SCLERODERRIS CANKER IN ONTARIO FOREST NURSERIES

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Frontispiece: Jack pine nursery bed depleted by Scleroderris lagerbergii

ABSTRACT

Destruction of pine plantations by the fungus *Scleroderris lagerbergii* (Lagerb.) Gremmen can usually be traced to infected nursery stock. The fungus may spread from one seedling to another even during shipping, and a limited nursery infection become magnified by the time the seedlings reach the planting site. The fungicides Maneb and Ziram are effective in reducing the extent of infection in the nursery, but every effort should be made to eliminate infected trees close to the beds in order to reduce the number of spores immediately available for infection.

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INTRODUCTION

The degree of damage that can be caused when nursery seedlings infected by the fungus pathogen *Scleroderris lagerbergii* (Lagerb.) Gremmen are inadvertently included in transplant stock used for the establishment of plantations has been described in detail elsewhere (Dorworth 1970), as have the means by which the fungus might be expected to spread. In brief, the fungus overwinters in the dead and dying branches and trunks of infected trees. Reproductive structures (the *ASCUS*; pl. *ASCI*) develop on the bark, needle fascicles, and needle bases from April through late July, depending upon the weather, and release spores (*ASCOSPORES*) during rainy periods. The ascospores may be windborne for several miles to the buds, needles, and expanding shoots of susceptible conifers, where they germinate and grow into the tissues of the tree if free water is available. Later in the year, from June through September, the same tree that produced the ascospores will ordinarily produce a second type of spore (the *CONIDIUM*; pl. *CONIDIA*) from a second type of reproductive structure (the *PYCNIDIUM*; pl. *PYCNIDIA*). The conidia appear in a long (to 3/16") white tendril, which is actually comprised of thousands of conidia held together by a sticky substance. These spores are distributed over short distances principally by splashing rain and irrigation water. In either case, infection is not visible until the following spring. Many trees may be killed and larger surrounding trees infected, though fewer than 1% of the seedlings in a plantation initially carried the fungus, and each new infection is potentially a new source of spores for further infections.

The disease is particularly important in Ontario where the Department of Lands and Forests has devoted considerable effort to the development of a site classification scheme, whereby each potential planting site is evaluated and the species of seedling best adapted to that site is automatically employed. If seedlings infected with *S. lagerbergii* are planted, the plantation is often effectively destroyed within the first 10 years, leaving some infected survivors to perpetuate the disease if further planting of susceptible species occurs. Conversely, if less suitable species are used than those dictated by the site selection program, the background research and immediate effort involved in the program are largely wasted. In either instance, the presence of *S. lagerbergii* in a replant area represents considerable loss of money and effort for the agency involved.

The problem is not confined to outplantings alone, and serious situations either did exist or continue to exist in Ontario nurseries themselves. Punter (1967) noted extensive infections in the Kirkwood

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and Swastika nurseries, and in a private nursery near Longlac. Plantation infections have since been found concentrated largely in the areas served by these nurseries (Dorworth, in press). Punter (1967) noted also that infections in the Kirkwood nursery necessitated the destruction of approximately 900,000 red pine, *Pinus resinosa* Ait., seedlings. This situation corresponds closely with that described from Sweden by Kohh (1964), where 20,000,000 Scots pine, *P. sylvestris* L., seedlings had to be discarded in 1959, and a total of 75,000,000 trees were damaged before the outbreak was brought under control. Kohh emphasized that damage consisted of death of seedlings in the nursery beds and of stock outplanted before the nature of the disease was understood. Control was eventually effected largely through application of the fungicide Maneb, although a potentially dangerous situation exists to this day.

Recently examinations of the Swastika and Kirkwood nurseries were made in response to Lands and Forests requests, and the seedling beds were found to be essentially free of *S. lagerbergii*. I believe that this resulted from the nurseries suspending production of red pine seedlings, which are far more susceptible to infection in the seedling stage than jack pine, *P. banksiana* Lamb. A potentially dangerous outbreak was detected, however, in the Thunder Bay nursery in pine seedlings in the fall of 1970, with infected seedlings scattered uniformly among several beds.

The nursery manager having a problem with *S. lagerbergii* has been faced with two alternatives to date. He could continue to grow susceptible species in his beds, accepting obvious losses as they occurred along with the danger of spreading the disease by including infected stock in his shipments, or he could discontinue production of susceptible species and convert his production to less susceptible, but very likely less desirable species. If he accepts the latter alternative, and pine is required for outplanting in the area serviced by the nursery, this pine must be brought in from distant points with the attendant problem of using non-acclimatized stock, and the ever-present danger of transmitting pathogenic fungi, insects, and nematodes to places in which they may not have occurred previously.

