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# GREY MOULD IN FOREST NURSERIES

## (BOTRYTIS CINEREA)

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Figure 1. One-year seedling of Douglas fir showing symptoms of tip infection by *Botrytis cinerea*. The shoot tip is dead and the characteristic investment of grey mould can be seen on the infected foliage just below the tip.

# GREY MOULD (BOTRYTIS CINEREA) IN FOREST NURSERIES

Grey mould, *Botrytis cinerea*, attacks a wide variety of important agricultural and horticultural crops (both in the open and under glass) as well as forest nursery stock, and is frequently the cause of damage to flowers, fruits and vegetables in gardens. Such crops as lettuce, strawberries and raspberries, tomatoes, beans, roses and anemones can be seriously damaged, but in suitable climatic conditions young shoots and other succulent parts of most plants are subject to infection.

## THE FUNGUS AND DISEASE DEVELOPMENT

*Botrytis cinerea* is the name given to the spore-producing (conidial or imperfect) stage of the ascomycete fungus *Sclerotinia fuckeliana*. In fact, the *Sclerotinia*-type fructification is rarely seen and the fungus is almost entirely propagated, disseminated and identified by the microscopic *Botrytis* fructifications and the spores they produce. The fructifications consist of branched fungal filaments (conidiophores) which project from the surface of the substrate in which the fungus is growing. At the tips of the conidiophore branches, groups of spores (conidia) are produced which are readily detached and dispersed (Figure 2). The conidiophores are borne in large numbers on the surface of infected leaves, or on other material in which the fungus is present, investing the affected part with a characteristic grey-brown mould (Figure 3). When seen through a lens, the branched conidiophores and clusters of conidia at the branch tips can easily be identified.

*Botrytis cinerea* is a facultative parasite, which means that the fungus can colonise dead material as well as causing infection in living tissue. This ability, which is common to a large number of important fungal pathogens, is an extremely important factor when considering the incidence and development of infection and the timing of control measures against the disease. *Botrytis* is one of the most common colonists of dead plant remains and occurs ubiquitously on forest litter. As forest nurseries are nearly always sited within or near plantations, the spores produced from the litter maintain a high level of infection potential in nurseries whenever conditions are suitable. Even in nurseries isolated from plantations the production of spores from the fungus growing in debris in cultivated soil or from the litter formed under other crops or vegetation in the vicinity, provides suitable inoculum for infection.

Spore trapping has shown that the spores of *Botrytis* are present in the air at all times of the year, being most numerous during summer and autumn. The spores are carried most commonly by wind, being deposited on plant surfaces of all sorts. Generally speaking, spores of *Botrytis* are present on leaves and young shoots, the two most important sites of infection by the fungus, throughout the year, but only under certain conditions can serious infection take place.

## DISEASE SYMPTOMS AND FACTORS ASSOCIATED WITH INFECTION

Serious infection by *Botrytis* is usually associated with periods of cool wet weather and most frequently occurs in dense seedbeds in the conditions of high humidity there. The fungus can attack shoots and foliage of nursery stock of all conifer and broadleaved trees, but infection of the root systems does not take place. Although capable of considerable damage, *Botrytis* is a weak parasite and infection is generally related to a number of important factors affecting the health or condition of the plants. Infection very often follows physical damage, the fungus first colonising the parts weakened or killed and then spreading to the healthy tissues. Any condition that weakens the plants generally, for example, root damage or attack by other organisms, nutrient deficiency, insufficient light, or infection of the shoot by some other fungus, increases the susceptibility to infection by *Botrytis*. Whatever the factors predisposing the host plants to infection, serious damage generally only occurs when these are accompanied by cool moist climatic conditions. Under such conditions even healthy undamaged plants may be

