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ETIOLOGY AND CONTROL OF LETHAL PHYTOPHTHORA CANKER ON ALMOND

Project Leaders: G.T. Browne[1] and M. Viveros[2]
Cooperators: H.E. Becherer[1] and P. Schrader[2]
[1]USDA-ARS, Department of Plant Pathology UC Davis and [2]UCCE, Bakersfield

Abstract

Most of the last year's research on lethal Phytophthora canker (LPC) focused on control of the disease, but some work continued on monitoring causal agents and circumstances associated with LPC occurrence. *P. cactorum* and *P. citricola* were found causing almond tree decline and death in two orchards that were not previously surveyed in Kern County. Additional blocks were inspected for LPC in Kings and Fresno Counties, but only Ceratocystis canker was present at those locations. Observations continue to indicate that *P. cactorum* typically infects near the soil surface and grows up the trunk, eventually killing the scion, whereas lethal *P. citricola* cankers usually first appear aboveground, especially in scaffold crotch pockets. Several chemical treatments were evaluated for preventive and curative management of LPC in a 10-year-old commercial orchard near Shafter. Treatment efficacy was determined by inoculating with *P. citricola* before or after chemical application and then assessing treatment effects according to the incidence and amount of canker development. Wounding was required for infection by *P. citricola* from agar-based or soil-based inoculm on trunks, scaffolds, and crotch pockets. A foliar spray of Nutri-Phite P+K (0-28-26 formulation, 4 pts. in 175 gal. water per A) on 10/29/99 prevented any significant development of cankers following inoculation with *P. citricola* at 3 weeks after the treatment and strongly suppressed development of cankers following inoculation at 14 weeks after treatment. A Bordeaux mixture (10-10-100 formulation) spray on the lower half of trees (3.1 gal. per tree) on 10/29 did not suppress canker development following wound inoculations either 3 or 14 wks after the spray application. One concentrated "paint" treatment with either Ridomil Gold (1 quart per 3 gal water) or Aliette WDG (1 lb. per gal. water) on active trunk and scaffold cankers caused by *P. citricola* significantly reduced the amount of post-treatment canker expansion, compared to a non-treated control, but an application of modified "magic elixir" (500 ml boiled linseed oil, 180 g basic $CuSO_4$, 80 ml Hexol) was ineffective. Results of rootstock screens indicated that Hansen 536 should be avoided where there is a history of LPC.

Background

Phytophthora is among the most important soilborne pathogens of almond. Risk of root or crown infection by the pathogen is greatest during cool to moderate temperatures with prolonged or frequent water saturation in or on soil. The water-filled pores in a saturated soil favor reproduction of *Phytophthora* and dispersal of its swimming zoospores, which are the principal agents of root system infection.

In addition to root and crown rot, *Phytophthora* can cause above-ground cankers on almond trees. In cool wet weather, pruning wounds are subject to infection by *Phytophthora syringae*,

the cause of pruning wound canker disease. This disease is usually not serious on established trees because *P. syringae* is sensitive to high temperatures, and the cankers cease development as weather warms in late spring and summer.

This project is focused on biology and control of a lethal canker syndrome that can be caused by either *P. cactorum* or *P. citricola*. We call the disease lethal Phytophthora canker (LPC) to distinguish it from the typically non-lethal pruning wound canker caused by *P. syringae*. LPC kills mature almond trees by girdling tree scaffolds and trunks. The lethal characteristic results from rapid tree colonization by the pathogen and the perennial nature of many of the cankers. LPC has occurred in microsprinkler-irrigated as well as flood-irrigated almond orchards. Trees on peach rootstock as well as trees on peach x almond hybrid have been affected by the disease, but LPC incidence appears to be greatest in Kern County. In the first two years of our project, most of the work dealt with understanding etiology and basic biology of the LPC (objectives 1-3, below). During the third year (1999), most of our work focused on control of the disease (objective 4).

Objectives

1. Determine the specific causal agents of lethal Phytophthora canker disease (LPC).
2. Determine locations where lethal Phytophthora cankers originate on individual trees.
3. Determine sources of inoculum that contribute to LPC.
4. Develop appropriate control measures for LPC.

Objective 1. Determine the specific causal agents of lethal Phytophthora canker disease (LPC).

Procedures. Orchard surveys were continued in 1999 to monitor which species of *Phytophthora* are causing LPC. As in previous years, bark samples were collected from suspected LPC cankers and cultured on selective medium in petri dishes to detect *Phytophthora* pathogens.

Results and discussion. In spring 1999 *P. citricola* and *P. cactorum* were both associated with LPC at very high incidence in a Kern County block that had not been surveyed previously. Another block in the county was affected by LPC caused by *P. cactorum*. Orchards in Kings and Fresno Counties were also inspected for LPC incidence, but at these locations the only prevalent canker symptoms were caused by *Ceratocystis*. The isolations of *P. cactorum* and *P. citricola* from LPC-affected trees in 1999 are consistent the results from 1997 and 1998 surveys, and Kern County continues to have the highest apparent incidence of the disease. Our previous tests confirmed pathogenicity of *P. cactorum* and *P. citricola* on almond.

Objective 2. Determine locations where lethal Phytophthora cankers originate on individual trees.

Procedures. As in previous years, LPC cankers were examined to determine where they started on trees.