As serious as this nursery problem may be, however, our current knowledge of *S. lagerbergii* is such that some methods are currently available to reduce losses caused by this pathogen. These are considered below in relation to what is known of the biology and epidemiology of *S. lagerbergii*.

DISEASE CYCLES IN THE NURSERY

Ascospores were mentioned earlier as a means whereby seedlings might become infected in the nursery from pre-existing sources. Once such infections occur, conidia are produced and serve as an ideal means of disseminating the fungus within the nursery bed. I achieved 13.2% infection of 3-1 seedlings in an experimental nursery near Thessalon, Ontario, in 1969 with a light application of conidia (80 spores/ft^2 of bed), and thus substantiated Gremmen's (1968) work demonstrating infection by conidia. The inoculations were conducted in August, during a relatively dry period, and a much higher percentage of infection might have been expected had wetter conditions prevailed during the experiment. Infections were recorded on the basis of symptoms, and were confirmed through reisolation of the fungus from 77% of the seedlings thus noted.

Regardless of the time of infection, symptoms are not evident until about 1 month before shoot elongation resumes the following spring. Symptoms in the experimental nursery at Thessalon first became evident the last week in May, 1970, as a yellow-orange discolouration of the bases of those needles immediately below the dead bud; ordinarily the terminal bud. As the shoots on adjacent healthy seedlings began to elongate, the foliage of the infected trees assumed a gray-green caste. The yellow-orange discolouration progressed toward the tips of the needles, becoming dark brown in the process. Similar symptoms were noted in Sweden by Kohh (1964), and in The United States by Skilling and Waddell (1970). Diseased and healthy seedlings were easily distinguishable, the symptoms being sufficiently distinct that they could be resolved on Kodak Verichrome Pan film (Figure 1). Basal browning appears as a dark area, whereas the gray-green foliage appears considerably lighter than the healthy foliage of adjacent trees.

Foliage below the last year's growth was frequently alive, and in many cases lateral branches had become dominant and exceeded the old leaders in height (Figure 2). Figure 2 may be compared with Figure 1 to identify and colour-code the various symptom zones described. Experience has shown that these new leaders persist only 1 year on seedlings of this age before the entire seedling dies. The additional year of life insures that ascospores will be produced subsequently on the dead tissues obvious during the current year. During weeding and similar maintenance operations, the dead tops of the infected seedlings are easily broken off and disregarded, with the fungus persisting only in the moribund tissues near the node. In common practice, the seedling would be considered healthy and lifted for outplanting, whether or not the old leader was absent, if a new leader was in evidence. As noted, one infected seedling in a nursery bed or plantation can become the focus, or centre of infection, from which the fungus spreads to adjacent trees.

In contrast to 2-year-old seedlings, 1-year-old seedlings are ordinarily killed the winter following infection. They ordinarily produce only conidia, are then laid prostrate by the rain and snow, and are quickly colonized by a variety of other fungi which displace *S. lagerbergii*. Such seedlings are not normally included in stock in-

