Frontline

Forestry Research Applications

Canadian Forest Service – Ontario

Technical Note No. 84

MINIMIZING LOSSES TO ARMILLARIA ROOT ROT IN ONTARIO SPRUCE

R.D. Whitney and M.T. Dumas

CATEGORY: Pest management
KEY WORDS: Black spruce, Armillaria, spruce, root rot, plantations, pest control

INTRODUCTION

Armillaria root rot is the most widespread and destructive root disease of trees in Ontario. The main species found within the province is *Armillaria ostoyae* [Romagnesi] Kerink (Dumas 1988) which attacks commercial hardwoods and conifers of any age. The Armillaria-infecting propagules are found wherever woody material is present in the soil.

DAMAGE

Studies of black spruce plantations, aged 7 to 20 years, revealed that up to 5% average annual mortality occurs as a result of Armillaria root rot. In studies of older white spruce plantations, aged 43 to 58 years, annual mortality ranged from 1 to 3%. Losses are similar for both spruce species in Ontario. Groups of dead trees cause gaps in the stand and, as disease pockets can spread at a rate of 1 to 2 m per year, future wood yields may be reduced.

Studies of natural stands in northern Ontario have shown that an average of 40% of living black spruce 30 to 150 years old were infected. An estimated 3% of the inventory was either dead standing or windfallen due to Armillaria. Butt rot and growth reduction in the remaining trees are estimated at 3 to 4% of gross merchantable volume per year. This chronic disease may have a more significant economic impact in managed forest stands.

RECOGNITION

Armillaria root rot can be suspected when dead or chlorotic trees are seen in young spruce stands, 5 to 15 years old (Fig. 1). Needle length and terminal and lateral internodes of the last 1 to 3 years are usually shorter than those on nearby healthy trees. Basal resinosis may also be present (Fig. 2). The disease is confirmed if white sheets of mycelium, termed mycelial fans, are present when bark is peeled back at the root collar or on the base of large roots of chlorotic or recently killed trees (Fig. 3). Annual honey-colored mushrooms (sporophores) may appear at the base of the tree in September or October (Fig. 4). However, absence of either fans or mushrooms on suspect trees does not mean that the disease is absent.

In larger trees, above-ground symptoms of chlorosis and growth reduction are similar, but the growth reduction period may be 5 to 10 years. In addition, older black spruce usually have excessive branch mortality in the lower crown and basal resin is often prolific (Fig. 2). Uprooted windfalls frequently draw attention to Armillaria in older black spruce (Fig. 5).

Yellow stringy decay in roots and stems near ground level can also indicate Armillaria, especially in older trees, but this decay can persist for many years without killing the tree. Black rhizomorphs (shoe strings) (Fig. 6), easily confused with roots of minor vegetation, are frequently present on root surfaces of large or small diseased trees; however, they can be present on uninfected trees as well.

Natural Resources Canada Ressources naturelles Canada

Canada

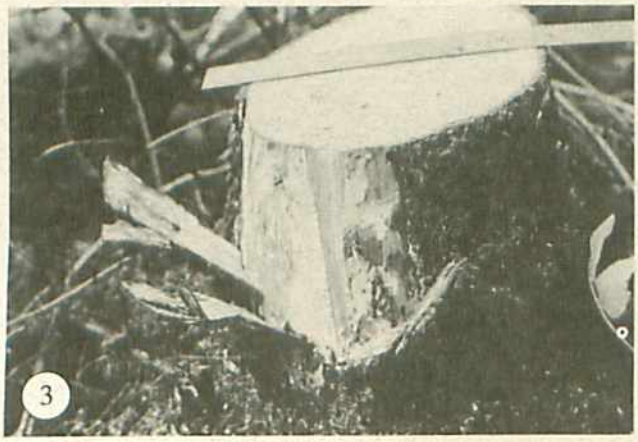

Figure 1. Dead saplings (centre) killed by Armillaria root rot.

Figure 2. Basal resinosis caused by Armillaria in 62-year-old living white spruce, Petawawa, Ontario.

Figure 3. White mycelial fans of Armillaria obscura *sporophores at the base of a recently killed 35-year-old white spruce, Petawawa, Ontario.*

Figure 4. Armillaria obscura *at the base of a recently killed 35-year-old white spruce, Petawawa, Ontario.*

Figure 5. Root weakening by Armillaria can lead to green windfalls like this 60-year-old planted white spruce, Petawawa, Ontario.