Results and discussion. In the LPC-affected blocks surveyed in 1999, some of the cankers had resulted from infections at or below the soil surface, while others were limited to aboveground tree parts. There was no apparent association with pruning wounds. *P. cactorum* and *P. citricola* were each associated with aboveground cankers, but only *P. cactorum* was isolated from cankers originating at or below the soil surface. Scaffold crotch pockets (natural depressions occurring where the scaffold branches join) were among common sites where the aboveground cankers had started. Pronounced crotch pockets allow collection of debris and water. In addition, the crotch pockets often have "growth cracks"-- ruptures in the bark that result from opposing expansion and load forces between scaffolds. We suspect that the cracks can serve as sites for *Phytophthora* infection. Because LPC cankers apparently result from soilborne as well as aboveground infections, our research on control addresses management of both types of attack. Technically, aboveground cankers that result from belowground infection are extensions of Phytophthora trunk or crown rot.

Objective 3. Determine sources of inoculum that contribute to LPC. No new work was done on this objective in 1999. As described in previous reports, *P. cactorum* and *P. citricola*, as well as other *Phytophthora* species, were detected in samples of orchard soil, scaffold crotch debris, and debris deposited on trees during normal harvest operations in orchards affected by LPC. Thus in LPC-affected orchards, viable *Phytophthora* inoculum can be present on aboveground parts of the trees as well as in the soil around them. Harvest operations play at least a partial role in dispersing the inoculum onto the scion parts. Aboveground LPC infections are probably limited to times of the year when free moisture is present on trees, due to rain, heavy dew, fog, or irrigation.

Objective 4. Develop appropriate control measures for LPC.

A. Chemical approaches

Experiment 1, chemical protection treatments for LPC, procedures. A 2-year test of chemical programs was concluded in an orchard affected by LPC caused by *P. citricola* near Delano. Separate treatments of Ridomil (Gold formulation, 2 qts. per sprayed A, sprayed on soil in 6-ft. bands on each side of tree rows), copper (depending on date: Kocide 101, 8 lb./A or Bordeaux 10-10-100, sprayed on trees in 175 gal./A,), or Nutri-Phite P+K (0-28-26, 4 pts./A, sprayed on trees in 175 gal./A) were applied according to label rates and schedules to replicated plots (5 replicate 56-tree plots per chemical treatment). Nutri-Phite is registered only as a fertilizer, the other materials are fungicides. During the years of the experiment, the orchard was surveyed annually to determine pre-existing and new incidences of LPC for each treatment. New incidence of LPC was insufficient for assessment of the spray programs. Therefore, lab bioassays involving inoculation of excised shoot sections were used to assess effectiveness of the treatments. Separate sets of shoots were collected from each replicate chemical plot on 4/30, 5/25, 7/2, and 7/25/99. The last chemical treatment application dates were 1/21/99 for the Bordeaux mixture and 3/30/99 for the Ridomil and Nutri-Phite. Each shoot sample was stripped of leaves and kept moist until inoculation. For each replicate chemical or non-sprayed plot, three shoots were inoculated with *P. citricola* using mycelial agar disks and one shoot was inoculated

with a sterile agar disk as a control. After inoculation, the shoots were incubated in a chamber at 100% r.h. for 5 days. Efficacy of the chemical treatments was assessed according to canker length in the treated shoots compared to that in the non-treated shoots.

Experiment 1, chemical protection treatments for LPC, results and discussion. Only data from the lab inoculations of shoots are presented. Although the Bordeaux treatment had a slight inhibitory effect on canker development on the first inoculation date, only the Nutri-Phite treatment suppressed cankers very much (Fig. 1). Nutri-Phite afforded canker suppression for about 3 months after application, although the magnitude of the effect diminished over time (Fig. 1). This positive result was used to design more intensive field studies, as described below.

Experiment 2, chemical protection treatments for LPC, procedures. On 10/29/99, the following spray treatments were applied in an orchard near Shafter:

Spray treatment	Treatment explanation
Control	(Non-sprayed)
Nutri-Phite P+K	(0-28-26 formulation, 4 pints Nutri-Phite P+K and 175 gal water, mixture sprayed @ 175 gal/A on all aerial tree parts with an air blast sprayer at 210 psi and 1.2 mph
Bordeaux mixture	(10-10-100; 10 lb $CuSO_4$+10 lb hydrated lime+100 gal water, applied with by directed hand gun to lower half of trees @ 3.1 gal/tree)

Each of the spray treatments was applied to four replicate four-tree plots (mainplots). Three weeks after spraying the trees were inoculated; the four following inoculation treatments were assigned randomly to each four-tree subplot (one inoculation treatment per tree):

Inoculation treatment	Treatment explanation
Non-wounded control	On four separate scaffold branches and on two sides of the trunk, 1 x 1-cm agar squares (sterile) were placed on non-wounded bark (either on latent buds or on smooth areas), moistened, and held in place with a secure wrap of duct tape. In addition, 100 ml of non-infested soil was placed in the crotch pocket and saturated with water.
Non-wounded, inoculated with *P. citricola*.	Inoculation was conducted as for the non-wounded control, except that the agar disks and the soil were colonized by *P. citricola*.
Wounded control	On four separate scaffold branches and on two sides of the trunk, 1 x 1-cm agar squares (sterile) were placed under 1 x 1-cm patches of bark that were removed with a chisel. After placement of the agar squares, the bark was replaced and held in place with a secure wrap of duct tape. In addition, the tree crotch pocket was wounded with four chisel cuts (each 2 cm wide and penetrating to the wood), filled with 100 ml of non-infested soil, and saturated with water.
Wounded, inoculated with *P. citricola*	Inoculation was conducted as for the wounded control, except that the agar squares and the soil were colonized by *P. citricola*.

