EFFECT OF DIATOMACEOUS EARTH, MALATHION, DIMETHOATE AND PERMETHRIN ON *LEPTOGLOSSUS OCCIDENTALIS* (HEMIPTERA: COREIDAE): A PEST OF CONIFER SEED[1]

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Abstract

Leptoglossus occidentalis Heidemann (Hemiptera:Coreidae) were exposed to diatomaceous earth, and sprays of dimethoate (0.1 and 1.0% a.i.) and permethrin (0.1% and 0.01% a.i.) in both laboratory and field tests and to malathion (0.1% a.i.) in a laboratory test. In field tests, permethrin and dimethoate caused significant ($P < .05$) mortality for two weeks after the sprays were applied and permethrin continued to be effective for a third week. Diatomaceous earth was not effective in field tests or in one of two laboratory tests. Malathion, dimethoate and permethrin caused significant mortality in both laboratory tests.

Seed bugs (*Leptoglossus* spp.; Hemiptera:Coreidae) severely reduce conifer seed crops by feeding on young conelets or mature seeds (Bradley *et al.* 1981; DeBarr 1979; Hedlin *et al.* 1980; Koerber 1963; Ruth 1980). In British Columbia (B.C.), the western conifer seed bug (*Leptoglossus occidentalis* Heidemann) has caused seed losses of between 36% and 41% on Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) (Hedlin *et al.* 1980; Ruth 1980). While seed bug populations and damage have not been monitored routinely in Douglas-fir seed orchards, the bugs are commonly noticed by seed orchard staff around cone harvest. The high value of seed orchard seed and the potential seed losses to *L. occidentalis* make the presence of these insects in orchards of concern.

While numerous insecticides have been tested against seed bugs in the southern United States (DeBarr 1978; DeBarr and Nord 1978; Nord *et al* 1984; Nord *et al* 1985), none has been tested against *L. occidentalis* in B.C. (Miller 1980). This paper reports the results of some initial insecticide screening trials against this insect.

Methods and Materials

A large colony of *L. occidentalis* at the Pacific Forestry Centre in Victoria, B.C. was reared from several years of collections around Victoria and Lake Cowichan, B.C. Adult and fifth-instar seed bugs were selected from this colony for these tests in August and September, 1986. To facilitate handling, the insects were placed in a 0°C cold room for between 30 min and 3 h prior to distribution to the various treatments.

Initial screening tested diatomaceous earth (D.E.) (Diacide Natural Insect Powder®, International Diatoms Ltd., Waterdown, Ont., a.i. [active ingredient(s)] = diatomaceous earth, pyrethrin 0.1%, piperonyl butoxide 1.25%) at full strength; malathion (Malathion 50 EC®, Chipman Inc., Stoney Creek, Ont.) at 0.1% a.i.; dimethoate (Lagon 2E®, Laters Chemicals, Richmond, B.C.) at 1.0% and 0.1% a.i.; and permethrin (Ambush 50 EC®, Chipman Inc., Stoney Creek, Ont.) at 0.1% and 0.01% a.i. All liquids were applied with a 500 ml hand sprayer. D.E. was applied from its original container: a plastic squeeze duster.

[1] Trade names and commercial enterprises or products are mentioned solely for information. No endorsement by the B.C. Ministry of Forests and Lands or the Canadian Forestry Service is implied, nor does it imply that the uses discussed have been registered. All use of pesticides must be registered by appropriate federal and provincial agencies before they can be recommended.

Small, potted Douglas-fir trees were either sprayed to run-off or dusted to the point where a light film was just visible on the foliage. After the sprays had dried, small twigs with foliage were clipped off and the clipped end of each twig was put in a small vial containing moist tissue. The vials were then placed in 1 L plastic containers. Packages of Douglas-fir seed, covered with gauze, were placed within the foliage to provide food for the insects during the trial and screened lids were placed on the containers after the insects were introduced. Five containers with about 20 insects each made up a treatment group for each insecticide. A final treatment (D.E. direct) consisted of dusting the insects, canister and foliage through the screened lid. Insects on untreated foliage served as checks.

