CHAPTER ONE

Damping-off

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Damping-off is the disease term used for fungal-caused mortality during those first critical few weeks from germination to just after seedling emergence. The soil-inhabiting fungi associated with damping-off are capable of causing rapid decay and mortality of seeds and germlings. These fungi are not host-specific.

Figure 1-1. Postemergence damping-off of Douglas-fir germlings. Fungal invasion of succulent stem tissue causes collapse of infected tissue, so that seedlings fall over.

Disease and hosts

Many species of fungi, often common soil saprophytes, are associated with damping-off and root rot. They become pathogenic when temperature, moisture, soil pH, and other conditions become favorable. In Pacific Northwest forest nurseries, *Pythium* and *Fusarium* species are the most common damping-off fungi. Others are *Rhizoctonia solani, Macrophomina phaseoli, Botrytis cinerea,* and *Phoma, Alternaria,* and *Phytophthora* species. In general, *Pythium* species cause problems early in the season when soils are cool and wet, while *Fusarium* species cause problems later when soils are warmer and moist to semi-dry. Exceptions occur, however, and any of these fungi can and do cause disease at any time during the growing season.

Damping-off fungi occur naturally in nearly all crop and forest soils. They are found worldwide in temperate and tropical zones alike. No conifer or hardwood is known to be resistant to damping-off in the Pacific Northwest. Those species or seedlots that germinate quickly and grow fast may sustain less damage from damping-off than slow-emerging, slow-growing species. Still, it is safe to assume that all nursery-grown tree species are susceptible to damping-off fungi.

Symptoms

Damping-off is defined as the fungal invasion of the succulent tissue of germinants or seedlings that leads to decay and early death. Damping-off attacks seedlings both before emergence (preemergence damping-off) and after (postemergence damping-off) and, depending on conditions, usually occurs within 30 to 45 days after sowing.

The only evidence of preemergence damping-off in nursery beds is that the germinating seedlings are sparse and patchy. This phase is difficult to detect, but may sometimes be diagnosed by digging up seeds that have not emerged and checking to see whether seeds or germinants are decayed or withered.

Postemergence damping-off, which occurs in the cotyledon stage, causes seedlings to wither and collapse (Figure 1-1). When the succulent root-collar tissue or the roots are penetrated by the pathogen, the disease is referred to as soil-infection damping-off. When the fungal invasion occurs higher on the stem or cotyledons, it is called top-infection damping-off.

The most obvious indicator of postemergence damping-off is the

collapse of the seedling. It may be possible to tentatively identify, at least to genus, the fungus responsible. Stem tissues of seedlings infected by *Pythium* sometimes separate around the root collar, with the epidermis sloughing away from the inner xylem tissue as an open shirt collar falls away from the neck of the wearer. The trees then fall over. Seedlings infected by *Fusarium* undergo a softening of the root-collar tissue, and the trees fall over at the point of softening without separation of the stem tissues. Seedlings with suspected *Fusarium* infection may be incubated overnight at room temperature in a moistened paper bag to produce a bloom of sickle-shaped macroconidia that can be easily identified under a microscope (see Figure 2-3).

Damping-off symptoms appear:
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Late spring through early summer

In broadcast-sown beds, which are uncommon in Pacific Northwest nurseries, seedlings may die in irregular bull's-eye patches, with the centers containing mostly fallen trees and the borders containing trees with early symptoms. In drill-seeded beds, the mortality pattern usually runs along the rows for a distance, then abruptly stops. Adjoining rows may be affected, showing a patchy effect (Figure 1-2).

It is not unusual for forest pathologists to isolate one or more species of damping-off fungi from apparently healthy seedlings within the first few weeks of germination. The fungi may be found either on root surfaces or within internal tissues and may have come from infested seed or surrounding soil. These symptomless seedlings usually remain healthy as long as moisture stress is low and other growing conditions are optimum.

Figure 1-2. Patchy, uneven density is the result of significant levels of pre- and postemergence damping-off.

Fungus biology

Damping-off fungi are inhabitants of the soil. They can be spread by movement of soil on equipment or seedlings, by cultivation, or by water. Infection occurs when seedling roots grow next to fungal inoculum, such as chlamydospores, sclerotia, or oospores. These structures then germinate and hyphae invade the seedling cells. Fungal invasion causes collapse and disintegration of cells and death of the seedling. The fungus may continue to develop in and utilize the killed tissue, often producing secondary inoculum, such as conidia, on the surface of the dead seedling. Mycelium, spores, or other structures survive and overwinter in seedling tissue or other organic material in the soil. Viability of overwintering inoculum is dependent on a number of factors, including soil moisture and temperature.

Damping-off may be confused with:
Cutworm damage
Frost heaving
Fusarium hypocotyl rot
Heat damage
Seedcorn maggot damage

Loss potential

Damping-off fungi can cause significant losses in forest nurseries. Losses may be large one year and minor the next. Mortality from preemergence damping-off can be estimated by calculating the difference between the number of seedlings and the number of seeds sown, after other factors, such as percent germination or bird depradation, are accounted for. Postemergence damping-off is best determined by marking small plots and counting mortality every few days. Individual

ᵞes can be marked with toothpicks monitor whether the disease is increasing, subsiding, or responding o treatment. Losses from preemergence damping-off often range from l5 to 40 percent of sown seed, while postemergence losses may be an additional 10 to 20 percent. Growers typically oversow to ensure a satisfactory crop.

Damage may be heavy in seedling beds that previously contained transplants or other agricultural crops. In fact, new nursery sites developed from cleared forest soils tend to have fewer damping-off problems than those established on previous agricultural croplands.

