Phytophthora Root Rot in Forest Nurseries of the Pacific Northwest[1]

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Abstract--Phytophthora root rot continues to cause significant damage in some Pacific Northwest nurseries. Recognition of the disease is discussed as is fungal biology, host-pathogen interactions and origin in nurseries.

Phytophthora root rot in Pacific Northwest bare root nurseries was first reported in 1975, causing severe damage to Douglas-fir (Pseudotsuga menziesii) (Pratt et al. 1976). That report and subsequent ones (Hamm & Hansen 1981, 1982A, 1982B, 1983) have identified the Phytophthora species that cause damage in Northwest nurseries (Table 1) and the susceptibility of conifer seedlings grown in the region (Table 2). Phytophthora root rot has rarely been found in containerized situations, due to the ability to regulate contamination from water, media and pots.

Table 1. Species of Phytophthora that cause root rot in Pacific Northwest Nurseries.

P. drechsleri
P. pseudotsugae
P. cinnamomi
P. cactorum
P. cryptogea
P. megasperma Douglas-fir
P. megasperma Broad host range

Typically, symptoms of Phytophthora infection are not exhibited until seedlings are approaching their second growing season, or following transplanting. Pre and post-emergence damping off can occur during the first year, but this is more commonly due to Fusarium and Pythium species. By early spring of their second year, root rotted trees begin to yellow as they break dormancy. Damage is often concentrated in low areas in the field where surface water accumulated during winter. By early summer the most severely infected seedlings have died. Seedlings not as severely infected commonly exhibit delayed bud break, poor elongation of the new terminal and lateral shoots (giving a bottle brush appearance) and chlorosis. Seedlings with light infection may not express distinct top symptoms. Below ground, severe Phytophthora damage is easily recognized. In trees moderately to severely rotted, root systems noticeably lack lateral roots and have a shortened tap root; less severely rotted trees possess fewer lateral roots and a shortened tap as compared to healthy seedlings. Light scraping of the root cortex of diseased seedlings with a knife exposes the cambial region and reveals the characteristic reddish brown discoloration of Phytophthora infected tissue in contrast to white, healthy tissue further up the stem.

Table 2. Conifer seedlings susceptible to Phytophthora root rot. Susceptibility of species marked with an asterisk (*) is known only from artificial inoculations.

Douglas fir	Western white pine
Western Hemlock	Grand fir
• Mt. Hemlock	White fir
• Incense cedar	Noble fir
• Sitka Spruce	Shasta red fir
• Englemann Spruce	Pacific Silver fir
• Lodgepole pine	* Western larch
Sugar pine	Ponderosa pine

With the exception of P. cinnamomi, these species of Phytophthora are quite adapted to the environmental conditions found in Pacific Northwest nurseries. Roth and Kulman (1966) concluded that P. cinnamomi was not a threat to the Douglas-fir forests of the region due to its requirement for simultaneous warm soil temperatures and high soil moisture. This requirement apparently holds for nurseries as well since P. cinnamomi has caused substantial

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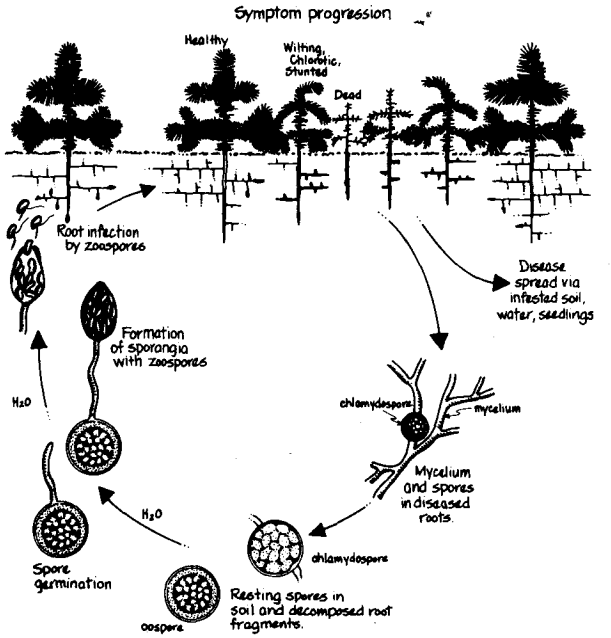

Figure 1. -- Life cycle of Phytophthora spp. on conifer seedlings.

damage only in: 1) a warmer coastal nursery; 2) in a bare root seed orchard; and 3) in containerized seedlings propagated for transplanting to a seed orchard. In contrast, the remaining Phytophthora species have been found in most major bare root nurseries in Oregon, Washington and into British Columbia. These species apparently survive well in nurseries under normal conditions. Moist periods favor production of sporangia, which in turn develop and release swimming s-pores called zoospores (Fig. 1).