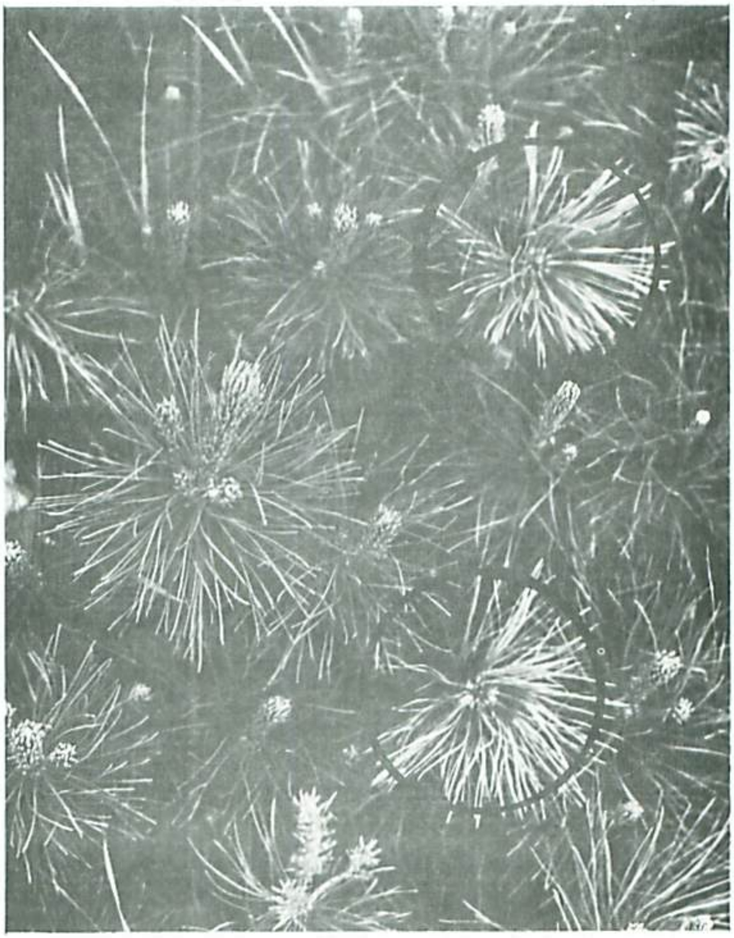

Figure 1. Seedlings of P. resinosa infected by S. lagerbergii exhibiting foliage colour different from that of adjacent healthy seedlings.

tended for outplanting, and do not constitute a hazard to the plantation.

INTENSIFICATION OF SCLERODERRIS INFECTION DURING HANDLING AND SHIPPING

Less well understood is the possibility of fungus proliferation as a result of nursery handling and shipping practices. *S. lagerbergii* is a "low temperature" fungus, capable of growth at temperatures near freezing. Ontario isolates tested in this laboratory in culture did not survive temperatures above 105°F after 12 hr exposure. The exact thermal death point of these isolates lies somewhere between 95 and 105°F and

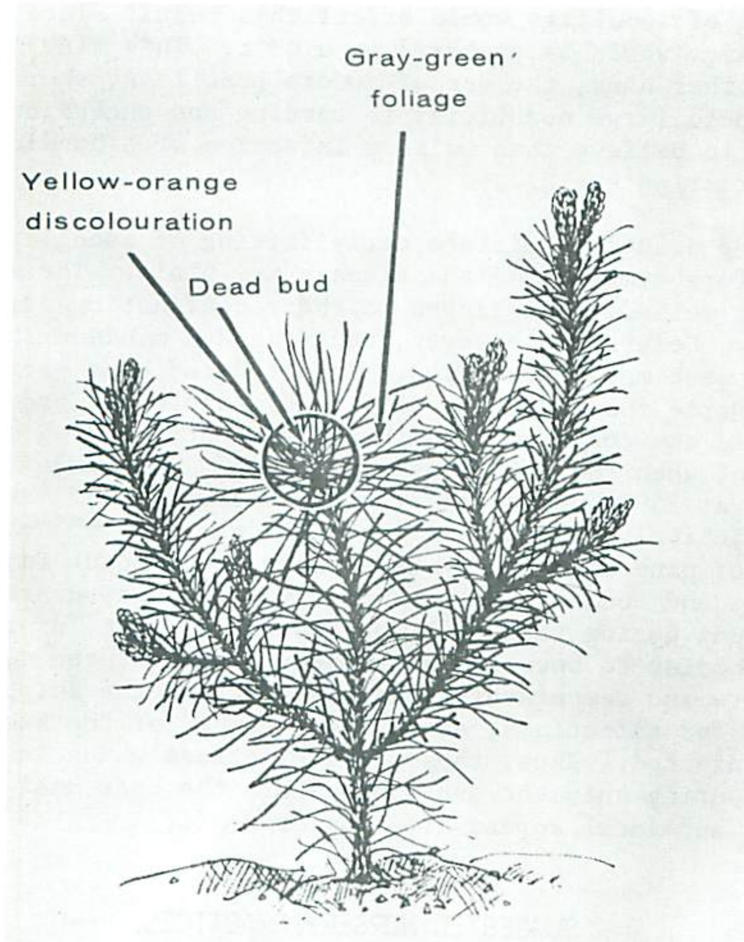

Figure 2. Progressive symptom development on a seedling of P. resinosa infected by S. lagerbergii.

this may explain the lack of serious infections in southwestern Ontario and southern Michigan, where prolonged high summer temperatures often prevail. Conversely, storage of seedlings at low temperatures cannot be expected to impede the activities of the fungus.

