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PHYTOPHTHORA ROOT DISEASE OF BAREROOT DOUGLAS-FIR SEEDLINGS USDA FOREST SERVICE LUCKY PEAK NURSERY, BOISE, IDAHO

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ABSTRACT

Phytophthora cactorum was consistently associated with decayed roots of small, chlorotic, bareroot Douglas-fir seedlings at the USDA Forest Service Lucky Peak Nursery, near Boise, Idaho. Species of *Fusarium* and *Pythium* were also commonly colonized roots of diseased seedlings, but were mostly secondary colonizers of diseased roots. *Phytophthora* infection resulted in reduced growth; affected seedlings had to be grown for an additional year to meet outplanting specifications. Soil fumigation and growing less-susceptible conifer species on poorly-drained sites where *Phytophthora* disease occurs will help reduce future losses.

The USDA Forest Service Lucky Peak Nursery near Boise, Idaho produces bareroot seedlings for reforestation of federal lands in the Intermountain Region. Several different species are produced, including Douglas-fir (*Pseudotsuga menziesii* var. *glauca* [Beissn] Franco). A crop of Douglas-fir sown in the spring of 1993 was lifted in the fall of 1995 and placed into cold storage. Seedlings were of insufficient height to meet outplanting specifications after two growing seasons. They were therefore left in beds for another growing season.

In April, 1996 seedlings were examined in cold storage; many were relatively small and displayed some crown dieback and chlorotic foliage (figure 1). Root systems of some seedlings appeared unhealthy with black roots and noticeable decay, particularly concentrated near root tips. Affected seedlings had been grown in the western portion of field 1 on heavy, poorly-drained soils. During seedling extraction, several roots had been broken, indicating poor structural root development.

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Eleven seedlings displaying chlorotic and/or dieback symptoms were analyzed in the laboratory for associated potential root-pathogenic fungi. Seedling roots were thoroughly washed to remove adhering soil particles, cut into pieces approximately 5mm in length, surface sterilized in a 10% solution of aqueous sodium hypochlorite, rinsed in sterile distilled water, and placed on agar media selective for either *Fusarium* and associated species (Komada 1975) or water mold fungi including *Pythium* and *Phytophthora* spp. This latter medium contained V-8 juice agar amended with the antibiotics pimaricin, rifamycin, ampicillin, and the fungicide pentachloronitrobenzene (James et al. 1990). A total of 400 root pieces selected from the eleven seedlings were assayed on the V-8 juice selective medium. Another 100 root pieces were assayed on Komada's medium. Plates with roots were either incubated under cool, diurnal, fluorescent light (Komada's) or in the dark (V-8 juice). Selected emerging fungi were transfered to potato dextrose agar or carnation leaf agar (Fisher et al. 1982) to aid identification. Suspected water mold fungi were grown for 5-7 days on water agar, blocks of which were tranferred to petri plates containing autoclaved pond water which stimulated production of sporangia, chlamydospores, and oospores. *Fusarium* species were identified using the taxonomic scheme of Nelson et al. (1983); water mold fungi were identified based on monographs by Middleton 1943 and Waterhouse 1963, 1968.

Figure 1. 3-0 bareroot Douglas-fir seedling from the USDA Forest Service Lucky Peak Nursery with chlorotic foliage caused by root infection with *Phytophthora cactorum*.

Fusarium spp. were isolated from about 90% of the Douglas-fir roots sampled. The major species isolated was *F. oxysporum* Schlecht. Other species encountered much less frequently included *F. solani* Mart., *F. acuminatum* Ell & Ev. and *F. avenaceum* (Fr.) Sacc. *Fusarium* spp. are common soil inhabitants at the Lucky Peak Nursery (James 1996; Stone et al. 1995) and commonly colonize roots of diseased as well as healthy conifer seedlings (James 1996; James and Gilligan 1988). The occurrence of extensive *Fusarium* root infection is not altogether unexpected, because these fungi are well adapted for quickly colonizing susceptible root material. *Fusarium* spp. may or may not cause disease; level of disease is usually related to amount of soil inoculum present (James and Gilligan 1986, 1990), percentage of virulent strains(James et al. 1991), and presence and extent of other competing fungi (James et al. 1993).

Isolations also resulted in substantial levels of water mold fungi. One hundred eighteen of the 400 sampled root pieces (29.5%) were colonized with fungi identified as either *Pythium* or *Phytophthora*. This level of infection is very high for the Lucky Peak Nursery, because water mold fungi are usually not detected at such high levels in soil or seedling root assays (James, unpublished; Stone et al. 1995). Three *Pythium* species were isolated from diseased Douglas-fir roots: *P. irregulare* Buisman (the most common), *P. ultimum* Trow., and *P. grandisporangium* sp. nov. Only one *Phytophthora* species (*P. cactorum* [Leb. & Cohn] Schroet.) was consistently isolated from diseased roots.

