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Soil Fumigation to Control Spread of *Fomes annosus*: Results of Field Trials

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ABSTRACT

A field trial was run to test the hypothesis that a band of roots killed by soil fumigation with methyl bromide would be unsuitable for invasion by *F. annosus* and would block the underground spread of the fungus from diseased trees to healthy trees. Infection centers in red pine plantations from New York to Rhode Island were delineated on the basis of symptoms and fruiting bodies, and were treated. Development of disease was observed in 11 centers for 4 years. Excavation and isolation from roots of trees and stumps adjacent to the fumigation line showed that the fungus had crossed the zone in only two centers, was prevented from crossing in many places in at least four centers, and was already outside the zone at the time of the treatment in six centers. The primary reason for failures appeared to be the inadequacy of the methods used to delineate the infection centers.

Additional key words: Red pine, *Pinus resinosa*, root rot, infection centers.

INTRODUCTION

PRELIMINARY STUDIES on the use of soil fumigation to prevent underground spread of *Fomes annosus* (Fr.) Cke. from diseased to healthy red pine trees (*Pinus resinosa* Ait.) were described in 1969 (*Houston and Eno 1969*). Results from these trials showed that methyl bromide, injected into the soil along a line adjacent to living red pine trees, killed all the roots in a continuous band from 5 to 7 feet (1.5 to 2.1 m) wide. These killed roots were soon colonized by soil fungi and apparently were rendered unsuitable for invasion by *F. annosus*.

These results, along with others that revealed that *F. annosus* was eliminated by fumigation from most dead infected roots, prompted establishment of a field trial in 1967-68 to test the use of soil fumigation in preventing the underground spread of *F. annosus* in a number of active infection centers.

This report is a summary of results from this field trial after 4 years.

MATERIALS AND METHODS

Fifteen infection centers in red pine plantations located in New York (7), New Hampshire (3), Rhode Island (2), and Connecticut (3) were treated in October or November (12 in 1967, 3 in 1968). Four centers in New York were abandoned later. Two of these were inadvertently harvested and two were in a plantation found to be heavily colonized throughout by *F. annosus*.

All infection centers contained trees dying from *F. annosus* attack. The centers were separated from each other by at least 10 rows of apparently healthy trees, and the perimeter of each center was less than 4 chains (80.5 m) except for one center that had a perimeter of 17 chains (342 m).

The extent of the infection centers and the locations of the fumigation lines were determined by the presence of fruiting bodies of *F. annosus* on trees and stumps. The fumigation line was established at least one healthy tree beyond the outermost tree or stump bearing fruit bodies. The positions of the stumps and trees in each plot were mapped, and their disease conditions were recorded (presence of fruiting bodies; and for trees, the color of the crown—green, yellow, brown).

Methyl bromide, at the rate of 1 pound (0.454 kg) per every 8 (1967) or 10 (1968) linear feet (2.4, 3.0 m), was dispensed into 20-inch-deep (50.8 cm) holes punched at 1-foot (0.3 m) intervals along the fumigation line as described earlier (*Houston and Eno 1969*). (Dow Chemical Co., Midland, Mich., provided material. Mention of a particular product should not be taken as an endorsement by the Forest Service or the U. S. Department of Agriculture.)

The effectiveness of the fumigant in killing roots, the progress of disease development, and the extent of fungus movement across the fumigation zone were measured in each plot. Six months after treatment, the roots in 2-foot-wide (0.6 m) trenches dug at right angles across the fumigation line were examined to determine if roots had been killed. Each center was examined annually for 4 years (1971 or 1972) to follow disease development (presence of fruit bodies and crown symptoms) inside and outside the plot, and to determine if break-over of infection had occurred.

At the close of the study in 1971 or 1972, all places where *F. annosus* had appeared on trees or stumps outside the fumigation zone, and many places where disease spread appeared to have been arrested by the treatment, were excavated. The root systems were

mapped, and root sections were removed for isolation of the pathogen. Root sections were washed under tap water and aseptically split longitudinally. Wood chips were plated onto a 2-percent malt agar medium and were examined after 7 days for the presence of *F. annosus*.

