

Effect of *Lophodermium seditiosum* on Growth of Pine Nursery Seedlings in Wisconsin

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ABSTRACT

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A needle cast disease caused by *Lophodermium seditiosum* has killed or severely damaged millions of red and Scotch pine seedlings in nurseries and Christmas tree plantations in many areas of the United States since the mid-1960s. Outbreaks of *L. seditiosum* periodically occur in nurseries when chemical control measures are not used or improperly applied. The impact of this disease on seedling height and diameter growth of three pine species grown in a Wisconsin nursery was studied. Pine seedlings were either protected with fungicides or left unprotected for 3 yr. In the nursery, seedling survival and height and diameter growth were significantly less in untreated than in treated plots. One year after outplanting, red pine seedling survival and height growth were not significantly different, but symptoms of *Lophodermium* needle cast were visible on 80% of the foliage of untreated seedlings and on only 20% of maneb-treated seedlings.

Lophodermium needle cast affects pine seedlings in many nurseries in several states (8). The highly pathogenic disease that was previously described as being caused by *L. pinastri* (Schrad. ex Hook) Chev. was actually caused by a newly described species, *L. seditiosum* Minter, Staley, & Millar (2,5). During the mid-1960s, millions of red pine (*Pinus resinosa* Ait.) and Scotch pine (*P. sylvestris* L.) in nurseries were seriously damaged or killed by the needle cast disease caused by *L. seditiosum* (7,11). Many nurseries unknowingly shipped infected planting stock. As a result, catastrophic damage occurred in Scotch pine Christmas tree plantations wherever stock infected with *L. seditiosum* was planted (8).

Chemical controls have been successful in managing *Lophodermium* needle cast disease in nurseries and Christmas tree plantations (6,8,10). However, outbreaks of this disease continue to occur periodically when control measures are not applied and where climatic conditions are conducive to disease development and pathogen spread. Recent outbreaks of *Lophodermium* needle cast were reported in the southern United States in 1986 (3) and in Michigan in 1988 (1).

In Europe, genetic differences and

correlations were found for height growth of Scotch pine and severity of *Lophodermium* needle cast (4,12), and young Scotch pine protected from *Lophodermium* infection by three fungicide applications were taller than untreated controls (9). The impact of this needle cast disease on the growth of nursery seedlings has not been documented in the United States. This information is critical to advising nursery managers on how to control this pathogen.

The objective of this study was to compare the impact of the needle cast disease caused by *L. seditiosum* on seedling height and diameter growth of three pine species in nurseries and on red pine seedling survival after outplanting.

MATERIALS AND METHODS

This study was established at a forest tree nursery near Rhinelander, Wisconsin. We used beds of 1-yr-old seedlings of red pine, Japanese red pine (*P. densiflora* Sieb. & Zucc.), and Spanish and French sources of Scotch pine. Each bed had been seeded to a density of 35 seedlings per 0.3 m². All plots were 1.2 × 3.1 m. Eighteen plots were randomly chosen in each bed of French and Spanish Scotch pine; each fungicide treatment was replicated three times within a bed, and nine unsprayed plots per bed served as controls. Six plots were established in each bed of red and Japanese red pine, one per fungicide treatment and three for unsprayed controls. Fungicides were applied three times a year for 3 yr, before and during

estimated periods of spore discharge and infection (8). The fungicides used were: 1) benomyl (Benlate 50WP), 9.6 lb FP/acre; 2) chlorothalonil (Daconil 2787-75WP), 6.0 lb FP/acre; and 3) maneb (Manzate 200-80WP), 5.8 lb FP/acre. A spreader-sticker (Dupont), 118 ml/378 L (4 oz/100 gal), was added to each fungicide solution.

At the end of the 3-yr period, 100 randomly selected seedlings from each plot were harvested in June by clipping them at the ground line. The incidence and severity of *Lophodermium* needle cast were rated on a scale of 0-5, where 0 = no healthy needles and 1 = 1-25%, 2 = 26-50%, 3 = 51-75%, 4 = 76-99%, and 5 = 100% of needles healthy. Seedling height and basal diameter also were measured. Analysis of variance was used to test for differences among means with respect to height and diameter. Chi-square tests were used to compare disease severity of treated and untreated plots.

