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Bioresponse of Nontarget Organisms Resulting from the Use of Chloropicrin to Control Laminated Root Rot in a Northwest Conifer Forest:

Part 1. Installation of Study

by

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ABSTRACT

Laminated root rot is a major root disease problem in the West. Several fumigants have been found effective in reducing or completely eradicating the pathogen from infested stumps and roots. In 1989 EPA approved the use of chloropicrin as a stump treatment to control laminated root rot. Reports detailing chloropicrin concentration in the environment as a result of the treatment or the potential impacts of chloropicrin on nontarget forest organisms are lacking. A disease control study was established to further evaluate the effectiveness and cost of stump application of chloropicrin to control laminated root. The bioresponse study described here will take advantage of plots and treated stumps established for the disease control study by monitoring treated areas and quantifying the changes in four segments of the ecosystem likely to be sensitive to chloropicrin: vascular plant community, detrital foodweb, soil microarthropods, and mycorrhizae formation. Due to the anticipated slow release of chloropicrin from the stumps, monitoring will continue for 3 years. Only preliminary results are available now.

INTRODUCTION AND BACKGROUND

Laminated root rot

Laminated root rot is widespread throughout the range of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco). Douglas-fir is the most economically important host, but nearly all conifers seem to be susceptible to some degree. The disease reduces forest productivity annually by about 4.4 million m^3 (Childs and Shea 1967, Nelson et al. 1981).

When infected trees die, the pathogen continues to live saprophytically in infested butts and large roots for as long as 50 years (Childs 1963, Hansen 1976, 1979). Infection in a young stand begins when roots of young trees contact residual infested stumps and roots from the preceding stand. The infection spreads between living trees through root contacts (Wallis and Reynolds 1965). Immediate succession by Douglas-fir or other highly susceptible species on a site infested with *Phellinus weirii* often results in more disease and heavier losses in the new stand (Wallis and Reynolds 1965).

Fumigation for control of laminated root rot

Fumigation is one means of reducing inoculum of some root rotting fungi (Thies 1984). Reports of fumigant application to soil as well as directly to wood to destroy particular fungi have been reviewed previously (Filip 1976; Thies and Nelson 1982, 1987). In 1989 use of chloropicrin to reduce inoculum of laminated root rot in Douglas-fir stumps was approved by the Environmental Protection Agency. While silvicultural manipulations will remain the most widely used control for laminated root rot, fumigation will be an alternative tool available to the land manager.

DISEASE CONTROL STUDY

The disease control study was established to determine the cost and degree of reduction in the reappearance of laminated root rot in a replacement stand using chloropicrin as a stump treatment. Stumps were fumigated during October 1988, and the area was intervals of 2 years to record seedling growth and mortality.

Study Area

The study area is an 8-ha clearcut on a 2% south-facing slope on the Olympic Peninsula near Matlock, WA (latitude 47° 14' N.; Longitude 123° 25' W.); mean elevation is 175 m; mean annual precipitation is 125 cm; soil in the study area is a Hoodsport Gravelly Sandy Loam. The Hoodsport soil series formed in glacial deposits of 50 to 75 cm of loose ablation till overlaying very compact lodgement till. The site is class III (McArdle et al. 1961), and supported a 65-year-old naturally regenerated stand that was predominantly Douglas-fir (99% by harvest volume). Western hemlock (*Tsuga heterophylla* (Raf.)Sarg.) constituted the remainder of the overstory. The understory was primarily salal (*Gaultheria shallon* Pursh) with some sword fern (*Polystichum munitum* (Kaulf.) Presl) and a lesser component of twin flower (*Linnaea borealis* L).

Plots

The study area was subdivided, systematically searched, and the location of each *P. weirii* infested stump was mapped (Thies and Hoopes 1979). Using a map depicting the locations of infested stumps, circular, 0.04-ha, nonoverlapping treatment plots were established in the study area in locations to include concentrations of infested stumps. An inoculum index (INOC) was calculated for each infested stump, based on stump diameter and stump condition, and summed to get a total INOC for each plot. Based on total INOC, plots were stratified into 8 blocks of 4 plots each.

Treatments

Treatment involved application of chloropicrin at either 100% or 20% of the labeled dosage, and either all stumps were treated or only those with stain (or advanced decay) typical of *P. weirii* were treated. Three chloropicrin treatments and an untreated check were randomly assigned within each group of four plots in a block:

1. check (nothing done to the stumps);

2. 100%, all stumps;

3. 20%, all stumps;

4. 100%, stain only stumps. The label dosage is about 3.3 ml of chloropicrin per kilogram of stump and root biomass.

