Armillaria root rot in Alberta

P. Blenis*, Y. Hiratsuka, and K. Mallett****
**Plant Science*
***Canadian Forest Service*
****Alberta Horticultural Centre*

Figure 1. Mushrooms of *Armillaria* growing at the base of a tree.

Armillaria root rot, caused by the *Armillaria mellea* complex is one of the most important tree diseases in the world (Wargo and Shaw, 1985). It is widespread in Canada, occuring from Newfoundland, where it is considered to be among their most serious forest diseases (Singh, 1975), to British Columbia, where it is a major problem in interior forests (Morrison, 1981). In Alberta, it has been identified as an important disease of conifer regeneration and intensively managed young conifer stands (Johnstone, 1981). *Armillaria* is not thought to have caused major losses in Alberta's natural forests, but forest management is becoming more intensive, and this will have at least two major implications. First, increasing investment in our forests dictates that we protect this investment from pathogens such as *Armillaria*. Secondly, the use of more sophisticated silvicultural techniques will permit us to reduce the losses from Armillaria root rot, provided that we have an adequate knowledge of this disease.

The fungus reproduces sexually by spores produced by mushrooms in the autumn (Fig. 1). Initial establishment of the fungus probably occurs when spores infect freshly cut stumps (Rishbeth, 1985). Such infections may be quite rare, however, once established, subsequent spread most likely occurs through vegetative growth. Trees reportedly may become infected if their roots come in contact with the roots of diseased trees (Morrison, 1981). The fungus also can spread by dark, root-like fungal structures, called rhizomorphs, which are capable of growing through soil and infecting tree roots. Following infection, the fungus may kill the tree by girdling the tap root or root collar. Foliage on fatally infected conifers turns to pale green to yellow to red, and excessive resin production often occurs at the base of the tree. Broad, flat masses of fungal mycelium, known as mycelial fans, develop in the cambial region. If the tree is not killed it may undergo a reduction in growth or become decayed.

Biological Species of Armillaria and Their Pathogenicity

Although *Armillaria* generally has been recognized as a virulent pathogen, there has been some skepticism about its ability to cause disease on vigorously growing trees (Leaphart, 1963). One explanation for the varied reports of *Armillaria's* pathogenicity is that the disease is not caused by a single species, *Armillaria mellea*, but by a number of species which may vary in pathogenicity. In 1979, Anderson and Ullrich showed that there were at least ten different biological species of *Armillaria* in North America. These were tentatively designated by the Roman numerals I–X, although subsequently, several have been given legitimate scientific names.

A cooperative project between the University of Alberta and the Canadian Forestry Service was initiated in 1982 to determine the number and relative importance of the different *Armillaria* species in Alberta. Mushrooms were collected, and their spores were used to initiate haploid cultures. It was possible to determine the species of these cultures by pairing them on an agar medium with haploid cultures from known species. If the two cultures were from different species, their morphology remained fluffy as they grew together; if they were the same species, the colonies became crusty as a result of mating.

Although reliable, this technique was time consuming and required haploid cultures, thus precluding identification of diploid cultures from dead or dying trees. Fortunately, however, it was found that species could be identified on the basis of the reaction of paired diploid cultures. If they were of different species a black line formed between them as they grew together, whereas no such line formed if they were of the same species. This diploid test was used to classify more than 100 cultures collected from 40 locations in Alberta. Biological species I (=*A. obscura*), species V, and a somewhat unusual form, initially designated as the "foothills type", and later found to be similar to *A. obscura*, were identified. *A. obscura* and species V occurred on conifer and hardwood trees; the "foothills type" was found only on conifers. Another form, possibly biological species VII (=*A. bulbosa*) was recovered from a conifer from southern Alberta.

Once the predominate Alberta species of *Armillaria* had been

identified, the next step was to determine if they differed in their ability to infect trees. Ten centimeter long segments of trembling aspen were placed in Erlenmeyer flasks, autoclaved, and inoculated with *Armillaria*. Two year old potted lodgepole pine seedlings were inoculated by placing these infected branch segments adjacent to the tap root of the trees. Infection was recorded six months later. Of the major Alberta groups, species V was the most pathogenic. Preliminary observations from a similar pathogenicity test performed on white spruce and lodgepole pine strongly suggested that the latter species is far more susceptible to this disease. An expanded experiment, using fourteen isolates of *A. obscura*, five isolates of species V, and a total of 1026 white spruce and lodgepole pine, is being done to get a better idea of the variability within the *Armillaria* species.

