SUPPRESSION OF SPRUCE NEEDLE BLIGHT IN COASTAL ALASKA[1]

by Paul E. Hennon and Jim R. Douglas

Abstract. To evaluate the efficacy of disease suppression, three fungicides were applied to 72 young Sitka spruce trees near Juneau, Alaska in an area of endemic infection by the needle blight fungus, *Lirula macrospora*. Treatments were applied to three branches shortly after spruce needles emerged in spring and, on one-half of the trees, again during shoot elongation. Trees treated with each of the three fungicides had significantly fewer dead needles one year after infection than did trees treated with the control. Needle death did not differ significantly among the three fungicides or on trees that were sprayed once compared to trees sprayed twice. None of the three fungicides caused observable injury to spruce tissues, nor significantly altered the shoot growth of sprayed trees. These results suggest that the disease can be controlled by applying chemical treatment at the correct time in spring shortly after bud break of spruce.

Spruce needle blight is the most damaging needle disease of spruce in western North America (1). The disease is caused by the fungus *Lirula macrospora*. In Alaska, Sitka spruce (*Picea sitchensis*) is attacked by *L. macrospora* as a forest tree and ornamental tree along all coastal areas within the range of the tree species (2). Homeowners frequently complain about the unsightly appearance of such trees in their landscaping or when they are cut from nearby forests as Christmas trees. Typically, tree death does not result from infection. Growth loss may occur in trees that are repeatedly infected, but this factor has not been studied.

In a recent study in Alaska, Hennon (3) described the life cycle of the fungus and development of symptoms on infected Sitka spruce. Results revealed that needles are infected in spring but symptoms are latent for one year; infected needles remain green until the following spring at which time they discolor to a reddish-brown color. An additional year is required before the fungus produces its fruiting body and infectious ascospores on two-year old needles that have become tan-colored. In the only other study of the life cycle of the fungus in North America, Walla (6) demonstrated that yet another year is required before spores are produced on white and blue spruce (*Picea glauca* and *P. pungens*) in North Dakota, where *L. macrospora* sporulates on three-year old needles throughout summer.

In Alaska, Hennon (3) also determined that the timing of ascospore release occurs in a relatively short period of time during spring and coincides with a critical developmental stage of Sitka spruce. Most spores are released after spruce bud break but before shoots are fully elongated. The current study applies this information on growth development and timing of fungal sporulation to determine if spruce needle blight can be controlled using fungicides.

Materials and Methods

Studies were initiated in a young stand of Sitka spruce 35 km north of Juneau, Alaska. This stand of trees has been consistently infected during recent years. Seventy-two trees that exhibited symptoms associated with this disease in the previous year were chosen for study. Tree age, basal diameter, and height averaged 11 years, 8.2 cm, and 3.0 m, respectively. Based on an examination of symptoms, trees were classified as having light, moderate, or heavy infection on two-year old needles. These are the needles that harbor the mature fruiting bodies and infectious spores of the causal fungus.

Sprays. A complete randomized block design was used where trees were grouped by severity of

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[1] Mention of a pesticide in this publication does not constitute a recommendation for use by the USDA, nor does it imply registration of a product under Federal Insecticide, Fungicide, and Rodenticide Act, as amended. Mention of a proprietary product does not constitite an endorsement by the USDA.

past infection and randomly assigned one of four treatments: spray with one of the three fungicides Benlate (benomyl), Bravo (chlorothalonil), and Fore (mancozeb) or spray with distilled water. These three fungicides were chosen because they were among the most effective in reducing the infection of a related fungus, *L. abietis-concoloris*, on white fir (*Abies concolor*) in California (4). Three branches at about breast height were selected for treatment from each tree. Each branch was labelled and sprayed to saturation with the appropriate treatment using a hand-held spray bottle. The three branches from each tree always received the same spray treatment.

The first topical spray was conducted on 2 June, 1989, shortly after bud break when young spruce needles were newly exposed and shoots were about 50% fully expanded. One half of the trees in each fungicide and control treatment received a second spray of the same fungicide on 20 June, 1989. Shoot lengths averaged 12 cm, about 90% of their final elongation at that time. Dry weather prevailed for at least 24 hours following each application.

Spore Release and Spruce Phenology. To monitor the presence and timing of infectious spore production, fungal sporulation was studied using the methods described by Hennon (3). The number of spores produced by *L. macrospora* was determined by counting the characteristic filiform ascospores (1) that were observed by microscopic examination of slides removed weekly from each spore trap from 9 May to 1 August 1989. Spore counts were converted to number of ascospores/mm^2, averaged for the three traps, and plotted against time.

