and protected unchallenged plants grew equally well.

All plants exposed to the inducer, *P. parasitica*, were protected from challenge by the pathogens. *P. citricola* (P1273 and P1346) was recovered from 17 and 80%, respectively, of feeder roots of unprotected plants (Fig. 1C). By comparison, recovery of *P. citricola* (P1273 and P1346) from plants protected by *P. parasitica* was reduced to 2.5 and 32.5%, respectively. *P. cinnamomi* was recovered from 61.5% of the feeder roots of unprotected plants, but from only 23% of roots from plants protected by prior exposure to *P. parasitica* (Fig. 2).

P. parasitica was recovered from 2.5 to 8.5% of roots from protected unchallenged plants and from 3.5 to 5.5% of roots from protected challenged plants.

TABLE 1. Local protection of *Persea indica* induced by inoculating stems with *Phytophthora parasitica* (M134) and challenging at the same site with *P. citricola* (P1273, P1287) or *P. cinnamomi* (Pc444)

Treatment (inducer/challenge)	Lesion length (cm)		
	0 hr[y]	2 hr	48 hr
Control/P1287	4.1 a[z]	4.3 a	4.2 a
M134/P1287	3.7 a	1.6 b	1.8 b
Control/P1273	...	...	5.8 c
M134/P1273	...	...	0 d
Control/Pc444	3.8 a	3.9 a	2.7 e
M134/Pc444	3.6 a	1.2 b	0.6 f

[y]Challenge inoculum was applied simultaneously with inducer inoculum (0 hr), or after a lag period of 2 or 48 hr.
[z]Means with the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test.

TABLE 2. Systemic protection of *Persea indica* induced by exposing the root system to zoospores of the inducer, *Phytophthora parasitica* (M134), or zoospores of the pathogens *P. citricola* (P1273 and P1287) or *P. cinnamomi* (Pc444), followed by challenge with pathogen zoospores on the stem after 4 days

Treatment (inducer/challenge)	Lesion length (cm)	Protection (%)
Control/P1273	6.0 a[y]	0
P1273/P1273	6.0 a	0
M134/P1273	3.1 b	48
Control/P1287	5.6 a	0
P1287/P1287	4.5 b	20
M134/P1287	2.6 c	53
Control/Pc444	4.0 a	0
Pc444/Pc444	D[z]	...
M134/Pc444	3.1 a	23

[y]Means with the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test.
[z]Plants developed severe root necrosis and died before challenge.

DISCUSSION

Strong local protection was demonstrated for *P. indica* against *P. citricola* and *P. cinnamomi* following inoculation with the nonpathogenic citrus isolate of *P. parasitica*. Protection of *P. indica* was observed as early as 2 hr after inoculation with inducer isolate, a much shorter induction period than observed in some other protection systems (8,16). The brief induction period required suggests that protection is achieved either by very rapid metabolic changes in the host, or by occupation of potential infection sites by the inducer zoospores. However, simultaneous inoculations with equal numbers of challenge and inducer zoospores did not affect local protection and suggests that site competition is an unlikely explanation for the protection

TABLE 3. Protection of seedlings of *Persea indica* planted in soil infested with *Phytophthora parasitica* (M134) and challenged 2 wk later with infested soil containing *P. citricola* (P1346) or *P. cinnamomi* (Pc444)[y]

Treatment (inducer/challenge)	Wilting[z] (%)	Dead (%)	Total diseased (%)
Control/P1346	10 a	40 a	50 a
M134/P1346	22 b	5 b	27 b
Control/Pc444	33 c	50 c	83 c
M134/Pc444	16 d	18 d	34 d

[y]Plants were assessed 4 wk after challenge for symptom development.
[z]Values with the same letter are not significantly different ($P = 0.05$) according to Duncan's multiple range test.

phenomenon. Phytoalexin accumulation has been proposed by Elliston et al (9) as a mechanism for restricting the development of virulent races of *Colletotrichum lindemuthianum* in locally protected hypocotyls of susceptible bean cultivars. However, no evidence exists for the presence of phytoalexins in *Persea* spp. (18) and to date we have been unable to isolate antifungal compounds from locally protected stems of *P. indica*.