Ecological Studies

Mortality is conspicuous in many young Alberta lodgepole pine stands but the ultimate fate of these stands is unknown. Will trees stop dying at about age 25, or will these centers of mortality continue to enlarge and cause further damage? To some extent this question may be answered by setting up permanent sample plots and doing surveys over a number of years. Nevertheless, it also is necessary to obtain a better understanding of the method(s) of fungal spread and the factors which influence it. Over eighty dead or dying lodgepole pines were excavated on a site near Hinton, Alberta, which had been logged about twelve years previously. Most infections had been caused by rhizomorphs. Infection by root contact, in the absence of rhizomorphs was less frequent; even if infected and healthy roots were in contact, there often was no evidence that the fungus had moved directly from one to the other. Although it was difficult to determine where these rhizormorphs had come from, it appeared that more had originated from logging debris and old infected stumps than from regeneration that had become infected and died. Lethal infections were usually associated with tap root infections. If infection was on a lateral root the fungus usually moved towards the end of the root rather than towards the root collar.

If future site classification system(s) include a measure of disease potential, it should be possible to integrate control measures with silvicultural practices to arrive at combinations of site preparation, species selection, and/or thinning schedules, that would maximize productivity on different sites. To test whether soil type would effect disease severity, soil was collected from four different locations, chosen to represent a range of favorableness for lodgepole pine growth. For each soil type, a total of 216 pine seedlings have been inoculated. The results are expected shortly.

Summary and Suggestions for Future Research

A. obscura and biological species V are the major species of *Armillaria* in Alberta (Mallett, 1985) and B.C. (Morrison et al, 1985). Both appear to be more pathogenic on pine than on spruce. If so, this suggests that one possible control measure on infested sites would be to plant or favor spruce.

Presently there are 10– to 20–year–old overstocked, infected lodgepole pine stands that require thinning. In order to know how and when to thin these stands to maximize yield, it will be necessary to understand the method and rate of spread of this fungus. It appears that the major method of fungal spread is by rhizomorphs, and that the major source of these rhizomorphs is debris from the previous stand. This implies that normal thinning could be carried out around areas of infection, provided that thinnings were done after infections associated with debris had stopped. To get a better idea if and when mortality stops it will be necessary to establish permanent plots and resurvey them at regular intervals. It also will be important to consider the possibility that even if *Armillaria* does not kill older trees, it may be having a significant impact by slowing tree growth or by decaying wood.

This disease probably is controlled best after harvest, before regeneration is established. Site sanitation and planting of more resistant species are two possible controls, but to determine whether they will be cost effective, it is necessary to know what losses would occur in the absence of such controls. Our attempts to determine the effect of soil type on infection are only the beginning of an overall strategy of developing a disease hazard rating system, based on site characteristics, that would be used to predict losses on a site and to guide management decisions.

Acknowledgements

Funding for this research was provided by the Alberta Forest Service (AFDRT program), and the Canadian Forest Service (PRUF & CFS Human Resource Development programs). Ecological studies were conducted by Mr. Henry Klein–Gebbinck and Mr. Martin Mugala, with the assistance of Mr. Bill Humphrey. The assistance of Mr. Bill Mattes of Champion Forest Products (Alberta) Ltd. is gratefully acknowledged.

References

Johnstone, W.D. 1981. Effects of spacing 7–year–old lodgepole pine in west–central Alberta. Can. For. Serv., Nor. For. Res. Cent. Nor–X–236.

Leaphart, C.D. 1963. Armillaria root rot. U.S.D.A. For. Pest Leaflet 78.

Mallett, K.I. 1985. Armillaria root rot in Alberta; identification, pathogenicity, and detection. Ph.D. thesis, University of Alberta.

Morrison, D.J. 1981. Armillaria root disease: A guide to disease diagnosis, development, and management in British Columbia. Can. For. Serv., Pac. For. Res. Cent., BC–X–203.

Morrison, D.J., D. Chu, and A.L.S. Johnson. 1985. Species of *Armillaria* in British Columbia. Can. J. Plant Pathol. 7:242–246.

Rishbeth, J. 1985. Infection cycle of *Armillaria* and host response. Eur. J. For. Path. 15:332–341.

Singh, P. 1975. Armillaria root rot: Distribution and severity in softwood plantations in Newfoundland. Acta Phytopathol. Acad. Sci. Hung. 10:389–406.

Wargo, P.M. and C.G. Shaw III. 1985. Armillaria root rot: the puzzle is being solved. Plant Dis. 69:826–832.