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New Approaches to Chemical Control of White Pine Weevil Damage

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ABSTRACT

There has been little recent research on control of damage by the white pine weevil, and available insecticides have been few and have become obsolete. Tests in Canada suggested that the insect growth-regulating chemical diflubenzeron (Dimilin[R]) was effective, and we have successfully repeated those tests in Maine using several formulations of Dimilin and several ground application systems. Aerial trials have not succeeded; the probable reasons for their failure are discussed.

We present a general description of the weevil and its damage, approaches to control of damage, and specific recommendations for use of ground applications of Dimilin, which has recently become registered for this use.

INTRODUCTION

Eastern white pine (*Pinus strobus*) was once the most important lumber species in the nation, and it is now one of the least important (Marty 1985). It has been called the most intrinsically useful of all American softwoods (Howard 1985) with a high inherent growth and financial potential (Irland 1985). However, although quality pine demands impressive prices, there is low demand for poor quality pine, and much of the existing inventory is of poor quality. Foresters are avoiding using it, and inventories are increasing in much of the white pine range (Marty 1985). Reasons for poor quality and avoidance by foresters are large management investments in pruning, thinning, and control of hardwood competition as well as losses to the white pine blister rust disease (*Cronartium ribicola*) and the white pine weevil (*Pissodes strobi*) (Smith and Seymour 1985). Some authors list the weevil as the most serious of these problems, at least in New England and New York (Robbins 1985; Houseweart and Knight 1985). Other conifers, including some Christmas tree and ornamental species, are also attacked.

Chemical control measures for weevil damage began with recommendations of lime sulphur and lead arsenate sprayed on leaders (MacAloney 1930).

We do not know how much this approach was used. There was considerable use of DDT, both as ground and aerial sprays, when that material was developed (Crosby 1958; Connola et al. 1955), but DDT was banned about 1970. As substitutes, methoxychlor and lindane were tried (DeBoo and Campbell 1973). The former produced less than optimal results in several tests. Lindane produced good results and has been widely used where it is allowed. Its use is restricted in many areas because of its chemical and environmental similarity to DDT; in Maine, each specific use must be approved by the State Board of Pesticides Control, and spraying for weevils from the ground is apparently one of very few uses of lindane presently approved.

Oxydemeton-methyl (Metasystox-R[R]) was registered for weevil control for a few years, and with its systemic action, it had the advantage of affecting weevil larvae within infested leaders. This product is no longer approved for forest applications. Benyus (1983) lists bendiocard (Ficam[R], Dicarb[R]) as registered for weevil control, but we know of no personal experience with this material in this region.

With this shortage of readily available chemical controls for the weevil, we were interested in reports of successful trials with Dimilin from Dr. Arthur Retnakaran, Forest Pest Managment Institute, Forestry Canada, Sault Ste. Marie, Ontario. After consultations with Retnakaran, we undertook tests in Maine to reproduce and expand upon his work.

In the following, we review the habits of the weevil and its damage, review available control strategies, and describe our tests with Dimilin and provide recommendations for its use.

THE WHITE PINE WEEVIL

The weevil is distributed throughout the range of eastern white pine, or from southeastern Canada west to the Great Lakes and south in the Appalachians to Georgia. In addition, forms such as the Sitka spruce weevil and Englemann spruce weevil, formerly considered as separate species, are now considered the same as the white pine weevil, which extends it's distribution to Pacific coast forests.

White pine weevils attack many species of pine and spruce, both native and exotic. For the Northeast, we can cite MacAloney (1930): severely attacked—white pine, Norway spruce; commonly attacked—pitch, jack, Japanese red, western white, limber, and foxtail pines, and red spruce; occasionally attacked—Scotch, western yellow, and mugho pines, and black spruce; rarely attacked—red and Himalayan pines, blue and white spruces, Douglas fir. We agree with MacAloney except that our observations suggest that hazard be increased for mugho pine and some strains of Scotch pine.