Local protection in *P. indica* appears to depend on host tissue invasion, since protection was not observed in the presence of heat-killed inducer zoospores or hyphae (4,7). Minute lesions, confined to the point of induction by zoospores of *P. parasitica*, were occasionally seen on stem-inoculated plants of *P. indica*, but these lesions were not a necessary prerequisite for local protection. Colonies of *P. parasitica* could not be recovered from these lesions, which suggested that host reponse, once elicited, does not depend on an active inducer. It also indicates that a hypersensitive reaction may have occurred. Cytological data on the extent of host tissue invasion by the nonpathogen and subsequent interactions with the challenge pathogens are needed to fully assess the mechanism of local protection.

P. indica is very susceptible to root rots caused by *P. cinnamomi* and *P. citricola* (5,19). In both laboratory and greenhouse experiments, *P. parasitica* was also recovered from a high percentage of root segments plated on selective media, even though visual assessment of root rot symptoms always proved negative. Plants were stunted if grown in soil amended with *P. parasitica* at rates necessary to affect protection. Perhaps this fungus should be considered a weak pathogen of roots of *P. indica*.

In contrast to results with *P. indica*, a significant growth stimulation was observed in plants of *P. americana* grown in the presence of *P. parasitica*. The nature of this stimulation is still enigmatic. Growth of control plants potted in soil amended with sterile millet was not enhanced, indicating that the millet carrier was not responsible for the stimulation of plant growth. Release of plant growth-stimulating nutrients from the decomposing millet seeds inoculated with *P. parasitica* is a possibility. Alternatively, *P. parasitica* infection of *P. americana* may be directly responsible for this growth response. Tuzun and Kuć (17) also observed stimulation of growth in tobacco plants systemically protected against downy mildew after receiving inducer inoculations of the pathogen, *Peronospora hyoscyami*, in stem tissue.

The strongest protection obtained in this study was that for seedlings of *P. americana* cultivar Topa Topa against *P. citricola* by a previous inoculation with *P. parasitica*. This protection was expressed in healthy new root growth in pathogen-infested soil. Topa Topa was also protected against *P. cinnamomi*, but only under less severe challenge conditions. If the root ball was surrounded with soil artificially infested at approximate field levels, then protection was overcome. However, a high degree of protection was observed when the soil surface was overlaid with soil infested at a level 10 times that found in the field. It is likely that the overlay challenge method delayed infection of the plants and delivered lower inoculum levels to the root system.

One explanation for the protection could be that *P. citricola* or *P. cinnamomi* fail to compete for root infection sites already occupied by *P. parasitica*. With cultivar Topa Topa, *P. parasitica* is

