BIOLOGY AND MANAGEMENT OF BOTRYTIS BLIGHT

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ABSTRACT

Botrytis cinerea is an important pathogen of conifer seedlings in western North America, especially within greenhouses. Environmental conditions in greenhouses, such as high humidity and cool temperatures, are conducive to infection by and spread of this fungus. To reduce losses from Botrytis blight, cultural practices aimed at reducing inoculum and altering environmental conditions necessary for infection should be combined with rotated use of different fungicides. Several fungicides used to control *Botrytis* in the past are no longer effective because the fungus has developed tolerance to them. Fungicides commonly used to control this disease are discussed.

INTRODUCTTON

Grey mold caused by *Botrytis* cinerea (Fr.) Pers. is one of the most damaging diseases of seedlings in forest tree nurseries. The disease is especially severe on containerized conifers in greenhouses where conditions are ideal for infection by and buildup of the fungus (James, Woo and Myers 1982; McCain 1978). However, Botrytis blight may also occur in seedbeds where it causes damage during cool, wet portions of the Year (James 1980; James and others 1983). The fungus is also responsible for losses to seedlings in storage (Smith and others 1973).

Although many conifer species are susceptible to *Botrytis,* greatest damage has been reported on Douglas-fir, western hemlock, lodgepole pine, and spruce in British Columbia (Sutherland and Van Eerden 1980), western larch, lodgepole pine, and Engelmann spruce In northern Idaho and northwestern Montana (James and Genz 1983; James and Gilligan 1983; James and others 1982), lodgepole pine, Scots pine, Engelmann spruce and blue spruce in Colorado (Gillman and James 1980), and giant sequoia and Douglas-fir in California (McCain and Smith 1978).

BIOLOGY

Of the 22 species of *Botrytis,* *B.* cinerea, the one that affects conifer seedlings, is the most common and has the widest host range (over 200 plant species) (Jarvis 1980b; Sutherland and Van Eerden 1980). Other Botrytis species are more pathogenically specialized and thus have narrower host ranges

A typical disease cycle for B. *cinerea* is shown in figure 1. Initial infection in nurseries results from spores produced on nearby infected plants or crop debris and from fungal resting structures (sclerotia) (Coley-Smith 1980; McCain 1978). Sclerotia often form after the growth phase of the fungus or following seedling mortality (Coley-Smith 1980). These sclerotia persist in soil, plant debris or within greenhouses and can produce both sexual (ascospores) and asexual (conidia) spores.

The sexual stage of the fungus is *Botryotinia fuckeliana* (DeBary) Whetzel, which has been found frequently in nature (Jarvis 1980b). Apothecia produced from overwintering sclerotia give rise to ascospores which may initiate infection (Jarvis 1980a). However, asexual conidia are responsible for most infection, spread, and buildup of the disease in nurseries.

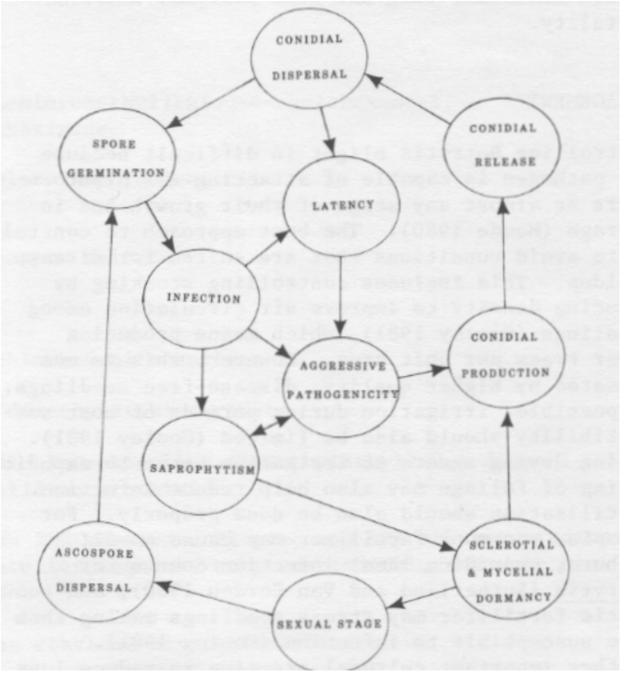

Figure 1.--Disease cycle of *Botrytis cinerea* (after Jarvis 1980a).

Conidia are dry and usually dispersed by air currents and less frequently carried by water droplets (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 and prolonged cool temperatures of about 13-14^{0} C are necessary for infection (Blakeman 1980). Germinating conidia form appressoria on the surface of leaves and germ tubes penetrate directly through the cuticle (Blakeman 1980). Wounded or necrotic

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host tissues are quickly infected and colonized (Sutherland and Van Eerden 1980).

Within the disease cycle, the fungus may become inactive (latent) following conidial dispersal or infection (figure 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 causing seedling stress 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 can occur quickly (Jarvis 1980a).

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

MANAGEMENT

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 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 during periods of host susceptibility should also be limited (Cooley 1981). Adding drying agents to irrigation water to expedite drying of foliage may also help reduce infection. Fertilization should also be done properly. 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 cultural practice to reduce loss 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 1. Some of the more important of these are discussed below.