Weevil attack begins in early spring when females chew holes through the bark, depositing one or a few eggs in such cavities. This attack is nearly always restricted to the upper third of the leader of the tree, the insects being guided there by reactions to light, temperature, and gravity (Sullivan 1959,1960). On hatching, larvae tunnel downward, feeding on the inner bark, usually killing the leader plus one or two whorls below the leader. Very small trees may be killed, but normally the result is that the branches below the killed section survive, and these compete for apical dominance. The likely result is a forked tree. Repeated attack results in very crooked boles, eliminating much of the sawlog value of trees. Losses of 40 % bd. ft. of sawlog volume as well as serious losses in board quality have been reported (Waters et al. 1955; Ferguson and Kingsley 1972). The natural growth form desired for Christmas and ornamental trees is also affected making damaged trees unmarketable.

By mid-summer the browned, killed leaders are readily visible although the wilting of green leaders is apparent before this. Weevil attack is also visible as a copious flow of pitch on the bark where eggs were laid. Full-grown larvae pupate within cavities chewed deeper into the wood of the leaders in mid-summer. After about two weeks, the resulting adults will emerge through the bark. These feed on bark in the crowns of host trees and mate during the later part of the summer. In late September or October, they will enter the soil, frequently beneath the tree within which they developed, to overwinter. These adults emerge the following spring and commence additional feeding, mating, and oviposition to complete the cycle. Spring emergence occurs very early, for some of the adults at least, often with some snow remaining on the ground. As will be noted later, this early emergence has an important influence in timing of spring control actions.

CONTROL OF WHITE PINE WEEVIL

We are chiefly concerned with chemical control of weevil damage in this bulletin. But other approaches have been recommended and practiced, and we review them in the following.

Cultural Control

With a relatively small number of trees, removal and destruction of infested leaders will limit future weevil numbers. Attacked and wilting leaders are easily recognized by early July. These should be pruned at the base of the internode within which the weevil larvae are feeding and destroyed. All but one vigorous lateral branch in the next whorl should be pruned as well. This branch will eventually become the new leader, and the tree will gradually develop a straight growth form (Dirks 1964). This sanitation of infested leaders with corrective pruning of the remaining living crown can be effective if done before weevil adults emerge from infested leaders in mid-summer. Annual pruning may be needed until desired tree height is reached. Some leader growth is inevitably lost, and small defects from the pruning will still result.

In another cultural procedure, it has been noted that pines growing under hardwood shade receive little injury from the weevil, and some mixed plantations of pines and fast-growing hardwoods such as aspens have been evaluated. In a related suggestion, pines planted at very high densities will, through crowding, cause injured trees to straighten more rapidly. Both of these prescriptions are less than perfect since pines growing in shade or in very dense concentrations will produce less than optimal growth, and this loss may be similar to the loss that would be produced by weevil damage (Marty and Mott 1964).

No realistic approaches to biological control of the weevil have ever been found. Many natural enemies have been noted (Dixon and Houseweart 1982), but no means of exploiting these enemies are known.

Chemical control remains as perhaps the only practical method to use where large numbers of trees are involved. It has probably been the most-used method. Below, we describe a newer chemical approach which will contribute, according to toxicity data, to greater health and environmental safety where chemical approaches are used.

EXPERIMENTS WITH DIMILIN IN MAINE

1989 Lagrange

This plantation consisted of alternating groups of about five rows of white pine and white spruce. Only pines were treated. Sprays were applied with hand-held, garden-type compressed air sprayers, and only the leader and upper whorl of branches were sprayed. Dimilin 25W (wettable powder) was the formulation used at two rates and on two dates (specified in Table 1). The diluent was water and dormant oil in a ratio of 90:10, respectively. Dimilin dosages were measured as ounces of active ingredient (AI) per gallon of spray. AI per acre is difficult to standardize since this will vary with the density of trees per acre and with the size of trees. One gallon of spray treated 150–200 trees in this plantation. Success was evaluated by counting attacked leaders in mid-summer.

Table 1. White pine weevil control trial at Lagrange Maine, 1989: Dimilin 25W; treated April 19 and May 4; white pine plantation.

