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PROTECTING LODGEPOLE PINE FROM MOUNTAIN PINE BEETLE ATTACK USING VERBENONE AND GREEN-LEAF VOLATILES ROCKY BOYS INDIAN RESERVATION, 2008

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INTRODUCTION

Verbenone, (4,6,6-trimethylbicyclo [3.1.1] hept-3-en-2-one), an anti-aggregation pheromone of mountain pine beetle (MPB), *Dendroctonus ponderosae* Hopkins, has been tested in a variety of formulations and uses over the past several decades. A 5-gram "pouch" formulation had been tested to protect pine stands and individual pine trees numerous times with mostly favorable results (Bentz and others 2005, Gibson and Kegley 2004, Kegley and Gibson 2004, Borden and others 2003, Progar 2003, Kegley and others 2003). However, the 5-gram pouch proved not to be effective over the entire MPB flight period and was ultimately replaced by a larger pouch. In 2004, a new 7.5-gram pouch was tested as a means of protecting individual trees. Additional tests were conducted in 2006 and 2007; those tests included evaluating the efficacy of verbenone plus a green-leaf volatile (GLV) pouch (50:50 blend of z-3-hexenol and cis-3-hexanol) for individual tree protection (Kegley and Gibson 2009).

In 2008, we tested a similar combination—verbenone alone, plus verbenone and GLV in lodgepole pine stands on the Rocky Boys Indian Reservation (RBIR) in north-central Montana. Instead of individual tree protection, we evaluated stand-level protection which is more difficult to achieve but may be more practical in certain situations.

METHODS

In mid-May, 2008, we selected 16 one-acre rectangular-plots in mature lodgepole pine stands on RBIR. Stands were selected in the Big Sandy Creek drainage, where moderate MPB activity

was experienced in 2007. MPB activity increased from 3,100 beetle killed LPP on about 930 acres in 2006 to 17,000 trees on 1,900 acres in 2007 on the RBIR. Groups of LPP killed by MPB in 2007 ranged between 30 and 200 and grouPs of 5 to 20 mountain pine beetle killed trees per acre were also recorded in and near the Big Sandy Creek drainage. Stands in the study area were scheduled to be thinned and/or salvaged later in 2008.

We evaluated four treatments: 1) 20, 7.5-gram verbenone pouches per acre (20 Verb/Acre); 2) 30 verbenone pouches per acre (30 Verb/Acre; 3) 20 verbenone pouches plus 20, 10-gram GLV pouches per acre (on alternating grid points) (Verb 20 + 20 GLV/Acre); 4) and no treatments (control). Each treatment was replicated four times and separated from other treatments in a block by approximately 330 feet. All blocks were within the same drainage and, therefore, were under similar beetle pressure, considering the long distances MPB can fly. Pouches for each treatment were evenly spaced throughout the one-acre plots. In addition, a standard MPB tree bait (Biota, Inc.) was placed at the center of each plot to improve consistency of beetle pressure across treatments.

A randomized block design with four blocks was used to test the difference in efficacy of the four treatments. Treatments were installed in June 2008 by RBIR personnel. Verbenone and GLV pouches were provided by Synergy Semiochemicals Corporation, Burnaby, B.C.

In September, following beetle flight, treatments were evaluated by looking at all trees greater than 5 inches diameter-at-breast-height (d.b.h.) in each treatment. All MPB host trees were recorded by d.b.h. and one of the following damage classes: 1) live (not attacked), 2) current MPB attack, 3) previous-year MPB kill, 4) older beetle-caused mortality, 5) current, unsuccessful attack (pitchout), 6) current MPB strip-attack, 7) older MPB strip-attack, 8) current secondary beetle attack, and 9) older secondary-beetle mortality. In addition, live non-host trees were recorded.

STATISTICAL ANALYSIS

Numbers of trees with no beetle attacks, pitchouts, strip-attack, and mass-attack were summarized by treatment. Also, SAS procedure GLIMMIX Procedure was used to test for differences between the control and other treatments (SAS 2006). Tukey-Kramer Multiple Comparison was used to test for differences between treatments.