Benomyl is a systemic fungicide that has been used operationally since the early 1970's. When It was first introduced, benomyl provided excellent control of many diseases over a wide range of crop plants. As a result, many growers began to use it exclusively to control Botrytis blight, especially in greenhouses (McCain 1978; Miller and Fletcher 1974). However, as early as 1971 tolerance to benomyl by *Botrytis* was evident (Bollen and Scholten 1971). Since then, there have been many reports of tolerance to this fungicide by different pathogens on a variety of crops including ornamental flowers, vegetables, fruit crops, and conifer seedlings (Cooley 1981; Gillman and James 1980; James and Gilligan 1983; Jarvis and Hargreaves 1973; Miller and Fletcher 1974). Simple tests have been developed to quickly assay *presence* of tolerant fungal strains. These involve growing the test organisms on nutrient media amended with the fungicide. Such tests have been used to evatute tolerance of *Botrytis* strains to benomyl and other fungicides throughout the West. Results indicate that tolerance of *Botrytis* to benomyl is so widespread that this chemical is usually ineffective and no longer recommended for use in most nurseries (Cooley 1981; Gillman and James 1980; James and Gilligan 1983).

Chlorothalonil is another fungicide that has been commonly used to control *Botrytis* in greenhouses. However, its ability to adequately control the disease has often been reduced, especially after continued use (James and Gilligan 1983). Recent tests indicate that some *Botrytis* populations in Oregon, Montana, and Colorado are tolerant to chlorothalonil (Cooley 1981; Gillman and James 1980; James and Gilligan 1983). Although tolerance to chlorothalonil is not as widespread as with benomyl, it is fairly common and has been shown to develop quickly in greenhouses (James and Gilligan 1983).

Captan is a general protective fungicide that is fairly effective against *Botrytis* (James and others 1982). However, tolerant strains to this fungicide have also been shown to exist (Cooley 1981; Gillman and James 1980; James and Gilligan 1983; Parry and Wood 1959).

Dicloran is an effective fungicide against *Botrytis* diseases (James end others 1982), even though tolerance of natural *Botrytis* strains has been found (Cooley 1981; Gillman and James 1980; James and Gilligan 1983; Webster and others 1970). Tolerant strains of the fungus can also easily develop in the laboratory (James, unpublished). Therefore, dicloran should not be used repeatedly unless rotated with other fungicides.

Two relatively new fungicides should also be mentioned. Iprodione was originally developed for turf diseases (Danneberger and Vargas 1982; Sanders and others 1978) and shows strong toxicity towards *Botrytis* (Pappas and Fisher 1979; Powell 1982). Vinclozolin is a chemical with specific action against *Botrytis* and related fungi (Pappas and Fisher 1979; Ritchie 1982). Iprodione has been tested against Botrytis blight of conifers and shows excellent promise (James and others 1982). Vinclozolin was also tested, but showed extensive phytotoxicity to western larch seedlings at label rates (James and Genz 1983). Both fungicides require more field tests and need to he registered for use on conifers. Previous tests (Cooley 1981; James and Gilligan 1983; Leroux and others 1977; Pappas and others 1979) indicate that strains of Botrytis tolerant to ipriodione and vinclozolin exists, although not in large numbers. Tolerant strains can also develop rapidly to these fungicides in the laboratory (James, unpublished).

Apparently none of the fungicides currently available can be considered completely effective against all Botrytis strains likely to be encountered. As a result, fungicide useage should be limited to the minimum amounts necessary for effective disease control. Also, different fungicides should be used in rotation so as not to exert selective pressure on Botrytis populations to develop tolerance. Rotated fungicides should have different modes of action, i.e. systemic chemicals alternated with broad spectrum protectants (Cooley 1981; James and Gilligan 1983).

For effective control of Botrytis blight, cultural practices, such as better sanitation, providing adequate air circulation, and reducing irrigation, should be combined with rotated use of different fungicides. Cultural practices can reduce fungal inoculum and alter environmental conditions necessary for infection, whereas fungicides can protect susceptible plant tissues from infection. The combination of both procedures is necessary for an effective control strategy.

Table 1.--Fungicides used to control Botrytis blight in containerized conifer nurseries.

Fungicide	Trade names	Manufacturers	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 dimethyldithiocarbmate
iprodione	Chipco 26019® Rovral®	Rhone-Poulenc	3(3,5-dichlorophenyl)-N-(1-methylethyl)-2,4-dioxo-1-imidazolidinecarboximide
mancozeb	Fore®	Dupont	Contains 16% maganese, 2% zinc and 62% ethylenebisdithiocarbamate ion/maganese ethylenebisdithiocarbamate plus zinc ion.
maneb	Dithane M-45®	Rhom & Haas	maganese ethylene bisdithiocarbamate
thiophanate-methyl	Zyban®	Mallinckrodt	dimethyl[(1,2-phenylene)bis(iminocarbonothyioyl)]bis (carbamate)
thiram	Thylate®	Dupont	Tetramethylthiuram disulfide
vinclozolin	Ronilan® Ornalin®	BASF Mallinckrodt	3-(3,5-dichlorophenyl)-5-ethenyl-5-methyl-2,4-oxazolidinedione
zineb	Zineb Dithane 278®	Rhom & Haas	zinc ethylenebisdithio-carbamate

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