Treatment	Attacks per 20 trees: plots 1	2	3	4	5	Attacks per 100-tree total	Percentage attacks
Untreated 1	9	6	5	11	7	38	38%
Untreated 2	4	6	9	10	6	35	35%
Untreated 3	5	6	5	6	4	26	26%
Untreated 4	7	6	7	6	6	32	32%
Summary of untreated: 131 attacks/400 trees							33%
1 oz. AI, April 19	0	0	0	0	2	2	2%
1 oz. AI, April 19	1	1	0	0	0	2	2%
Summary of 1 oz. AI: 4 attacks/ 200 trees							2%
1/2 oz. AI, April 19	0	0	0	0	0	0	0%
1/2 oz. AI, April 19	2	3	2	1	1	9	9%
Summary of 1/2 oz. AI: 9 attacks/ 200 trees							5%
1 oz. AI, May 4	1	2	1	0	6	10	10%
1/2 oz. AI, May 4	0	0	1	0	0	1	1%

Experiment totals:
131 attacks on 400 untreated trees—33 %
24 attacks on 600 treated trees—4 %

1990 Pittston

The Pittston plantation was about 12 acres of smaller white pine, 2 to 6 feet, but only about two acres were treated. A newer formulation of Dimilin, Dimilin 4L (flowable), was tested here, again with garden-type compressed air sprayers. Diluent was water, dormant oil, and propylene glycol in the ratio of 90:6:4 parts by volume. Four dosages were applied, as indicated in Table 2, with applications made on April 8, 1990.

Table 2. White pine weevil control trial at Pittston Maine, 1990: Dimilin 4L; treated April 8; white pine plantation.

Treatment	Number of trees treated	Total weevil attacks	% attacks
Untreated 1	268	88	33%
Untreated 2	76	35	46%
Summary of untreated: 123 attacks/ 344 trees			36%
4L 0.8oz. AI per gallon	126	1	1%
4L 0.4oz. AI per gallon	108	3	3%
4L 0.2oz. AI per gallon	87	2	2%
4L 0.1oz. AI per gallon	84	3	4%
Summary of treated: 9 attacks/ 405 trees			2%

1990 Old Town

The Old Town lot was an older plantation of Norway spruce with a past history of very heavy weevil attack. Trees were 6 to 12 feet in height and very bushy, and a volume of spray treated significantly fewer trees than in the young pine stand at Pittston. Applications were made using garden-type compressed air sprayers, and Dimilin 4L was used at three dosages and mixed as at Pittston. The 0.1 oz AI per gallon dosage was omitted at Old Town. Applications were made on April 8 with results measured in midsummer (Table 3).

Table 3. White pine weevil control trial at Old Town, Maine, 1990: Dimilin 4L; treated April 9; Norway spruce plantation.

Treatment	Number of trees treated	Total weevil attacks	% attacks
Untreated 1	63	38	60%
Untreated 2	62	40	65%
Untreated 3	61	31	51%
Summary of untreated: 109 attacks/ 186 trees			59%
4L 0.8oz. AI per gallon	60	2	3%
4L 0.4oz. AI per gallon	61	3	5%
4L 0.2oz. AI per gallon	60	8	13%
Summary of treated: 13 attacks/ 181 trees			7%

1990 Old Town

Also at the Norway spruce plantation in Old Town in 1990, we tried weekly ground applications of a single dosage of Dimilin to attempt to identify the period of time over which sprays were effective. While Dimilin 4L was used for the first treatment on April 9, Dimilin 2F was used in subsequent treatments. On each spray date, one gallon of spray was mixed and applied to about 60 trees. Each sprayed tree was tagged with color-coded plastic flagging, and all trees were evaluated for damage in mid-summer (Table 4).

Table 4. White pine weevil control trial on Norway spruce at Old Town, Maine, 1990: Timing of Dimilin sprays.

