

ENVIRONMENTAL FACTORS PREDISPOSE CONTAINER-GROWN CONIFER SEEDLINGS TO GRAY MOLD

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INTRODUCTION

Gray mold, caused by *Botrytis cinerea* Pers.: Fr., is a major disease of black spruce (*Picea mariana* [Mill.] B.S.P.) and other conifer seedlings grown in containers in greenhouses. Signs and symptoms of the disease normally begin to appear on the lower needles and stem portions after seedling canopies become dense or closed late in the growing season. Affected tissues are typically tan or medium brown in color and covered with mycelium and conidiophores of the pathogen (Fig. 1). Entire shoots can be killed as the disease progresses within the greenhouse, in subsequent cold storage, or after outplanting.

Factors reported to favor gray mold development on container-grown conifer seedlings include moderate temperature, long periods of high relative humidity (RH) or leaf wetness, low light intensity, and senescent needles (Peterson et al. 1988, Dugan and Blake 1989, Peterson and Sutherland 1990, Zhang and Sutton 1994a.) These

conditions can occur frequently once seedling canopies have developed and especially after canopy closure. In this note, effects of temperature, low light intensity, and drought on gray mold are described. Improving gray mold management by avoidance of certain environmental conditions is also discussed.

MATERIALS AND METHODS

Seeds of black spruce were sown in a mixture of peat and vermiculite (3:1, v:v) in paperpot containers in a greenhouse maintained at 20–30 °C and with a 16-hour photoperiod. Once a week seedlings were supplied with soluble 20-20-20 (N-P-K) fertilizer containing microelements. Four-month-old seedlings were used for all tests.

To examine the effects of high temperature, seedlings were placed in a growth chamber at 30, 35, 40, and 45 °C in darkness for various intervals of 0 to 143 hours. For treatments simulating drought, water was withheld from seedlings for periods ranging from 0–16 days under both growth room and greenhouse conditions. The growth room was operated at 20 °C, 40–60% RH, and a 16-hour photoperiod; the greenhouse at 16–28 °C, 25–80% RH, and natural light. To test the effects of low light intensity, seedlings were kept at 0, 7, 15, and 30 $\mu\text{mol m}^{-2}\text{s}^{-1}$ for 0–45 days.

After treatment under various temperatures, light intensities, and drought for defined periods, the seedlings were inoculated with a spore suspension of *B. cinerea*. Immediately after inoculation the seedlings were kept in a mist chamber for 36 or 48 hours. Four days after the inoculation the seedlings were sampled, surface sterilized, and incubated for 8 days. Sporulation incidence of *B. cinerea* on needle segments of seedlings was then determined.



Figure 1. Gray mold on container-grown black spruce seedlings.



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RESULTS

Effects of Low Light Intensity

For the most part, sporulation incidence of *B. cinerea* on seedling needles increased with a corresponding decrease in light intensity (Fig. 2). Light intensities below 7 to 15 $\mu\text{mol m}^{-2}\text{s}^{-1}$ effectively predisposed seedlings to gray mold. At light intensities of 0 and 7 $\mu\text{mol m}^{-2}\text{s}^{-1}$, sporulation incidence was 0 for up to 9 days, then progressively increased, and reached maxima of 45.6 and 32.2 %, respectively, after 27 days. The sporulation incidence varied from 13.3 to 40.0% after exposure to low light for 30 and 45 days. However, less than 6% sporulation incidence was observed under higher light conditions of 15 and 30 $\mu\text{mol m}^{-2}\text{s}^{-1}$ for up to 45 days.

Effects of High Temperature

Botrytis cinerea sporulated on spruce seedlings that were kept in darkness at 30, 35, 40, and 45 °C prior to inoculation (Fig. 3). The level of sporulation on seedling needles generally increased with duration of the temperature treatments. At 45 °C, sporulation incidence increased sharply after only several hours of exposure and reached 94% after 4 hours. At 35 and 40 °C, sporulation incidence on needles increased less sharply and reached 94–99 % after 44 hours. At 30 °C, however, sporulation incidence was very low after the initial 96 hours. It only reached 20% after more than 120 h of exposure.

Effects of Drought

Botrytis cinerea was not observed on seedling needles when the preinoculation drought period was short, but sporulation incidence increased progressively when water was withheld for more than 8 days. It peaked at 93% under greenhouse conditions (Fig. 4). Sporulation incidence was 0% after a 12-day drought period. However, it increased with extension of the drought period and reached approximately 45% under growth room conditions.

