Susceptibility of Pacific Northwest Conifers to Phytophthora Root Rot

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Seedlings of 11 conifer species were inoculated with 5 species of Phytophthora—P. cactorum *(Lebert & Cohn) J. Schroet.,* P. cryptogea *Pethybr. & Lafferty,* P. drechsleri *Tucker,* P. megasperma *Drechsler, and* P. pseudotsugae *Hamm & E.M. Hansen—to determine susceptibility to phytophthora root rot. Pine, cedar, larch, and spruce species showed tolerance to the disease whereas some true fir and hemlock species were quite susceptible. Other species showed intermediate susceptibility. Management of phytophthora root rot is discussed, utilizing this information on relative susceptibility of various conifers grown in the Pacific Northwest.* Tree Planters' Notes 40(1):15-18; 1989.

Phytophthora species cause varying amounts of damage on bareroot conifer seedlings in the Pacific Northwest. Many conifer species are susceptible to *Phytophthora (4, 5, 7).* Although infection and mortality of seedlings is usually confined to nurseries, stock quality and survival of infected seedlings after outplanting may also be adversely affected *(6).*

Damage in nurseries is most severe in fields with heavy soil or topography that favors water accumulation. Although phytophthora root rot can be effectively controlled with fungicides *(2)*, an integrated control program is recommended *(1)* to ease the selection pressure on the fungi that results in development of resistant strains. One aspect of an integrated program involves planting tolerant tree species in *Phytophthora-infested* nursery soils.

Previous work *(4, 7)* showed western redcedar *(Thuja plicata* Donn ex D. Don) to be immune to infection by *Phytophthora* species; white fir *(Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.), sugar pine *(Pinus lambertiana* Dougl.) and ponderosa pine *(Pinus ponderosa* Dougl. ex Laws.) to be tolerant; and Douglas-fir *(Psuedotsuga menziesii* (Mirb.) Franco), western hemlock *(Tsuga heterophylla* (Raf.) Sarg.), noble fir *(A. procera* Rehd.), Pacific silver fir (*A. amabilis* Dougl. ex Forbes), and California red fir *(A. magnifica* A. Murr.) to be susceptible.

Several important western conifers have not yet been tested. A more complete knowledge of the relative susceptibility of the majority of conifer species grown in Pacific Northwest nurseries to *Phytophthora* would give nursery managers a greater selection of tolerant tree species for problem areas in their nurseries. In this paper, we compare the susceptibility of 11 conifer species (including 9 that had not been tested previously) to the more common species of *Phytophthora* found in bareroot nurseries in the Pacific Northwest.

Methods

One-year-old bareroot seedlings of the following species were tested: mountain hemlock *(Tsuga mertensiana* (Bong.) Carr.), incense cedar *(Libocedrus decurrens* Torr.), east-side Douglas-fir,* west-side Douglas-fir,* Sitka spruce *(Picea sitchensis* (Bong.) Carr.), Engelmann spruce (*P. engelmannii* Parry ex. Engelm.), ponderosa pine, lodgepole pine *(Pinus contorta* Dougl. ex Loud.), western white pine (*P. monticola,* Dougl. ex D. Don), western larch *(Larix occidentalis* Nutt.), grand fir *(Abies grandis* (Dougl. ex D. Don) Lindl.), and California red fir. Douglas-fir, ponderosa pine, and California red fir had been previously tested *(4)* and were used as reference points to allow for comparisons with previous studies.

Each seedling was transplanted into a mixture of cornmeal sand (CMS) inoculum and soil *(4)*. The five most commonly isolated species of *Phytophthora* were

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**East-side* and *west-side* refer to seed sources originating on the east and west sides of the Cascade Mountains.

used: *P. cactorum* (Lebert & Cohn) J. Schroet., *P. cryptogea* Pethybr. & Lafferty, *P. drechsleri* Tucker, *P. megasperma* Drechsler Group 2 *(3)* and P. *pseudotsugae* Hamm & E.M. Hansen. All were originally isolated from conifers grown in Pacific Northwest nurseries or seed orchards. Inoculum for each *Phytophthora* species was a mixture of 3 isolates, each of which was inoculated and incubated separately in CMS and then mixed together with steamed soil in a 1:16 ratio. The inoculum-soil mix was then added to 450-ml plastic seedling containers (Dee-pots) when seedlings were planted.