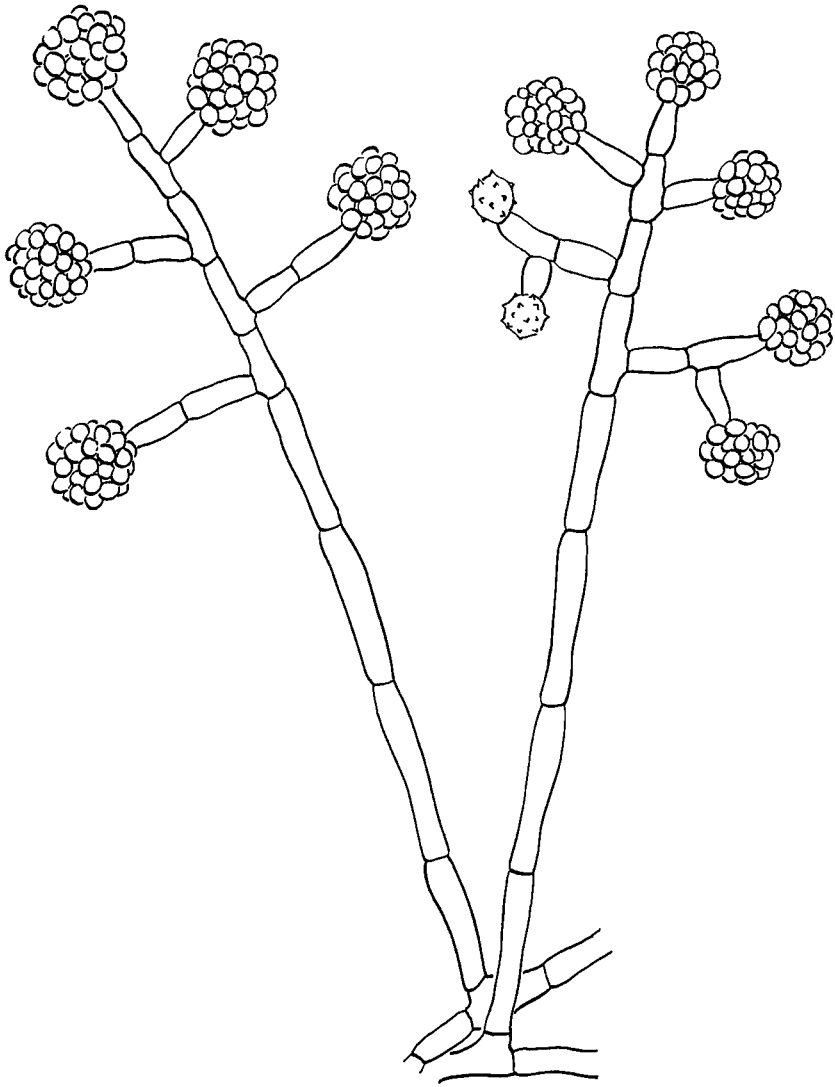

Figure 2. Diagram of two conidiophores of *Botrytis cinerea* showing terminal branching and the clusters of conidia borne on the swollen end cells of each branch. The conidiophore on the right shows two branch tips from which the conidia have been removed. Note the minute projections from the terminal cells on which the conidia are produced.

Figure 3. Infected foliage on a larch transplant showing delicate Grey mould development. The globular white structures are the clusters of conidia borne on the conidiophore branch ends. This is the typical appearance of the mould as seen through a low-powered hand lens.

attacked if the fungus is able to colonise some moribund tissue still attached to the plant. An example of this is the infection of two-year seedbeds of Western hemlock. Under the shade of luxuriant new growth, the needles on the lower parts of the plants become moribund. In a prolonged period of cool wet weather *Botrytis* infects these dead or dying needles, and in the humid conditions beneath the seedling canopy, this vigorous fungal growth spreads to the tissue of the shoot and healthy leaves and may cause serious damage.

Frost damage is probably more frequently associated with *Botrytis* infection than is any other factor, and of particular importance are early autumn frosts, which occur at a time when general climatic conditions are conducive to the rapid development of the fungus, and when abundant spores are present on and over the crop. Other types of physical damage quite often associated with infection by *Botrytis* are hail, and "shoot tip burning" following the application of nitrogen top dressings. The latter can be prevented by careful sweeping of the seedling or transplant sections with wooden laths, heavy sacking or freshly cut birch branches immediately after dressing. Occasionally severe damage by *Botrytis* occurs in nurseries in which the stock remains covered by snow for several weeks; this is more common on the Continent that in Britain.

