Management of the Top Blight Disease Complex[1]

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Abstract.--The "top blight disease complex" refers to five separate but related diseases affecting above-ground portions of bareroot Douglas-fir seedlings. Disease losses can be reduced by altering cultural practices or applying fungicides[3]. The following paper provides practical approaches and techniques for reducing losses from top blight.

INTRODUCTION

The top blight disease complex refers to diseases of above-ground portions of bareroot Douglas-fir seedlings. They are described elsewhere in these proceedings by P. Ham. Five distinct diseases comprise the complex (Hansen and Ham 1985):

1. Fusarium hypocotyl rot. Caused by Fusarium *oxysporum.* Affects hypocotyl 'region and above during sumer of the 1-0 year;

2. Upper stem canker. Caused by *Phoma eupyrena* and Fusarium *roseum.* Affects mid to upper stem in late summer and early fall of the 1-0 year;

3. Lower stem canker. Caused by *Fusarium roseum* and *Phoma eupy rena.* Affects lower stem near soil level from winter through flush of new growth on 2-0 seedlings;

4. Phomopsis canker. Caused by *Phomopsis* sp.. Affects new growth of seedlings during summer of the 2-0 year;

5. Botrytis canker. Caused by *Botrytis cinerea.* Affects new shoots during summer of the 2-0 year.

Losses to top blight can be substantial. Mortality exceeding 30% of the crop has been caused by both hypocotyl rot and lower stem canker.

Disease occurrence varies widely among nurseries. Some nurseries may experience recurrent epidemics of one disease only, while others may suffer from all five. Disease severity also varies highly from year to year, and appears practically unpredictable. In a given nursery, a top blight disease may be epidemic one year and absent the next.

Factors influencing occurrence and severity of top blight are poorly understood. Consequently, disease prediction is difficult. Fortunately, research by Oregon State University, the USDA Forest Service, and Weyerhaeuser Company, has greatly improved our understanding of these diseases and of techniques for controlling them. The purpose of this paper is to present management strategies, based on current knowledge, that should reduce losses to diseases of the top blight complex.

APPROACH TO DISEASE MANAGEMENT

Occurrence and severity of top blight diseases apparently are governed by a complex of factors including weather, sowing date, pathogen populations, soil moisture, etc. - in short, anything that affects the seedling or the pathogens likely affects disease. In plant pathology jargon this concept is called the "disease triangle", which states that disease

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[3]The use of company names or proprietary products in this paper does not constitute endorsement or guarantee by the Oregon Forestry Department, and does not imply criticism of those not mentioned.

results from the interaction of the plant (host) and pathogen as regulated by the environment. This is the basis for understanding disease development and should also form the basis for control strategies.

Nursery cultural practices alter the environment, the seedling, and even the pathogen. However, no single practice stands out as the trigger to an epidemic. Fumigation and fungicides can reduce disease in many cases, but even the most intense chemical regime does not guarantee a disease-free crop. In fact, some of the most severe top blight losses have occurred in nurseries despite fumigation and fungicide treatments.

The suggested approach to disease management is to consider the probable effects of nursery practices on disease development and, whenever possible, adjust them in a way that should reduce disease severity. Even though a single cultural practice may have little apparent effect on disease incidence, the cumulative effect of adjusting several different practices should reduce losses.

The remainder of the paper presents several opportunities for reducing disease losses. Many recommendations, particularly fungicide treatments, are based on several years of data from Oregon, Washington, and California. Other suggestions, concerning soil splash and soil moisture conditions, rely on observations over several growing seasons. Finally, some recommendations are unproven logical deductions. Suggestions may change as understanding of disease dynamics improves.

THE FIRST STEP - RECOGNIZING THE PROBLEM

The most important step in disease management is recognizing and identifying the problem in your nursery. Few nurseries will have all diseases, and the same disease may behave differently in one nursery than in another. To assume that all diseases are present could result in wasting resources to control insignificant diseases. Accurate identification allows a focused and efficient control effort.

Pathologists, and many nursery personnel, are adept at disease identification, but identification is only part of the issue. Understanding disease development over time in your nursery is critical. This can be accomplished by assigning disease responsibility to someone (a consultant or nursery employee are logical choices) who provides nursery-specific monitoring and understanding of diseases over time. This person also could maintain liaison with pathologists from universities and government agencies.

DISEASE MANAGEMENT BEFORE SOWING

Cover Crops

Cover crops are used commonly in forest nurseries to protect soil, replenish nutrients, and maintain organic matter content. They may increase or decrease disease occurrence, or they may have no effect.