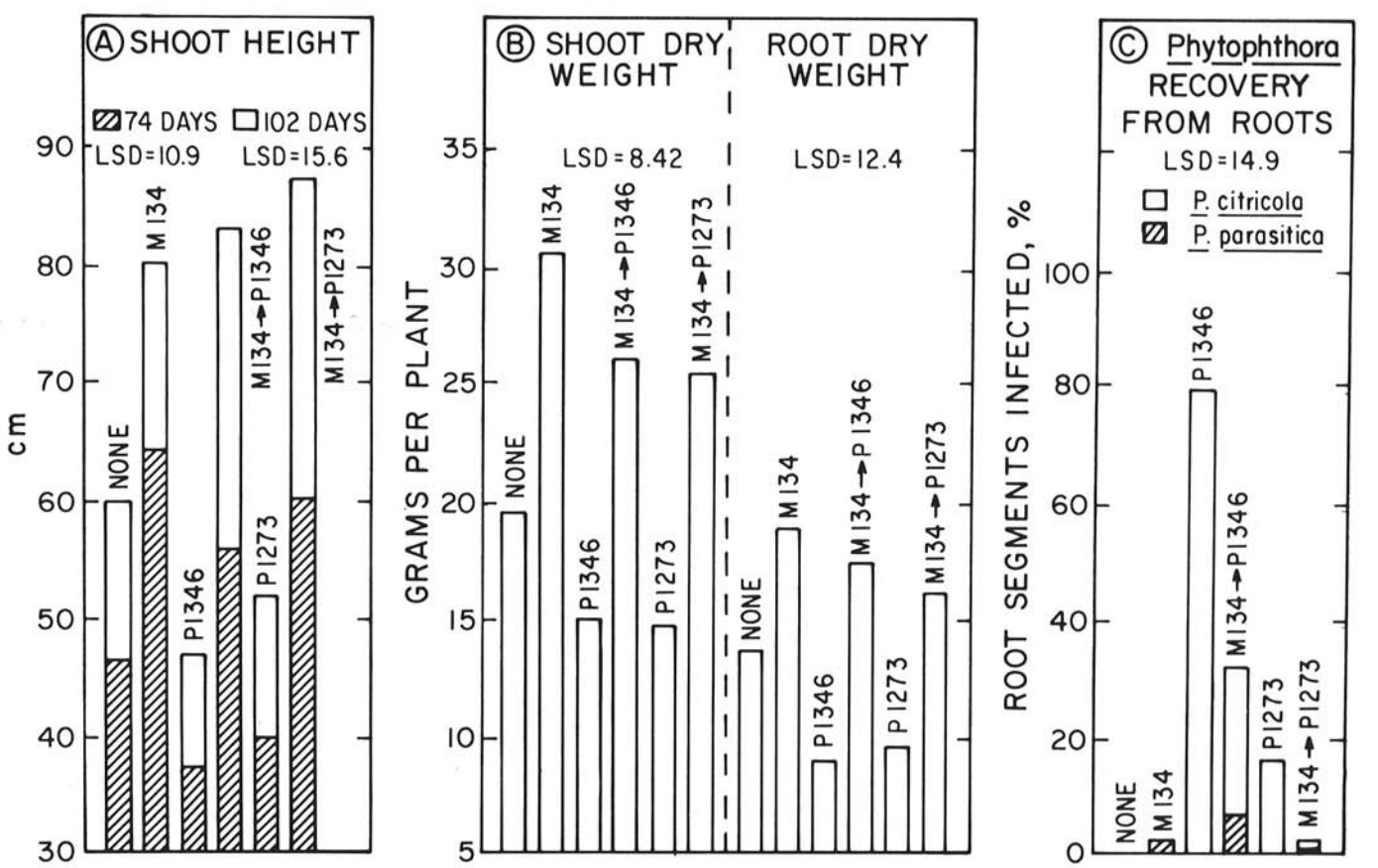

Fig. 1. Growth and protection of *Persea americana* 'Topa Topa' against *Phytophthora citricola* after prior inoculation with the nonpathogen *P. parasitica* (M134). Plants were grown for 6 wk in UC-mix amended with millet seed infested with *P. parasitica*. Plants were subsequently challenged by transplanting them into UC-mix artificially infested with either of two pathogenic isolates of *P. citricola* (P1273 or P1346). The experiment was terminated 8 wk after challenge. Treatments consisted of: None, unchallenged control plants grown in uninfested UC-mix; M134, unchallenged plants grown in UC-mix infested with *P. parasitica*; P1273 or P1346, plants grown in uninfested UC-mix and subsequently challenged with UC-mix infested with either of two isolates of *P. citricola*; M134 → P1273 or M134 → P1346, plants grown in UC-mix infested with *P. parasitica* and subsequently challenged with UC-mix infested with an isolate of *P. citricola*. **A,** Mean shoot heights were measured at 4 wk (74 days) and 8 wk (102 days) after challenge. **B,** Shoot and root dry weights measured at 8 wk after challenge. **C,** Recovery of *Phytophthora* spp. from feeder roots 8 wk after challenge. Species of *Phytophthora* were identified by plating root segments on selective media.