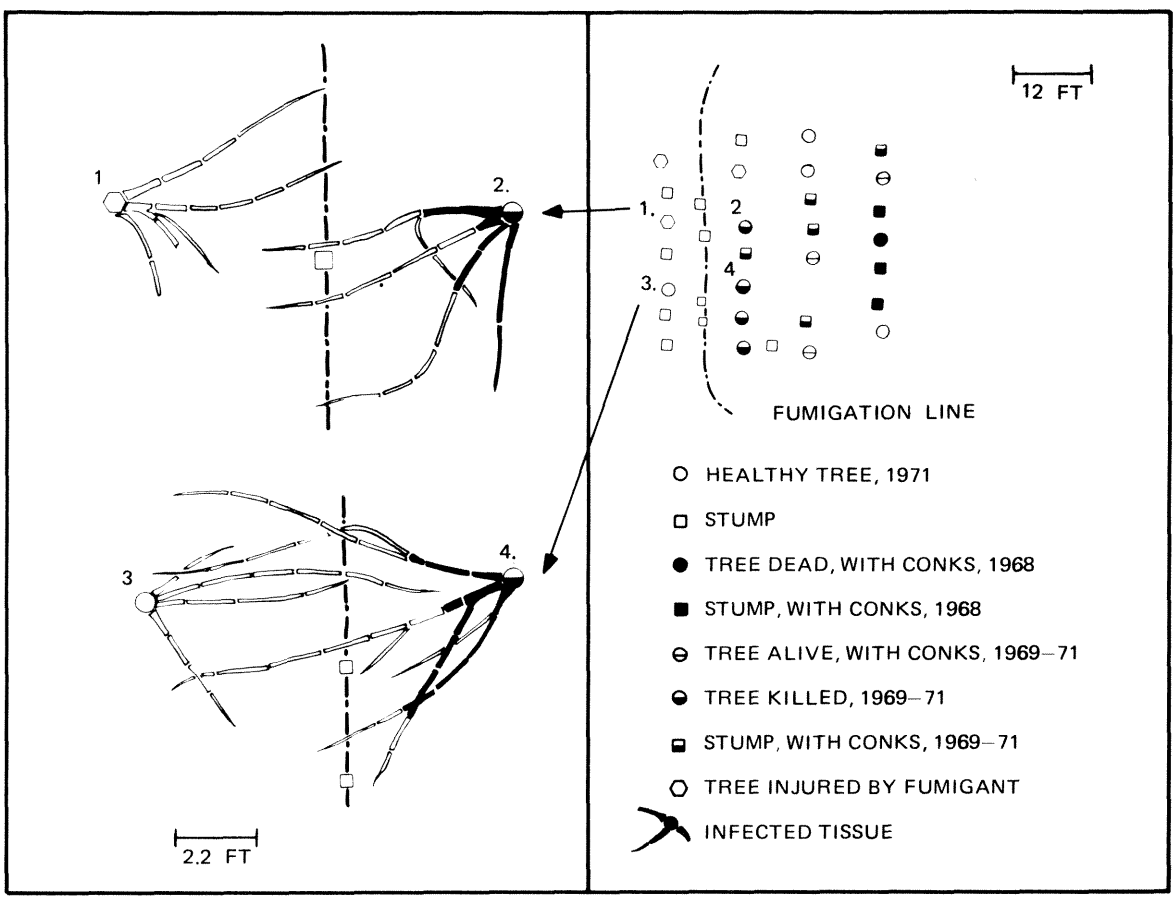
RESULTS

Six months after treatment, all red pine roots had been killed back to distances ranging from 2.5 feet (0.8 m) to 6 feet (1.8 m) on either side of the fumigation line. However, the roots of both white pine (*P. strobus* L.) and Norway spruce (*Picea abies* [L.] Karst.) in several plantations where these species were mixed with red pines seemed to be unaffected by the fumigant.