Figure 6. Rhizomorph of Armillaria obscura *penetrating the bark of a living 9-year-old planted white spruce. Rhizomorph originates from the dead poplar root in the lower left corner of the photograph.*

FACTORS AFFECTING ARMILLARIA ROOT ROT

As with all tree diseases, the three primary conditions for development are: 1) presence of pathogenic inoculum; 2) susceptibility of host; and, 3) favorable environment for the disease.

Inoculum

Armillaria ostoyae, a native parasite, is generally distributed throughout the boreal forest. It resides in living or dead woody material, especially recently cut stumps. Either the extension of rhizomorphs from the food base to living roots, or direct contact between infected and healthy roots, can result in infection. Massive amounts of inoculum can build up in recent cutovers where fresh woody material becomes available for the fungus. A similar flush of inoculum can occur in roots of woody weed species killed mechanically or by the use of herbicides. Other events contributing to inoculum potential include selective cutting, extensive blowdown, and wildfires. Initial research reveals that hardwood stumps may be more potent as inoculum sources than are conifers.

Host

Vigorous host trees, free from stress, can usually confine infections to root lesions or heartwood decay. Most older infected black spruce studied were holding the disease in check. Bark injury in roots, resulting from chewing by insects or small mammals, wind-induced breakage, or logging machinery, may provide infection courts. Energy spent in the healing process reduces tree vigor and further increases susceptibility to infection.

Long-term observations have indicated the proportion of trees dying annually from this disease decreases beyond 20 to 30 years of age, though their roots remain infected.

Environment

Host resistance, expressed as prolific resin production or walling-off of infected tissues, can be interfered with when trees are stressed. Drought, frost, competition, toxic chemicals, wounding, defoliation, suffocation of roots, and any other stress agent can weaken the resistance mechanism and allow the fungus to proceed along the cambium of the roots and root collar to kill the tree.

Armillaria seldom attacks trees growing on very moist soils or peat. Hot fires may kill shallow rhizomorphs (the main infecting agent of Armillaria) on root surfaces and in the soil, but do not kill mycelium present on the cambium or that present in roots and stumps, unless these are consumed by the fire.

MINIMIZING LOSSES

Once a tree is infected with Armillaria there is no known practical means of ridding it of the parasite. Manipulation of the three requisites of the disease must be done to hold losses to a minimum. Preharvest surveys can be conducted to evaluate the potential impact of the disease by determining areas of heavy windfall or tree mortality.

Inoculum

Knowing how much Armillaria exists on a site can influence the choice of regeneration methods. A recently devised technique, employing bark bags to trap rhizomorphs (Ip 1991), gives a quantitative measure of disease potential. For highly valued plantings, such as seed orchards or parks, this method may be used and followed-up by removal of infected stumps and roots to a minimum diameter of 1 to 2 cm. If done prior to seeding or planting, inoculum and hence mortality, will be reduced in the developing stand.

Armillaria root rot can probably be avoided in seed orchards if they are established on agricultural land that has sustained no woody growth on it for at least 50 years.

Host

Matching of indigenous seed provenances with suitable sites and maintaining high tree vigor are probably the most important host-related actions that can be taken to prevent losses. Conversely, planting species off-site reduces tree vigor and increases susceptibility. On infected sites, pines are preferred since they have a higher resistance to the disease. Seeded trees are less susceptible to infection than is bare root stock.

Environment

Black spruce stands on wet sites are seldom attacked. Stands on dry upland sites with light soil should be harvested as early as management objectives can be attained, since they are most susceptible to Armillaria. Spacing and cleaning operations in young stands often increase dead root material and thus the likelihood of disease. These practices should be avoided in spruce stands on hazardous sites (dry, high inoculum). When applying herbicides, care should be taken to adjust rates of application to kill hardwoods to ground level only, since keeping roots alive helps to prevent them from becoming infected. Any operation or activity that causes wounds to tree roots or butt areas should be minimized.