Infection usually follows damage to the young tender foliage at the tips of the shoots, and progresses back down the shoots. The occurrence of shoot tip death and the presence of the typical grey mould on the dead and weakened needles or leaves is the most common symptom of *Botrytis* attack (Figure 1). However, in the case of infection in dense hemlock seedbeds described above, tip symptoms are often entirely absent and the disease can only be identified by parting the plants and examining the lower foliage and stem bases. In such conditions the fungus can usually be recognised by the presence of black sclerotia on the infected stems, as well as by the grey mould. These sclerotia are small swollen, black, round or oval structures (about 2-3 mm. in length) which are usually formed in the superficial tissues of the stem, or less often on foliage, bursting through the epidermis as they mature (Figure 4).

## TREE SPECIES AFFECTED

As mentioned before, in certain climatic and environmental conditions, all species are subject to infection by *Botrytis*. In general, however, serious damage is much more frequent on conifers than on broadleaved tree species. Among the conifers, *Sequoia* and *Cupressus* species are most subject to infection, but these are usually raised in very small quantities in forest nurseries. Sitka spruce, Douglas fir and Western hemlock are probably the most commonly attacked conifer species, but whereas shoot tip infection is usual on the spruce and Douglas fir, basal attack is most frequent on the hemlock. Infection is markedly less common on Norway than on Sitka spruce. Tip infection may also occur on the larches, particularly Japanese larch, and on the less commonly planted conifers. The susceptibility of Lodgepole pine is much higher than that of either Scots or Corsican pine, and in fact damage is seldom seen on the last two species. Records in recent years indicate that Lodgepole pine is particularly prone to infection following hail damage.

## CONTROL MEASURES

Because of the unpredictable incidence of this disease in forest nurseries, no regular spraying programme can be recommended, although routine spraying in late summer and autumn may be justified with *Sequoia* and *Cupressus* species.

For use in forest nurseries, Bordeaux mixture is undoubtedly the most effective material to apply against this disease. With other crops, Bordeaux mixture has generally been supplanted by other, more modern fungicides, notably captan and thiram, because of the copper-sensitivity of the crops concerned. However, Bordeaux mixture (and other somewhat less effective copper-containing sprays) can be used with perfect safety on all forest tree species. Although less easy to prepare and

Figure 4. A sclerotium of *Botrytis cinerea*, produced under the epidermis of an infected needle on a Douglas fir seedling.

apply than the other fungicides mentioned, the better fungicidal action of Bordeaux and its more tenacious adhesion after spraying, compensate for the extra handling difficulties.

Bordeaux mixture should be applied as a 4 : 4 : 40 mixture, i.e. 4 lbs. copper sulphate and 4 lbs. of hydrated lime in 40 gallons of water. The most homogeneous and stable mixture is prepared by dissolving the copper sulphate in 35 gallons of water and mixing this into a drum or sprayer tank containing 5 gallons solution of hydrated lime. Bordeaux mixture is most effective when prepared immediately before use. Granulated and powder forms of copper sulphate are available and reduce mixing time considerably. In one-year seedbeds, the spray should be applied at about 5 gallons per hundred square yards, but with larger stock this rate may be increased. With basal infection of hemlock, the spray nozzle should be kept beneath the upper foliage.

It is rarely practicable to carry out preventative treatment against *Botrytis*, but this may be worth while in dense two-year seedbeds after a week or so of wet weather during the late summer and autumn. Usually the first application must be delayed until the first signs of infection are evident, and then applied, if necessary, at three-weekly intervals until the end of September or the beginning of October.

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Figure 2 is from a sketch by the author. The coloured photographs are drawn from the Forestry Commission collection.



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