The growth of shoots was monitored to describe the relationship between production of spores by *L. macrospora* and development of susceptible tissues by the host. Bud length and, after bud break, shoot length were measured each week (from 9 May to 1 August, 1989) on the shoot emerging from the spore trap and two adjacent shoots for each of the three trees with a spore trap. Bud and shoot lengths were converted to a percentage of the final shoot length for the year, averaged for all shoots, and plotted against time.

Effects of Sprays on Spruce Growth and Disease. The length of growth for each branch sprayed was measured at the end of the 1989 growing season and averaged for the three branches for each of the 72 trees. An analysis of variance and Bonferonni multiple comparison procedure $p<0.05$ (5) were used to determine if any fungicide had an effect on branch growth. Injury to needles caused by fungicides was noted by inspecting the appearance of sprayed needles at the end of summer.

Disease on needles was measured by symptom expression produced by *L. macrospora* infection. The incidence of infection was determined by assessing the percentage of brown needles from all needles that occurred on the terminal and two distal side branches of each of the three branches sprayed. Because infected needles remain green for one year before they begin to discolor (3), needle color was evaluated on 11 June 1990, approximately one year following the spray treatments. More than 100 needles per branch were counted. Needles were evaluated again on 13 August 1990, but results were only minimally different from earlier observations and some dead infected needles had dropped; thus, the 11 June observations were used for analysis. Differences by fungicide treatment and spray intervals were evaluated by two-way analysis of variance and Bonferonni's multiple comparison procedure (5) at the $p<0.05$ significance level.

Results and Discussion

Spore Release and Spruce Phenology. Infectious spores were produced in small numbers throughout May, peaked to a weekly high of 2.6 spores/mm^2 near the middle of June and were found in small numbers throughout July (Fig. 1). The first topical spray was administered before sporulation began to peak, but not before a small number of spores were produced. The second spray was conducted during peak sporulation, after many spores contacted needles. The quantity and pattern of sporulation by *L. macrospora* was generally similar to that reported by Hennon (3) in 1987 and 1988; a single peak of spore release occurred in early and late June, respectively.

Spruce buds began to swell and expand during early May (Fig. 2). By the middle of May, spruce

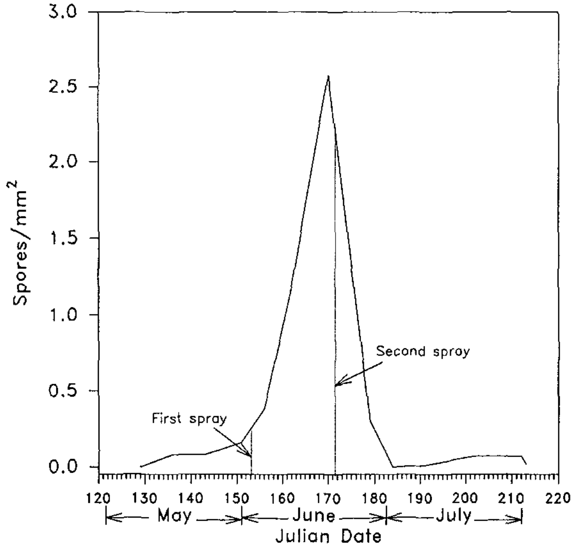

Figure 1. Concentration of ascospore release by the spruce needle blight pathogen, *Lirula macrospora*, during 1989. Values represent average spore densities from three spore traps charted approximately once per week. The timing of the first and second spray treatments are noted.

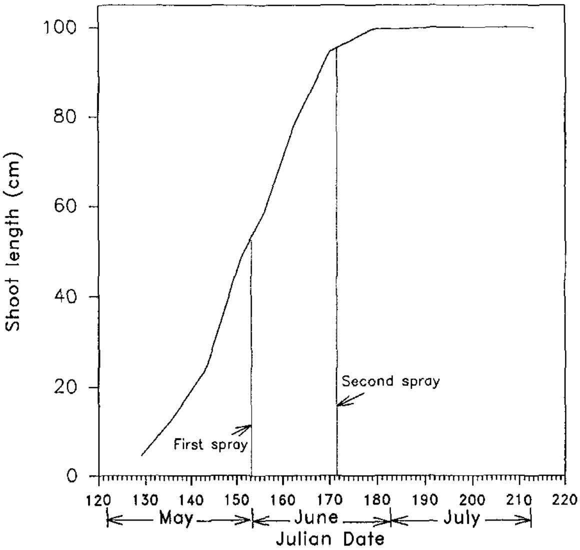

Figure 2. Shoot growth of Sitka spruce during the growing season of 1989. Values represent averages of the total seasonal shoot growth of three branches from each of three trees. The timing of the first and second spray treatments are noted.

buds burst, exposing new needles for the first time. Bud caps generally remained on new shoots for one week after bud break before falling away. Even though shoots began to elongate, needles remained clumped, adhering closely to shoots for an additional week. Thus, needles were not fully exposed to *L. macrospora* spores until the end of May, which coincided with the first application of sprays. Shoots elongated quickly and reached more than 90% of their final length at the time of the second topical spray on 20 June. Although shoots were almost fully elongated at that time, needles still had the bright green color and soft flexibility of new needles. Final shoot lengths for the growing season, which averaged 12.4 cm, were typically reached before the end of June.