To evaluate the impact of *Lophodermium* needle cast on outplanted seedling survival and height growth, 75 3-yr-old red pine seedlings from both maneb-treated and untreated nursery beds were studied. Seedlings were planted at a 2 × 2 m spacing in three 25-tree plots for each treatment group using a randomized design. After one growing season, tree survival and height and the presence or absence of *L. seditiosum* were recorded. Analysis of variance was used to test for differences among means of seedling height growth.

RESULTS

Properly timed applications of the three chemicals protected all three pine species from *L. seditiosum* needle cast disease. There were few significant differences in the effectiveness of the three fungicides in preventing disease (Table 1). Seedling mortality caused by infection with *L. seditiosum* was high in unsprayed plots. For example, 85% of the red pine seedlings in unsprayed plots, but none of those in sprayed plots, died ($n = 235$) (Fig. 1).

All trees in the treated plots had significantly healthier foliage than those in the unsprayed plots ($P = 0.05$) (Table 1). Sprayed red pine, Japanese red pine, and Spanish Scotch pine had nearly

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100% healthy foliage, whereas unsprayed red pine, Japanese red pine, and Spanish Scotch pine had only 25, 62, and 12% healthy foliage, respectively. Sprayed French Scotch pine had nearly 75% healthy foliage and unsprayed French Scotch pine, only 25%.

Sprayed trees of all three species were significantly ($P = 0.05$) taller than

unsprayed trees (Table 1, Fig. 2). Red pine sprayed with maneb, Japanese red pine sprayed with benomyl or chlorothalonil, French Scotch pine sprayed with benomyl, and all sprayed Spanish Scotch pine had significantly ($P = 0.05$) greater stem diameters than those of unsprayed trees.

After 1 yr in the field, no red pine

seedlings had died, whether treated or untreated. Maneb-treated seedlings were taller than untreated seedlings, but the difference was not significant. However, 80% of the foliage of untreated seedlings, but only 20% of that of maneb-treated seedlings, showed symptoms of *Lophodermium* needle cast.

DISCUSSION

L. seditiosum has caused extensive mortality to nursery seedlings and damage to plantation trees in the past (8). Effective fungicide controls have been developed, but recent outbreaks of the disease indicate that control recommendations are not always followed, nursery managers and Christmas tree growers are not aware of them, or chemicals are being improperly applied.

Results of this study underscore the impact that *L. seditiosum* has on nursery seedling survival and growth. The reduced seedling height, diameter, and presumably vigor of unsprayed trees were due to the loss of healthy foliage caused by the fungus. Apart from direct mortality and reduced growth in the nursery, the greatest hazard is in shipping infected planting stock. Although there were no significant differences in seedling height, due to variability of seedling growth within the planting, *L. seditiosum* remained active in untreated seedlings 1 yr after outplanting. Because of decrease in healthy foliage, tree growth and quality may be less in outplanted infected trees than in healthy trees that were protected from infection.

Moving the fungus to new areas can

Table 1. Impact of needle cast caused by *Lophodermium seditiosum* on mean height and diameter growth of red pine (RP), Japanese red pine (JRP), Spanish Scotch pine (SSP), and French Scotch pine (FSP) in a Wisconsin nursery

Treatment	Foliage rating ^y				Height (mm)				Diameter (mm)			
	RP	JRP	SSP	FSP	RP	JRP	SSP	FSP	RP	JRP	SSP	FSP
Benomyl	5.0 a ^z	4.9 a	5.0 a	3.9 ab	42 a	69	46 ab	64 a	5.2 a	8.3	8.5 a	6.9
Maneb	4.9 a	5.0 a	4.8 a	3.4 a	50	60 a	49 a	60 ab	5.6	5.4 a	8.3 a	6.0 a
Chlorothalonil	5.0 a	5.0 a	5.0 a	4.1 b	40 a	64 a	45 b	58 b	4.4 b	6.6	7.3	5.9 a
Control	1.4	2.6	0.4	1.1	31	47	30	43	4.9 ab	5.6 a	5.9	5.8 a

^yScale of 0-5, where 0 = no healthy needles and 1 = 1-25%, 2 = 26-50%, 3 = 51-75%, 4 = 76-99%, and 5 = 100% of needles healthy.

^zValues followed by the same letter are not significantly different ($P = 0.05$).