Two months after inoculation, effects of the spray and inoculation treatments were assessed by determining canker incidence and size. Also, to determine effects of the spray treatments on survival of *P. citricola* in the wounded bark, samples were collected from discolored bark around the inoculation points, or, where possible, from margins of the cankers.

Experiment 2, chemical protection treatments for LPC, results and discussion. No cankers developed on trees without wounding (data not shown). The non-wounded trees were reinoculated on 2/08/00 (14 weeks after the spray treatments) as described above for the inoculation treatments involving wounding, except that the crotch pockets were not reinoculated.

Only negligible amounts of discolored bark occurred around the wounded control inoculation points on tree scaffolds or trunks, whether they were inoculated on 11/17 or on 2/8 (Fig. 2 A-D, Fig. 3 A-D). The non-sprayed and Bordeaux-treated trees that were wound inoculated with *P. citricola* developed extensive cankers on the scaffold branches and trunks, regardless of inoculation date (Fig. 2 A-D, Fig. 3 A-D). In contrast, trees sprayed with Nutri-Phite on 10/29 and wound inoculated with *P. citricola* on 11/17 developed no cankers (Fig. 2- A,B; Fig. 3 A,B), and those inoculated on 2/8 developed significantly smaller cankers than the non-sprayed control (Fig. 2 C,D; Fig. 3 C,D). On non-sprayed and Bordeaux-treated trees, three of four scaffold crotch pockets that were wounded and received soil artificially infested with *P. citricola* developed infections by the pathogen. None of the non-wounded or Nutri-Phite-treated crotch pockets had developed cankers by the time of evaluation.

The pre-inoculation spray treatment with Nutri-Phite reduced incidence of *P. citricola* detection in samples collected on 1/18 from trees inoculated 11/17 (Fig. 4 A). This indicated that the treatment was not uniformly lethal to the pathogen, despite the canker prevention. Nutri-Phite treatment had no effect on detection of the pathogen in samples collected 4/14 from trees inoculated on 2/8 (Fig. 4 B).

The results of Experiment 2 suggest that a Nutri-Phite spray treatment in the fall could contribute greatly to prevention of LPC caused by *P. citricola*. The protective effects of the treatment were more pronounced at 3 weeks after application than at 14 weeks after application. Ideally, chemical approaches to LPC management would protect trees during moderate temperatures and intermittently wet conditions occurring in late fall, winter and early spring, which are probably the most favorable times of the year for infection by the pathogen.

Work is underway to determine effectiveness of early spring treatments with Nutri-Phite that could supplement protection from a fall spray with the material. *P. cactorum* and *P. citricola* are both included in the work. In addition, an experiment involving monthly inoculations throughout the year was established to determine seasonal effects on development and expansion of LPC cankers and help guide scheduling of LPC treatments.

Experiment 3, therapeutic treatments for LPC, procedures. Branch segments (3-6 cm in diameter, about 46 cm length) were collected from almond trees in Kern County and wound inoculated with *P. citricola* on agar disks or with an agar control on 11/22. Infections were allowed to develop for 5 days while the branches were incubated in humid chambers. On the fifth day, all cankers were measured and topical treatments of Aliette WDG (1 lb. per gal. water), Ridomil Gold (1 quart per 3 gal. water), or "magic elixir" (500 ml boiled linseed oil, 180 g Kocide, 80 ml Hexol) were applied with paint brushes to cover the canker-affected bark and extend at least 10 cm beyond the margins of diseased tissue. Additional sets of inoculated and non-inoculated branches received no chemical (chemical controls). Just before the chemical

treatments, a chisel was used to make 1-cm-long cuts through the bark and into the wood on half the number of each set of branches. The cuts were oriented in a "fish-scale" manner, and up to about 40 cuts were made per branch, spaced to cover the area to be treated with a topical treatment. The other branches received no bark preparation before topical treatments were applied.

Experiment 3, therapeutic treatments for LPC, results and discussion. Each of the topical treatments without bark preparation reduced the amount of post-treatment canker expansion by about 50%, compared to the non-treated control cankers (Fig. 5). Administering the bark cuts before topical treatment improved effectiveness of "elixir" and Ridomil Gold, but not Aliette (Fig. 5). The elixir treatment did not affect detectability of the pathogen when we cultured bark pieces from the cankers (75-80% of the bark pieces from the elixir-treated cankers yielded the pathogen in culture plates, Fig. 5), but the Aliette treatment (with bark preparation) and the Ridomil treatment (with or without bark preparation) reduced detectability of the pathogen in culture (Fig. 5). The chemical treatments were also tested in a commercial orchard near Shafter, as described below.

Experiment 4, therapeutic treatments for LPC-affected trees, procedures. Scaffold branches and trunks of commercial almond trees near Shafter were wound inoculated under bark patches with sterile or *P. citricola*-colonized agar patches on 10/22. On 12/2, canker incidence and size were determined, and therapeutic treatments of Aliette WDG (1 lb. per gal. water), Ridomil Gold (1 qt. per 3 gal. water), or modified "magic elixir" (500 ml boiled linseed oil, 180 g basic $CuSO_4$, 80 ml Hexol) were applied with paint brushes to cover the canker-affected bark and extend at least 10-20 cm beyond the margins of diseased tissue. A control for the topical treatments received no chemical. Just before the chemical treatments, a hatchet was used to make cuts through the bark and into the wood on half the number of branches and trunk sites to receive each chemical or control topical treatment. The cuts were about 5 cm wide and oriented in a "fish-scale" manner, and about 5-15 cuts were made per inoculation/canker site, depending on canker size. The other branches received no bark preparation before topical treatments were applied.

