Phytophthora Shoot Blight and Canker Disease of *Abies* spp.

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ABSTRACT

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Phytophthora citricola was identified as the cause of a shoot blight and canker on *Abies concolor* and *A. magnifica*. *A. concolor* suffered twig and branch dieback, but in *A. magnifica*, the fungus also entered stems through branch infections, causing top dieback and mortality. The disease was observed only in trees sprinkler-irrigated with ditch water during the spring flush of growth.

A serious twig blight and canker disease of *Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr. (white fir) and *A. magnifica* A. Murr. (red fir) occurred in 1980 and 1983 in a Christmas tree plantation near Pollock Pines, CA. Trees 3–8 yr old and 0.5–3 m tall were infected. Pollock Pines is in El Dorado County at an elevation of 1,200 m on the western slope of the central Sierra Nevada. *A. concolor* occurs in surrounding native stands. Isolations from 50 necrotic shoots in summer 1980 occasionally yielded *Cytospora abietis* Sacc., but most isolations were sterile. At this time, the disease was attributed to *C. abietis*, because this fungus is a known pathogen of *Abies* spp. (3).

In 1983, the disease occurred again and appeared to be associated with overhead irrigation. Isolations made in late spring from necrotic shoots and from cankers originating from shoot infections consistently yielded *Phytophthora citricola* Sawada (identified by S. M. Mircetich, Department of Plant Pathology, University of California, Davis). This finding led us to test the pathogenicity of *P. citricola* as an aerial pathogen of *Abies* spp. and to determine when and how the fungus infects the host.

MATERIALS AND METHODS

An isolate of the *P. citricola* from cankered *A. magnifica* was grown on a medium consisting of V-8 juice (200 ml), $CaCO_3$ (2 g), and agar (20 g) in 1 L of water. The same isolate was used in all tests. Seven-millimeter disks 4–5 mm thick were cut from a 5- to 7-day-old

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culture grown at 20–22 C under fluorescent lights. Five to 10 disks were placed in petri dishes containing 10–15 ml of tap water to induce formation of sporangia. Zoosporangia formed in 3–5 days. To induce zoospore release, plates were chilled for 30 min at 4 C.

On 6 May 1984, a zoospore suspension (1×10^4/ml) was atomized onto the emerging foliage of 3- to 4-yr-old *A. concolor* and *A. magnifica* grown in nursery beds at the USDA Forest Service, Institute of Forest Genetics (IFG), Placerville, CA, a few miles west of Pollock Pines. Weather conditions were cool (18 C) and cloudy at 6:30 P.M., when the trees were inoculated. Five inoculated trees of each species were covered with polyethylene bags and five were not covered. Five uninoculated trees of each species were covered with polyethylene bags and five uninoculated trees were not covered to serve as controls. The bags were removed at 8:00 A.M. the following morning.

The inoculations were repeated on 30 May at Pollock Pines on plantation-grown *A. concolor* and *A. magnifica* trees 1.5–2 m tall. The same procedures were followed except three or four individual terminal and lateral shoots in the upper and midcrown on three trees of each species constituted the replicates.

In another test, germinated seeds (radical-emerged) of *A. magnifica* were planted in 7.5-cm plastic pots containing a sand-peat potting mixture into which V-8 juice agar cultures of *P. citricola* had been incorporated (60 ml/2 L of potting mixture). Each pot contained two seedlings. Ten pots containing inoculated potting mixture and 10 pots containing uninoculated potting mixture were placed under continuous fluorescent lighting, watered as needed, and held at 20–22 C.

RESULTS AND DISCUSSION

All of the inoculated trees at the IFG became infected. Three to five shoots were infected on each tree. Wilting of young shoots occurred 7 days after inoculation, and by 14 days, the infected shoots turned brown and dried. On 29 May, 23 days after inoculation, the infection in *A. magnifica* had progressed into the main stem and was moving toward the base of the plants. Infection in *A. concolor* was confined to the new growth. Isolations from one or two symptomatic shoots from each inoculated tree of both species resulted in the recovery of *P. citricola*.

The results at Pollock Pines were similar. Eleven of 12 inoculated, bagged shoots and nine of 12 inoculated, nonbagged shoots of *A. concolor* became infected. With *A. magnifica*, nine of 12 inoculated, bagged shoots and two of 12 inoculated, nonbagged shoots became infected. Isolations from one or two symptomatic shoots from each inoculated tree resulted in the recovery of *P. citricola*. No uninoculated plants became infected.

Again, the infections in *A. concolor* did not proceed past the current-season flush of growth, whereas infections in *A. magnifica* continued down the shoot and into the main stem. At the IFG, some small *A. magnifica* were killed. At Pollock Pines, only tops were killed when the main stem was girdled by infections entering through inoculated side branches. All aerial infections occurred in the spring flush of new shoots. No infections originated in older growth.

All 20 seedlings of *A. magnifica* planted in infested potting mixture were killed by the fungus within 7–10 days. Most infections appeared to originate at the hypocotyl. The fungus was readily recovered from diseased plants. Two uninoculated seedlings died, but *Phytophthora* sp. was not recovered from them.

Aerial infection caused by *Phytophthora* spp. is rare on conifers and unknown in *Abies* spp. *P. lateralis* Tucker & Milbrath, which causes a serious root disease of *Chamaecyparis lawsoniana* (A. Murr.) Parl., occasionally attacks foliage hanging near the soil (5). *P. citricola* infects new shoot growth of *Pieris japonica* (Thunb.) D. Don during periods of heavy rain and flooding (1).

In this study, circumstantial evidence implicates irrigation water as the source of *P. citricola* inoculum. At Pollock Pines, water is drawn from an open ditch and applied by sprinklers at a critical time for infection as the new growth is emerging. Mircetich et al (2) has found *P. citricola* in several surface-water irrigation sources in California. Various *Phytophthora* spp. were recovered from the Pollock Pines ditch water but not *P. citricola*. *P. citricola* is present in relatively low numbers in surface waters compared with other *Phytophthora* spp. (S. M. Mircetich, *personal communication*), and this may explain in part our failure to recover it. Although the fungus occurred only as an aboveground pathogen in young plantation firs, greenhouse tests confirmed that it can kill seedlings of *A. magnifica* when grown in infested soil. *P. citricola* has been reported as a root rot of *A. fraseri* (Pursh) Poir. (4).

About 10–20% of *A. magnifica* in the Pollock Pines plantation that received sprinkler irrigation during the spring flush of growth became infected and were unsalable. Fewer than 1% died from girdling infections attributable in part to removal of infected shoots by the grower. Very few *A. concolor* trees were culled as a result of the disease.

The disease is under complete control in the Pollock Pines plantation by withholding overhead irrigation during the spring flush of growth. Overhead irrigation is still practiced in this plantation, but applications are not made until the new growth is mature.

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