RESISTANCE MECHANISMS OF LARIX OCCIDENTALIS (WESTERN LARCH) TO ARMILLARIA OSTOYAE IN THE SOUTHERN INTERIOR OF BRITISH COLUMBIA.

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SUMMARY

Preliminary investigation has revealed several potential resistance mechanisms operating in western larch which may provide tolerance to Armillaria ostoyae. Infections on the root systems of mature, vigorous trees are often stopped before reaching the vascular cambium by the formation of necrophylactic periderms or what appears to be the rapid production of multiple layers of phellem. If periderm formation fails to prevent cambial infection resinosus and callusing may check the fungus which is then confined by compartmentalization to woody tissues present at the time of infection. Adventitious roots form on the callused ends of infected roots and appear to be protected from further infection by the compartmentalization process. Ongoing investigation will reveal if there is a relationship between root size and age with respect to the tolerance of western larch to attack by A.ostoyae.

INTRODUCTION

It has been recognized for some time that western larch shows resistance to Armillaria root disease in British Columbia (see Morrison 1981). However the reasons for this resistance have never been investigated. A study is presently underway in the southern interior of B.C. which aims to confirm the apparent resistance of western larch to A.ostoyae, determine the tree age at which resistance begins and characterize the nature of the resistance shown.

All conifer species in B.C. are susceptible to A.ostoyae when less than about 15 years old (Morrison et al. 1992). Observations in planted and natural regeneration on diseased sites confirms larch to be just as vulnerable as other species. However, as age increases, larch shows an increasing resistance until about age 25 at which time roots contacting inoculum are either not infected or infection is checked (Morrison et al. 1992). In other species mortality may continue throughout the rotation resulting in unstocked or understocked openings (Morrison et al. 1985)

The use of larch to regenerate diseased sites has been recommended wherever the ecosystem permits (Morrison et al. 1992). However, additional evidence to support the use of western larch on sites infested with A.ostoyae is required. Specifically at what age do planted and naturally regenerated larch begin to show resistance and what is the nature of the resistance?

This paper briefly outlines some preliminary results.

MATERIALS and METHODS

Several larch root systems of trees approx. 95 years old and naturally regenerated seedlings 7-8 years old were excavated on diseased sites in the Interior Cedar - Hemlock biogeoclimatic zone near Nelson in the southern interior of B.C.. Infected bark samples were dissected from infection points and immediately stored in liquid nitrogen. Freezing the sample immediately preserves the chemical integrity of the sample (Mullick 1977). At the lab, these samples were embedded in OCT (Optimal Cutting Temperature) compound, sectioned in a cryostat at -20° C and examined on a microscope with the stage cooled to approx. -35° C. Sections were examined using either bright field, polarizing light or fluorescence microscopy. Biochemical and structural alterations are revealed by a change in fluorescence characteristics (Soo 1977).

Older roots with A.ostoyae lesions which appeared to be callused and checked were removed and taken to the lab where they were dissected longitudinally through the lesion and examined.

RESULTS and DISCUSSION

Roots of trees younger than about 15 years appear to have an initial reaction involving resinosus and periderm formation in the inner bark (Fig. 1). However, this reaction does not appear to be capable of halting the advance of infection. This is supported by the frequent occurrence of dead and dying western larch seedlings and saplings in areas where A.ostoyae occurs.

In older trees the response appears to be quite different. Resin soaked lesions on the surface of larger roots indicated that infection had occurred sometime in the past. In most cases the infection was checked and the fungus confined to tissues present at the time of infection (Fig. 2). This compartmentalization process is characterized by resin soaked barrier zones and discoloration of the wood (Shigo & Tippett 1981).

Often small diameter woody roots become infected some distance from the root collar. As the infection advances along the root it is often checked before it reaches the root collar. At this point callusing and adventitious roots generally develop and the infection is confined to the inner woody tissues present at the time of infection (Fig. 3).

Often A.ostoyae will attempt to invade larger roots via small lateral roots which, like the roots of seedlings, appear incapable of a strong resistance reaction. In these cases the A.ostoyae infection is checked by the larger root at the junction with the smaller root. This phenomenon also occurs when smaller roots become infected close to the root collar (Fig. 4). Infection is compartmentalized when it reaches the root collar.

Internal advancement is very slow in all cases and infection is frequently held quiescent for decades.

Compartmentalization starts after bark killing stops (Shigo & Tippett 1981). Xylem cells, produced by the vascular cambium beyond the limit of the dead bark, develop into barrier zones (Shigo & Tippett 1981). Compartmentalization has not been observed in the roots of young larch trees.