Experiment 4, therapeutic treatments for LPC-affected trees, results and discussion. The topical treatments with Aliette or Ridomil significantly suppressed subsequent expansion of cankers caused by *P. citricola*, but the elixir did not (Fig. 6 A, B). The amount of canker expansion following Aliette or Ridomil treatments was about 30-50% of that resulting on non-treated cankers (Fig. 6 A,B). Bark preparation with a hatchet before application of the therapeutic treatments did not significantly improve efficacy (Fig. 6 C).

The results indicate that topical concentrated applications of Aliette and Ridomil hold promise for therapeutic treatment of LPC cankers. These treatments are not registered for use on almond at this time. It is unknown why elixir did not suppress canker growth in the orchard while it did in the humid chambers (Experiment 3). Possible factors include greater bark thickness in the orchard test and trapping of vapors from the elixir that were inhibitory to *P. citricola* in the humid chambers.

B. Genetic approaches

Evaluation of resistance to *Phytophthora* in *Prunus* rootstocks, procedures. Judicious rootstock selection may help avoid Phytophthora crown rot as well as above-ground Phytophthora cankers that originate from root crown infections. Hardwood cuttings provided by Dave Wilson Nursery and the Foundation Plant Material Service were rooted and grown in potting soil in a greenhouse, allowed to go through dormancy in a lath house, and returned to a greenhouse for evaluations of resistance to *Phytophthora*. The stocks were transplanted into 2-liter pots with either non-infested soil (as a control) or soil artificially infested with multiple-isolate mixtures of *P. cactorum* or *P. megasperma*, the most prevalent species causing crown rot on almond in California. To favor infection by the pathogens, the plants were subjected to a 48-hr flooding episode every 2 weeks. Three months after inoculation, the root systems were washed free from soil and rated for severity of root and crown rot.

Evaluation of resistance to *Phytophthora* in Prunus rootstocks, results and discussion. Only Hansen 536 (clonal peach x almond hybrid) developed a significant amount of crown or root rot in soil infested by *P. cactorum* (Fig. 7 A,B). In contrast, most of the *Prunus* selections were susceptible to root rot caused by *P. megasperma*, including Nemaguard and Lovell (peach); Hansen 536; and Atlas and Viking (complex hybrids involving peach, almond, plum, and apricot) (Fig. 7 A,B). Marianna 2624 (clonal *P. cerasifera* x *munsoniana*) and Citation (clonal peach x plum) were both resistant to *P. cactorum* and *P. megasperma*.

The results indicate that growers should avoid use of Hansen 536 where there is a history of LPC. *P. cactorum* often infects trees near the soil line and in this case a highly susceptible rootstock adds to the infection risk. Growers should also avoid burial of almond graft unions, because almond scion tissue is more susceptible than most almond rootstocks to *Phytophthora*.

C. Cultural approaches

Tree training experiment, procedures. Scaffold crotch pockets were identified as important sites of aboveground LPC infection in previous years. A tree training study was initiated in 1998 on first-leaf trees to determine if early selection of scaffolds that are spread out along the trunk may help to avoid formation of the water-collecting, growth-crack-prone scaffold crotch pockets. The training treatments included:

Treatment 1:	Spring 1998 selection of three main shoots around the trunk; shoots originating at the same level on the trunk. Shoots not chosen as scaffolds were bent down.
Treatment 2:	Spring 1998 selection of three main shoots around the trunk, shoot origins separated vertically by several inches on the trunk. Shoots not chosen as scaffolds were bent down.
Treatment 3:	Fall 1998 selection of three main shoots around the trunk; shoots originating at the same level on the trunk.
Treatment 4:	Fall 1998 selection of three main shoots around the trunk; shoot origins separated vertically by several inches on the trunk.
Treatment 5:	Conventional fall 1998 selection of five main shoots distributed along the trunk.

Due to the time required for scaffold crotch pockets to form, results are not yet available for this experiment. As soon as pockets begin to form, their liquid-retaining volume will be determined and incidence and severity of growth cracks will be assessed for each training treatment.