In the pacific northwest, preliminary data indicate that cover crops of beans, peas, oats, and sudan grass result in higher populations of soil-borne Fusarium than in bare fallow areas[4]. Bare fallow with frequent tillage has reduced pathogen and nematode levels in British Columbia forest nurseries . However, the correlation between soil pathogen populations and disease incidence has not been established.

High soil pathogen populations likely increase probability of disease occurrence, particularly for hypocotyl rot. Nurseries that experience chronic losses from hypocotyl rot could reduce Fusarium levels by bare fallowing rather than cover cropping.

Monitoring Populations of Soil-Borne Pathogens

The most important pathogens of the top blight complex, Fusarium and Phoma, occur in the soil. Fusarium populations can be quantified by assaying soil samples on culture media that allow only Fusarium and a few other fungi to grow. Abundant Fusarium in the soil appears to increase

[4]Hamn, Phil. 1986. Personal conversation. Oregon State University, Corvallis, Oregon.

[5]Sutherland, Jack. 1984. Personal conversation. Pacific Forest Research Centre, Victoria, British Columbia.

probability of Fusarium-caused disease[6]. Techniques for selective isolation of Phoma from soil are unavailable, and the importance of Phoma populations are unknown.

Reliable correlations between soil pathogen counts and amount of disease have been difficult to establish. It is thought that soil populations could form the basis for disease prediction. Consideration of soil pathogen counts with disease history, crop history, and other factors has enabled crude disease prediction in several nurseries. British Columbia, Washington Department of Natural Resources, and private consultants successfully use soil counts as input to pest management decisions (McElroy 1984).

How much Fausarium is too much? Should I fumigate if I have 1,500 propagules of Fusarium per gram of soil? It is doubtful tat anyone can give an answer that will apply to all nurseries. However, after monitoring soil pathogen counts and disease levels for a few seasons, a nursery should be able to address these questions with some confidence. It is certainly an improvement over complete guesswork. Soil pathogen assays are available from certain consulting firms. Some nurseries chose to do their own assays.

Fumigating Nursery Soils

Fumigation can effectively reduce soil pathogen populations and improve conifer seedling yield and quality (Bloomberg 1965, Sinclair et al 1975). Methyl Bromide/ chloropicrin is most widely used and is highly effective. Efficacy of other chemicals is discussed elsewhere in these proceedings by F. McElroy and by Y. Tanaka.

Despite demonstrated effectiveness for disease control at many nurseries, fumigation does not guarantee a disease-free crop. Conversely, nurseries have produced excellent crops without fumigation. Pathogens can recolonize fumigated soils during the time between fumigation and sowing, and although they may not attain levels as high as those before fumigation, they may be high enough to initiate serious disease. It has also been speculated that fumigation alters the balance of microflora in a way that gives advantage to pathogens growing among reduced populations of antagonistic organisms.

Fumigation is an expensive treatment, so the question often becomes "is it worth it?" Reliable disease prediction would help answer that question. Other benefits such as weed control, as well as pesticide use regulations and economics must be weighed along with disease control benefits. Soil assays and continual evaluation of fumigation effectiveness can be used to decide whether or not fumigation is necessary.

Seed Treatments

The occurrence of Fusarium-caused disease in 1-0 beds that have been fumigated prompts questions about the source of Fusarium. Fusarium spores can blow into a field on dust or debris particles or they can recolonize upward from soil beneath the level of fumigation (Marois et al 1983). Fusarium occurs in and on Douglas-fir seed (Bloomberg 1966), and seed-borne Fusarium can cause seedling disease (Graham and Linderman 1983, James 1985). However, the importance of Fusarium on seed in bareroot nurseries is poor understood.

It seems reasonable to assume that Fusarium on seed could contribute to increased disease. Many seedlots will have little or no Fusarium. Those that do can be detected by assaying seed samples on culture media selective for Fusarium (the same media is used for the soil assays mentioned earlier). Monitoring disease levels in seedlots with different pathogen levels will add another bit of information to nursery-specific understanding of disease behavior.

Treating seeds with fungicides has had variable success, and often has reduced seed viability (Sutherland 1984). Rinsing seed for up to 48 hours in running water should remove much of the surface Fusarium[7]. Strong recommendations about see(T treatment will be possible only after additional research and nursery field studies.

[6]McElroy, Fred. 1985. Personal conversation. Peninsu-Lab, Inc., Kingston, Washington.