While dissemination of zoospores in the soil is quite limited (Duniway 1976), widespread infection can result if surface water accumulates or water or equipment moves through contaminated blocks. Zoospores are attracted to exudates from roots of susceptible hosts. This may partially explain why root pruned transplants are sometimes severely damaged. Zoospore production and dissemination decrease with declining soil moisture, although root rot severity on infected trees may continue to increase through the summer. Irrigation extends the period of dissemination on poorly drained soils.

Phytophthora can be isolated from live, infected seedlings throughout the year. Longterm survival apparently is by resistant structures (e.g., oogonia, chlamydospores) in soil or in infected roots or dead trees (Hansen et al. 1980). Fortunately other factors must be limiting disease development on forest sites.

These Phytophthora species lower survival of infected outplanted seedlings but do not spread from infected stock to adjacent healthy trees (Hansen et al. 1980).

Losses due to Phytophthora root rot are highly variable. Factors such as crop type (1+0, 2+0, 2+1 etc.) seedling species, moisture (artificial and natural) and/or soil type are important. Most extensive damage in past years has been seen in transplanted Douglas-fir. As mentioned previously, wound sites on transplanted seedlings apparently attract zoospores but high soil moisture due to watering after transplanting (favoring zoospore formation), seedling stress from uplifting, storage, root pruning, etc., and transplanting into unfumigated, possibly heavy and warming spring soils and the amount of Phytophthora present on seedlings or in the soil, probably all contribute to disease severity. Substantial losses also occur in 1+0 and 2+0, usually when seedlings have been planted in areas where water is allowed to stand particularly in bed ends or low spots in the field (Hansen et al. 1979).

Susceptibility of the tree species grown in Northwest nurseries varies as does the aggressiveness of the Phytophthora species. P. cinnamomi, where conditions allow, and P. cryptogea have been shown to be highly aggressive to most native conifers (8); P. megasperma Douglas-fir (Hamm and Hansen 1981, Hansen and Hamm 1983) is generally less aggressive but more damaging than P. drechslei and P. cactorum, while P. megasperma Broad host range (Hamm and Hansen 1981, Hansen and Hamm 1983) and P. pseudotsugae are usually only weakly aggressive. Interestingly, these later two species are the most often isolated from diseased seedlings. Pathogenicity information is based on controlled in vitro testing for a period of 8-10 weeks. The extended length of time seedlings are grown in nurseries (1-3 years), coupled with a long favorable environment, can allow even the least aggressive of these fungal species to cause significant damage in a nursery setting. Generally, hemlock, true firs and Douglas-fir seedlings are the most susceptible to Phytophthora infection, followed by spruce and pine. Western red cedar was undamaged by any Phytophthora species in our tests (Hamm and Hansen 1982B, S.A. Cooley & P.B. Hamm unpublished).

Host specificity was generally not evident, except that isolates of P. cryptogea from sugar pine caused significantly greater root rot on that host than did isolates of the same species from other hosts (Hamm and Hansen 1982B). Although both groups of P. megasperma are pathogenic on most conifers tested, P. megasperma Douglas-fir is pathogenic only to conifers while P. megasperma Broad host range has a larger host range (Hansen and Hamm 1983).

The origin of Phytophthora in nurseries of the region is an ongoing question. Most likely Phytophthora was present in the soil prior to nursery establishment. The species found (except P. pseudosugae) are common agricultural pathogens and since most nurseries were established on long used agricultural sites, their prior presence seem reasonable. This is supported by the fact that some isolates which attack Douglas-fir can cause disease on soybean and alfalfa. The occurrence of many of the same Phytophthora species in many nurseries is best explained by movement of transplant stock between nurseries.

During the twelve years since Phytophthora was first reported in the Pacific Northwest bare root nurseries, these fungi have been directly responsible for the closure of two large nurseries and substantial reduction in production in several others. Dollar loss also occurs through poor survival of infected seedlings outplanted to forest sites (Hansen et al. 1980). More basic and applied research is needed to better understand the biology of these organisms and to develop integrated control strategies. This point is examplified by the continual, sometimes extensive losses that occur due to Phytophthora throughout the region.

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