In addition to the direct losses of bed stock, indirect losses may be reckoned in shortages of healthy seedlings for outplanting on forest sites.

Management

The best defense against damping-off fungi is an effective and conscientious disease-prevention program. This includes knowledge of soilborne disease populations, a well-orchestrated pesticide program, and careful attention to environmental conditions in the nursery. The nursery environment is the strongest influence on the proliferation of damping-off fungi. Soil moisture, timing and amount of irrigation, air and soil temperatures, method and timing of sowing, depth of soil over seed, soil pH, combinations of soil fungi and nematodes, timing and type of nutrients applied, type of organic matter, type of cover crop, history and pattern of pesticide use, and many other factors affect the incidence and severity of damping-off.

It is to the grower's advantage to bring the entire crop through its initial growth stages rapidly and evenly in order to narrow the damping-off infection "window." No single factor alone governs control of the disease, but good management will take the following factors into account:

SOIL MOISTURE AND DRAINAGE

Ideally, nurseries should be located on light, well-drained soils. Wet soil generally favors damping-off. Depth of irrigation is critical to young seedlings, especially during hot weather. It is important to irrigate deeply enough for water to reach seedling roots—a depth that increases steadily as the roots grow—but not so much that the soil is saturated. Too-shallow watering stresses tender roots in moisture-deficient lower soil layers, while creating a warm, wet upper soil layer that favors the buildup of damping-off fungi. Soil moisture and rooting depth should be monitored regularly during the growing season. Cool weather that prolongs germination, or hot weather that speeds it up, require particular attention to watering.

TIMING OF SOWINGS

Sowing when temperatures are warm enough to promote rapid, even germination tends to reduce problems with damping-off. Warm-weather sowing requires constant diligence in controlling irrigation.

SOIL pH

Damping-off fungi thrive in neutral to alkaline soils. A soil pH of between 5.2 and 5.7 (moderately acid) not only helps prevent damping-off problems but is ideal for growing Pacific Northwest conifer species. Aluminum sulfate drenches, sulfur (200 to 500 pounds/acre), and acid peat applications can be used to maintain the acid condition of the soil. When aluminum sulfate is used, beds should be kept moist to prevent burning of the roots.

Irrigation water that is even slightly alkaline can, over a period of years, decrease soil acidity. The change usually occurs slowly because of the tremendous buffering ability of the soil. It can be reversed by acidifying the water with either sulfuric or phosphoric acid. The acidification process can be speeded up by adding sulfur to the soil and then maintaining the pH with acidified water.

SOIL MICROFLORA

No two nurseries are alike in their makeup of soil organisms. Each has its own combination of soil microflora, consisting of bacteria, fungi, nematodes, and insects, and each combination influences the population of pathogenic fungi in the soil, the amount of infections, and the expression of disease symptoms. Growers should learn the soil microflora "personality" of their nurseries.

NUTRITION

Nitrogen applications made too early promote damping-off. Germinating seed and new germlings do not need much supplemental nutrition; the endosperm contains sufficient food to get seedlings well on their way.

MULCHES AND COVER CROPS

Cover crops grown and turned under just prior to sowing conifers may, depending on their type, retard or encourage damping-off problems. Legume cover crops promote large populations of damping-off fungi, grass crops somewhat smaller populations. Bare fallowing discourages the buildup of potential pathogenic fungi in the soil.

ASSAYS FOR SOILBORNE DISEASES

Assays for soilborne pathogens measure populations of particular fungi in the soil. Soil assays have been developed for *Pythium*, *Fusarium*, *Macrophomina,* and *Phytophthora* species (see the passage on monitoring of fungi in Chapter 33, Principles of Integrated Pest Management). Although population levels of these fungi indicate potential risk and the severity of disease in future crops, they are not reliable predictors of crop loss. The grower should use the assay as a warning signal to give an indication of potential problems and to help determine disease prevention measures, such as fumigation.

SOIL FUMIGATION

Fumigating soil prior to sowing is a common practice in Pacific Northwest nurseries. Several different materials have been used successfully, including dazomet, methyl isothiocyanate/1,3-dichloropropene, and mixtures of methyl bromide and chloropicrin. Fumigation decreases *Fusarium* and *Pythium* populations sometimes to near zero. Methyl bromide with 33 percent chloropicrin will hold these pathogens in check for most of the first growing season. Follow-up disease control is done as needed with a carefully prescribed fungicide application plan.

FUNGICIDES

Treatment of seed with fungicides is not recommended. In previous years seed treatment was customary, but fungicides applied to the seed coat offer little or no protection to the emerging seedling. In addition, some seed treatments are phytotoxic.

Although the effectiveness of fungicides to control damping-off is highly variable (see the passage on fungicides in Chapter 33), many growers use them. Several fungicides are registered for use in forest nurseries to control soilborne diseases. Certain fungicides or combinations of fungicides seem to work better in one nursery than another. The fungicide metalaxyl has systemic properties and may be used prior to sowing to reduce populations of *Pythium* and *Phytophthora* in the soil. Metalaxyl is available in granular and liquid formulations.

The first post-plant fungicide application should be made when most seedlings have emerged and the seeds begin to drop from cotyledon leaves. A good all-purpose preventive treatment for damping-off is a 50-50 mixture of captan and benomyl applied as a drench at rates recommended on the label. If frequent applications are planned, alternation of the captan-benomyl mix with other fungicides is advised to minimize the buildup of resistant pathogens.

Selected references

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