ARMILLARIA ROOT ROT AND FOREST MANAGEMENT

Planning for disease control in the next tree crop should begin prior to harvesting. Apart from using less susceptible species on infected sites and removing woody material, silvicultural operations would rarely be conducted specifically to reduce the impact of the disease. This is largely due to uncertainty about their effectiveness and economic return. It may be impractical to identify stumps infected with the disease after harvesting, but upland sites in Ontario can be assumed to have a supply of *A. ostoyae* in the range of 5 to 15 infected stumps per hectare. Regenerated trees on such areas can be expected to become infected when their roots contact inoculum.

Transplant shock and small size predispose planted trees to infection. If trees are vigorous, however, only a few will die. This could explain why the average mortality in young spruce stands is only 1 to 2% per year. Even so, the rate of infection is exponential and will result in high levels of decay in the harvested material. The stand will also be very susceptible to blowdown at an early age.

The spread of the disease from root to root in susceptible trees is facilitated in monocultures with overlapping roots, especially if the genetic base is narrow. To date, container seedlings have proven to be less susceptible than bare root stock. Possibly this is because the latter has a higher number of deformed roots.

Site preparation can have both beneficial and adverse effects on the spread of this disease. When machines bring infected roots and stump parts to the surface, the mycelium and rhizomorphs of Armillaria species dry out and become less infective for trees subsequently planted on the site. However, if roots and stumps remain partly buried, the infected parts can cause even higher proportions of regenerating trees to become infected as compared with those on undisturbed sites. Site preparation machinery that breaks up the rhizomorphs of some Armillaria species can actually stimulate their growth if broken sections remain buried. As such, regenerated trees become even more infected than on untreated sites.

A LOOK AHEAD AT CONTROL THROUGH BIOLOGICAL METHODS

Control methods for Armillaria are limited at this time due partly to the complex environment the pathogen inhabits. However, research at the Canadian Forest Service – Ontario looks promising. It is concentrating on the isolation of certain soil bacteria that inhibit the growth of Armillaria, and on fungi that are parasitic on its infective structures. This research is the first stage of work that may possibly lead to a vaccination for seedlings, thereby making them resistant or immune to disease even before they are planted.

REFERENCES AND FURTHER READING

Dumas, M.T. 1988. Biological species of *Armillaria* in the mixedwood forest of northern Ontario. Can. J. For. Res. 18:872–874.

Ip, D. 1991. Detection and assessment of *Armillaria* in young conifer plantations of northwestern Ontario and northeastern China. M.Sc. thesis, Lakehead University, Thunder Bay, ON. 52 p.

Morrison, D.J. 1981. Armillaria root disease: A guide to disease diagnosis, development and management in British Columbia. Dep. Environ., Can. For. Serv., Victoria, BC. Inf. Rep. BC–X–203. 16 p.

Shaw, C.G., III; Kile, G.A. 1991. Armillaria root disease. For. Serv., Washington, D.C. USDA Agric. Handbook 691. 233 p.

Whitney, R.D. 1988. The hidden enemy – root rot technology transfer. Agric. Canada, Can. For. Serv., Sault Ste. Marie, ON. 35 p. (Also available as VHS videocassettes in English and French).

Dr. Michael Dumas

Dr. Roy Whitney

Dr. Michael Dumas, a research scientist with the Canadian Forest Service – Ontario, conducts research into biological control methods for nursery and decay fungi.

Dr. Roy Whitney, a retired pathologist, spent much of his career with the Canadian Forest Service – Ontario where he conducted research into root rots of native tree species in Canada.

NODA • EDNO

CANADA ONTARIO Northern Ontario Development Agreement / Entente de développement du nord de l'Ontario

Forestry • Foresterie

Natural Resources Canada / Ressources naturelles Canada

Canadian Forest Service / Service canadien des forêts

Ministry of Natural Resources / Ministère des Richesses naturelles

Ontario

The preparation of this note was funded under the Northern Ontario Development Agreement's Northern Forestry Program.

Additional copies of this publication are available from:

Natural Resources Canada
Canadian Forest Service – Ontario
Great Lakes Forestry Centre
P.O. Box 490
Sault Ste. Marie, Ontario
P6A 5M7
(705) 949-9461
(705) 759-5700 (FAX)

Catalogue No. Fo 29–29/84E
ISBN 0–662–22572–4
ISSN 1183–2762