

## CHEMICAL CONTROL OF BALSAM WOOLLY APHID (*HOMOPTERA: ADELGIDAE*) ON SEEDLINGS OF *ABIES AMABILIS*

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### ABSTRACT

Assessment was made of the effectiveness of four insecticides for eradicating *Adelges piceae* (Ratz.) from *Abies* seedlings. Seedlings with overwintering immature aphids were top dipped in the insecticides in fall or spring (before or after cold storage), while those with mature, egg laying aphids were treated in spring. The overwintering immature aphids were completely killed by all of the insecticides and it was recommended that any one of the following treatments would provide sanitation of *Abies* from aphid during this stage: 1.0% propoxur suspension; 2.0% carbaryl suspension; 2.0% Insecticidal Soap solution; 0.5% permethrin emulsion. Treatment of mature aphids was less effective due to relative tolerance of bwa eggs and it was recommended that treatment during this stage of the aphid be avoided.

### RÉSUMÉ

On a évalué l'efficacité de quatre insecticides à éradiquer *Adelges piceae* (Ratz) des semis d'*Abies*. Les semis chez lesquels s'étaient installés des pucerons non adultes pour passer l'hiver ont été trempés par le haut dans les insecticides à l'automne ou au printemps (avant ou après entreposage à froid), alors que ceux abritant des pucerons adultes aptes à la ponte ont été traités au printemps. Les pucerons non adultes ont tous été tués par les insecticides, d'où la recommandation que n'importe lequel des traitements subséquents fournirait une protection à *Abies* contre les pucerons à ce stade de développement: suspension de propoxur à 1%, suspension de carbaryl à 2%, solution de savon insecticide à 2% et émulsion de perméthrine à 0,5%. Le traitement s'est avéré moins efficace contre les pucerons adultes et les auteurs ont recommandé d'éviter de les traiter à ce stade.

### INTRODUCTION

Balsam woolly aphid (bwa), *Adelges piceae* (Ratz.), is a serious pest of the true fir (Balch 1952) and has caused substantial damage to fir stands in Washington, Oregon and British Columbia (Vyse 1971). In response to the potential threat caused by bwa to the *Abies* inventory in the province, regulations were enacted in 1966 which quarantined all nursery stock, prohibited the seeding of any new *Abies* spp. and restricted the movement of logs (B.C. Order-In-Council 460, B.C. Reg. 58/66, 1966). Recently these regulations were revised to permit growers to plant *Abies* (B.C. Order-In-Council 44, B.C. Reg 7/77, 1977). However, in order to minimize the possibility of bwa spread, it was specified that all growing stock be treated with suitable insecticides prior to transportation to the outplanting sites.

Chemical control studies of bwa (Hopewell and Bryant 1966, 1969; Randall, Hopewell and

Nigam 1967; Nigam 1972; Puritch and Talmon de l'Armée 1974; Puritch 1975) and other adelgids (Campbell and Balderston 1972a, 1972b) indicate that there are several insecticides which could be used to eliminate bwa from *Abies* growing stock and provide a sanitation treatment. Hopewell and Bryant (1966) treated 10 m-high *Abies balsamea* (L.) Mill with 8 insecticides in 16 different formulations and reported that propoxur gave the highest bwa mortality. They later reported that it performed very well in a subsequent field trial (Hopewell and Bryant 1969). Propoxur was also rated as one of the best insecticides for ground application of bwa in an assessment of 27 chemicals (Randall, Hopewell and Nigam 1967), although it was ineffective in an aerial application (Nigam 1972). Carbaryl, another carbamate, has been highly effective in controlling two other adelgid species: *Adelges abietis* (l.) (Campbell and Balderston 1972b) and *Adelges cooleyi* (Gillette) (Campbell and Balderston 1972a). Besides these carbamates, certain fatty acid derivatives have been found capable of controlling bwa. Puritch and Talmon de l'Armée (1974) and Puritch (1975) reported that the 18-carbon unsaturated fatty acids, primarily oleic,

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and their potassium salts were toxic to all instars of the aphid, including the overwintering neosistens. Recently, investigations have shown that certain synthetic pyrethroids, including permethrin, are effective against various aphid species (Nigam, personal communication).

