EFFECT OF A COMMERCIAL INSECTICIDAL SOAP ON GREENHOUSE WHITEFLY (HOM: ALEYROD.) AND ITS PARASITOID, *ENCARSIA FORMOSA* (HYM: EULOPH.)

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ABSTRACT

Safer's Insecticidal Soap (IS) was topically applied at six concentrations to all growth stages of greenhouse whitefly as well as larvae and adults of the whitefly parasitoid, the eulophid wasp *Encarsia formosa*. IS at 0.5% ai caused more than 94% mortality of all whitefly larval stages and adults, and more than 82.5% mortality of whitefly pupae. Adults hatched from treated pupae occasionally showed altered development. *E. formosa* adults were more tolerant to IS than whitefly and 81.5% survived a 0.5% IS treatment. It was concluded that IS is an effective pesticide for greenhouse whitefly and should be integrated with *E. formosa* in greenhouse trials.

INTRODUCTION

The greenhouse whitefly, *Trialeurodes vaporariorum*, Westwood, (Homoptera: Aleyrodidae) is a serious pest of greenhouse plants, infesting a wide variety of ornamentals and most vegetables, especially cucumbers and tomatoes (Harris 1974). Besides causing direct damage to plants as a result of feeding on the leaf sap, their honeydew stimulates the growth of sooty mold fungi which disfigure leaves and interfere with photosynthesis.

Chemical control of whitefly has several disadvantages. Whitefly eggs are highly resistant to almost all insecticides (Harris 1974) and larval and pupal stages are much less sensitive than adults (French *et al.*1973). This variation in the tolerance of different growth stages coupled with the parthenogenic reproduction of whitefly necessitates the use of repeated sprays during the growing season. Whitefly has been shown to rapidly develop resistance to most organochlorine and organophosphorous compounds such as BHC and malathion (Harris 1974). Chemical treatment may also encounter a produce problem with phytotoxicity, environmental hazards, and cost.

Encarsia formosa Gahan (Hymenop: Eulophidae) has been used successfully in biological control programs against whitefly. Unfortunately, the use of the parasitoid, *E. formosa*, has encountered problems. If this small wasp is introduced at the wrong stage of whitefly development, it will die out and additional introductions will be necessary. Since the wasp's rate of development is temperature dependent, being optimum at 21 to 27°C, temperatures below this level prevent it from breeding as fast as whitefly. Whitefly can therefore cause substantial plant damage before the parasitoid can catch up. *E. formosa* is very sensitive to most pesticides and treatments to control the whitefly or other insect pests can easily eliminate the parasitoid.

Obviously, the best approach to controlling whitefly would be one in which the parasitoid was integrated with a suitable pesticide that has the ability to reduce the whitefly population without harming the wasp. Recently a fatty acid salt formulation has been registered[1] for the control of whitefly. This product has also been reported to be fairly innocuous to many hymenopterous parasitoids. (S. F. Condrashoff, unpublished data[2]). It was decided therefore to test this product for its effect on both *T. vaporariorum* and *E. formosa* to establish its potential for inclusion in an integrated control program for whitefly.

MATERIALS AND METHODS

Treatments consisted of a water control and 6 concentrations of Safer's Insecticidal Soap (IS), a

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commercial 50.5% fatty acid salt formulation (Puritch *et al.* 1980). Treatments were applied to 0.01, 0.05, 0.10, 0.50, 1.0 and 1.5% v/v concentrations. Tests were carried out on every growth stage of whitefly, *vis.* eggs; 1st, and 2nd and 3rd instars; pupae, and adults. Whiteflies were obtained from Agriculture Canada greenhouses, where they were being reared as part of a biological control program.

In the egg bioassay, cucumber leaves infested with large numbers of freshly laid whitefly eggs, were selected and taken to the laboratory. Each leaf was cut into sections, with each section containing at least 50 eggs. The sections were randomly assigned to one of the seven treatments. Three replicate samples were used per treatment. An area within the leaf section was outlined with tanglefoot and cleared of all debris, dead eggs and other instar stages. Normal looking eggs were then counted. The samples were subsequently sprayed to wetness with their designated treatment using a chromatographic mister and put on wetted cotton pads in open petri dishes. These dishes were placed on laboratory benches under fluorescent lights, at 22°C for incubation. After 3 or 4 days all the hatched eggs were counted and removed. Another assessment was made 10 days after treatment, which is the normal incubation period for whitefly eggs. If normal eggs were still evident after the 10-day assessment, observations continued until they hatched or desiccated.

Bioassay of the 1st, 2nd, 3rd instars and pupae followed the basic procedure outlined for the whitefly eggs. No tanglefoot was used on leaf sections containing 2nd, 3rd instars or pupae because these stages are immobile. Assessments were made 4 days after treatment of the 1st, 2nd and 3rd instar stages. The samples were also observed 8 days after treatment to ascertain that the undeveloped larvae were dead. Pupae were assessed 6 days after treatment. Fungal growth on the leaf surface made later assessments unreliable. Abnormalities of hatched 1st instars or adults were noted.