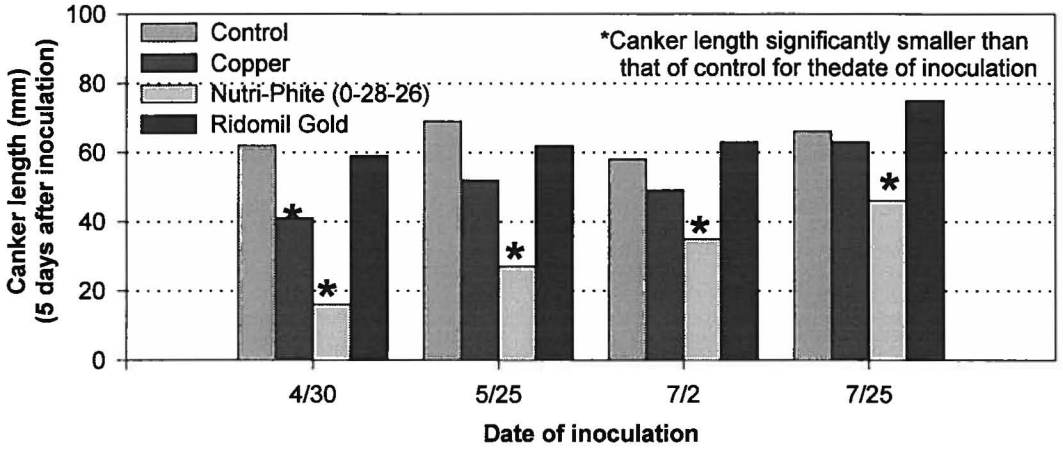

Fig. 1. Experiment 1, effect of selected pre-inoculation chemical treatments on canker development in excised shoots inoculated with *Phytophthora citricola*. Each chemical treatment and the non-treated control were allocated to five replicate plots in a commercial almond orchard near Delano; the copper treatment (Bordeaux mixture, 10-10-100, 175 gal/A) was applied 1/21/99, whereas Nutri-Phite P+K (0-28-26, 4 pts./sprayed A, foliar) and Ridomil Gold (2 qts./ sprayed A, soil spray) were applied on 3/30/99. Separate sets of shoots were collected from the plots on dates given and inoculated in a lab with *P. citricola* by placing the pathogen in bark wounds. Chemical efficacy was assessed according to canker length relative to the non-treated control. Shoots wound inoculated with agar disks (the inoculation control) developed no cankers. The test detects systemic effects of the treatments in shoots and is not expected to indicate activity in the roots, crown, or trunk of trees.

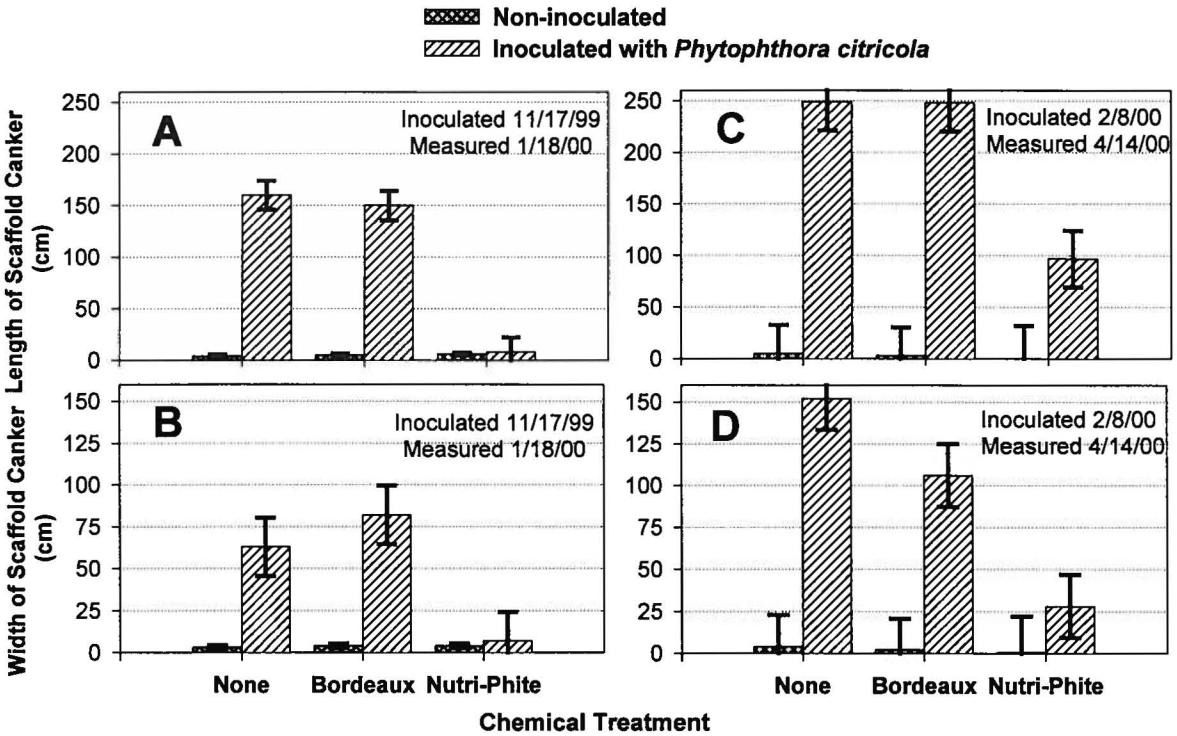

Fig. 2. Experiment 2, effect of pre-inoculation sprays on subsequent development of lethal Phytophthora cankers caused by *P. citricola* on almond scaffold branches. Bordeaux mixture (10-10-100, 3.1 gal/tree, applied on lower half of trees), Nutri-Phite P+K (0-28-26 formulation; 4 pints per sprayed A in 175 gal water; complete foliage spray), and a non-sprayed control were applied on 10/29/99. At 3 weeks and 14 weeks after the spray treatments (11/17/99 and 2/8/00, respectively), four scaffold branches on each of four replicate trees were wound inoculated with *P. citricola* and an equal number of controls were wound inoculated with sterile agar. The size of resulting cankers was measured 2 months after inoculation. Vertical bars delimit 95% confidence intervals for the treatment means. Note that Nutri-Phite prevented development of cankers following inoculation at 3 weeks after the treatment (**A** and **B**) and strongly suppressed canker development following inoculation at 14 weeks after the treatment (**C** and **D**).