Following the initial test, both rates of permethrin and dimethoate were tested again. The procedure was the same as above except that foliage was clipped from open grown Douglas-fir in the Pacific Forestry Centre arboretum and then sprayed. Concurrently, these insecticides were applied to lodgepole pine *(Pinus contorta* Dougl.) branches in the arboretum. One branch on each of five trees was sprayed with each mixture. *L. occidentalis* (about 20/branch) were caged on the branches the next day in nylon mesh bags. One unsprayed branch on each tree served as checks. Insects used in the arboretum were replaced at weekly intervals for two more weeks to test for residual activity of permethrin and the 1.0% rate of dimethoate. All mesh bags were thoroughly washed between uses.

D.E. was tested further after obtaining a new package. Containers and insects were prepared as before. D.E. was applied by dusting over open containers and allowing the subsequent dust cloud to settle as a light film over the contents. This treatment was applied over either insects and foliage (D.E. direct) or over foliage, with the insects being added afterward (D.E. residual).

In the arboretum, a mechanical duster was used to dust two lodgepole pine trees and one Douglas-fir tree with D.E. On each tree, five branches showing a light film of the insecticide were selected and about 20 *L. occidentalis* were caged on in mesh bags. Five branches on one untreated pine served as a check.

Depending on the test, counts of dead and moribund insects were made at two or more of the following intervals: 24 h, 48 h, 96 h, 1 week, 2 weeks. Except for D.E., tests were terminated after one week or when all of the treated insects were dead. On D.E. treated branches, *L. occidentalis* remained caged for a second week. At the end of each test, tallies were made of live and dead *L. occidentalis* in each replicate and counts were pooled by treatment. Results for each assessment period were analysed by chi-square tests and where the overall tests were significant, pairwise comparisons were made using the overall degrees of freedom to determine significance (Fleiss 1981). *L. occidentalis* is a very active insect and when escapees made the counts inconsistent, that replicate(s) was not used in the analysis.

Results and Discussion

Cooling the seed bugs at 0°C to ease handling did not appear to harm them. Mortality was low in all of the checks. This was not unexpected in that late instar and adult *L. occidentalis* have been overwintered in the rearing colony outdoors where the temperature occasionally dips below 0°C.

In the initial screening, all sprays caused significant mortality ($P < .05$) within 24 h after application (Table 1). Malathion was not so effective as either permethrin or dimethoate in providing an initial knockdown, however after one week there was no difference between the sprayed insecticide treatments. Permethrin at 0.01%, had a high initial knockdown within 24 h but some *L. occidentalis* had recovered by 48 h. This situation was reversed again by one week after treatment. This did not occur in the second test (Table 1) where both permethrin and dimethoate again caused significant mortality ($P < .05$).

D.E. did not cause significant mortality in the initial tests (Table 1) but did in the second (Table 2). After discussions with the local distributor, it was concluded that the product used initially may have absorbed too much moisture and had thus become ineffective. The results with the fresh product used in the second test seem to bear this out. It caused 85.7% to 97.1%

Table 1: Percent mortality* of *Leptoglossus occidentalis* exposed to insecticide treated foliage in containers.

Treatment	Mortality in First test n**	24 h	48 h	1 week	Mortality in Second test n	24 h	48 h	1 week
check	100	1.0c	1.0c	2.0b	100	2.0c	2.0b	3.0
D.E. residual	100	0c	0c	1.0b	-	-	-	-
D.E. direct	100	6.0c	6.0c	13.0b	-	-	-	-
malathion 0.1%	61	68.3b	73.7b	86.8a	-	-	-	-
permethrin .01%	80	95.0a	82.4b	93.8a	99	85.9b	91.9a	89.9a
permethrin .10%	100	100 a	100 a	100 a	100	100a	100a	100a
dimethoate 0.1%	103	99.1a	100 a	100 a	100	90a	100a	100a
dimethoate 1.0%	100	100a	100 a	100 a	100	95ab	100a	100a

* Based on counts of live and dead insects, percentages followed by the same letter in a column are not significantly different, $P < .05$; chi-square test.

** N = number of insects exposed.

mortality within 24 h. Curiously, D.E. application to the insects directly was less effective than relying on residual activity alone (Table 2). Reasons for this are unclear but it may be because the cooled immobile insects placed in the "D.E. residual" containers had to move through the insecticide on the container floor as they "woke up", as well as through the insecticide on the foliage where they tended to congregate. The *L. occidentalis* in the "D.E. direct" treatment were mobile and many were on the foliage already. These may have been protected from initial exposure and did not make so much contact as those having to move around on the container floor. Either way, D.E. caused an acceptable level of control in the second laboratory test.

