USE OF CHEMICALS TO PROTECT TREES FROM MOUNTAIN PINE BEETLE ATTACK

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ABSTRACT: Preventative chemical strategies to mitigate the effects of mountain pine beetle depredations are reviewed. Various formulations and rates of carbaryl are shown to be effective in protecting individual lodgepole pine from successful attack by MPB. A 1% formulation of Sevin brand XLR will provide two years of protection. This is one half the registered rate. Results of field tests of various formulations of "pine oil" for individual tree protection indicate highly variable results. No further testing of "pine oil" is recommended because the manufacturer has suspended development.

INTRODUCTION

Chemical intervention to mitigate the effects of mountain pine beetle (MPB) (Dendroctonus ponderosae Hopkins) infestations has a long history. In a review of the history of chemical and mechanical tactics to suppress MPB infestations, Klein (1978) states that an oil formulation of naphthalene was the first chemical used against MPB (Salman 1938). This occurred in the mid-1930s and for the next 30+ years, a myriad of chemical insecticides were tested for MPB suppression. The chemicals tested for use in direct control programs included the following: DDT, lindane, ethylene dibromide, copper sulfate, aldrin, dieldrin, heptachlor and others.

During the mid-1960's it became apparent that efforts to control populations of MPB by spraying individual infested trees was an expensive and futile endeavor. Concurrent with this realization was an increased effort to develop insecticides for individual tree protection. The primary objective of individual tree protection is to protect standing live trees from bark beetle attack rather than kill beetles once they have successfully colonized a tree. Mortality of high-value trees located in campgrounds or other administrative sites can have long-range management effects. The value of these individual trees, cost of their removal, and loss of campgrounds can sometimes justify protecting individual trees until the main threat of an infestation subsides.

Lyon (1965) reviewed many of the early studies designed to prevent attack by bark beetles. In these studies many of the same compounds used in direct control strategies were tested for efficacy in preventing MPB attack of individual trees. Starting in the mid-70's there was a shift away from the chlorinated hydrocarbons and toward newer compounds. This change in direction was the result of at least two considerations: recognition of potential environmental problems associated with the chlorinated hydrocarbons, and discovery by Rodgers (1976) that oil formulations were phytotoxic especially to thin barked species of pine.

Recently research has demonstrated the effectiveness of several water based formulations of carbaryl for protecting individual trees from attack by bark beetles. Smith and others (1977) and McCambridge (1982) clearly demonstrated the effectiveness of a 2% formulation of Sevimol® in preventing successful attack by MPB on both lodgepole (Pinus contorta var. latifolia Engelm.) and ponderosa pine (P. ponderosa Laws.). Gibson and Bennett (1985) and Page and others (1985) confirmed these earlier results. It's of interest to note that research by Hall and others (1982) and Haverty and others (1985) demonstrated the same efficacy of water-based formulations of Sevimol for western pine beetle (Dendroctonus brevicomis Hopkins) on ponderosa pine.

There are several objectives to this paper. First, I will review the results of the most recent research on the effectiveness of carbaryl for preventing attack by MPB on lodgepole pine. Second, I will present some preliminary data covering three years of testing with several formations of "pine oil."

CARBARYL

In 1983, Shea and McGregor (1987) rigorously tested two water-based formations of carbaryl for effectiveness in preventing MPB attacks on individual lodgepole pine trees. This study was initiated because Union Carbide Corp. (now Rhone-Poulenc Inc.) had removed Sevimol from the market place. The study had two objectives: to compare the efficacy of Sevin brand XLR (the

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proposed replacement) with Sevimol, and to determine whether lower rates of Sevimol and Sevin brand XLR could provide acceptable protection with the same longevity.

The experimental design and subsequent analysis followed that described by Shea and others (1984). The two formulations were Sevimol and Sevin brand XLR, each applied at 0.5%, 1.0% and 2.0%. About 2.0 gallons of formulated material was applied to each treatment tree (ca. 0.02 gal/ft^2 of bark surface) in the early summer of 1983. The fate of each study tree was followed for two years with a separate set of control trees for each year.

In the fall of 1983, evaluations indicated that all treatments were effective (fig.1) in protecting the test trees from mass attack by MPB. Only one tree in the 0.5% Seven brand XLR treatment group died because of attack by MPB; none of the remaining trees in any treatment group were successfully attacked. Evaluations conducted in the fall of 1984 after two MPB flight seasons clearly indicated that the 0.5% formulations of Sevimol and Sevin brand XLR were beginning to fail (fig.2). However the 1% and 2% dosage rates of both formulations remained effective (>80% survival). This test demonstrated that managers can expect to achieve effective protection of individual lodgepole pine trees with a 1% formulation of either Sevimol or Sevin brand XLR. This concentration is one half the EPA registration rate (EPA Reg No 264-333) and represents a substantial cost savings and reduction of the amount of carbaryl being placed in the high-value,high use site.