[7]James, Robert. 1986. Personal conversation. USDA Forest Service, Missoula, Montana.

MANAGING SPECIFIC TOP-BLIGHT DISEASES

Fusarium Hypocotyl Rot Seed treatment.

Fusarium on seed can cause hypocotyl rot in Douglas-fir seedlings. The effectiveness of treating seeds with fungicides needs clarification through research. If Fusarium seedlot assays reveal abundant *Fusarium*, rinsing seeds in running tapwater for 48 hours should reduce probability of hypocotyl rot.

Sow seed early.

Observations strongly suggest that sowing as early as possible reduces amount of hypocotyl rot. Early sowing has also been recommended to reduce hypocotyl rot severity in sugar pine seedlings (Brownell and Schneider 1985). Early sowing may allow seedlings to attain large size and develop resistance to hypocotyl rot before the environment of the nursery bed favors disease development.

Fertilization.

Sinclair et al (1975) reported that fertilization with urea increased severity of *Fusarium* root rot of bareroot Douglas-fir seedlings. Summer mortality, which may have been partly due to hypocotyl rot, was highest in seedlings receiving pre-sow urea. A "best guess" recommendation at this time is to avoid urea fertilization during the first 8 weeks following sowing. Effects of form of nitrogen fertilization and timing of its application are being studied in several northwest nurseries during 1986[9].

Irrigation.

Irrigation regimes, particularly those used for cooling during summer, appear to affect hypocotyl rot severity. Elsewhere in these proceedings, Ken Russell discusses a strategy of deep watering (as opposed to frequent shallow watering) to reduce hypocotyl rot losses.

During 1986 at the Oregon State Forest Nursery, uneven irrigation affected hypocotyl rot occurrence. Portions of beds within 10 feet of sprinkler heads remained wet longer than areas between 10 and 15 feet of sprinkler heads, indicating that more water was deposited at the heads than between them. In parts of the nursery where hypocotyl rot occurred, disease severity in the dry areas was nearly double that occurring in wet areas (35% versus 20%, respectively). Drier soils may have permitted higher temperatures near ground level which stressed seedlings and favored disease development (Brownell and Schneider 1985).

Fungicides.

Among fungicides tested in Pacific Northwest nurseries from 1983-1985, Benlate, Daconil 2787 and Chipco 26019 (Chipco not registered for forestry use) appeared most effective, but effectiveness was highly variable (Cooley and Kanaskie 1986). Other factors such as weather and cultural practices appear capable of overriding the effects of fungicid s applied as often as twice per week [70]. If fungicide treatments are used, begin treatments at full emergence and follow label rates. Tank mixes and alternating chemicals are recommended.

Preliminary studies suggest that Bayleton may reduce incidence of hypocotyl rot[10]. Further testing of this material is recommended.

Upper Stem Canker

Cultural practices.

Upper stem canker appears most severe in seedlings whose growth is prolonged through late summer into early fall, and in seedlings grown at very high densities (50-75 trees per square foot). Infections often are associated with splits in the stem which may result from rapid seedling diameter growth in late summer. Disease

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[8] Littke, Willis. 1986. Personal conversation. Weyerhaeuser Company Centralia Forestry Research Center, Centralia, Washington.

[9] Cooley, S. J. and A. Kanaskie. 1986. Unpublished study plan - effect of nitrogen fertilization on disease of Douglas-fir seedlings in the first growing season. USDA Forest Service, Portland, Oregon.

[10] Kanaskie, A. 1986. Unpublished data on file at Oregon State Department of Forestry, Salem, Oregon.

risk should decrease if cultural practices such as fertilization and irrigation are used to limit rapid diameter growth and to prevent succulence from continuing into fall. If upper stem canker is a serious concern in your nursery, consider inducing bud-set earlier than normal.

Fungicides.

Chipco 26019, Daconil 2787, Difolatan, and Benlate were most effective in Pacific Northwest nurseries, but only Daconil 2787 and Benlate are registered (Cooley and Kanaskie 1986). Treatment should continue through budset of the 1-0 year. Tank mixing and alternating chemicals are recommended. Coverage of the seedling stem (not foliage) is important; spreaderstickers should enhance performance. Time applications so irrigation or rain will not wash materials off before they dry.

Lower Stem Canker

Avoid creating areas of poor drainage.

During evaluations of fungicides, lower stem canker occurrence appeared more strongly related to wet areas in the beds than to fungicide treatments (Cooley and Kanaskie 1986). Increased disease has also been observed in beds receiving heavy tractor traffic during winter months [1]. Ripping tractor paths, eliminating low spots during land-planning, and limiting tractor traffic on wet fields should help reduce occurrence of lower stem canker.