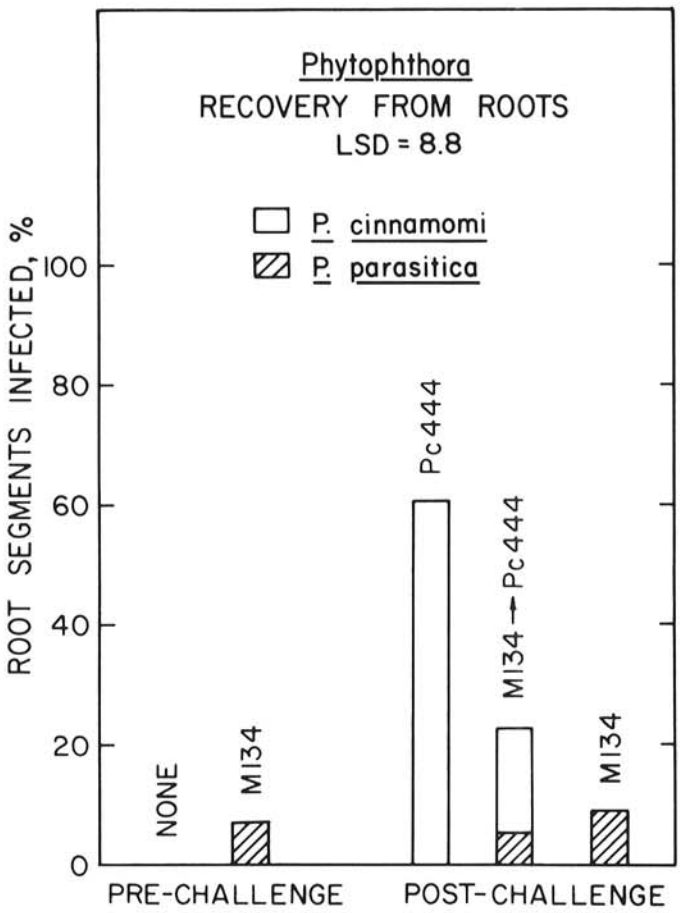

Fig. 2. Recovery of *Phytophthora cinnamomi* (Pc444) from roots of *Persea americana* 'Topa Topa' receiving prior inoculation with a nonpathogenic *Phytophthora parasitica* (M134). Plants were grown in uninfested or infested UC-mix for 6 wk prior to challenge with UC-mix infested with *P. cinnamomi* and applied as an overlay to the soil surface. The experiment was terminated 8 wk after challenge and feeder root segments were plated on selective media to determine percent recovery and identification of *Phytophthora* spp. The treatments consisted of: None, unchallenged control plants grown in uninfested UC-mix; M134, unchallenged plants grown in UC-mix infested with *P. parasitica*; Pc444, plants grown in uninfested UC-mix and subsequently challenged with *P. cinnamomi*; M134 → Pc444, plants grown in *P. parasitica*-infested UC-mix and subsequently challenged with *P. cinnamomi*.

able to move out of the original root ball and compete for infection sites on new root growth. However, site competition seems an unlikely explanation since *P. parasitica*, by occupying less than 5.5% of the root system, caused a 60–85% reduction in root infection by a pathogen. Many potential infection sites of a protected root system would still be available to such a pathogen. A more plausible explanation is that *P. parasitica*, by colonizing much of the root system in the original root ball, causes a physiological change in the newly formed root system that protects it from further attack by a challenge pathogen. We hypothesize that this requires the production of a signal than can be transmitted through the developing root system and induce resistance in these new root tissues.

