DISEASES OF CONTAINERIZED CONIFER SEEDLINGS

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INTRODUCTION

Three major groups of diseases affect containerized conifer seedlings in western North America. These include damping-off/root diseases, Sirococcus shoot blight, and Botrytis blight. Several other diseases may occur (table 1), but their effects are generally much less severe than these three. Diseases of containerized conifers may proliferate in a greenhouse environment because seedling growing conditions are often conducive to disease development. Therefore, disease impact can usually be reduced by altering environmental factors to reduce pathogen buildup or host susceptibility.

Damping-off/Root Diseases

These diseases are caused primarily by four genera of fungi: *Pythium*, *Phytophthora*, *Rhizoctonia*, and *Fusarium*. Significant losses usually occur only when seed is infested with these pathogens; the typical container growing medium of vermiculite, peat, or perlite is generally not contaminated with these pathogens (Peterson, 1974).

Water mold fungi (*Pythium*, *Phytophthora*) are favored by high humidity regimes produced in greenhouses. Most damping-off occurs before or within a few days of seedling emergence (Sutherland and

Table 1.--Minor diseases of containerized conifer seedlings in western North America.

Name of disease	Causal organism(s)	Hosts	Reference
Needle tip dieback	*Alternaria* spp.	Engelmann spruce white spruce	Sutherland and van Eerden (1980)
Shoot tip blight	*Diplodia pinea* (Desm.) Kickx.	Ponderosa pine	Schweitzer and Sinclair (1976)
Fusarium top blight	*Fusarium oxysporum* von Schlechtendahl ex Fr.	Douglas-fir pines	Sutherland and van Eerden (1980)
Shoot blight	*Pestalotia* spp.	Amabilis fir western larch	Sutherland and van Eerden (1980)
Needle dieback	*Phoma* spp.	Pines spruce western hemlock western redcedar	Sutherland and van Eerden (1980)
Leader/branch dieback	*Sclerophoma* (=*Phoma*) *pityophila* (Corda) Hohn.	Lodgepole pine Sitka spruce	Miller (1974)

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van Eerden 1980). However, Pythium and Fusarium can also cause damage after seedlings are 1 or more months old (Peterson 1974). Late damage by Pythium is especially common when high humidity is maintained for extended periods. Nitrogen fertilization during periods of seedling susceptibility may also increase losses from damping-off (Peterson 1974).

Phytophthora is usually an important pathogen only on woody ornamentals in containerized operations (Peterson 1974). Apparently, the growing medium used in forest seedling production provides enough air space and proper moisture drainage to discourage Phytophthora.

Fusarium is a common seed inhabitant of many conifer species (Sutherland and van Eerden 1980). If present, Fusarium rapidly colonizes young seedling tissues and may mask primary infection by other fungi, such as Pythium (Peterson 1974).

Damping-off and root diseases are best controlled by providing clean seed, noncontaminated growing media, and environmental manipulations within greenhouses during periods of maximum seedling susceptibility. Applications of fungicides after damping-off becomes evident is usually not very effective (Peterson 1974). Seed treatment with fungicides has usually eliminated pathogens on seed, but has also frequently reduced seedling emergence (Peterson 1974). Other problems with fungicide seed treatment include lack of prolonged seed protection because of leaching of fungicides, resistant fungal populations may exist, and most fungicides are not effective against all potential damping-off fungi (Sutherland and van Eerden 1980). Because of these problems, many growers have emphasized treatment of seed in a continuous running water bath for at least 48 hours or use of hydrogen peroxide. Incorporating fungicides into growing media to improve seedling survival has been tested (Pawuk and Barnett 1974) and may be used if media is suspected of being contaminated. Improving air circulation and reducing watering during periods of high seedling susceptibility may also help reduce losses from damping-off or root diseases.

Sirococcus Shoot Blight

Sirococcus strobilinus Pruess is commonly associated with tip dieback and mortality of young pine seedlings grown within seedbeds of nurseries where cool, wet conditions prevail (Schwandt 1981; Smith 1973). However, in British Columbia nurseries, the disease is more prevalent on container-grown conifers (Sutherland, Lock and Farris, 1981). Sirococcus occurs rarely in container operations in the United States.

Sirococcus shoot blight is particularly damaging in British Columbia coastal nurseries where it primarily affects seedlings of Sitka spruce (Picea sitchensis (Bong.) Carr.), white spruce (P. glauca (Moench) Voss), and Engelmann spruce (P. engelmannii Parry (Sutherland, Lock and Farris 1981). Other hosts include lodgepole pine (Pinus contorta Dougl.), ponderosa pine (Pinus ponderosa Laws.) and occasionally western hemlock (Tsuga heterophylla (Raf.) Sarg.). The pathogen is often seedborne on spruce, but apparently not on the other host species (Sutherland, Lock and Farris 1981).