Effects of Sprays on Spruce Growth and Disease. None of the fungicides caused any observable damage to spruce needles. Several needles had been chewed, probably by insects, and a small number exhibited the symptoms and fruiting bodies of the rust fungus *Chrysomyxa ledicola*, but over 99% of needles from all treatments were unharmed. In addition, the fungicides had no detectable affect on growth as average shoot growth for the growing season did not differ significantly among treatments.

Trees treated with each of the three fungicides had significantly fewer infected needles than water-treated controls (Table 1, Fig. 3). An average of 7.9% of needles on control trees were infected. Although not severely diseased, this level of infection gave spruce trees the characteristic unhealthy, discolored appearance when viewed from a distance. While each fungicide lowered the infection level to an average of 1.6, 1.7, and 2.1% needles infected for Fore, Bravo, and Benlate respectively, none completely eliminated the fungus. The lower disease levels gave trees a markedly improved appearance, but dead needles retained in the interior of the crown from previous years' infection were still visible. Where the disease is chronic, annual spray treatments may be required to improve the trees' appearance.

Although differences for the number of sprays were not significant, trees sprayed twice rather than once tended to result in less frequent infection when the fungicides Benlate and Fore were

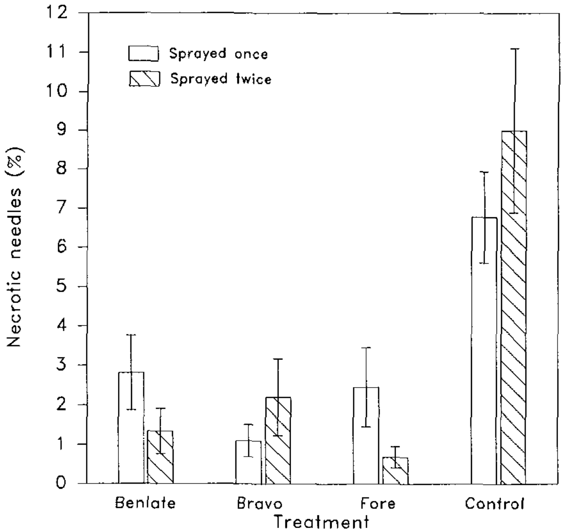

Figure 3. Incidence of needle infection. Values represent average percentage of necrotic one-year old needles from three branches on each of 9 trees that were sprayed once or 9 trees sprayed twice for each fungicide treatment. Bars represent ± one standard error.

Table 1. Summary of analysis of variance of percent brown (necrotic) needles as affected by fungicide treatment (three fungicides and a control) and number of times sprayed (once or twice).

Source	Degrees of freedom	Mean square	F value	Probability
Fungicide	3	162.9	15.7	0.0001
Applications (no.)	1	1.1	0.1	0.7
Fungicide x applications	3	23.1	2.2	0.09
Error	64	10.4		
Total	71			

used, but more infection in Bravo-treated spruce. The effectiveness of the second spray was apparently not related to whether the fungicide was classified as a systemic (Benlate) or contact (Fore and Bravo). Of the various treatments, the best disease suppression was achieved with two applications of Fore, which resulted in less than 0.7% needle infection and better than a 10-fold level of disease control.

The level of attack in recent years had no significant effect on the frequency of infection in 1989. Thus, the infection level for a particular year cannot be predicted by how severely it was attacked in years immediately preceding.

The timing of fungal sporulation appears to be closely linked to the emergence of succulent spruce needles in spring. The greatest quantity of spores has been produced during a brief several weeks in June, each of the three times that spore release has been measured in Alaska. Consistently, peak sporulation occurred after bud break, but prior to completion of shoot elongation and the period when spruce needles fully developed their waxy cuticle layer and stiff texture. It is conceivable that spruce needles are susceptible to infection only in the newly emerging state and that the fungus is well-adapted in the timing of its sporulation. Thus, ascospores produced earlier would be present before bud break when new needles are unavailable and those produced after shoot elongation would encounter spruce needles with resistant thick cuticles. With this fungal pathogen so well-timed in its sporulation, control efforts must be equally well-timed to successfully reduce disease severity.

Any of the three fungicides are probably suitable for controlling the fungus L. macrospora on Sitka spruce. In the present study, the two contact fungicides Fore and Bravo tended to reduce the disease more effectively than did the systemic Benlate, but differences were not significant and all fungicides exhibited some level of disease suppression.

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