Treatment	Number of trees treated	Total weevil attacks	% attacks
Untreated 1	63	38	60%
Untreated 2	62	40	65%
Untreated 3	61	31	51%
Summary of untreated: 109 attacks/ 186 trees			59%
4L, 0.4oz. AI per gal., Apr. 9	61	3	5%
2F, 0.4oz. AI per gal., Apr. 16	60	7	12%**
2F, 0.4oz. AI per gal., Apr. 24	61	4	7%
2F, 0.4oz. AI per gal., Apr. 30	62	17	27%
2F, 0.4oz. AI per gal., May 7	60	19	32%
2F, 0.4oz. AI per gal., May 16	62	22	35%
2F, 0.4oz. AI per gal., May 25	62	27	44%

** Extended rain immediately following treatment.

1991 Pittston

Tests in 1989 and 1990 involved hand hydraulic sprayers. In 1991, we used a back-mounted mist blower in the applications in order to evaluate a different spray system. Portions of the same Pittston planting of white pine treated in the earlier years were treated on April 5, 1991. Dosages were mixed as 1.6, 0.8, and 0.4 oz. AI of Dimilin 4L per gallon of spray. Mixes were the Dimilin, plus 15 fl. oz. of dormant oil, plus sufficient water to make 2.5 gallons of spray. The 2.5 gallons of spray treated 320 to 350 of the small trees at Pittston. Observations of weevil damage were made in mid-July (Table 5).

Table 5. White pine weevil control trials at Pittston, Maine, 1991: Dimilin 4L, white pine, treated April 5.

Treatment	Number of trees treated	Total weevil attacks	% attacks
Untreated	400	272	68%
4L 1.6oz. AI per gallon	350	7	2%
4L 0.8oz. AI per gallon	350	28	8%
4L 0.4oz. AI per gallon	320	27	9%
Summary of treated: 62 attacks/ 1020 trees			6%

1991 Old Town

Mist blower trials, using the single dose of 0.8 oz. AI per gallon of 4L, were applied on April 20 on a part of the Norway spruce plantation at Old Town. A single mix of 2.5 gallons of spray was applied. Because of the bushy nature of these larger trees, the 2.5 gallons treated only 120 trees. Treated trees were flagged and examined for infestation in July (Table 6).

Table 6. White pine weevil control trial at Old Town, Maine, 1991: Dimilin 4L; treated April 20; Norway spruce plantation.

Treatment	Number of trees treated	Total weevil attacks	% attacks
Untreated	146	86	59%
Treated	120	4	3%

1991 Howland

The Howland site was a planting of about two acres of jack pine, eight feet in height, within an International Paper Co. seed orchard. The estimated number of trees was 1400, and this was the only time in these experiments that an entire plantation was treated. The single dosage of 2 oz. AI per acre (0.8 oz. AI per gallon) of 4L was used, employing the mist blower, and six gallons were used for the total treatment. Treatment was applied on April 20 with results measured in mid-July. There was no jack pine in the region to use as a control, and our comparison is made against the rate of weeviling in the plantation in the year prior to treatment (Table 7).

Table 7. White pine weevil control trial at Howland, Maine, 1991: Dimilin 4L; treated April 20; jack pine plantation.

Treatment	Number of trees treated	Total weevil attacks	% attacks
Untreated (1990)	1400	42	3%
Treated (1991)	1400	0	0%

Aerial Tests

Two attempts at control of white pine weevil damage using Dimilin applied by aircraft were made. In 1989, Dimilin 25W was applied to about four acres of the white pine plantation at Pittston using a helicopter from Maine Helicopters of Augusta. The final application rate was 2 oz. AI of Dimilin in 3 gallons of water plus dormant oil per acre. The insecticide mixture was actually applied at 1.5 gallons per acre sprayed from two directions to ensure complete coverage. Because of the proximity of dwellings, nozzles producing large spray droplets, ca. 400 microns, were used to reduce drift. The spray was applied on April 18.

In 1990, we contracted to spray two naturally regenerated stands of white pine in Old Town and Maxfield, both about 10 acres in size. Damage in these stands from the preceeding year was used as the control. Applications were made using a Thrush fixed-wing aircraft fitted with Micronair nozzles from Michael Lavoie Applicators of Presque Isle. Although we did not measure spray droplet diameters, we would expect droplets of 100 microns or less with this system. The applications were made at 3 oz. AI per acre diluted to 3 gallons of spray, and were applied on April 14.