Infection within greenhouses occurs via water-splashed spores originating from seedborne diseased spruce or diseased trees adjacent to the greenhouses (Sutherland and van Eerden 1980). On spruce, symptoms usually appear first on random seedlings within about 6 weeks of emergence (Sutherland, Lock and Benson 1982). Symptoms appear between the period before the seedcoat is shed through to secondary needle appearance and leader development. On species where the fungus is not seedborne, such as lodgepole pine, damage tends to appear after secondary needles have developed (Sutherland, Lock and Farris 1981). Primary needles are initially killed from the base upward, followed by the remainder of the epicotyl and above-ground portions of the hypocotyl. Killed seedlings are desiccated, light to reddish-brown, and usually remain upright. Black pycnidia often form on the inner base of diseased needles (Sutherland and van Eerden 1980).

occurs in endosperm and embryo tissues of seeds with either shrunken or normal-appearing contents. Because most spruce seeds are presently collected from wild trees, there are no practical methods for reducing or preventing seed infection.

Incidence of Sirococcus shoot blight should diminish as disease-free seed produced in seed orchards becomes prevalent (Sutherland and van Eerden 1980). Nursery managers should be alerted before sowing seedlots with severe blight history so that remedial action can be taken at the first appearance of the disease. Such action includes roguing diseased seedlings and applying protective fungicides. Other recommendations include reducing relative humidity, increasing temperatures in cool greenhouses, and providing supplemental light during cloudy periods (Sutherland and van Eerden 1980).

Botrytis Blight

Grey mold caused by *Botrytis cinerea* (Fr.) Pers. is usually the most damaging disease of containerized conifers. The disease is especially severe in greenhouses, where conditions are ideal for infection by and buildup of the fungus (James, Woo and Myers 1982; McCain 1978).

Although many conifer species are susceptible, greatest damage has been reported on Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), western hemlock, lodgepole pine, and spruce in British Columbia (Sutherland and van Eerden 1980), western larch (*Larix occidentalis* Nutt), lodgepole pine, and Engelmann spruce in northern Idaho and northwestern Montana (James and Genz 1983; James and Gilligan 1983; James, Woo and Myers 1982), lodgepole pine, Scots pine (*Pinus sylvestris* L.), Engelmann spruce and blue spruce (*Picea pungens* Engelm.) in Colorado (Gillman and James 1980), and giant sequoia (*Sequoiadendron giganteum* (Lindl.) Buchholz) and Douglas-fir in California (McCain and Smith 1978).

species has a wide host range with more than 200 hosts described. Other *Botrytis* species are more specialized in their pathogenicity and have narrower host ranges (Jarvis 1980b).

A typical disease cycle for *B. cinerea* is shown in figure 1. The sexual stage of the fungis is *Botryotinia fuckeliana* (DeBary) Whetzel, which has been found frequently in nature (Lorbeer 1980). Apothecia produced from overwintering sclerotia give rise to ascospores which may initiate infection (Jarvis 1980a). However, conidia are responsible for most spread and buildup of the disease within greenhouses.

Initial infection in greenhouses occurs from nearby infected plants or plant debris and sclerotia (Coley-Smith 1980; McCain 1978). Conidia are dry and dispersed in air currents or sometimes in water (Jarvis 1980a). Conidial dispersal occurs primarily when the relative humidity is rising or falling rapidly (Jarvis 1980a). Presence of free moisture on foliage for several hours is necessary for infection (Blakeman 1980). Prolonged cool temperatures of about 13-14° C are also necessary. Germinating conidia form appressoria on the surface of leaves and germ tubes penetrate directly through the cuticle (Blakeman 1980). Wounded or necrotic host tissues are quickly infected and colonized (Sutherland and van Eerden 1980).

Within the disease cycle, latency may occur following conidial dispersal or infection (fig. 1). However, when inoculum is abundant and environmental and host susceptibility conditions are conducive, "aggressive pathogenicity" occurs (Jarvis 1980a). Conducive environmental conditions include high relative humidity, cool temperatures, and free surface moisture on foliage. Host susceptibility factors include nutrient imbalances and presence of senescent tissues for saprophytic buildup of inoculum (Sutherland and Van Eerden 1980). When conditions for infection are ideal and inoculum abundant, latent periods are short and epidemics may occur quickly (Jarvis 1980a).

Figure 1. Disease cycle of *Botrytis cinerea* (adapted from Jarvis 1980a).

Resting structures (sclerotia) often form after the growth phase of the fungus or following seedling mortality (Coley-Smith 1980). Sclerota persist in soil, plant debris, or on greenhouse benches and floors; they produce either sexual or asexual spores upon germination (fig. 1).

