SUSCEPTIBILITY OF THREE *STETHORUS* SPP (COLEOPTERA: COCCINELLIDAE) TO SELECTED CHEMICALS USED IN N.S.W. APPLE ORCHARDS

P. J. WALTERS

NSW Department of Agriculture, Agricultural Research Station, Bathurst, 2795. Present Address: Schering Pty. Limited, Wood Street, Tempe, NSW 2044.

Abstract

The contact susceptibility of *Stethorus loxtoni*, *S. nigripes* and *S. vagans* in the egg, larval and adult stages to 27 chemicals was assessed. The chemicals tested at field concentration included insecticides, miticides, fungicides, herbicides, chemical thinners and an antifeedant. Seven of these chemicals were highly toxic e.g., azinphos-methyl, DDT, carbaryl, endosulfan, malathion, methidathion, tetrachlorvinphos, while twelve were non-toxic e.g., vamidothion, *Bacillus thuringiensis*, Ryania, phenisobromolate, chlordimeform, cyclosulfyne, azaform, benomyl, captan, diuron, N.A.A., fentin hydroxide. The feasibility of these chemicals being used in an integrated control program is discussed.

Introduction

Readshaw (1971) concluded that in Australian apple orchards, "the only predators of practical significance are the small black beetles of the genus *Stethorus*". There are three species: *S. loxtoni* Britton and Lee, *S. nigripes* Kapur and *S. vagans* (Blackburn).

Stethorus spp reach an equilibrium at values of about 100 mites per *Stethorus* per 100 leaves and any application of broad spectrum insecticides, inevitably leads to a wide oscillation in the numbers of both predator and prey (Readshaw 1970). The development of an integrated control program will therefore require either the replacement of broad spectrum chemicals by more specific ones which do not affect beneficial predators and parasites, or timing the use of these broad spectrum applications to minimise their harmful effects. This paper deals with the search for chemicals that are non-toxic to *Stethorus* spp yet may be used if necessary to control insect pests, diseases and limit fruit set. Two herbicides were also screened to evaluate their toxicity to *Stethorus* adults which overwinter in leaf litter and herbage around the base of the trees (Readshaw 1971).

Colburn and Asquith (1970, 1971) working with *S. punctum* in Pennsylvania and Edwards and Hodgson (1973) with *S. nigripes* in Tasmania investigated the toxicity of chemical pesticides against *Stethorus* adults in the laboratory. Results were obtained by dipping adults in solutions for 15 seconds. They recognised that their method was far more severe than the conditions found in an orchard and probably yielded higher mortalities than would otherwise occur. Further work was required using a less severe test method to indicate the relative toxicity of pesticides.

Since *Stethorus* actively search for prey throughout a tree, they continually walk over chemical residues on leaves and therefore accumulate these residues through their tarsi. For this reason, all stages of the three Australian species of *Stethorus* were exposed to pesticide deposits on filter paper, as recommended by F.A.O. for stored product insects (Anonymous, 1970). It was considered to be more realistic due to the fact that the effect of slightly toxic chemicals could be gauged with longer residual recordings.

Materials and Methods

The insects used were raised in laboratory cultures which originated from adults collected at Bathurst Agricultural Research Station. Each pesticide was tested at the recommended field concentration (Lloyd *et al.* 1972).

The 15 chemicals and their percentage concentration which caused mortality in the tests are listed in Table 1. All pesticides used were commercial formulations made up with water. Seven centimetre diameter Whatman No. 42 ashless filter papers were impregnated with 0.5 ml of each preparation and left overnight to dry. Chemicals not listed in Table 1 due to zero mortality in tests were *Bacillus thuringiensis* 0.6%, Ryania 0.6%, phenisobromolate 0.075%, chlordimeform 0.1%, cyclosulfyne 0.06%, azaform

0.05%, benomyl 0.025%, captan 0.1%, diuron 0.4%, N.A.A. 0.002% and fentin hydroxide 0.025%.