Each combination of fungus species and host was replicated 10 times. For controls, 10 seedlings of each tree species were transplanted into soil mixed with uninoculated CMS. Potted seedlings were placed on a greenhouse bench and watered to saturation daily. Seedlings inoculated with the same *Phytophthora* species were blocked together and a buffer space between groups was made to avoid cross-contamination. Containers were arranged randomly within each *Phytophthora* species group.

Seedlings were observed daily for development of aboveground symptoms of *Phytophthora* infection including chlorosis, wilting, and mortality. Dead or dying seedlings were removed, and isolations from symptomatic root tissue were attempted at 3- to 5-day intervals according to described methods *(4)*. Root symptoms include reddish-brown discoloration of cambium and missing or rotted fine roots. The occurrence and identity of resulting *Phytophthora* colonies were recorded.

After 10 weeks, all remaining nonsymptomatic seedlings were carefully removed from containers. Roots were washed and then rated according to the severity of disease on a scale of 0 to 4: 0 = 0 to 10% of root system killed, 1 = 11 to 25%, 2 = 26 to 50%, 3 = 51 to 75% and 4 = 76 to 100%. Seedlings killed during the study period were given a rating of 5. Isolations were made from a total of 5 seedlings from each host—fungus combination, including the prior isolations from killed seedlings.

Results and Discussion

Mortality. Table 1 lists the percentage of seedlings killed for each *Phytophthora* species pooled over all tested hosts. The percentage of seedlings from which the inoculated species was recovered also is shown (percent reisolation). Isolates of *P. cryptogea, P. cactorum,* and *P. pseudotsugae* caused the highest overall mortality; isolates of *P. megasperma* the least. *P. cryptogea* was the most frequently reisolated. Only one uninoculated control seedling died (California red fir); *P. pseudotsugae* was isolated from this seedling.

Table 1—*Mortality and reisolation of each of 5 species of* Phytophthora *on 11 conifer hosts*

	% killed	% reisolated*
Control†	0.8	1.5
P. megasperma Group 2	3.3	18.3
P. dreschleri	5.0	16.7
P. pseudotsugae	11.3	19.5
P. cryptogea	12.5	65.0
P. cactorum	14.2	34.4

*Percent of seedlings from which inoculated *Phytophthora* was reisolated.
†Non-inoculated sterile CMS mixed with soil for control seedlings.

Table 2 lists the percentage of killed seedlings for each host species pooled over all five *Phytophthora* species and the percentage of seedlings from which

Table 2—*Mortality and reisolation of* Phytopthora *spp. for each of 11 inoculated conifer species*

	% killed	% reisolated*
Ponderosa pine	0.0	4.0
Lodgepole pine	0.0	8.0
Western larch	0.0	55.0
Western white pine	2.0	29.2
West-side Douglas-fir	6.0	12.5
Incense cedar	6.0	20.0
Sitka spruce	6.0	20.0
Engelmann spruce	12.5	50.0
East-side Douglas-fir	14.0	46.2
Grand fir	17.5	35.0
California red fir	22.0	56.0
Mountain hemlock	27.5	57.1

*Percent of seedlings from which inoculated *Phytophthora* was reisolated.

inoculated *Phytophthora* was recovered. Mountain hemlock and California red fir suffered the highest mortality. No mortality occurred in lodgepole and ponderosa pine and western larch. Other host species showed intermediate mortality. Over twice as many Douglas-fir seedlings from the east-side seed source were killed compared to those of west-side origin. Generally, the highest reisolation rates were obtained from seedlings species showing the highest mortality.

Root Rot. Table 3 lists the average root rot rating for each host—fungus combination. The amount of root rot was greatest in California red fir and least in lodgepole and ponderosa pine. Mountain hemlock and Douglas-fir showed relatively severe root rot, with average root rot ratings greater than 1 (over 25% of root system killed). Western larch, Engelmann and Sitka spruce, incense cedar, grand fir, and the pines all showed relatively low amounts of root rot, with average root rot ratings of less than 1. East-side and west-side Douglas-fir showed similar amounts of root rot overall even though percent mortality was different (table 2). A more extensive study is needed to determine if differences in susceptibility between Douglas-fir seed sources are significant.