It was decided, therefore, to assess these four promising insecticides; *viz.* propoxur, carbaryl, insecticidal fatty acid salts (soaps) and permethrin as treatments for sanitizing *Abies* seedlings against bwa. Since seedlings are usually transported in late fall or early spring, after cold storage, assessments were made on the overwintering populations in October or April. In addition, treatments were applied to mature, egg-laying aphids in the spring.

#### MATERIALS AND METHODS

*Abies amabilis* (Dougl.) Forbes seedlings, obtained from the Campbell River Nursery, were used for all tests. Seedlings were 2-0 bare-root or 1-0 container grown stock and were potted at 4 or 5 per pot. Plants were maintained in the greenhouse during summer and infested with bwa by laying eggs and crawlers on top of the foliage.

##### A. Overwintering, Immature Aphids.

Treatments on the overwintering aphids were applied either in the fall or spring (Table 1). For the fall treatment, seedlings were uprooted and bundled in groups of 20. Each bundle was then top-dipped up to the roots in the designated insecticide, drained and allowed to dry at room temperature for 24 h. Bundles were selected at random for treatment and four bundles were assigned to each concentration of each treatment. The following treatments were used: propoxur 4.0, 2.0, 1.0%; carbaryl, 6.0, 4.0, 2.0%; Safer's Insecticidal Soap (Safer Agro Chem Ltd.), 2.0% and permethrin, 2.0, 1.0, 0.5%.

Propoxur and carbaryl concentrations were prepared from 70% and 85% wettable powders, respectively, while Insecticide Soap concentrations were prepared from 50% liquid concentrate and permethrin from 50% emulsifiable concentrate. After treatment, bundles were temporarily repotted until January when they, along with untreated seedlings reserved for spring treatment, were uprooted, placed in B.C. Forest Service boxes and stored at 0°C. In March 1977, all seedlings were taken out of storage; the fall seedlings were repotted at 4 per pot, while the remaining untreated seedlings, were treated with the same treatment-concentration as the fall group (with the exception of propoxur) and were also repotted. Propoxur concentrations, in the spring, were prepared from 12.8% emulsifiable concentrate rather than the wettable powder and were applied at 4% and at 1.75 and 0.93% rather than 2.0 and 1.0%.

Assessment of aphid populations was carried out in April (Table 1). Aphid mortality was assessed by recording the number of living and dead aphids present on the terminal bud, one lateral bud and one node from two seedlings selected at random from each pot. For each treatment-concentration, total number of seedlings assessed varied from 36 to 46 and the number of aphids averaged 563.

##### B. Mature Aphids

Treatments were applied to aphids in the egg laying stage during March of 1978 and 1979 (Table 1). Concentrations tested are listed in Table 2, with the 1979 treatments marked with an asterisk. In these tests, seedlings were planted at 4 per pot and treatments were applied by inverting the pots and top dipping the seedlings up to the root collar. Sixteen pots (64 seedlings) were used per treatment concentration and 48 pots were used as water-treated

Treatment Group	Time of Treatment	Time of Assessment
A. Overwintering Immature Aphids		
1. Fall treatment	October 1976	April 1977
2. Spring treatment	March 1977	April 1977
B. Mature Aphids		
1. 1978	March 1978	April 1978
2. 1979	March 1979	April 1979

TABLE 1. Schedule of insecticide treatment for balsam woolly aphid control.

checks. Assessment of aphid populations was done in April, a month after treatment, in the manner previously described, on half (32) of all treated seedlings. Egg numbers were recorded as high (>20) medium (10 to 20) or low (1 to 10) for each seedling. Egg viability was assessed by collecting the eggs and allowing them to hatch on filter paper in petri dishes. Aphid mortality in all tests was corrected according to Abbott's formula (Abbott 1925).

RESULTS AND DISCUSSION

A. Overwintering, Immature Aphids

All concentrations in all treatments in the fall and spring groups gave total mortality of the overwintering aphids. These aphids were primarily in the neosistens stage, although a few had developed as far as 2nd or 3rd instars prior to the spring treatment. With the exception of the 4% propoxur prepared from the emulsifiable concentrate, which caused slight