The major cause of seedling stunting, dieback, and chlorosis was probably root disease caused by *P. cactorum*. *Phytophthora* root infection has commonly been associated with disease symptoms of Douglas-fir seedlings at other nurseries in the Pacific Northwest (Hamm and Hansen 1982, 1987). *Phytopathora* spp. particularly cause blackened, decayed roots that may also be colonized by other potential pathogens, especially *Pythium* spp. (Hamm and Hansen 1987; Hansen et al. 1980). Unfortunately, *Phytophthora* spp. are often difficult to isolate from seedling roots because of presence of other root-colonizing fungi (Hamm and Hansen 1987). However, when *Phytophthora* spp. are found at relatively high levels, they are usually considered the primary cause of disease with other isolated organisms being mostly secondary (Hamm and Hansen 1982).

Phytophthora cactorum is a common, widespread pathogen of many different types of hosts, including conifer seedlings (Adams and Bielenin 1988; Aldwinkle et al. 1975; Ellis et al. 1982; Hamm and Hansen 1987). This species has also been isolated from root crowns of western larch (*Larix occidentalis* Nutt.) in a tree improvement plantation at the USDA Forest Service Nursery in Coeur d'Alene, Idaho (James 1993). The fungus can be very aggressive, attacking conifer seedlings quickly, deteriorating roots, and causing mortality (Hamm and Hansen 1982, 1983, 1987). Once it is established in roots or root crown tissues, *P. cactorum* may be rapidly replaced by other fungi; as this happens, the original colonizing *Phytophthora* may be very difficult to detect (Hamm and Hansen 1987; James 1993).

Phytophthora spp. are most commonly associated with heavy clay-like soils located in poorly-drained portions of nurseries (Hamm and Hansen 1987; James 1993). They tend to cause problems where water accumulates, primarily because they spread via water-borne zoospores (Stamps et al. 1990; Waterhouse 1963). Therefore, improving water drainage may be important for reducing further damage by these pathogens. This may not always be easy to do because of nursery soil characteristics. Therefore, perhaps a better approach for reducing future damage by *Phytophthora* diseases is to grow the most disease-tolerant species in areas where high disease impacts are expected. For example, most pine species are not as susceptible to *Phytophthora*-associated root diseases as Douglas-fir (Hamm and Hansen 1982). There may also be conifer host specificity within certain *Phytophthora* species (Hamm and Hansen 1981; Hansen et al. 1986). Therefore, pine production should be emphasized in fields known to have high *Phytophthora* potential. In those areas where

disease potential is less (better-drained, lighter soils), Douglas-fir should probably be grown. Another possible alternative is to concentrate pine production at the Lucky Peak Nursery and grow Douglas-fir at other Forest Service nureries where the *Phytophthora* disease potential is less and conditions for producing Douglas-fir seedlings are more favorable (J. H. Stone Nursery - Medford, OR; Coeur d'Alene Nursery, ID).

Phytophthora root diseases are also controlled by standard soil fumigation; these pathogens are especially susceptible to killing by methyl bromide/chloropicrin (James 1989; James et al. 1990). Unfortunately, methyl bromide will soon no longer be available for soil fumigation (Stone et al. 1995). The major alternative fumigant (dazomet) is not as effective as methyl bromide/chloropicrin in eliminating soil-borne pathogens, particularly in heavy soils that occur at the Lucky Peak Nursery (Hoffman and Williams 1988; James, unpublished; Marshall 1983). In some cases, soil drenches with specific water mold fungicides, such as metalaxyl, may help reduce disease severity. However, such applications are expensive and not always effective (Ellis et al. 1982; Hamm et al. 1984). Development of fungicide-resistant *Phytophthora* strains may also occur (Bielenin and Jones 1988).

It is likely that some seedlings with *Phytophthora* root infection were outplanted. Hansen et al. (1980) previously found that the fungus does not spread on roots following outplanting on typical forest sites. Rather, infected plants usually produce new, non-diseased roots. Level of disease symptoms on outplanted plants seems related to the extent of noticeable root decay on seedlings leaving the nursery. Usually, seedlings with extensive root decay are culled at lifting so they would not normally be outplanted.

Phytophthora spp. are common soil inhabitants that have both pathogenic and saprophytic phases. However, these fungi tend to become more pathogenic when large amounts of susceptible hosts are grown in infested fields (Hansen 1987). As a result, *Phytophthora* spp. become specialized pathogens, capable of causing disease on only one or a few host species. In the absence of susceptible species, less host specialization will occur and the overall *Phytophthora* population will tend to be less virulent.

Probably the best alternative for control of *Phytophthora* diseases at the Lucky Peak Nursery is prevention by planting disease-tolerant pine species in areas where *Phytophthora* pathogens are known to occur. Soil fumigation with dazomet should reduce *Fusarium* root disease impacts (James, unpublished) and may help reduce soil populations of *Pythium* and *Phytophthora*. Periodic soil assays for population levels of these potential pathogens should help growers predict disease losses in the future; such monitoring should be an important part of the integrated pest management system at the nursery. Hopefully, implementation of these procedures will help reduce root disease losses in the future

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