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Ecological Impacts of Using Chloropicrin to Control Laminated Root Rot in Northwest Conifer Forests:

Growth and Mycorrhiza Formation of Planted Douglas-fir Seedlings After Two Growing Seasons

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Abstract

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Bareroot Douglas-fir seedlings inoculated with *Rhizopogon* sp. and processed by standard nursery and reforestation procedures performed equally well whether planted near Douglas-fir stumps previously fumigated with two dosages of chloropicrin to control *Phellinus weirii* infection or near stumps not fumigated. Before stump-fumigation can be generally recommended for *Phellinus*-rehabilitation sites, the fate of the chemical and its derivatives must be directly assessed under various conditions of stand age, soil, and weather.

Keywords: *Rhizopogon*, ectomycorrhiza, *Pseudotsuga*, outplanting, chloropicrin, *Phellinus*, reforestation.

Summary

Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) is highly susceptible to infection by laminated root rot (*Phellinus weirii* (Murr.) Gilb.), which ultimately leads to death of the host. After death of the host, *P. weirii* continues to live saprophytically in infected large woody debris for 50 years or more. Chloropicrin can reduce *P. weirii* inoculum in Douglas-fir stumps. If chloropicrin fumigation is to be used as an alternative silvicultural tool to reduce losses from *Phellinus* infection, an evaluation of the effects of chloropicrin on nontarget organisms is needed.

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It seems that chloropicrin fumigation of Douglas-fir stumps does not influence the growth of *Rhizopogon*-inoculated Douglas-fir seedlings planted nearby. This study examined only one habitat condition with one soil and moisture regime: the effects might be different elsewhere. Even though we found no effects from fumigation on seedling performance, we caution foresters to consult with specialists when deciding whether to use stump fumigation as part of a laminated root rot mangement program.

Introduction

Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) is highly susceptible to infection by laminated root rot (*Phellinus weirii* (Murr.) Gilb.), which ultimately leads to death of the host. Laminated root rot reduces forest productivity by 4.4 million cubic meters per year in western Oregon and western Washington (Nelson and others 1981).

After death of the host, *P. weirii* continues to live saprophytically in the lower portion of the stem and the root system for 50 years or more (Hansen 1979, Thies 1984). The resident inoculum readily infects roots of planted or naturally occurring Douglas-fir seedlings, thereby leading to early death (Hadfield 1985).

Fumigation with chloropicrin nearly eliminates the fungus from infected stumps (Thies and Nelson 1987). In 1989, use of chloropicrin to reduce *P. weirii* inoculum in Douglas-fir stumps was approved by the Environmental Protection Agency. If fumigation is to be used as an alternative silvicultural tool to reduce losses from *Phellinus* infection, an evaluation of the effects of chloropicrin on nontarget organisms is needed.

This study indirectly assesses the hazard of chloropicrin in the ecosystem by measuring the direct effects on Douglas-fir seedlings planted near fumigated Douglas-fir stumps.

Methods

Installation and study design are presented by Thies and others (1990) and Ingham and others (1990). Basically three treatments were applied: no treatment, 100 percent of labeled dosage, and 20 percent of labeled dosage, regardless of presence of *P. weirii*. Presence of *P. weirii* was determined by characteristic staining and decay of the wood (Nelson and others 1981). The label dosage is 3.3 milliliter chloropicrin per kilogram of stump and root biomass. Chloropicrin was applied by drilling holes in each stump and adding the required chemical. Subsequently, all holes were plugged and sealed to contain the fumigant.

Bareroot Douglas-fir seedlings were grown at the Oregon State Forest nursery at Elkton, Oregon, for 2 years. All seedlings were inoculated with *Rhizopogon* sp. spores at time of sowing (Castellano 1987).