Soil splash on seedling stems.

The accumulation of rain- or irrigation-splashed soil on lower foliage and stems of seedlings, called "soil cones" or "soil collars", is strongly associated with lower stem canker (Hansen and Hamm 1985, Kliejunas et al 1985, Morgan 1983). Soil accumulation usually begins during summer of the 1-0 year and continues through winter. Soil collars put the soil-borne pathogen in close contact with seedlings and may provide an environment conducive to disease development.

Prevention of soil collar formation can reduce losses to lower stem canker. The addition of redwood mulch or shade lath reduced soil cone formation and Phoma blight incidence on fir and Douglas fir in a northern California nursery (Kleijunas et al 1985). At a Washington nursery during 1983, fewer seedlings had lower stem cankers in moss-covered beds (no soil collars) than in moss-free beds (abundant soil collars)[12].

Establishing a thick carpet of moss appears to be the simplest and most economical method of preventing soil collars, but this approach will only work in nurseries with naturally-abundant moss. Mosses are often eliminated from nursery beds with herbicide treatments. However, choosing herbicides that do not kill mosses will allow moss to develop during the 1-0 year.

Of the shade lath and mulch treatments, the latter is most practical. Other types of mulch may be effective and should be field-tested. A liquid latex acrylic sealant was tested in northern California, but it was ineffective[13]. Mulch treatments must be applied before soil buildup occurs.

Fungicides.

Field trials indicate generally poor control with fungicides. Fungicide ineffectiveness for preventing lower stem canker probably occurs because: 1) fungicides may not penetrate soil collars, and; 2) weather can prevent timely applications during the likely period of infection (winter). Of materials tested, Daconil 2787 was most effective; Benlate and Difolatan (Difolatan not registered) had variable effectiveness (Cooley and Kanaskie 1986). Exact time of infection is unknown, so fungicides may need to be applied from budset through shoot emergence in spring.

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[11]Littke, Willis. 1986. Personal conversation. Weyerhaeuser Company Forestry Research Center, Centralia, Washington.

[12]Kanaskie, Alan. 1984. Unpublished data. Weyerhaeuser Company Centralia Forestry Research Center, Centralia, Washington.

[13]Kliejunas, John. 1985. Efficacy of Soiul Seal concentrate for reducing soil cone formation in nursery beds at Humboldt nursery, unpublished report. USDA Forest Service, San Francisco, California.

Botrytis Canker

Cultural practices.

Reducing seeding density improves air flow and lowers humidity, providing conditions unfavorable for disease development. Avoid seedling injury: anything that injures seedlings - machinery, frost, excessive fertilization, herbicides - increases the risk of Botrytis-caused losses. Clipped seedling tops following top-mowing may also encourage *Botrytis* buildup.

Fungicides.

Benlate, Daconil 2787, and vinclozolin (Ronilan, Ornalin) are among chemicals registered for *Botrytis* in bareroot conifer nurseries. Daconi Tappeared most effective in northwest nurseries, and Benlate yielded variable results (Cooley and Kanaskie 1986).

Fungicide applications, if necessary, should begin when disease appears. Apply with techniques that put the chemical on the target, i.e., use rollers to bend seedlings during spraying, or use high tank pressures or atomizing nozzles. Reduce likelihood of developing fungicide resistance by applying minimum effective rates and alternating (not tank mixing) chemicals with different modes of action. In many cases, fungicide treatments for other top blight diseases may provide adequate *Botrytis* control.

Phomopsis Canker

Phomopsis canker usually is not severe enough to warrant specific fungicide treatments. Information on fungicide effectiveness is limited, but protective treatments during the flush of growth should be effective, and should be tested.

COMMENTS ON FUNGICIDE USE

Fungicide treatments can be cost-effective in bareroot nurseries, particularly for diseases that cause mortality. Because fungicide application costs tend to be small, even slight increases in disease-free seedlings may pay for treatment costs (Cooley and Kanaskie 1986). However, applying fungicides only when necessary will improve economic returns and may prevent development of fungicide-resistant pathogens.

Most fungicide testing has yielded variable results within and among nurseries. Fungicide evaluations should be ongoing and nursery specific - it may take several years to determine the most effective materials. Effectiveness can only be evaluated if treated areas are compared to untreated areas; leaving a few small areas untreated whenever applying fungicides will provide a wealth of information.

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