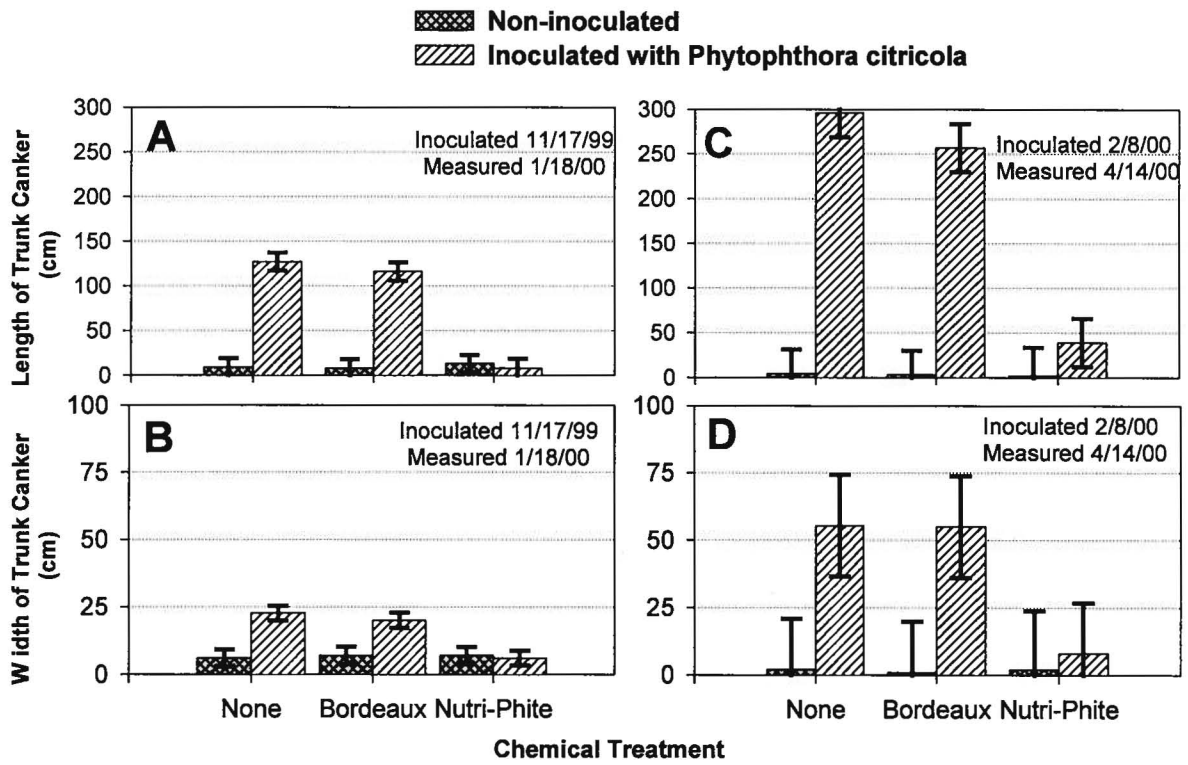

Fig. 3. Experiment 2, effect of pre-inoculation sprays on subsequent development of lethal Phytophthora cankers caused by *P. citricola* on almond tree trunks. Bordeaux mixture (10-10-100, 3.1 gal/tree, applied on lower half of trees), Nutri-Phite (0-28-26 formulation; 4 pints per sprayed A in 175 gal water; complete foliage spray), and a non-sprayed control were applied on 10/29/99. At 3 weeks and 14 weeks after the spray treatments (11/17/99 and 2/8/00, respectively), four replicate trees were wound inoculated with *P. citricola* and four were wound inoculated with sterile agar (control). The size of resulting cankers was measured 2 months after the inoculation dates. Vertical bars delimit 95% confidence intervals for the treatment means. Note that Nutri-Phite prevented development of cankers following inoculation 3 weeks after the treatment (**A** and **B**) and strongly suppressed canker development following inoculation 14 weeks after the treatment (**C** and **D**).

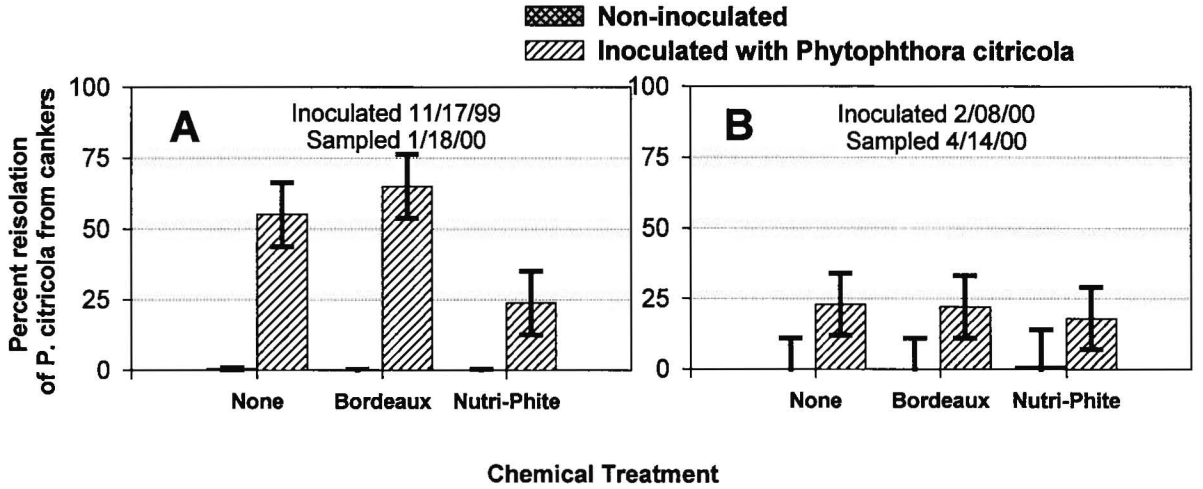

Fig. 4. Experiment 2, effect of pre-inoculation spray treatments (described above) on subsequent ability to isolate *Phytophthora citricola* from cankers or points of inoculation following assessment of cankers from inoculations at **A**, 3 weeks after spray treatment and **B**, 14 weeks after spray treatment. Note that Nutri-Phite did not eradicate *P. citricola* from canker tissue. Vertical bars delimit 95% confidence intervals.