Insecticide	Concentration (%)	Number of Aphids (All Instars)		Mortality (%)	Corrected % Mortality <sup>2</sup>	Amount of Eggs
		ALIVE	DEAD			
Control (H <sub>2</sub> O)	1	437	52	10.6		H <sup>3</sup>
	2	499	45	8.3		H
	3	472	50	9.6		H
	4* <sup>1</sup>	408	48	10.5		L
	5*	226	20	8.1		L
	6*	363	31	7.9		L
Propoxur	0.50	0	521		100.0	L(-) <sup>4</sup>
	0.25	0	486		100.0	L
	0.10*	0	466		100.0	L
	0.025	226	331		55.4	H
	0.025*	23	497		94.9	L
	0.01*	281	347		48.9	L
Carbaryl	1.00	3	577		99.4	L(-)
	0.50	10	560		98.1	L
	0.05	290	212		35.8	M
	0.05*	90	141		57.1	L
	0.025*	211	169		39.0	L
	0.01*	467	51		0.0	L
Insecticidal Soap	2.00	33	384		90.7	0
	1.50	5	392		98.6	0
	1.00	12	499		97.4	0
	1.00*	200	562		71.1	L
	0.50*	295	271		42.7	M
	0.10*	646	267		22.2	H
Permethrin	0.25	0	560		100.0	L(-)
	0.10	0	532		100.0	L
	0.01	12	436		97.0	L
	0.01*	64	368		83.7	L
	0.005*	61	296		81.2	L
	0.0025*	154	155		45.3	L

<sup>1</sup> \*Denotes 1979 treatment; no asterisk denotes 1978 treatment.

<sup>2</sup> Mortality corrected according to Abbott's formula (Abbott 1925).

$$P_t = \frac{P_o - P_c}{100 - P_c} \times 100 \quad \text{where } P_t = \text{corrected mortality, } P_c = \text{control mortality (average control mortality used in calculation) and } P_o = \text{observed mortality.}$$

<sup>3</sup> L = low egg numbers (1 to 10), M = medium egg numbers (10 to 20) and H = high egg numbers (>20).

<sup>4</sup> (-) eggs nonviable when tested, absence of mark indicates eggs viable when tested.

TABLE 2. Effect of insecticidal application on mortality of balsam woolly aphids infesting *Abies amabilis* seedlings. Aphids were treated during the adult, egg laying stage in spring.

foliar damage, there was no evidence of phytotoxicity. Controls of the fall and spring groups had 68 and 63% aphid mortality, a situation that may have resulted from the storage conditions and frequent repotting of the seedlings. Thus all four insecticides could provide a suitable sanitizing treatment if applied to bwa during its immature, overwintering stage, either before or after cold storage. This stage mainly occurs during December to February in south-western British Columbia (McMullen and Skovsgaard 1972).

#### B. Mature Aphids

Effects of the various concentrations of the four insecticides tested are summarized in Table 2. Only 0.25% permethrin and 0.5% propoxur gave 100% aphid mortality and killed all the eggs. Lower concentrations of these compounds, viz. 0.1% permethrin and 0.25 and 0.1% propoxur, gave 100% aphid mortality but left viable eggs. No eggs were observed in three of the higher concentrations of Insecticidal Soap. Since this insecticide is not completely ovicidal at these concentrations (Puritch 1975), the eggs possibly hatched and developed into neosistens in the interval between treatment and assessment. A similar situation likely occurred in the lower concentrations of the other three insecticides, thereby decreasing the true percentage mortality by 1 or 2 points.

It should be noted that in a previous test using a portable spraying chamber, application of 5% propoxur at a dosage rate of 11.23 l/ha caused 61% mortality to eggs, while caus-

ing 100% mortality to adult aphids (Nigam, unpublished results). The difference between these and present results may be due to differences in spraying and dipping techniques. However, they indicate the relative tolerance of eggs to insecticidal treatment compared to aphids. Therefore, the safest time to treat seedlings for bwa would be during the overwintering stages when no eggs are present. If, owing to some unforeseen reason, spraying at this time cannot take place, treatments should be applied 14 days apart to bracket the egg hatching stage of 12 days (Atkins 1972).

#### CONCLUSIONS

It is recommended, on the basis of these results, that sanitization of *Abies* spp. nursery stock from bwa take place by dipping seedlings during the overwintering stage of the aphid with any one of the following treatments:

1. 1.0% propoxur suspension
2. 2.0% carbaryl suspension
3. 2.0% Insecticidal Soap solution
4. 0.5% permethrin emulsion

Treatment during the summer, when bwa eggs are present, should be avoided wherever possible, but if essential, should be applied at least twice over a 2-week period.

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