Application of fumigant

Treatment holes, 3.2 cm diameter, were drilled vertically into each stump top either at stained areas when present, or in unstained wood. Stumps with a diameter of 32.5 cm or less had a minimum of four treatment holes drilled, one in each quadrant of the stump top; larger stumps had at least eight treatment holes drilled with at least two in each quadrant of the stump top. To avoid drilling through the stump, holes extended only slightly below the soil line. A dose of chloropicrin was distributed equally to all holes in a stump. After fumigant application, each hole was plugged tightly with a hemlock dowel that was sealed to resist passage of the fumigant.

MEASURING BIORESPONSE TO CHLOROPICRIN IN A FOREST ECOSYSTEM

Ecological impacts of chloropicrin

Chloropicrin (trichloronitromethane) is a general biocide that has been used as a soil fumigant and studied for its effectiveness in reducing specific pests; however, examination of the literature does not provide a basis for predicting the effects of chloropicrin applied to stumps on nontarget organisms. The effect could be beneficial as in agricultural fields where pathogens are reduced or negative such as the observed reduction in vesicular-arbuscular mycorrhizae in crop soils (McGraw and Hendrix 1986).

Chloropicrin has documented effects on bacteria, fungi, nematodes, and higher plants. To our knowledge, there is no published information on the effects of chloropicrin on protozoa, lichens, N-fixing bacteria, or moss, but these organisms are important in nutrient cycling in forests and should be investigated. Castro et al. (1983) found that four species of *Pseudomonas* were capable of degrading chloropicrin by successive dehalogenation to nitromethane. Other reports indicate, however, that chloropicrin is toxic to soil bacteria (Martin and Kemp 1986; Ono 1985).

The maximum distance chloropicrin diffuses in a root system or the rate at which it leaves the root system is not known. Two growing seasons after treatment the odor of chloropicrin was commonly detected when roots were cut 1 m or less from the treated stump, and occasionally detected when roots were cut as far as 2.4 m from the stump (Thies and Nelson 1987). Increasing moisture levels (20% of field capacity and above) and decreasing temperature reduce volatilization rates of chloropicrin (Tanagawa et al. 1985). Thus we anticipate that disappearance of chloropicrin from a treated site in the Pacific Northwest may take several years.

Objectives

To determine the changes in population or diversity of specific nontarget components of a coastal ecosystem that occur as a direct result of the application of chloropicrin to stumps on an infested site to control laminated root rot.

This research will provide data to evaluate the impact of applying chloropicrin to stumps on four essential and potentially sensitive segments of the forest ecosystem: vascular plant community, detrital foodweb, soil arthropods, and the formation of mycorrhizal roots on Douglas-fir seedlings. Additionally, this research will establish the field persistence of concentrations of chloropicrin adequate to have an impact on higher plants. This research will form a basis for developing future pest management strategies involving the use of chloropicrin in forestry.

Research approach

Five separate evaluations are being conducted simultaneously by various research teams, each collecting samples from the same plots. Stumps on the study area were fumigated in fall 1988 as part of the disease control study described above. Sampling for bioresponses began in spring 1989 and will continue through fall 1991; analysis and publication should be completed by the end of 1992. In general, each team will evaluate the impact of the existing chloropicrin treatments on a class of indicator organisms on an area (plot) basis. In some instances, we will also look at the worst case situation and examine the impact immediately adjacent to treated stumps. We are prepared to shift our sampling emphasis if early results indicate that more or less intensive sampling is appropriate. We are also prepared to continue the evaluation for additional years if analysis of the data after the third sampling season suggests that it would be worthwhile and if additional funding can be obtained.

The disease control study involved four treatments, three chloropicrin treatments and an untreated check, randomly assigned to four plots within each replicate. These treatments were applied to eight replicate groups of plots. Replicate blocking was based on the inoculum found on each plot. Due to limitations of resources, the bioresponse evaluations are being conducted on five replicates of three treatments:

1. check (nothing done to the stumps);
2. 100% labeled dosage, all stumps treated;
3. 20% labeled dosage, all stumps treated.

In general, the statistical analysis will be an analysis of variance of a randomized complete block design with three treatments and five replicates. We anticipate making two orthogonal contrasts: check vs. all treatments and 100% labeled dosage vs. 20% labeled dosage. Additional analyses will be made of appropriate data to examine shifts in populations and species richness over time.

The following five evaluations are being conducted:

1. field persistence of chloropicrin;
2. impacts on naturally occurring higher plants;
3. impacts on the detrital foodweb;
4. impacts on the soil arthropods; and
5. Impacts on mycorrhiza formation.

COOPERATION

The following organizations are cooperating in support of this study: Simpson Timber Co.; Great Lakes Chemical Co.; National Agricultural Pesticide Impact Assessment Program (NAPIAP), U S Department of Agriculture; Pacific Northwest Research Station, U S Department of Agriculture, Forest Service; and the departments of Forest Science, Botany and Plant Pathology, and Entomology, Oregon State University.

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