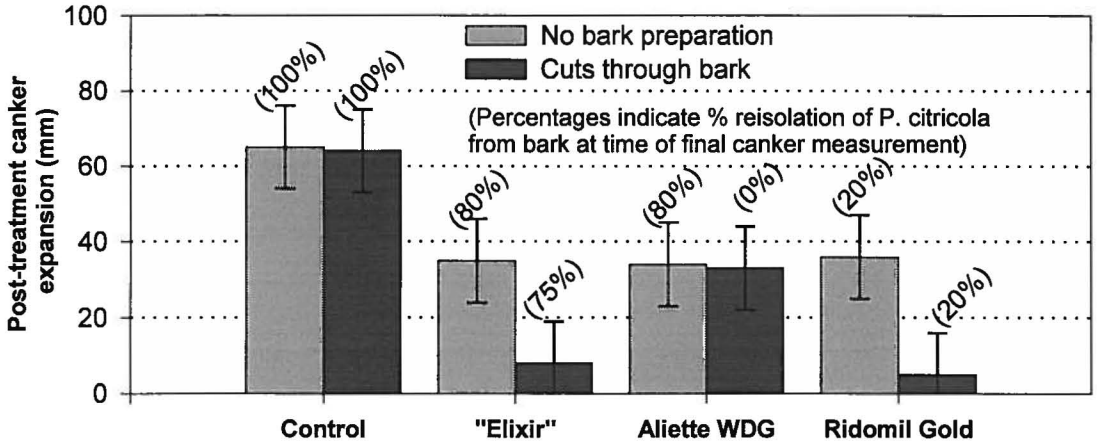

Fig. 5. Experiment 3, effect of topical treatments on subsequent expansion of pre-existing cankers caused by *Phytophthora citricola* on excised scaffold branch segments. The branch segments (3-6 cm dia., about 46 cm length) were excised from almond trees, wound inoculated with agar-based inoculum of *P. citricola* or a sterile-agar control, and allowed to incubate in humid chambers for 5 days. On the fifth day, canker lengths were determined, bark preparation occurred, and chemical treatments were applied (see text). One week after the chemical treatments, cankers were measured again to determine the amount of canker growth occurring after chemical treatment, with and without bark preparation. Vertical error bars delimit 95% confidence intervals for means. No significant necrosis occurred on the non-inoculated controls. Percentages indicate incidence of cankers from which *P. citricola* was culturable after the treatments and final canker measurements.