Eggs

Eggs were obtained by placing at least 10 pairs of adults in a modified Huffaker cell (Huffaker 1948) and leaving overnight with an excess supply of *Tetranychus urticae* (Koch) as food. Next morning the adults were removed, the eggs collected and the process repeated daily. Ten eggs were placed on each treated filter paper surface. To prevent cannibalism by newly hatched larvae, eggs were held in individual compartments. A sheet of perspex, 0.5 cm thick, containing a series of holes of 0.5 cm diameter and covered by a glass plate proved satisfactory for this purpose. Mortality was recorded as the number of eggs failing to hatch.

Larvae

Ten first instar larvae were placed in each of 2 modified Huffaker cells totalling 20 larvae per chemical concentration. Each cage was supplied with an excess of *T. urticae* eggs and larvae and mortality counts made 24 h later. Mortality was recorded when a larva failed to move after being prodded.

Pupae

Five pupae were placed on each treated filter paper and held inside a glass ring 2.5 cm high with a diameter of 4.9 cm and covered by a glass petrie dish lid. Mortality was recorded as the number of adults failing to emerge.

Adults

Adults were collected from the mass culture containers (Walters 1974). Twenty were placed on each treated filter paper and confined with a glass ring as for the pupae. Mortality was recorded at 24 and 48 h when an adult failed to move after being prodded.

In every test a control was included to enable correction for natural mortality. No deaths were recorded in the controls.

Results and Discussion

The results for *S. loxtoni*, *S. nigripes* and *S. vagans* are summarised in Table 1. The chemicals are grouped as insecticides, miticides, fungicides, herbicides and miscellaneous. Within these groups, the chemicals are listed in decreasing order of toxicity to the adult beetles. In nearly every test, chemicals highly toxic to the larval and adult stages of each species, ranged from being harmless to moderately toxic to the egg stages. Toxicity of a chemical was therefore evaluated by its effect on first instar larvae and adults. The difference in susceptibility between the three *Stethorus* species to each chemical tested was minor.

Insecticides proved to be the most toxic group of compounds, with all the broad spectrum chemicals killing 100%. Ryania, *Bacillus thuringiensis* and vamidothion produced zero to negligible mortality. Dimethoate proved toxic to 50% of *S. nigripes* larvae but non-toxic to the other species as a contact insecticide. It is worth noting that on one occasion *T. urticae* were raised on dimethoate treated bean plants and suffered no apparent ill effects. The poison ingested by the mites killed 100% of *S. nigripes* through stomach action, when the live mites were supplied as food.

Miticides, as a rule, proved to be less severe in that chlordimeform, cyclosulfyne, phenisobromolate, dicofol, tetradifon and azaform were either non-toxic or slightly toxic. Tricyclohexyltin-hydroxide was highly toxic at the recommended field rate of 0.02% w/v and this effect was generally halved if the rate was halved. After 24 h exposure to tricyclohexyltin-hydroxide at 0.02% negligible mortality of adults was observed but after 48 hours 100% mortality was recorded in all 3 species.

Fungicides such as benomyl and captan were non-toxic. Binapacryl proved highly toxic to adults at the recommended field concentration after 48 h. Dinocap had a

variable effect on larvae proving highly toxic to *S. loxtoni*, moderately toxic to *S. nigripes* and non-toxic to S. *vagans*. Significant mortality was obtained after 48 h exposure of *S. loxtoni* adults to dinocap yet it proved non-toxic to the other species.

Of the remaining chemicals, the blossom-thinning compound naphthalene acetic acid (NAA) and the fungicide and antifeedant compound fentin hydroxide were non-toxic. The herbicide, diuron was non-toxic but simazine proved moderately toxic to *S. loxtoni* and slightly toxic to other species.