LITERATURE CITED

1. Baker, K. F., ed. 1957. The U. C. System for Producing Healthy Container-Grown Plants. University of California, Division of Agricultural Services, Agricultural Experiment Station, Extension Service, Berkeley. 322 pp.
2. Bega, R. 1954. Biological control of wilt of sweet potato. (Abstr.) Phytopathology 44:482.
3. Coffey, M. D., and Bower, L. A. 1984. In vitro variability among isolates of six *Phytophthora* species in response to metalaxyl. Phytopathology 74:502-506.
4. Cohen, Y., and Coffey, M. D. 1984. Protecting *Persea indica* seedlings from *Phytophthora citricola* by a prior inoculation with three other *Phytophthora* spp. (Abstr.) Phytopathology 74:807.
5. Cohen, Y., and Coffey, M. D. 1984. Pathogenicity of *Phytophthora citricola* from avocado to *Persea indica*. (Abstr.) Phytopathology 74:846.
6. Dehne, H. W., and Schönbeck, F. 1979. Untersuchungen zum Einflüss der endotrophen Mycorrhiza und Pflanzenkrankheiten. I. Ausbreitung von *Fusarium oxysporum* f. sp. *lycopersici* in Tomaten. Phytopathol. Z. 95:105-110.
7. Dolan, T. E., and Coffey, M. D. 1984. Biocontrol of *Phytophthora cinnamomi* on *Persea indica* and *P. americana* by prior inoculation with *Phytophthora parasitica*. Phytopathology 74:807.
8. Elliston, J., Kuć, J., and Williams, E. B. 1976. Protection of *Phaseolus vulgaris* against anthracnose by *Colletotrichum* species nonpathogenic to bean. Phytopathol. Z. 86:117-126.
9. Elliston, J., Kuć, J., Williams, E. B., and Rahe, J. E. 1977. Relationship of phytoalexin accumulation to local and systemic protection of bean to anthracnose. Phytopathol. Z. 88:114-130.
10. Gessler, C., and Kuć, J. 1982. Induction of resistance to Fusarium wilt in cucumber by root and foliar pathogens. Phytopathology 72:1439-1441.
11. Kannwischer, M. E., and Mitchell, D. J. 1978. The influence of a fungicide on the epidemiology of blank shank of tobacco. Phytopathology 68:1760-1765.
12. Kellam, M. K., and Coffey, M. D. 1985. Quantitative comparison of the resistance to Phytophthora root rot in three avocado rootstocks. Phytopathology 75:230-234.
13. Matta, A., and Garibaldi, A. 1977. Control of Verticillium wilt of tomato by preinoculation with avirulent fungi. Neth. J. Plant Pathol. 83 (Suppl. I):457-462.
14. Ogawa, J. M., and Lyons, J. M. 1983. How commodity marketing orders help solve crop problems in California. Plant Dis. 67:1042-1046.
15. Schönbeck, F. 1978. Einflüss der Endotrophen Mycorrhiza auf die Krankheitsreseistenz hoherer Pflanzen. Z. Pflanzenkr. Pflanzenschutz 85:191-196.
16. Sequeira, L. 1983. Mechanisms of induced resistance in plants. Annu. Rev. Microbiol. 37:51-59.
17. Tuzun, S., and Kuć, J. 1983. A new technique which immunizes against blue mold (*Peronospora hyoscyami* f. sp. *tabacina*) and increases growth of tobacco. (Abstr.) Phytopathology 73:823.
18. Zaki, A. I., Zentmyer, G. A., Pettus, J., Sims, J. J., Keen, N. T., and Sing, V. O. 1980. Borbonol from *Persea* spp.—chemical properties and antifungal activity against *Phytophthora cinnamomi*. Physiol. Plant Pathol. 16:205-212.
19. Zentmyer, G. A. 1980. *Phytophthora cinnamomi* and the diseases it causes. Phytopathological Monograph 10. American Phytopathological Society, St. Paul, MN. 96 pp.
20. Zentmyer, G. A., Jefferson, L., Hickman, C. J., and Chang-Ho, Y. 1974. Studies of *Phytophthora citricola*, isolated from *Persea americana*. Mycologia 66:830-845.