Effective Control of a New Woolly White Fir Nursery Aphid (Homoptera: Aphididae)[1]

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Abstract.- Damage by a woolly fir aphid (*Mindarus* sp. Nr. *victoria* Essig [Homoptera: Aphididae]) was first reported in white fir (*Abies concolor* [Gord. & Glend.] Lindl.) nursery beds at Placerville, California, in 1987. The 47% cull rate attributed to this aphid resulted in a total loss of $204,000 (nursery plus site preparation cost). To reduce aphid damage to nursery seedlings, 11 different insecticide formulations were tested for aphid control during 1988 and 1989. One application of acephate, chlorpyrifos, diazinon, dimethoate, esfenvalerate, cyfluthrin and fluvalinate in the Spring significantly reduced aphid infestations until midsummer. Two applications of acephate, chlorpyrifos, diazinon, dimethoate, and fluvalinate were effective in reducing aphid populations throughout the growing season. Carbaryl, azadirachtin, and soap were apparently not effective against this aphid in the nursery environment.

INTRODUCTION

In 1987, a woolly fir aphid (*Mindarus sp. nr.. victoria* Essig [Homoptera: Aphididae]) was first noticed in the USDA Forest Service Nursery at Placerville, California, in the central Sierra Nevada. Initial infestations were on 2+0 seedlings of white fir (*Abies concolor* [Gord. & Glend.] Lindl.) and bristlecone fir (*A. bracteata D.* Don). This new woolly white fir aphid was first identified as the balsam twig aphid (*Mindarus abietinus* Koch.) and later as *Mindarus victoria* Essig (Dr. L. Ehler, personal communication). Separating this aphid from near relatives became necessary after the documentation of its unique biology. The winged or slate stage migrates into 2+0 white fir beds in May and into the 1+0 white fir beds in early August. This is an atypical life cycle for any of the *Mindarus* species in the western United States (Ferrell 1989; Nettleton and Hain 1982; Stein 1991).

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Damage to 1+0 stock results in curled needles and an enlarged, club-like apex of current growth, in conjunction with the formation of an abnormal bud rosette. On 2+0 seedlings, this aphid feeds on elongating shoots, causing discoloration and curling of new needles, distortion of current growth, and mortality of the terminal bud (fig. 1). In 1987, after several applications of malathion were used on an operational scale, the cull rate for 2+0 white fir seedlings was still 47% (William Scheuner, personal comm.). Normal cull rates for white fir grown in the Placerville nursery usually range between 20% and 30%. In 1988 and 1989 we evaluated several insecticides for effective control of this particular aphid infesting 2+0 white fir seedlings.

METHODS

This study was conducted at the USDA Forest Service Nursery located 4.8 km north of Placerville, California. Inspection of 1+0 seedbeds on February 17, 1988, indicated that a significant portion of 1.8 million white fir seedlings was infested with *Mindarus* sp. and had been damaged during the first growing season.

Figure 1.-Distorted needles and terminal bud damage to 2+0 white fir seedlings caused by colonies of *Mindarus sp.*

The experiment was conducted as a randomized split-plot design in 1988 and a completely randomized design in 1989. In 1988, one of six treatments was randomly assigned to each white fir bed. Once the treatments had been assigned, each white fir bed (replicate) was subdivided into two 3- by 1-m plots, and randomly assigned the number 1 or 2. The number of each plot corresponded to the number of applications of a specific insecticide. Each insecticide treatment had 11 replicates, and the untreated controls had 30 replicates. In 1989, white fir beds were subdivided into three 3- by 1-m plots and numbered consecutively. Each of the 9 treatments was randomly assigned to the plots and replicated 10 times.

Insecticides in both years were applied using a pressurized garden sprayer. The application rate for each chemical in both years was approximately 153 1/ha (100 gal/acre). At each examination, the proportion of 5 seedlings infested by *Mindarus sp.* was recorded from each of 4 random sample points within a plot.

In 1988, insecticides were first applied on March 28, to coincide with the expected appearance of aphids in the spring. When the aphid infestation rate in treated plots had increased to 10%, a second insecticide spray was applied on May 27 to the remaining half of each treatment plot. In 1989, six insecticides were applied only once on July 11 to seedlings with established aphid colonies. Five additional applications, at weekly intervals, were made for azadirachtin and soap.

Differences among insecticides in the proportion of infested seedlings were evaluated by analysis of variance for all data in 1988 and 1989. Dunnett's multiple comparison procedure was used for pairwise comparisons of treatment means and the untreated control, at an experimentwise alpha level of 0.05 (Dunnett 1955).

RESULTS AND DISCUSSION

A single application of all the tested insecticides in 1988 (acephate, chlorpyrifos, diazinon, dimethoate, and fluvalinate) significantly reduced the percentage of 2+0 white fir seedlings infested with *Mindarus up* to 73 days after spraying (Table 1). Although the March spray was applied 29 days before initial aphid migration into the fir beds, we believe insecticide residues were sufficient to reduce the number of *Mindarus* colonies. The white fir aphid population began to recover 51 days after the insecticide application (Table 1). A second spray was applied on May 27 as the infestation rate in treated beds reached the arbitrary threshold of 10%. All five insecticide treatments caused a significant reduction in aphid-infested seedlings for 27 days after spraying (Table 2). The two systemic insecticides (acephate and dimethoate) seem to be the most effective at reducing the aphid populations. The three insecticides without systemic properties (fluvalinate, chlorpyrifos, and diazinon) caused an approximate threefold reduction in the percentage of infested seedlings. We found that chlorpyrifos was efficacious at half the effective rate used by Nettleton and Hain (1982) for a similar species of *Mindarus*.