Use patterns of this tree protection strategy in MPB infested areas vary greatly. Data from Loomis (1985) and other sources (personal communications) indicated that approximately 100,000 trees were treated for protection from MPB during 1979-1987 (fig.3). More than 80% of these trees were treated with a 2% formulation of carbaryl (probably Sevimol). However, during the field seasons of 1986, 1987, and 1988, USDA Forest Service individual-tree-protection programs have utilized the 1% concentration of carbaryl. For instance, personnel on the Deerlodge (1986) and the Flathead (1987) National Forests treated 1800 and 1200 campground trees, respectively, and report approximately 100% protection (personal communication with Region 1 FPM). Obviously these data have important economic and environmental implications.

PINE OIL

Recently there has been considerable interest, effort, and discussion concerning the use of "pine oils" as a repellent for protecting individual trees from attack by various species of bark beetles. "Pine oil" is a generic term referring to a complex mixture of naturally occurring or synthetically derived secondary and tertiary terpene alcohols and other terpene hydrocarbons. The naturally processed "pine oils" are refined by-products of the pulp and paper industry.

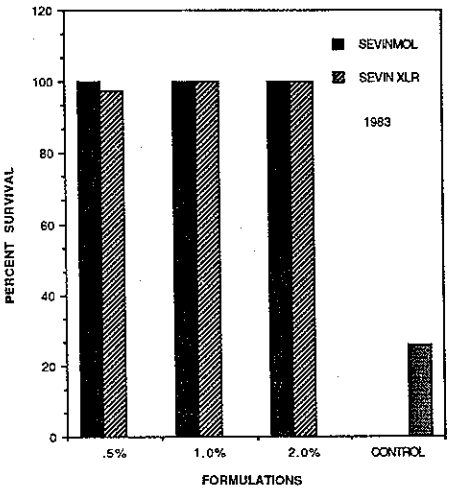

Figure 1--First year efficacy results of various rates of Sevimol and Sevin brand XLR after the 1983 field season.

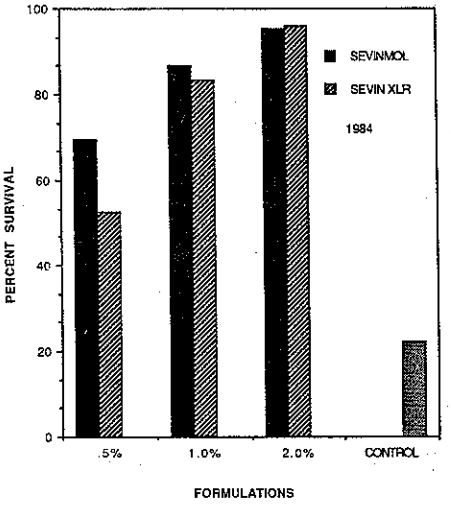

Figure 2--Second year efficacy results of various rates of Sevimol and Sevin brand XLR after 1984.

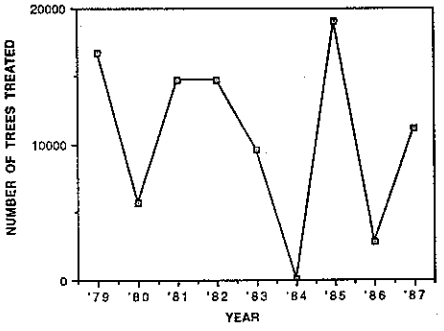

Figure 3--Use patterns of preventive sprays for mountain pine beetle 1979-1987.

Nijolt and McMullen (1980) first demonstrated that "pine oil", formulated as Norpine 65, could effectively prevent MPB from successfully attacking individual lodgepole pine. This was followed by a number of published reports indicating similar results on different populations of MPB (McMullen and Safranyik 1985; Richmond 1985) and other species of Dendroctonus (Nijolt and others 1981).

After considerable laboratory studies conducted to isolate the active fractions of Norpine 65, Mark McGregor (R-1, Entomologist) and I initiated field experiments to test the efficacy of various formulations for protecting individual trees from attack by MPB. These field tests were conducted because it was concluded, after discussions with representatives of Northwest Petrochemical Corp., that registration of Norpine 65, or any other unrefined formulation of pine oil, by EPA for individual tree protection would be a near impossibility. This conclusion was reached based on the nature of the Norpine 65 formulation with its numerous components, some of which had never been indentified, and the probability that each of these components would have to be subjected to numerous toxicological studies.