What is the difference between the necrophylactic periderms produced in young susceptible larch roots and those formed in the older resistant roots that halts infection in the bark to allow the formation of barrier zones? Necrophylactic periderms formed by young susceptible roots appear to be easily breached by the invading fungus. In older roots this is not the case. Phellum in the necrophylactic periderms of western larch is characterized by the presence of reddish-purple contents (Soo 1977). However, pigmentation of the phellem cells close to the phellogen in older resistant roots appears to be more intense and repeated periderm formation deep in the phloem is common (Fig. 5). Resistant roots, especially those close to the root collar, are also capable of forming multiple layers of phellem cells quite rapidly (Fig. 6). These layers are characterized by early rapid production of thin walled cells followed by cells with thick suberized walls and dark red pigmentation when mature.

CONCLUSION

These preliminary observations suggest there may be a relationship between root size and age with respect to the resistance of western larch to A.ostoyae. Differences in defensive responses of susceptible and resistant roots include increased pigmentation of phellem tissues and multiple layers of phellem in the necrophylactic periderms of resistant roots as well as the ability to compartmentalize infected tissues. In order to characterize in greater detail and determine the age at which these changes occur these responses are being further investigated utilizing inoculated and naturally infected roots on trees of various ages.

ACKNOWLEDGMENT

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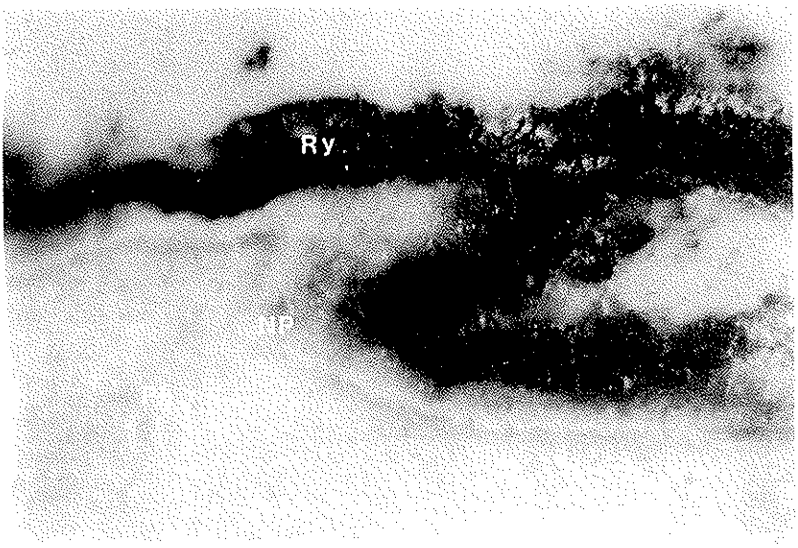

Figure 1. Necrophylactic periderm (NP) formation in the root of 6 a year old larch seedling infected with A.ostoyae, X 26. Ry; rhytidome, Ph; phloem.

Figure 2. A 5.8 cm diam. root, 70 years old from 95 year old larch tree, with A.ostoyae infection confined for 15 years.

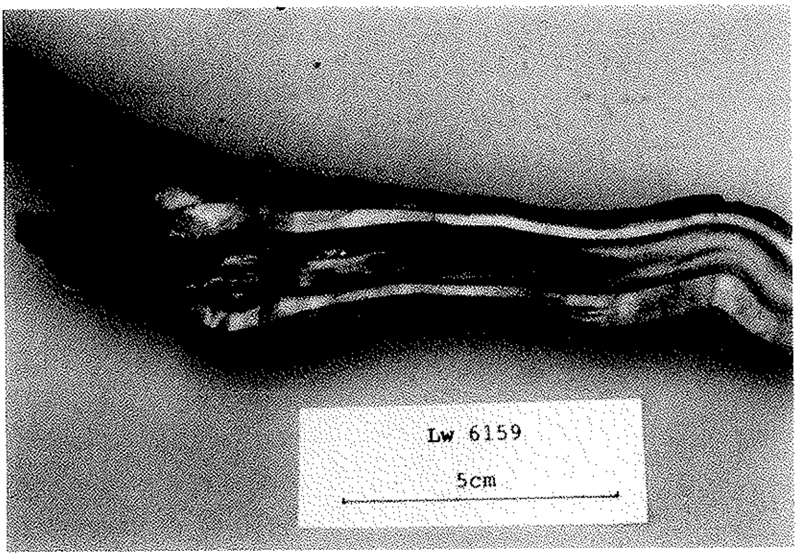

Figure 3. Callus and adventitious root formation on a 52 year old root infected with A.ostoyae. Infection has been confined to inner woody tissues for 20 years.