RECOMMENDATIONS AND CONCLUSIONS

High temperature, low light intensity, and drought conditions, each and in combination, predisposed black spruce seedlings to gray mold. Seedlings that were kept in normal (nonextreme) environments failed to develop symptoms of gray mold. Observations from this study suggest that maintenance of air temperature below about 30 °C at the soil surface, spacing of seedlings to increase light intensity in the lower portions of seedling canopies, and regular, but not excessive, irrigation to avoid drought stress are potential measures for controlling gray mold. The treatments tested were conditions that can commonly occur in commercial greenhouses. High temperatures (>35 °C) within the seedling canopy are not unusual in greenhouses on sunny days. Additionally, low light levels at the base of the seedlings are common with dense, container-grown stock. While this work has indicated that any of these conditions, acting independently, can result in an increase in

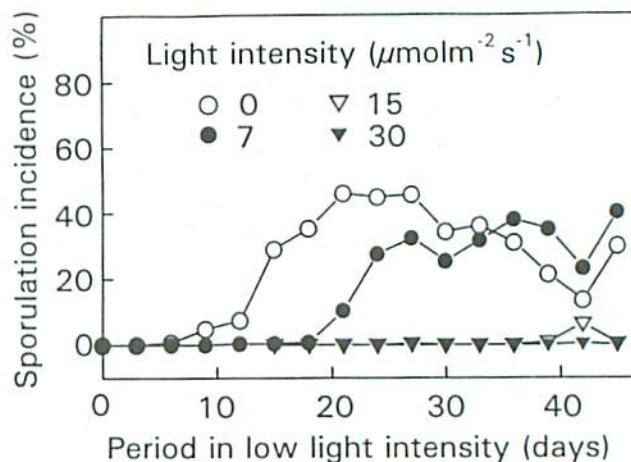


Figure 2. Effect of preinoculation exposure duration under various light intensities at 30 °C on the sporulation incidence of *Botrytis cinerea* on black spruce seedlings.

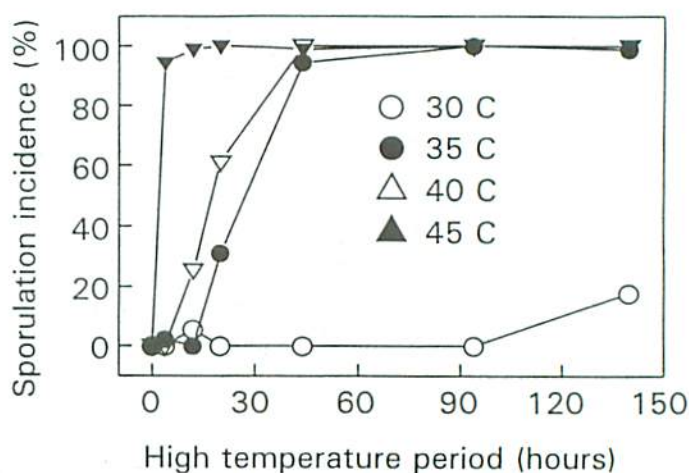


Figure 3. Effect of preinoculation exposure duration at various temperatures in continuous darkness on the sporulation incidence of *Botrytis cinerea* on black spruce seedlings.

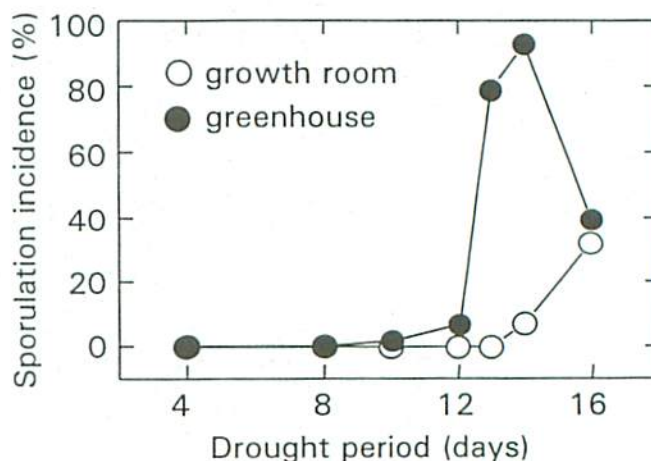


Figure 4. Effect of drought period prior to inoculation, under greenhouse and growth room conditions, on the sporulation incidence of *Botrytis cinerea* on black spruce seedlings.

gray mold, more often they act in concert. This is particularly true for high temperatures and low light conditions. Earlier work (Zhang and Sutton 1994a) also indicated that excessive periods of free water (>12 h) on container-grown stock, while not a predisposing factor, will increase spore production of the fungus and increase infection. Good silvicultural practices that lessen environmental extremes will diminish gray mold incidence and allow for a reduction in the use of fungicides to control the disease in commercial greenhouses.

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