Adult whiteflies were collected for testing using a small vacuum-suction device. The vial containing the collected whiteflies was chilled by placing it on ice for 1 min. This treatment immobilized the adults and they were separated into individual petri dishes, each dish containing 20-30 adults. Each dish was chilled again, and the immobilized adults were sprayed to wetness using the chromatographic mister. The adults were counted and the dishes were left uncovered within cages at 22°C for 24 hrs., when they were assessed for mortality. A second group of whitefly adults was treated in the same manner as just described but the petri dishes were covered immediately after spraying and kept covered for 24 hrs. before assessment.

A bioassay of the toxicity of IS to *E. formosa* that were parasitizing whitefly scales was made, using the same procedures described for whitefly larvae and pupae. The assessments were made 10 and 15 days after treatment. Adult *E. formosa* were treated in a similar manner to the adult whitefly bioassay where the petri dishes were left uncovered within cages after spraying.

All tests were corrected for control mortality using Abbott's formula:

$$P_t = \frac{P_o - P_c}{100 - P_c} \times 100$$

where Pt = correctly mortality; P_c = control mortality (average control mortality as used in the calculations) and Po = observed mortality. Results for each growth stage were statistically analyzed using a complete randomized block test design with 3

TABLE 1. Percent mortality of various growth stages of greenhouse whitefly after topical application of Safer's Insecticidal Soap (IS) (water treated control mortality averaged 10.86%). Within columns, means not followed by the same letter are significantly different at the 5% level.

Conc of IS	% Mortality Developmental Stage						
	Egg	1st Instar	2nd Instar	3rd Instar	Pupae	Adults[1] a	Adults[2] b
0.00 (water)	0.0a	0.0a	0.0a	0.0a	0.0	0.0a	0.0a
0.01	6.8ab	3.6a	20.5b	4.6ab	54.2b	8.0a	0.5a
0.05	3.1ab	34.0b	31.0b	23.1b	44.1b	0.8a	1.2a
0.10	5.9ab	78.0c	64.6c	51.2c	77.4bc	34.7b	25.2b
0.50	6.8ab	98.9d	95.2d	94.8d	82.5bc	100.0c	100.0c
1.00	9.7b	100.0d	98.8d	95.8d	91.3bc	100.0c	96.6c
1.50	8.4ab	100.0d	97.7d	99.7d	95.2c	100.0c	100.0c
LC_{50} by Probit Anal.	NA[3]	0.12	0.04	0.10	0.01	NA[3]	0.16

[1] Treated adults left covered for 24 hours after treatment until assessment

[2] Treated adults left uncovered after spraying until assessment at 24 hours

[3] Probit not calculable from data obtained

replicates, and treatment means were compared with Neuman-Keuls multiple range test. The LC_{50} for each growth stage was calculated using a probit analysis.

RESULTS AND DISCUSSION

All larval instar stages and the adult whiteflies were sentitive to IS application; concentrations of 0.5% or greater gave more than 94% mortality (Table 1). The mortality of adults held in enclosed petri dishes for 24 hours after spraying (Adults a, Table 1) was not different from the mortality of adults held in open dishes (Adults b, Table 1). Thus whiteflies that survived the initial topical treatment did not succumb to contact with the wetted filter paper and saturated environment over the following 24 hours. This suggests that the IS acted as a contact insecticide and had little residual activity over the testing period.

It would be of interest to determine if the mortality caused by topical treatment would be similar to the mortality in an otherwise untreated whitefly population exposed to treated filter paper in a closed petri dish. Condrashoff (unpublished research results) noted that adult whiteflies returning to a wet IS-treated leaf were killed upon landing. It is unclear, however, if these adults had been contacted by the spray prior to returning to the leaf. Pupae responded in the same way as the larval stages but were more sensitive at the lower concentration levels with an average of 54% mortality at 0.01% concentration (Table 1). Only the eggs were tolerant to the IS treatment with a maximum mortality of 9.7% at the 1.0% level of IS. Whitefly eggs are tolerant to a wide variety of pesticides (French *et al.* 1973).

Some adults that emerged from treated pupae suffered from morphological abnormalities. These took the form of improperly developed wings or an absence of the normal waxy secretions on the body and wings. Puritch (1978) reported that *Tenebrio molitor* pupae treated with potassium salts of oleic and linoleic acid, frequently developed into abnormal adults. It was suggested that the soaps may affect the permeability of cell membranes in the pupae during the crucial stages of metamorphosis and thereby affect the concentration and localization of the insect's growth hormones.