D.E. was not effective outside in the arboretum (Table 3). Mortality in all cases remained at less than 7.5%. Reasons for this failure are not known but at least two factors may have been involved. Diatomaceous earth acts as a desiccant (Ross 1981) so the greater humidity outside

Table 2: Percent mortality* of *Leptoglossus occidentalis* exposed to D.E. in containers.

Treatment	n	24 h	48 h	1 week & 2 weeks
check	100	0a	0a	1.0a
D.E. direct	98	85.7b	86.7b	88.7b
D.E. residual	104	97.1c	95.2c	95.2c

* Based on counts of live and dead insects, percentages followed by the same letter in a column are not significantly different, $P < .05$; chi-square test.

Table 4: Percent mortality* of *Leptoglossus occidentalis* exposed to insecticide treated branches. Groups of insects were placed on branches one day, one week and two weeks after insecticides were applied.

Treatment	Mortality During First Week			Mortality During Second Week				Mortality During Third Week			
	n**	24 h	96 h	n**	24 h	48 h	7 days	n**	24 h	96 h	7 days
check	95	11.3c	12.6b	103	1.0b	1.0b	2.9b	99	0a	0c	1.0c
dimethoate 1.0%	98	89.8a	100a	98	0b	5.1b	94.9a	98	0a	46.9b	70.4b
dimethoate 0.1%	98	64.3b	100a	-	-	-	-	-	-	-	-
permethrin 0.1%	98	91.1a	100a	99	91.9a	93.9a	100a	100	98.0b	100a	100a
permethrin 0.01%	99	80.0a	100a	100	96.0a	100a	100a	100	100b	100a	100a

* Based on counts of live and dead insects, percentages followed by the same letter in a column are not significantly different, $P < .05$; chi-square test.

** N = number of insects exposed.

Table 3: Percent mortality* of *Leptoglossus occidentalis* exposed to D.E. treated branches outdoors.

Treament	n	24 h	48 h	1 week	2 weeks
check	94	1.1a	1.1a	2.1a	3.2a
D.E.	72	0 a	0 a	0 a	7.5a
D.E.	59	1.7a	3.4a	5.1a	6.8a
D.E.	74	1.4a	1.4a	2.7a	6.8a

* Based on counts of live and dead insects, percentages followed by the same letter in a column are not significantly different, $P < .05$; chi-square test.

compared to that in the laboratory may have reduced the effectiveness. Also heavy dew formed each night and 17.2 mm of rain (Environment Canada 1986) fell during the test. A second factor which may have reduced the efficacy of D.E. is the amount contacting the insects. Although all of the branches had a visible coating of material on them, this may not have been enough for the insects to pick up a lethal dose. In the laboratory, the seed bugs were more confined to treated surfaces.

Both rates of permethrin and dimethoate caused high mortality when *L. occidentalis* was exposed to them on branches outside (Table 4). Many insects were moribund on the bottom of the bags on permethrin treated branches less than 2 h after exposure. Both insecticides caused 100% mortality in less than 96 h (Table 4).

The residual effectiveness of permethrin did not decrease over the three weeks of the test (Table 4). Both rates caused more than 90% mortality within 24 h and 100% mortality in less than 96 h in the second and third weeks. This residual activity was aided by the dry weather. There was little rain (18.3 mm) during the test and most of it (12.4 mm) fell just two days before the end of the third week. Nord *et al.* (1984) also reported that permethrin has a long residual life.

Dimethoate lost some of its effectiveness with time and by the second week of the tests it was taking longer than permethrin to kill *L. occidentalis* (Table 4). By the third week dimethoate did not provide an acceptable level of control.

Conclusions

Our results show that dimethoate and permethrin are effective against *L. occidentalis* at the rates used and that permethrin will continue to be effective for more than three weeks after application. While D.E. was effective against seed bugs in laboratory tests, it was ineffective outdoors. Increasing the amount of D.E. used or using it under very dry conditions may improve its efficacy.

Future research should test permethrin and dimethoate in a more operational context. Demonstrating an increase in filled seeds on cones from trees protected from *Leptoglossus occidentalis* could help further quantify both seed bug damage and the efficacy of these insecticides.

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