Growth of new roots into the fumigation zone 2 years after treatment was determined in 2-foot-wide (0.6 m) trenches cut across the zone in several centers. In four trenches, small new roots, 4 to 6 inches (10.2 to 15.2 cm) below the soil surface, extended into the fumigation zone, sometimes as far as the injection line (3 to 4 feet, 0.9 to 1.2 m). In another six trenches, no roots had grown into the zone.

Some trees adjacent to the injection line were injured above ground by the fumigant. Marked cambial injury occurred on trees closer than 4 feet (1.2 m) from the line. On some trees the cambium of the entire side

Figure 1.—Disease development in a portion of a large infection center from 1968 to 1971 (right) and the results of isolation from roots excavated in 1972 (left). The fumigant treatment effectively blocked the spread of *F. annosus* across the fumigation zone.



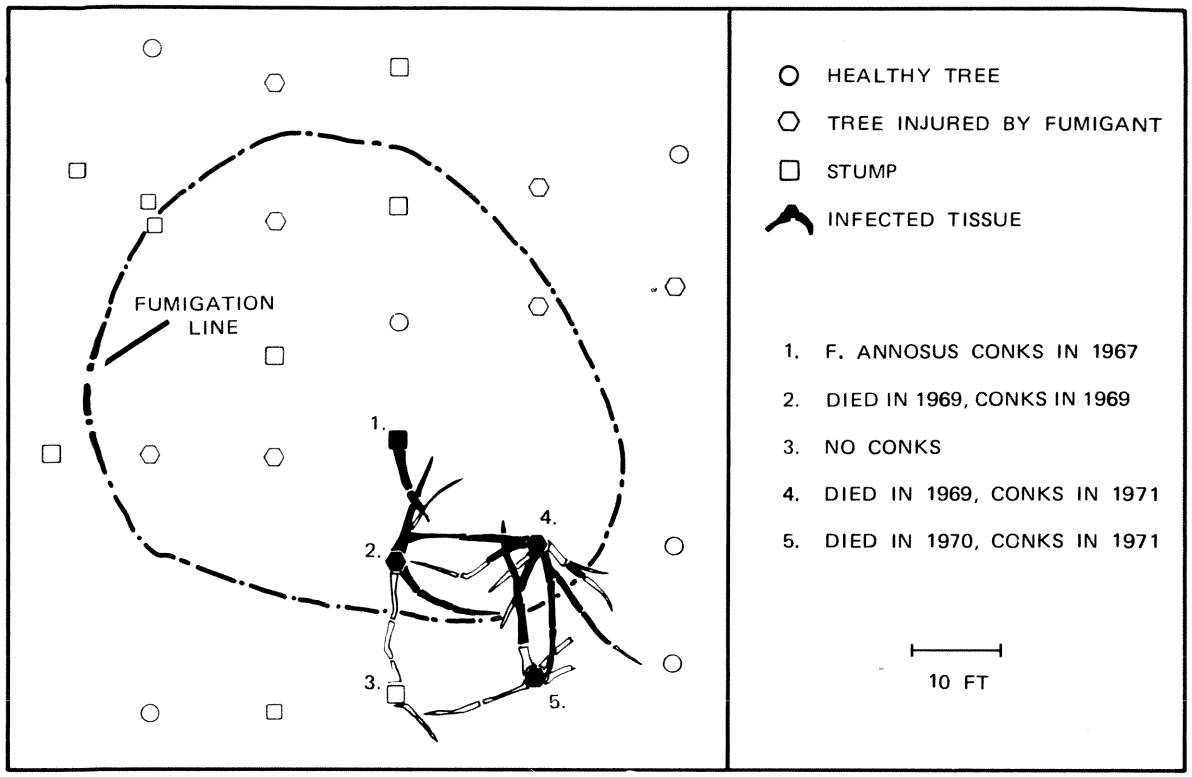


Figure 2.—Disease development in an infection center from 1967 to 1971 and the results of isolations from roots excavated in 1971. *F. annosus* crossed over the fumigation zone on fumigant-killed roots of a tree that was infected at the time of treatment.

facing the injection line was killed to 10 feet (3.0 m) or more above ground.