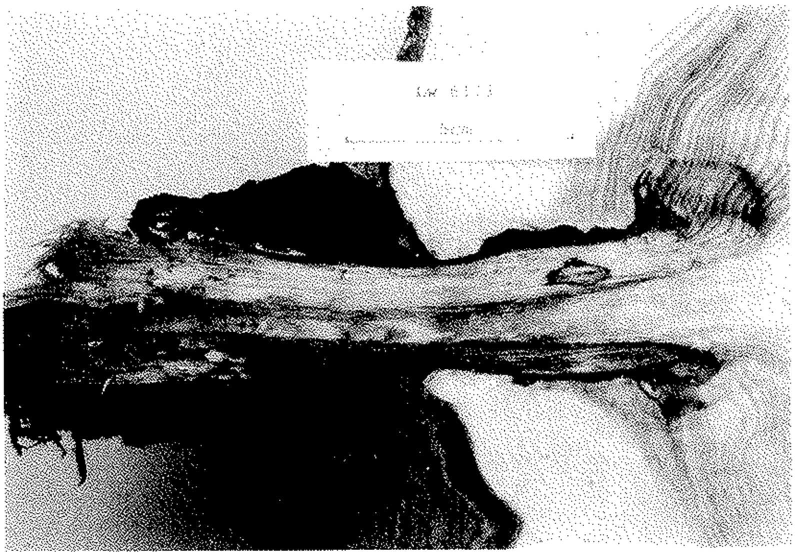

Figure 4. A 2.5 cm diam. root, approx. 45 years old infected at the root collar of a 93 year old larch tree. Infection has been confined for 25 years.

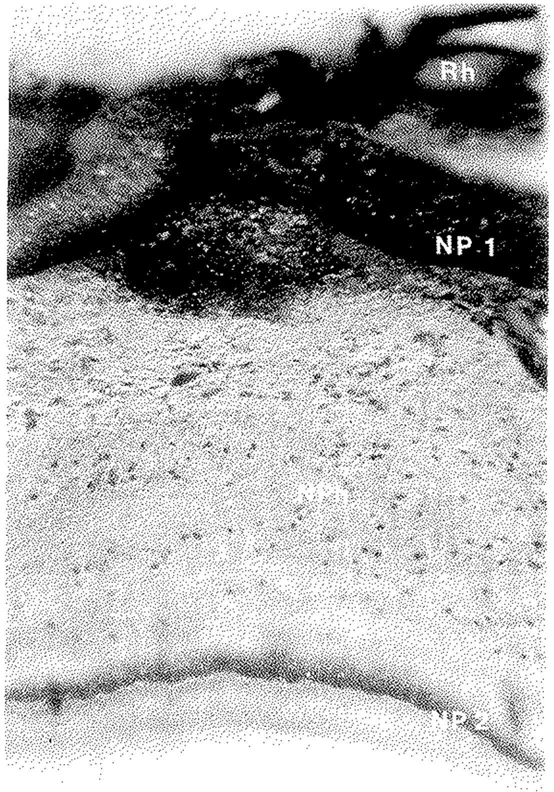

Figure 5. Repeated necrophylactic periderm formation (NP 2) deep in the phloem in response to a rhizomorph (Rh) infection at the root collar of a vigorous 15 year old larch, x13.5. NP 1, non-active periderm; NPh, non-functional phloem.

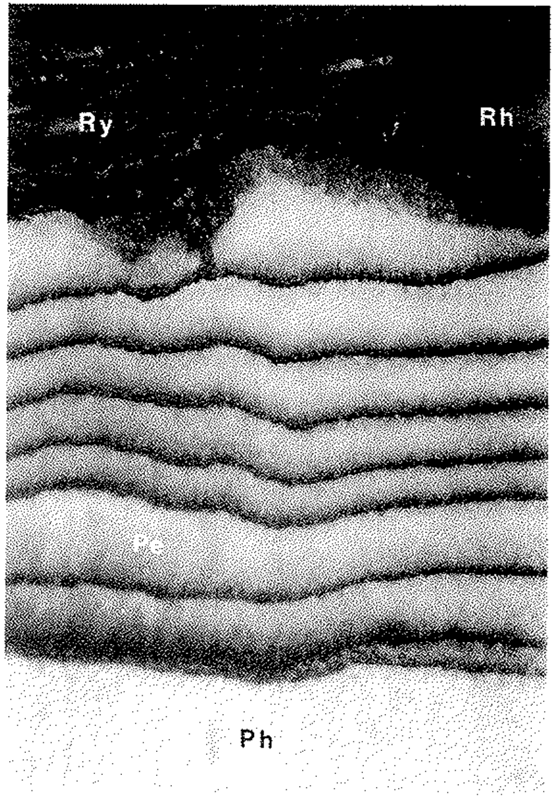

Figure 6. Multiple layers of phellem (Pe) produced in response to a rhizomorph (Rh) infection on a 6 cm root from a 95 year old larch, X 26. Ry, rhytidome; Ph, functional phloem.

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