The design of these experiments follows that described earlier in Hall and others (1982) and Shea and others (1985). The tests were conducted during 1984-1986 in the Flathead National Forest of northwestern Montana. No synthetic baits were used in any of the experiments. A confidentiality agreement between the USDA/Forest Service and Northwest Petrochemical Corp. prevents, at this time, disclosure of specific contents in each formulation.

The results of 1984 tests are presented in figure 4. Greater than 60% of the control trees were successfully attacked indicating rigorous test conditions. None of the pine treatments met the predetermined success criteria that at least 24 of the 30 trees must survive to test the H_o:S(survival) $\geq$ 90% against H_a:S = 70%. Given a sample size of 30-35 trees these parameters provide a conservative binomial test (alpha = .05) to reject H_o when more than six trees die. The Norpell, Fraction B and Fraction C formulations are all distillation tower refinements of Norpine 65P. The results obtained from Fraction B and Fraction C suggest that perhaps some attraction was occurring that resulted in highter attack rates on trees within these treatments when compared to the controls.

Results of the 1985 field experiment (fig. 5) were similar to those obtained in 1984 in that all the treatments failed to provide adequate protection given the criteria described previously. However two things are of obvious interest. First the Norpine 65P formulation performed very poorly. Second the formulation Norpine M+O provides some suggestion of effect, given the high attack rate on the control trees and the percentage of trees not attacked or stripped attacked.

Finally, the results of the 1986 field experiments are presented in figure 6. The reduced sample size seriously affected the strength of the conclusions and was the result of a loss of trees due to firewood cutting and other uncontrolled events. Both the Norpine 65P and Norpine Poly M indicate considerable effectiveness. The protection provided by the Norpine Poly M formulation is especially noted because fully 80% of the test trees were not attacked at all in contrast to the Norpine 65P treatment where only

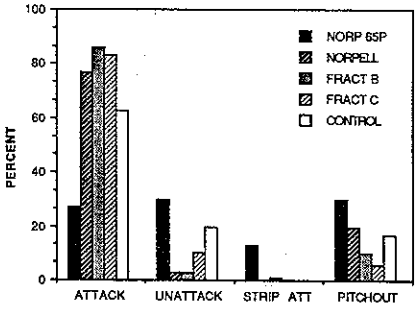

Figure 4--1984 results of various formulations of "pine oil" to prevent MPB attack on lodgepole pine.

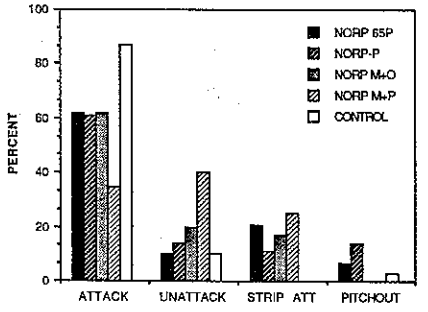

Figure 5--1985 results of various formulations of "pine oil" to prevent MPB attack on lodgepole pine.

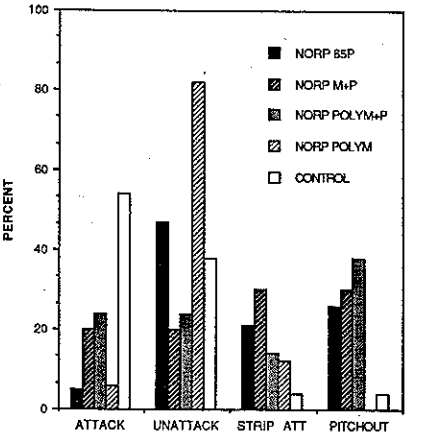

Figure 6--1986 results of various formulations of "pine oil" to prevent MPB attack on lodgepole pine.

47% of the trees were unattacked. These results would be especially encouraging if not for the fact that Northwest Petrochemical Corp. has experienced corporate difficulties unrelated to "pine oil" production and has decided to forego further development of this product.

Summarizing, preventive sprays for protection of individual high-value trees from attack by MPB is successfully employed throughtout the affected areas. Recent research and operational use has demonstrated that a 1% formulation (one half the registered rate) of carbaryl provides excellent protection. At the present time "pine oil" formulations do not appear promising as an alternative to insecticidal preventive sprays.

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