CHAPTER FOUR

Gray Mold

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Gray mold, caused by *Botrytis cinerea*, is a disease that causes blight of flowers, leaves, and shoots, and decay of fruit in hundreds of woody and herbaceous plants. It occurs worldwide, flourishing where the air is moist and stagnant.

Gray mold grows as a saprophyte on dead plant material in all forest nursery seedbeds in the Pacific Northwest. Under optimum conditions, it causes significant damage to densely grown bareroot seedlings. The disease can also be particularly damaging to container stock, both in the greenhouse and outdoors when seedlings are set out to harden off. *Botrytis cinerea* may also ruin packed nursery stock under poor storage conditions where daily temperatures fluctuate from the ideal—near freezing—to 10 or 15 degrees higher. As damaging as gray mold can be, however, it responds quickly to changes in microclimate and management practices, and therefore is easily controlled in most cases.

Gray mold may be confused with:
Frost damage
Rosellinia needle blight
Senescent needles

Figure 4-1. Dead lower needles caused by *Botrytis* on densely sown Douglas-fir seedlings.

Disease and hosts

Western hemlock, Douglas-fir, and Sitka and Engelmann spruce can all be severely damaged by gray mold. Though pines are somewhat resistant, probably because of their more open growth habit, they are susceptible under conducive conditions. True firs fit in the same susceptibility category as the pines. In California, gray mold is especially damaging to giant sequoia and coastal redwood. Hardwoods can also become infected. It is reasonably safe to assume that all forest nursery stock in the Pacific Northwest is susceptible.

Under the mild-climate conditions in nurseries west of the Cascades, infection can occur at nearly any time. Gray mold often appears after an abiotic event that causes plants to die back, such as a winter freeze or spring frost, fertilizer burn, herbicide injury, or lower needle dieback in dense seedling stands. Such an event predisposes seedlings to infection by causing abnormal amounts of dead plant material upon which the disease builds.

A typical scenario in a coastal nursery would be a severe early-winter or spring freeze that kills many needles and portions of stems on seedlings. The warming, wet weather that usually follows a cold snap allows rapid and massive build-up of *Botrytis* inoculum on the dead plant material, creating a high potential for infection of living plant tissue (See Figure 27-3). The sublethal plant injury causes leakage of cellular nutrients onto needle surfaces, stimulating spores that have landed there to germinate.

Symptoms

Initial signs of gray mold on conifer nursery stock are usually found on the lower stems of seedlings in dense seedbeds or wherever abnormal amounts of dead plant tissue are found (Figure 4-1). At first, degenerating needles appear to be water-soaked, and eventually develop tan, mushy spots. After the disease intensifies on masses of killed needles, it spreads upward into healthy shoots. When shoots are attacked first, the disease may move downward. Brown, sunken areas called cankers, caused by the fungus growing in the phloem, girdle healthy stem tissue (Figure 4-2), causing the entire shoot or leader to collapse and hang down in a withered mass of dead needles. Small, dark, irregular resting or survival bodies called sclerotia are found in the cankers on plant material that has been infected for some time. Under optimum temperature and humidity conditions, webs of reddish-brown mycelium produce masses of gray spores resembling grapes on a vine. These dry spores are released in gray clouds when disturbed. Both mycelium and spore clusters are easily visible to the naked eye (Figure 4-3).

Gray mold symptoms appear:
All ages
Year-round

Fungus biology

Since spores, mycelium, and the resistant sclerotia of *B. cinerea* are almost always present on dead plant debris, infection can occur nearly year-round in the moist maritime climate of coastal nurseries. Interior nurseries with definite winter seasons would have the greatest potential for infection during late summer and fall. The fungus probably overwinters as sclerotia and mycelium in old plant debris. It enters healthy tissue indirectly via wounds and attached dead vegetation, or directly by penetrating intact plant surfaces that have adequate free surface moisture (Figure 4-4).

Early in the infection process of healthy needles or leaves, germ tubes from germinating spores swell to form holdfast structures, anchoring the spore and initial hyphae to plant surfaces. Hyphal strands containing enzymes and toxins grow from the holdfasts and either penetrate and degrade the cuticle and epidermal cells, or enter through stomates (Figure 4-5).

Botrytis cinerea has an unusually wide temperature range, from 0 to more than 25 degrees C with optimal growth and conidia production occurring between 20 and 22 degrees C. Spore germination is known to occur at temperatures as low as 0 to 5 degrees C, which accounts for damage to trees in storage.

The conidial (asexual) state of another fungus, Rosellinia needle

Figure 4-2. Stem canker caused by *Botrytis.* Fungus first attacks needles and then grows from the dead needles into the stem. Photo courtesy of Tom Landis.

Figure 4-3. Close-up view of *Botrytis* sporulating on dead conifer needles.