Neither aerial test showed any reduction in weevil damage from the controls; in all cases of treated plots and controls, weevil damage ranged from 30 to 55 percent of trees.

DISCUSSION OF THE TESTS

Ground tests, using both compressed air and airblast applications on three species of host trees, were uniformly successful, usually producing 90 percent reduction or better in weevil damage. We believe that these results are conservative in that, as a rule, small plots within a plantation were treated leaving the treated areas surrounded by large areas of untreated and infested stands. This was particularly true in the Norway spruce plantation at Old Town where crown closure was such that treating blocks of trees was difficult, and treatment was applied to transects of trees winding through the plantation where there were openings. Individual treated trees were often surrounded by untreated trees. We believe that where entire plantings can be treated control will be better, approaching 100 percent. Where we treated an entire planting, the jack pine stand in Howland, 1990, we achieved 100 percent reduction in damage. But, since pretreatment level of damage was only 3 percent of trees, we cannot necessarily apply that result to heavily infested stands. Even if reduction of damage to zero cannot be achieved in one year in a heavily infested stand, it probably can be accomplished with 2 or 3 consecutive years of treatment.

In applying treatments, the targets were the leader(s) and upper whorl of branches. The remainder of the tree received only drift or drip. We also treated trees from only one side; where rows of trees were plainly visible, only the alternate trails between rows were traveled, treating trees in both rows on either side of a trail. Much more spray was required to treat larger, bushy, multiple-leader trees such as the Norway spruce at Old Town. Calculating a uniform spray rate per acre under circumstances of different tree size and density is difficult.

A very conservative method of assessing weevil damage was used throughout all trials whereby damaged trees were tallied, not damaged leaders. Although an individual tree may support five or more leaders which could be attacked, if one was killed the tree was recorded as successfully attacked. Rarely was more than one leader attacked in the treated blocks, but frequently two or more leaders were killed on individual trees within the untreated check areas. The trial to evaluate timing of sprays (Old Town, 1990, Table 4) suggested that the first three applications, April 9 to 24, produced the desired result, but that efficacy declined strongly thereafter. We conclude that sprays must be applied early, before mid-April in central Maine. Canadian colleagues (A. Retnakaran, personal communication) recommend treatment while some snow still remains.

Overwintering white pine weevil adults become active in spring well before many other insect species.

Most of our ground tests have shown a dosage response, but based on our experience to date, we cannot identify the minimum effective dosage. Users will need to make some judgements here based on their goals and application costs.

We are not surprised that aerial treatments failed. In early spring, all weevils that we have observed are on the bark of the leaders. This vertical target, the leader bark, is difficult to coat with chemical falling downwards. In addition, the cylinder of needles surrounding the leader will intercept spray droplets, preventing them from reaching the bark. We have no plans for continuing aerial trials with Dimilin.

As this is written, we understand that "terminal weevils" has been or will be added to the label of Dimilin by the manufacturer and can be legally used.

RECOMMENDATIONS FOR USE OF DIMILIN

1. Dimilin should be mixed at rates of 0.1 to 0.8 oz. AI per gallon of spray for either hydraulic or air blast application. With the common planting rate of 1000 trees per acre, this would be the equivalent of 2 to 4 oz. of Dimilin (AI) per acre. But, in all cases label rates should not be exceeded.
2. Dormant oil should be added in the mix in the ratio 10 : 90 of oil to water.
3. Sprays need be applied only to the leader and upper whorl of branches with application to one side of the tree.
4. Early spring application is essential, before mid-April in central Maine, somewhat earlier or later depending on location. Application with some snow still remaining is often necessary.
5. More than one year of application may be necessary to reduce damage to near zero. Thereafter, it may be possible to cease applications until damage levels begin to increase again. Damage increases will depend on the level of infestation in surrounding stands.

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