Field observations in plantations in Ontario and in The United States often reveal discrete rows of trees killed by *S. lagerbergii*, adjacent to rows of non-infected trees and trees in the early stages of infection. This would indicate that the dead rows of trees originated from uniformly infected bundles of seedlings, and are a source of secondary infection to the adjacent trees.

Field packaging of seedlings would effect this result since a pocket of infected seedlings would be packaged as a unit. This view is widely held. On the other hand, the use of modern practices, whereby seedlings are transported in large quantities to sorting and packaging sheds, would lead one to believe that uniform infection of a bundle of seedlings occurs after packaging.

Shipping practices dictate early lifting of seedlings from the beds, often before symptoms of the disease are plain. The seedlings are tightly packed, wetted, and shipped to their destinations with the least possible delay. Delays do, however, occur, and a minimum shipping time of 3 days to a week may be expected. Infected red pine parts, stored in Sault Ste. Marie for 5 days at 40°F in plastic bags, produced viable conidia while in the containers, although current fruiting structures were not evident when the seedlings were placed in storage. After 2 weeks' storage at 35°F under similar conditions, *S. lagerbergii* was found growing actively over the surfaces of dead pine branches and the dead portions of pine seedlings. Were the same to occur in a tightly packed, wetted, and cooled crate of nursery seedlings, average shipment time and movement during transport would be sufficient for these microscopic fungus bodies to become distributed throughout the mass of seedlings. Moisture and temperature conditions within the shipping crates are also ideal for infections, and a large number of the seedlings could become infected. Thus, those very practices which insure seedling survival during shipment and storage are the ones most favourable to development and local spread of *S. lagerbergii*.

SUGGESTED NURSERY PRACTICES

Observations here and elsewhere suggest the need for implementation of certain preventative practices in nurseries where *S. lagerbergii* is a problem.

1. New nursery sites should be chosen away from stands of older, susceptible trees to avoid the possibility of later infection.

2. Skilling and Waddell (1970) recommend the use of the fungicides Maneb 80W or Ziram 76W at 3% of the active ingredient applied at 3.1 and 3.3 lb/100 gal water, respectively. These workers applied 57 oz spray per 100 ft^2 of bed with sprayers calibrated to deliver 0.05 gal/min at 40 psi, in each of 14 sprays applied over the period from late May to early September. These treatments reduced infection in a Michigan nursery by 90%.

3. New plantings of susceptible species should be avoided in nurseries where *S. lagerbergii* prevails in windbreak trees,

border trees, or in immediately surrounding plantations. We suggest that borders of susceptible trees be underplanted with alternative species with the aim of eventually replacing those existing sources of infection that lie closest to the nursery beds. Red pine, jack pine, and Scots pine are the worst offenders, and *S. lagerbergii* was found in spruce during the summer of 1970. Cedar, *Thuja* spp., is recommended as a replacement species wherever possible.

4. Lifting of susceptible species should be delayed as long as is feasible in the spring, and the seedlings examined closely before lifting in an attempt to detect any of the symptoms of infection described earlier. Infected seedlings should be removed in a block with surrounding, apparently healthy seedlings, and burned.

5. Shipment of seedlings susceptible to *S. lagerbergii* should be expedited above that of all other species, so that a minimum of time elapses between packaging and receipt of trees. The crates should be opened upon receipt and the foliage permitted to dry. Outplanting procedures should be as usual, but planters should be made aware of the symptoms of infection by *S. lagerbergii* and encouraged to either discard seedlings which bear symptoms, or to return these to their supervisors for laboratory confirmation. The latter course will lend greater insight into problems that might develop later in the plantation.

In nurseries where *S. lagerbergii* is a problem, we must, at present recommend the application of fungicides after each rain from at least the middle of May through July 1, to insure maximum protection from the fungus. The rapid development of shoots during this period leaves new tissues unprotected within a short time after each spray. In any event, the nursery manager will lessen the chances of infection by eliminating those sources of spores closest to the nursery beds.

We are presently trying to devise a system whereby the fungus can be eliminated from seedlings with heat treatment. Additional information on fungicides that remain active within the seedlings, avoiding the need for frequent sprays, may be available within a year. We recognize that not all problems fit the situations described here, and nursery managers might wish to seek further information or specific assistance from the Forest Research Laboratory, Canadian Forestry Service, P.O. Box 490, Sault Ste. Marie, Ontario.

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