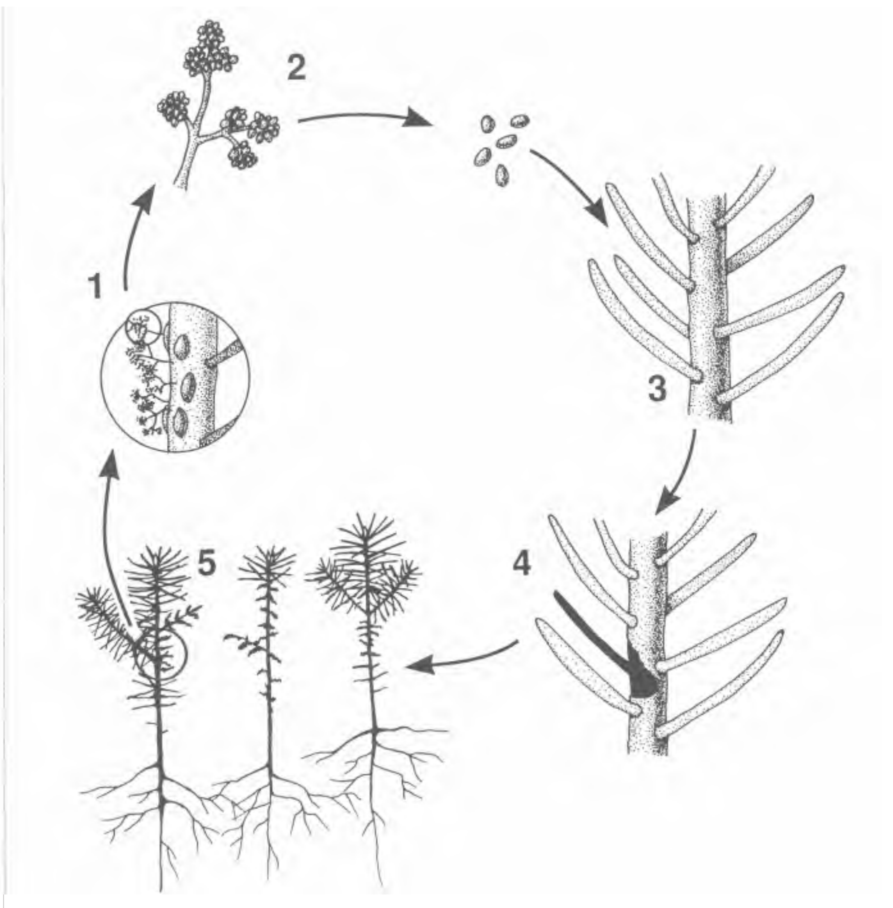

Figure 4-4. Disease cycle of gray mold. The fungus overwinters on plant debris as mycelium or sclerotia (1), producing conidia which are transported by wind (2). Spores infect damaged, moribund, or dead needles (3), and the fungus may grow into the stem, sometimes causing a girdling canker (4). New conidiospores are formed on dead needles, spreading the disease to adjacent seedlings, particularly where planting density is high and moisture is retained on the lower, senescent foliage (5).

blight, caused by *Rosellinia herpotrichiodes,* may be confused with *B. cinerea.* Rosellinia needle blight is often seen on the lower stems and branches of Douglas-fir seedlings under the same crowded conditions that bring on outbreaks of gray mold. The mycelium of the two fungus species are similar in appearance and color. Presence of the gourd-like *Rosellinia* perithecia (fruiting bodies) on the twigs of Douglas-fir seedlings distinguishes the two species. *Rosellinia herpotrichiodes,* however, is not common in coastal nurseries.

Management

Gray mold can be largely eliminated with adjustments in cultural practices. It is essential to keep the microclimate within the canopy as dry and well aerated as possible. Also, better control of growth and hardening off allows seedlings and transplants to go into the dormant season in good health, reducing the amount of dead foliage in the event of an early freeze.

A significant change in general nursery management that resulted in reduced *B. cinerea* problems was the lowering of seedling bed density from 50 to 25 trees per square foot. It was common for the more densely planted beds to have constant troubles with gray mold in the lower crowns. This management switch was initiated mainly to grow sturdier seedlings with better root systems, but there was an added benefit in the biological control of gray mold through lower humidity and vastly improved canopy aeration. Gray mold has never been a serious problem in transplant beds because they almost always have adequate air circulation.

Irrigation practices can be adjusted to help prevent infection. Normally, irrigation is either reduced or eliminated late in the season when the disease is at its most infectious state. Should an outbreak coincide with irrigation needs, it is important to make sure the foliage is allowed to dry quickly. Consider watering early in the morning when humidity is highest. Since free water is usually already present on foliage at this time, more water won't increase wetness, and midday winds can dry the foliage before nightfall.

Canadian researchers have found that 3 hours of temperatures around 15-20 degrees C and 98 percent relative humidity is sufficient for infection if there is free water on needle surfaces. The most recent research makes use of "needle wetness sensors" to obtain the most precise readings to date of optimum conditions for infection. Needle surface wetness offers a more direct measure of the conditions for successful infection than does relative air humidity. The sensor is connected to a data logger, which immediately informs the nursery manager when conditions are right for infection. This technology was developed primarily for container nurseries, where gray mold is an ongoing problem, but it could be used in bareroot nurseries as well. Removing diseased seedlings, particularly when diseased areas are small and localized, can reduce the spread of gray mold within a