Phytophthora cryptogea and *P. cactorum* were the most aggressive of the 5 *Phytophthora* species tested. They caused the most mortality and the most severe root rot. *Phytophthora megasperma* Group 2 and *P. drechsleri* were the least pathogenic. *P. pseudotsugae* was intermediate. Similar results were obtained by others *(4, 7)*.

Conclusions

Based on results from this and previous tests *(4, 7)* and field observations, tested hosts and their relative susceptibility to *Phytophthora* species found in nurseries in the Pacific Northwest can be listed as follows:

Highly tolerant
- western redcedar
- lodgepole pine
- ponderosa pine
- western larch

Tolerant
- incense cedar
- Sitka spruce
- Engelmann spruce
- western white pine
- sugar pine

Table 3—*Average root rot ratings for 11 conifer species from the Pacific Northwest inoculated with species of* Phytophthora

Seedling species	Control	*P. megasperma*	*P. drechsleri*	*P. pseudotsugae*	*P. cactorum*	*P. cryptogea*	Ave.
Lodgepole pine	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0
Ponderosa pine	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0
Western larch	0.0 a	0.0 a	0.0 a	—	0.2 a	0.4 a	0.12
Western white pine	0.1 a	0.0 a	0.1 a	0.3 a	0.8 a	0.3 a	0.27
Sitka spruce	0.0 a	0.0 a	0.0 a	0.0 a	1.5 a	0.9 ab	0.40
Engelmann spruce	0.0 a	0.1 a	0.1 a	0.0 a	1.5 ab	2.1 b	0.63
Incense cedar	0.8 ab	1.0 ab	0.6 ab	0.0 a	0.2 ab	1.9 b	0.75
Grand fir	0.5 a	1.2 a	0.8 a	—	0.0 a	2.1 a	0.92
West-side Douglas-fir	0.0 a	0.6 ab	1.4 abc	2.6 c	2.2 c	2.0 bc	1.47
Mountain hemlock	0.0 a	0.5 ab	2.3 c	—	1.9 bc	4.0 d	1.74
East-side Douglas-fir	0.3 a	0.9 a	0.6	4.3 b	3.1 b	1.8 a	1.83
California red fir	1.8 ab	1.9 ab	0.5 a	3.5 b	3.0 b	3.6 b	2.38
Mean root rot rating	0.29	0.52	0.58	1.19	1.46	1.59	

Root rot ratings: 0 = 0 to 10%, 1 = 11 to 25%, 2 = 26 to 50%, 3 = 51 to 75%, and 4 = 76 to 100% root rot. Ratings in each horizontal row followed by the same letter do not differ significantly according to Duncan's new multiple range test ($P < 0.05$).

Susceptible

white fir
grand fir
Pacific silver fir
Douglas-fir

Highly susceptible

mountain hemlock
western hemlock
noble fir
California red fir

Recommendations

Knowledge of relative susceptibility of hosts and pathogenicity of various *Phytophthora* species should be useful to northwest nursery managers when they plan sowing and transplanting locations. Highly susceptible species should never be placed in disease-conducive areas. Tolerant or susceptible species, if placed in disease-conducive areas, should be given cultural or chemical treatments to reduce the likelihood or severity of disease. Highly tolerant species can be put in disease-conducive areas with relatively little risk.

Some caution should be exercised, though, when predicting field outcome from greenhouse results. Changes in the pathogen population characteristics, the existence of different, more aggressive isolates in nursery fields than those used in greenhouse tests, or ideal field environments may result in severe disease in hosts previously thought tolerant. An integrated control program, incorporating both cultural and chemical practices, is recommended *(1)*. Such a program would include

1. Proper soil management, ensuring adequate drainage through and over the soil.
2. Irrigation practices that avoid constantly saturated soils.
3. Removal of chronic wet areas from production.
4. Use of tolerant tree species in diseased or disease-conducive areas.
5. Good sanitation practices to insure that diseased seedlings or soil do not contaminate disease-free areas.
6. Pre-sowing fumigation, if economically, socially, and environmentally feasible.
7. Fungicide applications for high-risk seedlings (very susceptible seedlings and seedlings planted in diseased areas or disease-conducive areas).

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