The dosage rate was reduced from 1 pound of methyl bromide per 8 linear feet (2.4 m) of line in 1967, to 1 pound per 10 linear feet (3.0 m) in 1968 to avoid this injury. But even at the lowered rate, cambial injury occurred on many trees. Indeed, in several instances, trees as far as 6 to 7 feet (1.8 to 2.1 m) from the line were affected. During the course of the study, a number of these fumigant-injured trees died after they were colonized by one or more species of bark beetles and borers.

The treatment appeared to have successfully blocked the outward spread of the fungus in one to several places in at least four plots. (fig. 1). The fungus was isolated from roots up to the point where they had been killed earlier by the fumigant. In one case, the fumigation treatment had blocked the passage into the plot of *F. annosus* from an undetected infected tree outside the plot. In two plots, infections outside the fumigation zone appeared to have originated when the fungus crossed the zone on fumigant-killed roots. In figure 2, the roots of tree 4 that were killed by fumigation soon became colonized by *F. annosus*. Crown symptoms in 1968 indicated that tree 4 was infected at the time of treatment.

In six plots, old stumps and trees (outside the fumigation zone) were found that had been infected previously. Fruiting bodies usually did not develop on old infected stumps until mid-way through the study.

DISCUSSION AND CONCLUSIONS

In this study there were many instances where the fumigant-killed root barrier seemed to inhibit spread of *F. annosus*. Most of these were cases in which saprophytic fungi had had the opportunity to thoroughly colonize the killed roots before they were attacked by *F. annosus*. If the fumigant-killed roots could be inoculated with an aggressive fungus antagonistic to *F. annosus*—such as *Peniphora gigantea* (Fr.) Massee (*Rishbeth 1961*)—the success rate of the treatment might be markedly enhanced.

Of the 11 centers followed throughout the study, only two developed outside infections that clearly appeared to have crossed the fumigation zone. In both cases, the pattern of disease development (revealed by tree symptoms and conk development) suggests that the apparently healthy tree next to the fumigant line was already infected at the time of treatment. It is likely that killing of roots on the side opposite an encroaching infection may have helped speed the pathogen across the freshly killed tissue ahead of colonization by saprophytic fungi.

The absence of fruiting bodies and of symptoms obviously is not reliable evidence of freedom from infection. In many cases, old stumps created in thinnings 5 to 8 years before treatment bore fruiting bodies one to several years after treatment—clear evidence that they had been infected many years earlier.

A possible aid in detecting infected, nonsymptomatic, and nonfruiting trees is the Shigometer (Northeast Electronics Corporation, Concord, New Hampshire). Shigo and Berry *(in press)* reported the successful use of this instrument to discriminate between healthy and infected red pine trees. The use of this instrument to detect infected living trees would probably have reduced the instances where break-over occurred and those cases where failure occurred because previously infected trees were missed outside the fumigation zone.

Although roots of white pine and Norway spruce were not affected by the fumigant, and both species were infected with *F. annosus*, no instances of break-over could be attributed to their presence. However, the possibility that roots of these species could serve as bridges across a fumigation zone should be considered in any control attempt.

The above-ground bole damage and tree mortality caused by fumigation and subsequent beetle attack could have been reduced considerably had trees adjacent to the fumigation line been removed at the time of treatment, or if the fumigation line had been run along rows of stumps of trees removed at the time of treatment. If such procedures were followed, the stump surfaces should be treated *(Hodges 1974)* to preclude their infection by airborne spores of *F. annosus*.

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