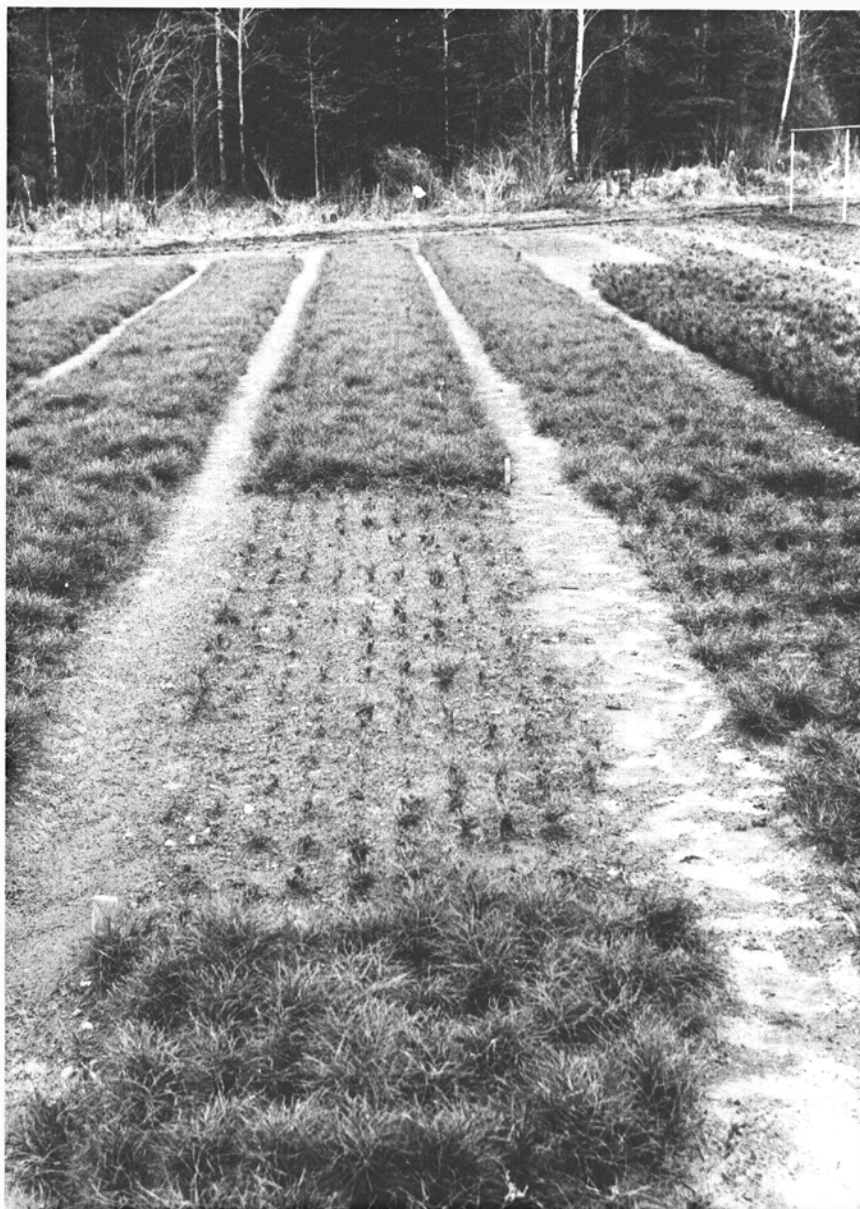


Fig. 1. Red pine seedlings killed by *Lophodermium* needle cast in unsprayed plot (center foreground); seedlings in adjacent plots were protected by fungicide sprays.



Fig. 2. Sprayed and unsprayed red pine seedlings harvested at ground line after 3 yr. The two large seedlings on the right were protected from *Lophodermium seditiosum* for 3 yr by three applications of benomyl per year; the three small seedlings on the left were not protected by a fungicide.

cause damage to plantations established with infected planting stock or to adjacent plantations of susceptible trees. This has been a serious problem in Christmas tree plantations, where needle cast disease has made trees unsaleable because of loss of foliage. Control of this disease in the nursery is important; once widely distributed and established in plantations, the disease is more difficult and expensive to control.

Nursery managers and Christmas tree growers need to monitor for the presence of *L. seditiosum* and take appropriate control measures as soon as possible and at the proper times. Preventive as well as cultural and chemical controls have been developed that can minimize damage (8).

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