Of the original eight blocks for each treatment, five blocks each of three treatments were systematically chosen to represent a gradient, north to south, of the treated area for a total of 15 blocks. In the winter after fumigation, three stained and three nonstained stumps were randomly selected on each of five replicate blocks per fumigant treatment and planted with bareroot 2-0 Douglas-fir seedlings at 45 degree intervals, beginning with true north, and at a distance of 0.5 and 1.5 meters from the edge of each stump. Four seedlings at each distance from each stump were harvested in each of 2 years and assessed for growth and mycorrhiza development (6 stumps/block × 4 seedlings per distance × 5 blocks = 120 seedlings per treatment per distance from stump per year). Seedlings planted at the cardinal directions were harvested after the first growing season, and intermittent seedlings were harvested after the second growing season. Number of live seedlings in the field, seedling height, root collar diameter, shoot oven dry weight, and root oven dry weight were measured. Before drying, each seedling root system was carefully washed free of soil with tap water, and relative mycorrhiza diversity and abundance (percentage to the nearest 10 percent, ocular estimate under stereomicroscope) was assessed in the laboratory.

Table 1—Seedling growth and mycorrhiza formation before outplanting and 2 years after outplanting

Seedling location[a] and treatment	Height	Stem caliper	Root dry weight	Mycorrhiza symbiont[b]		
				Thele	Rhiz	Ceno
	Cm	*Mm*	*Grams*	----- *Percent* -----		
At planting[c]	35.1	5.4	2.4	48	51	0
In control	45.9	10.2	6.8	60	42	21
In 20	50.4	9.9	6.2	59	50	17
In 100	49.7	10.3	6.6	52	45	16
Out control	48.1	10.1	6.7	58	43	17
Out 20	51.3	10.0	6.4	59	45	19
Out 100	50.9	10.5	6.9	61	48	14
Mean square error from ANOVA[d]	143.7	7.23	17.9	705.4	473.6	98.4

[a] "In" refers to the 0.5 meter-distance from stump; "out" refers to the 1.5 meters distance from stump. "20" refers to 20 percent of label dosage of chloropicrin; "100" refers to 100 percent of label dosage of chloropicrin.
[b] Refers to the percentage of the feeder root system for those seedlings that had this morphological type. "Thele" equals *Thelephora terrestris*; "Rhiz" equals *Rhizopogon*-like; "Ceno" equals *Cenococcum geophilum*.
[c] Data not included in the statistical analysis.
[d] Not the same as the units of measure at top of column.

Analysis of variance was used to test for differences between treatments. Data on mycorrhiza percentage and number of live seedlings were transformed to allow for statistical analysis. Differences between treatment means were compared by the Scheffe F-test at a = 0.05.

Results

At the end of the second growing season, there were no significant differences among treatments (table 1). Stained and nonstained stumps within treatments were analyzed separately; no apparent differences were found and the stumps were combined for further analyses. All surviving seedlings grew well and had well-developed ectomycorrhizae. Seedling survival averaged 80 percent across all treatments after two growing seasons.

Rhizopogon-like and *Thelephora*-like ectomycorrhizae were present on seedlings at planting and persisted through both growing seasons without much change in percentage of the feeder roots colonized. *Cenococcum geophilum* readily colonized planted seedlings at a low level across all treatments. *Cenococcum geophilum* is distributed worldwide and often colonizes Pinaceae but usually at a low incidence, as in this study. A number of other mycorrhiza types were recorded, but they neither formed a discernible pattern nor were found on more then a few of the total number of seedlings.

Ectomycorrhizae of *Rhizopogon* sp. were present to a significant degree on all seedlings before outplanting. Zak (1971) reported that *R. vinicolor* moderately to strongly inhibits *Phytophthora cinnamomi, Pythium debaryanum, P. sylvaticum, Fomes annosus*, and *Phellinus weirii* (as *Poria weirii*) in culture. To what degree *Rhizopogon* ectomycorrhiza protects these seedlings from *Phellinus* in the field is unknown and requires additional study. Most pathogen-mycorrhiza interactions are studied in the laboratory or greenhouse, so that field data on this interaction are lacking.

It seems that chloropicrin fumigation of Douglas-fir stumps does not influence the growth of *Rhizopogon*-inoculated Douglas-fir seedlings planted nearby. This study examined only one habitat condition with one soil and moisture regime: the effects might be different elsewhere. Even though we found no effects from fumigation on seedling performance, we caution foresters to consult with specialists when deciding whether to use stump fumigation as part of a laminated root rot management program.

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