RESULTS

Verbenone successfully protected stands of lodgepole pine on the RBIR from attack by MPB. The 30 Verb/Acre treatment provided the highest level of protection. There were significantly more untreated control trees attacked than in any of the treatments ($p<.0001$) (Table 1 & 2)). The largest difference in number of trees mass attacked was between the control and the 30 Verb/Acre, 20 Verb = 20 GLV/Acre and 20 Verb/Acre, in that order.

Following beetle flight in 2008, about 31% of trees were mass attacked in the 20 Verb/Acre, 4.2% in Verb 30/Acre, 8.6% in 20 Verb + 20 GLV/Acre and 50% in the controls (Table 3). Number of strip-attacked trees was similar across all treatments. Number of unsuccessful attacks in the 30 Verb/Acre treatments (87 trees) was much higher than in other treatments. This may suggest that there was sufficient beetle pressure in this treatment, but the level of verbenone in the stand was adequate to prevent large numbers of beetles from either entering the stand or mass attacking trees, despite the beetle bait at the center. In fact, in one 30 Verb/Acre replication, only 20 out of 210 available trees were mass attacked, despite having 14 currently-infested trees on the plot and the pheromone-baited trap.

Number of currently infested trees across all treatments was high. An epidemic of mountain pine beetle is described as greater than one-infested tree/acre. All of the blocks and most of the treatments had greater than one-infested tree/acre.

Table 1. Test of Fixed Effects

Effect	**Num DF**	**Den DF**	**F Value**	**Pr>F**
TREAT	3	9	236.88	<.0001
BLOCK	3	0	122.15	

Table 2. Treatment of Least Squares Means (adjusted treatment means)

Treatment	Estimate	Standard Error	DF	t-value	Pr>(t)	Mean	Standard Error Means
Control	0.06397	0.07138	9	0.90	0.3935	0.5160	0.01783
20 Verb+ 20 GLV	-2.6568	0.1076	9	-24.68	<.0001	0.06557	0.006596
20 Verb	-1.3399	0.07642	9	-17.53	<.001	0.2075	0.01257
30 Verb	-3.4513	0.1528	9	-22.58	<.0001	0.03073	0.004552

Table 3. Total Number of Trees Attacked, Unsuccessfully Attacked and Green Trees across Treatments.

	Green	Mass Attacked	Strip Attacked	Unsuccessful Attacks	2007 Attacks	Total # of LPP/Treatment
TREATMENT						
20 Verb/Acre	660	322	4	18	39	1043
30 Verb/Acre	1016	49	6	87	14	1172
20 Verb + 20 GLV/Acre	1115	111	6	8	54	1294
Control	560	624	4	6	56	1250

DISCUSSION

Verbenone has been tested alone and in combination with GLV, against various hosts, and in a variety of environmental settings. In this study, 30 7.5 gram verbenone pouches per acre provided significantly better protection from beetle attacks than the other verbenone treatments. Bentz et al. (2005) showed that 40 lower dose 5-gram verbenone pouches per acre were significantly more effective at reducing beetle attacks than 20 5-gram pouches.
The combination of GLV to the standard 20 verbenone pouches per acre was significantly more effective than 20 Verb/Acre treatment.

Kegley and Gibson (2009) showed that verbenone, in combination with GLV, resulted in less MPB-caused mortality on individual trees, than verbenone alone.

We may never achieve the level of tree protection, on an area basis, with verbenone and/or GLV that we would find desirable or comparable to insecticide treatments. Especially where MPB populations are extreme and currently infested trees cannot be removed in conjunction with verbenone applications, we may realize less-than-desirable results.

Reducing stocking densities (McGregor and Oakes 1987) and removing infested trees reduces the level of MPB-caused mortality. Techniques that increase stand vigor and reduce beetle pressure may also improve the efficacy of verbenone treatments. Nelson et al. (2006) showed that removing infested trees enhanced silvicultural and pheromone treatments and resulted in a greater reduction in beetle-infestation intensity. Additional trials are underway by the U.S. Forest Service to evaluate the effect of removing infested trees from verbenone treated stands. Verbenone is one of a resource manager's tools that can be used in a truly integrated pest management program incorporating silviculture and prevention, especially when beetle populations are not extreme.

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