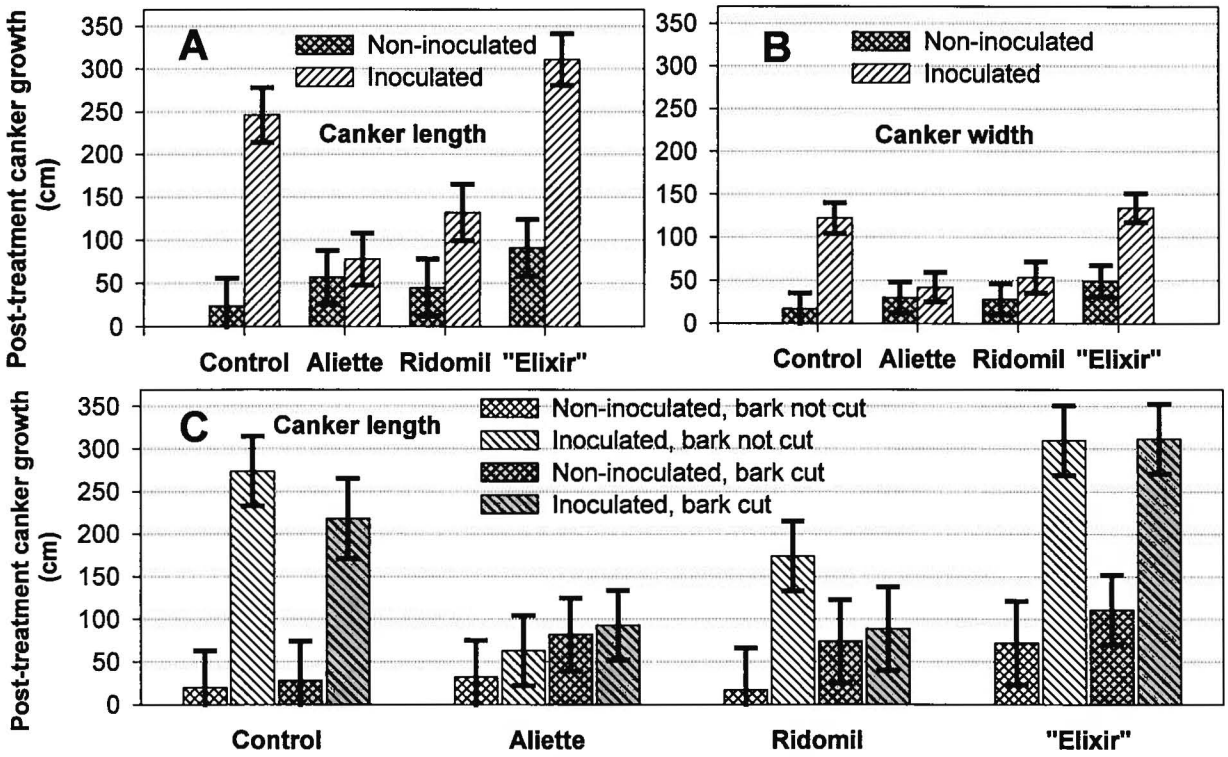

Fig. 6. Experiment 4, effects of therapeutic topical treatments on cankers caused by *P. citricola* on commercial almond trees near Shafter. Scaffold branches and trunks of the trees were wound inoculated under bark patches with *P. citricola*-colonized agar or sterile agar (control) on 10/22/99. On 12/2, canker incidence and size were determined, and the cankers were painted with concentrated Aliette WDG, Ridomil Gold, or modified "magic elixir" (see text). A control for the topical treatments received no chemical. Just before the chemical treatments, a hatchet was used to make cuts through the bark and into the wood on half the number of branches and trunk sites to receive each chemical or control topical treatment. The cuts were oriented in a "fish-scale" manner, and about 5-15 cuts were made per canker, depending on canker size. The other branches received no bark preparation before topical treatments were applied. Note that: **A-C**, Aliette and Ridomil treatments were effective, whereas the "elixir" was not; and **C**, there was no major effect of bark preparation on efficacy of the topical treatments.

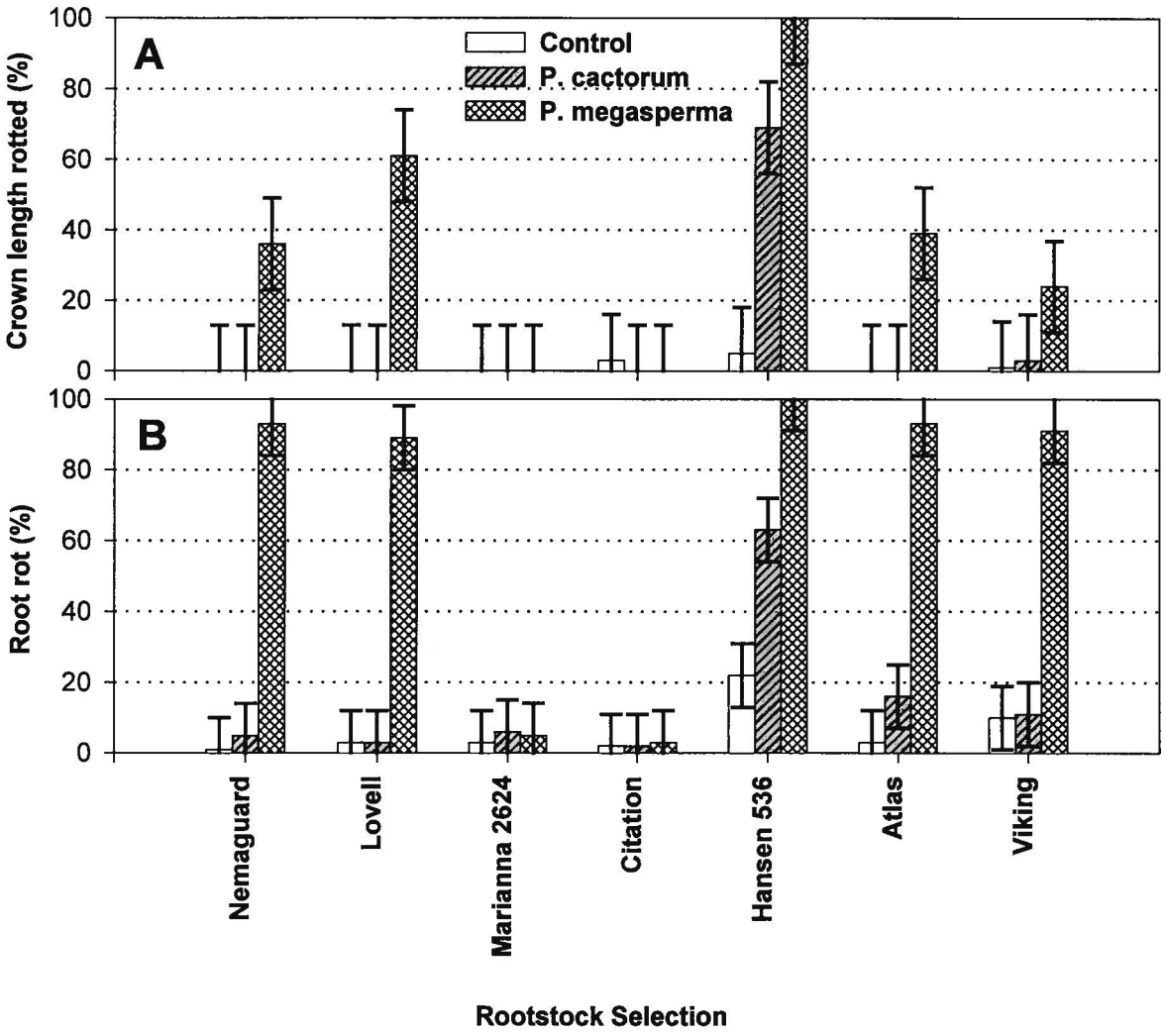

Fig. 7. Relative resistance to *Phytophthora cactorum* and *P. megasperma* in seven selected commercial and experimental *Prunus* rootstocks. The selections were rooted as hardwood cuttings, grown for one year and allowed to go through dormancy, then transplanted into 2-liter pots with non-infested soil or soil artificially infested with four-isolate mixtures for each *Phytophthora* species. Three months after transplanting, rootstock resistance was assessed according severity of **A**, crown rot and **B**, root rot. Note the susceptibility of Hansen 536 and the resistance of Marianna 2624 and Citation. Vertical error bars indicate 95% confidence intervals for the means.