Table 1.-Percentage of *Mindarus* infested white fir seedlings after a single application of insecticide on March 28, 1988

		Postspray[1]				
Treatment	Pre-spray	16 d	38 d	51 d	59 d	73 d
Acephate	0.0	0.0	0.0	7.7*	11.4*	9.1*
Chlorpyrifos	0.0	0.0	2.3	8.2*	11.4*	4.1*
Diazinon	0.0	0.0	0.0	6.8*	12.7*	9.1*
Dimethoate	0.0	0.0	0.0	6.4*	6.4*	9.1*
Fluvalinate	0.0	0.0	0.0	8.6*	8.6*	10.9*
Untreated	0.0	0.0	5.0	35.0	39.0	30.5

[1]Means followed by an asterisk in a column differ significantly from the control at the 5% level (Dunnett 1955).

Table 2.-Percentage of *Mindarus* infested white fir seedlings after two insecticide applications (March 28 and May 27, 1988)

		Postspray[1]			
Treatment	Prespray	6 d	13 d	27 d	41 d
Acephate	11.4	0.9*	0.0*	0.5*	0.0
Chlorpyrifos[2]	11.4	0.5*	0.0*	4.6*	0.0
Diazinon	12.7	0.0*	0.0*	6.8*	0.0
Dimethoate	6.4	0.0*	0.0*	0.0*	0.0
Fluvalinate	8.6	4.6*	3.6*	5.5*	0.0
Untreated	39.0	41.7	30.5	15.0	0.0

[1]Means followed by an asterisk in a column differ significantly from the control at the 5% level (Dunnett 1955).

[2]The second application of chlorpyrifos was at the registered rate of 0.28 kg active ingredient per acre (0.25 lb ai/acre).

Table 3.-Percentage of *Mindarus* infested white fir seedlings after one insecticide application on July 11, 1989

		Postspray[1]			
Treatment[2]	Prespray	8 d	15 d	22 d	30 d
Esfenvalerate	21.5	7.5*	15.5*	10.0	23.5
Cyfluthrin	21.5	5.0*	15.5*	16.0	21.5
Fluvalinate	19.0	6.0*	10.5*	7.5	13.0
Azadirachtin	28.5	25.0	29.5	13.0	8.0
Carbaryl	30.5	22.0	38.0	19.5	9.0
Carbaryl (SL)	34.0	21.5	39.5	23.0	0.0
Dimethoate	33.5	1.0*	0.0*	5.5*	9.0
Soap	28.5	28.5	36.5	19.0	17.0
Untreated	32.5	34.0	45.0	20.0	15.0

[1]Means followed by an asterisk in a column differ significantly from the control at the 5% level (Dunnett 1955).

[2]Azadirachtin and soap were sprayed a total of 6 times.

When insecticide formulations were sprayed directly on established aphid colonies in 1989, only half were effective. Esfenvalerate, cyfluthrin, and fluvalinate significantly reduced infested seedlings for 15 days (Table 3). Dimethoate, with its systemic properties, significantly reduced in-

Table 4.-Insecticides and application rates for tests of efficacy against *Mindarus* infesting 2+0 white fir at the Placerville Nursery

Common name	Formulation	Application rate (kg ai/ha)[1]	Cost ($/acre)	Efficacious
Acephate	Orthene 75S (75% SC)	0.56	5	Yes
Chlorpyrifos	Dursban 4E (44.4% EC)	0.56	10	Yes
Chlorpyrifos	Dursban 4E (44.4% EC)	0.28	5	Yes
Diazinon	Diazinon (25% EC)	0.56	4	Yes
Dimethoate	Cygon (23.4% EC)	1.12	8	Yes
Carbaryl	Sevimol (40% SC)	1.12	—	No
Carbaryl	Sevin SL (41.2% SC)	1.12	—	No
Esfenvalerate	Asana XL (8.4% EC)	0.06	7	Yes
Cyfluthrin	Tempo 2W (20% WP)	0.06	7	Yes
Fluvalinate	Mavrik 2E (25% EC)	0.06	6	Yes
Azadirachtin[2]	Margosan-O (0.3% EC)	0.02	—	No
Soap[2]	Safer Soap (49%)	6.10	—	No

[1]Kilograms of active ingredient per hectare.

[2]Chemicals with six applications made at weekly intervals on established aphid colonies.

fested seedlings for at least 22 days. Once again the pyrethroids caused a three- to fourfold reduction in aphid colonies, whereas reduction associated with dimethoate approached zero and the effects lasted a longer period of time. Both formulations of carbaryl, soap, and azadirachtin were not effective. Eleven insecticides and dilutions were tested in 1988 and 1989 (Table 4).

CONCLUSIONS

Spring applications of acephate, chlorpyrifos, diazinon, dimethoate, and fluvalinate insecticides significantly reduced the percentage of aphid-infested 2+0 white fir seedlings. Established aphid colonies were also significantly reduced with the summer application of either dimethoate, esfenvalerate, cyfluthrin, or fluvalinate. Two spray applications (spring and summer) with effective insecticides appeared to reduce aphid infestations during peak populations. Insecticide application in late spring may eliminate the need for more than one spray during the same growing season.

These results indicate that nursery managers have some latitude in choice of insecticides and establishing application schedules. Flexible spray schedules in the late spring or early summer would accommodate various scenarios for both aphid biology and cultural nursery practices. Although Placerville is the only production nursery where this aphid is currently found, it may have a wider distribution, especially in Christmas tree plantations. That this undescribed species has been mistaken for the balsam twig aphid would suggest the distinct possibility of a distribution beyond central California.

LITERATURE CITED

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