Adult *E. formosa* were substantially more tolerant to direct IS than whitefly and suffered only 22.4% mortality at 1.0% IS. (Table 2) This mortality was caused by direct application of IS to the immobilised *E. formosa*. Since adult whiteflies appeared to be unaffected by IS residue, it is likely that untreated *E. formosa* landing on treated leaves would also be unaffected by residues. Harbaugh and Mattson (1976) applied 5 chemicals including malathion and nicotine sulfate to adult *E. formosa* at recommended rates and found that all compounds caused 100% mortality to the parasitoid. Residues of malathion were toxic to the wasps for 2-3 weeks. The larval stages of *E. formosa* were more sensitive to IS than were adults and had an LC_{50} of 0.15% IS. No attempt was made in this study to test different stages of the parasitoid larvae. Perhaps the earlier stages may be less sensitive. Investigations on pupae of *Argresthia cupressela* (cypress leaf miner) treated with IS and parasitized by the wasp *Charmon gracilis* showed that 1.0% IS treatment of pupae did not affect the parasitoid (Puritch, unpublished data).

TABLE 2. Percent mortality of *Encarsia formosa* in adult and larval (within whitefly scales) stages, after topical application of Safer's Insecticidal Soap (IS). Within column, means not followed by the same letter are significantly different at the 5% level.

% Concentration of SI	Developmental Stage	
	Adults	Larvae
0.00	0.0a	0.0a
0.01	0.0a	14.2a
0.05	1.4a	20.0a
0.1	5.0a	27.0a
0.5	18.5b	78.5b
1.0	22.4b	94.2b
1.5	98.2c	97.9b
LC_{50}	1.00	0.15

The high mortality caused by concentrations of IS of 0.5% and higher (Table 1) show that this compound is an effective pesticide for all whitefly stages other than eggs. If used at 0.5% concentration, IS would effectively control whitefly populations with little effect on adult *E. formosa*. In view of the many beneficial features of the environmentally compatible Insecticidal Soap solution this compound should be assessed in any integrated program that includes the parasitoid, *Encarsia formosa*.

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THE LETTUCE APHID, *NASONOVIA RIBISNIGRI* (HOMOPTERA: APHIDIDAE) DAMAGING LETTUCE CROPS IN BRITISH COLUMBIA

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ABSTRACT

The lettuce aphid, *Nasonovia ribisnigri* (Mosley), is recorded for the first time as a serious pest of lettuce in the Cloverdale area of British Columbia.

In the summer of 1981 several lettuce growers in the Cloverdale area of British Columbia suffered severe and unexpected crop losses caused by the lettuce aphid, *Nasonovia ribisnigri* (Mosley). Although this aphid had been present on other plants in the lower mainland of B.C. for many years (Forbes, Frazer and MacCarthy, 1973), it had not been recorded previously as a pest of lettuce. The aphid was found in marketed heads in September 1981 and resulted in an estimated retail loss of $80,000. Crops which were headed up and infested with aphids had to be ploughed in because the heads were considered unmarketable. In 1982 lettuce aphids were found in commercial lettuce plantings in late May and by the end of June they were causing rejection of some shipments for marketing. The infestation became progressively worse and during August several plantings had to be ploughed in. Both crisp heading and butter-head lettuce crops were seriously affected.

N. ribisnigri (Fig. 1) is a medium-sized (2-3 mm long) olive-green aphid with a distinctive dorsal sclerotic pattern. Its antennae are long with secondary sensoria on the basal 1/4 - 3/4 of segment III in apterae (Fig. 2A) and all along segment III in alatae (Fig. 2B). Its cornicles are cylindrical, with a distinct preapical annular circumcision (Fig. 2C). Its cauda is finger shaped usually with 7 hairs (Fig. 2D). Both Hille Ris Lambers (1949) and Heie (1979) give detailed morphological descriptions of the various morphs of the aphid. We have also collected and reared a pink form of *N. ribisnigri* in B.C.

This is an heteroecious aphid with *Ribes* spp. as primary hosts and secondary hosts in the Compositae and several other plant families. In B.C. we collected adult fundatrices and fundatrigeniae (mostly alate) on black currant, *Ribes nigrum* L., in mid-May. Migration to lettuce and other secondary hosts takes place in late May and in June. Migration back to *Ribes* probably takes place in September and October. In England during mild winters some of the aphids are able to continue to breed on lettuce outdoors throughout the winter. This can probably occur in the Fraser Valley too and would result in sizeable populations of lettuce aphids being present on overwintered lettuce and other secondary hosts ready to infest newly planted crops in the spring.

In Canada, this aphid has been previously recorded in B.C., Quebec and New Brunswick (Smith and Parron, 1978). In the eastern United States it has been collected in New York, Vermont, Pennsylvania, New Jersey, District of Columbia