Symptoms of *Botrytis* infection usually become apparent when crowns of containerized conifers begin to close; affected seedlings usually occur in isolated pockets (Gillman and James 1980; James, Woo and Myers 1982). The fungus usually first attacks senescent tissues at the base of seedlings and then spreads to surrounding live host material (Smith, McCain and Srago 1973; Sutherland and Van Eerden 1980). Symptoms on infected seedlings include needle necrosis, twig and stem lesions and mortality.

Controlling Botrytis blight is difficult because the pathogen is capable of attacking all plant parts at almost any stage of their growth and in storage (Maude 1980). The best approach to control is to avoid conditions that are best suited for disease buildup. This includes controlling stocking by reducing density to improve air circulation among seedlings (Cooley 1981), which means producing fewer trees per unit area. However, this is compensated by higher quality, disease-free seedlings. If possible, irrigation should also be limited (Cooley 1981). Adding a drying agent to irrigation water to expedite drying of foliage may also result in reduced levels of infection. Fertilization should also be properly controlled. For example, too much fertilizer may cause seedlings to burn, providing ideal infection courts for *Botrytis* (Sutherland and van Eerden 1980), and too little fertilizer may stress seedlings making them more susceptible to infection (Cooley 1981). Another important practice to reduce losses from Botrytis blight is sanitation, aimed primarily at reducing inoculum. Sanitation practices include periodic removal of infected plants and plant debris and cleaning greenhouse benches and floors with a surface sterilant between crops (Cooley 1981). Potential inoculum sources outside greenhouses, especially those upwind, should be eliminated when possible.

As containerized production of conifers has increased, Botrytis blight has become more important. As a result, many growers have had to rely on fungicides to keep losses at acceptable levels. Several fungicides either used operationally or showing promise for future use, are listed in table 2.

Certain fungicides have special advantages, such as low cost, ease of handling, and improved efficacy. However, most recommendations for fungicide use stress rotating chemicals to discourage tolerance buildup in *Botrytis* populations (Cooley 1981; Gillman and James 1980; James and Gilligan 1983). Tolerance has been demonstrated for most of the commonly used fungicides, especially if they have been used repeatedly. When tolerance develops, alternative chemicals are usually tried. However, unless precautions are taken, Botrytis may become resistant to these new chemicals. For example, two new fungicides (iprodione and vinclozolin) developed for other crops, have shown promise in controlling Botrytis in conifer greenhouses (James, Woo and Myers 1982; Powell 1982). However, laboratory studies indicate that several isolates of Botrytis can quickly develop tolerance to both of these chemicals even at high concentrations (James, unpublished). Therefore, apparently none of the chemicals currently available can be considered completely effective against all Botrytis strains likely to be encountered. As a result, fungicide usage should be limited to the minimum amounts necessary for effective disease control. Also, rotated fungicides should have different modes of action, i.e., systemic chemicals alternated with broad spectrum protectants (Cooley 1981; James and Gilligan 1983). Combining proper cultural practices with prudent use of fungicides is usually necessary for effective control of Botrytis blight.

Table 2. Fungicides used to control Botrytis blight in containerized conifer nurseries

Fungicide	Trade name	Manufacturer	Chemical name
benomyl	Benlate® Tersan 1991® Benomyl	 Dupont Lilly Miller	Methyl-1-(butylcarbamoyl)-2 benzimidazole carbamate
captan	Captan Orthocide®	Stauffer Chevron	N-[(Trichloromethyl)thio]-4-cyclohexene-1, 2-dicarboximide
chlorothalonil	Bravo 500® Daconil 2787®	Diamond Shamrock	Tetrachloroisophthalonitrile
copper	Tri-Basic®	CP Chemical Phelps Dodge Cities Service	Basic copper sulfate
dicloran	Botran®	Tuco	2,6-Dichloro-4-nitroaniline
ferbam	Carbamate	Dupont	Ferric dimethyldithiocarbamate
iprodione	Chipco 26019®	Rhone-Poulenc	3(3,5-dichlorophenyl)-N-(1-methylethyl)-2,4-dioxo-1-imidazolidinecarboximide
mancozeb	Fore®	Dupont	Contains 16% maganese, 2% zinc and 62% ethylene bisdithiocarbamate ion/maganese ethylene bisdithiocarbamate plus zinc ion
maneb	Dithane M-22®	Rhom & Haas	Manganese ethylene bisdithiocarbamate
thiophanate-methyl	Zyban®	Mallinckrodt	dimethyl[(1,2-phenylene)bis(iminocarbonothioyl)]bis(carbamate)
thiram	Thylate®	Dupont	Tetramethylthiuram disulfide
vinclozolin	Ronilan® Ornalin®	BASF	3-(3,5-dichlorophenyl)-5-ethenyl-5-methyl-2,4-oxazolidinedion
zineb	Zineb Dithon Z78®	Rhom & Haas	Zinc ethylenebisdithio-carbamate

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