Some of the results conflicted with those obtained by Edwards and Hodgson (1973) using the dip method. If they had used a longer observation period of 48 h instead of 18 h, it may have revealed that leptophos, endosulfan and binapacryl are highly toxic to *Stethorus* spp. They linked captan equally with DDT as a toxic chemical. In my tests captan was non-toxic to all stages and it has been used successfully for 5 seasons in the pest management block at Bathurst Agricultural Research Station where *Stethorus* spp have successfully controlled *T. urticae* populations. The fact that dimethoate was moderately toxic by the dip method and cyclosulfyne (Omite^{R}) was highly toxic, may lend weight to the supposition that the beetles when submerged and then left to dry may consume some of the chemical mixture, thus distorting the results by enabling some of the chemicals to exert a stomach action.

Chlordimeform has been shown to exhibit ovicidal action on *Chilo suppressalis*, rice stem borer (Ikeyama and Maekawa 1973) reduce fecundity and egg fertility in *Heliothis zea* (Boddie) (Etheridge 1972) and *Spodoptera littoralis* (Dittrich 1967). Consequently adult *Stethorus* screened against chlordimeform 0.1% a.i., were retained and supplied with an excessive number of *T. urticae* while contained in a modified Huffaker cell. However, no effect on laying or hatching was observed.

The key pest, as shown in the Co-operative Research Program (Lloyd *et al.* 1970) is *Cydia pomonella* (L) codling moth. Provided no broad spectrum insecticides are applied, predators and parasites can control most other pests, especially *T. urticae*. As

TABLE 1

PERCENT MORTALITY OF EGG, LARVAE AND ADULT STAGES OF *S. LOXTONI*, *S. NIGRIPES* AND *S. VAGANS* TO CHEMICALS COMMONLY USED IN N.S.W. APPLE ORCHARDS

Material	Conc.	Percent Mortality								
		S.loxtoni			*S.nigripes*			*S.vagans*		
		eggs	larvae 24 hrs.	adults 48 hrs.	eggs	larvae 24 hrs.	adults 48 hrs.	eggs	larvae 24 hrs.	adults 48 hrs.
INSECTICIDES										
Azinphos-methyl	0.05	70	100	100	10	100	100	60	100	100
carbaryl	0.1	40	100	100	20	100	100	10	100	100
DDT	0.1	100	100	100	80	100	100	20	100	100
endosulfan	0.066	70	100	100	60	100	100	20	100	100
malathion	0.05	0	100	100	10	100	100	20	100	100
methidathion	0.05	70	100	100	80	100	100	60	100	100
tetrachlorvinphos	0.1	0	100	100	10	100	100	20	100	100
leptophos	0.05	—	—	100	—	—	—	—	—	100
vamidothion	0.05	0	5	5	0	0	0	0	0	0
dimethoate	0.06	0	0	5	0	0	0	0	0	0
MITICIDES										
tricyclohexyltin-hydroxide	0.02	10	100	100	10	95	100	0	95	100
dicofol	0.04	0	0	0	50	25	0	0	25	10
tetradifon	0.02	0	0	0	20	0	0	0	0	10
FUNGICIDES										
binapacryl	0.05	0	30	100	20	40	70	0	20	75
dinocap	0.02	100	90	50	20	35	5	10	20	0
HERBICIDES										
simazine	0.4	—	—	60	—	—	10	—	—	25

chlordimeform is active on other lepidopterous pests and is used in the U.S.A. for *C. pomonella* control, apples were dipped in a 0.1% solution. They proved 100% toxic to first instar *C. pomonella* larvae in laboratory studies. If further field work proves that chlordimeform is effective against codling moth, the regular application of broad spectrum insecticides may be reduced or eliminated.

In an integrated control program dependent on *Stethorus* spp as the major predator of *T. urticae*, it can be safely postulated from the data in this paper that vamidothion would be acceptable for the control of *Eriosoma lanigerum* (Hausmann), woolly aphid, NAA for blossom-thinning, benomyl and captan for *Podosphaera leucotricha* (Ell et Ev.) Salm, powdery mildew and *Venturia inaequalis* (Cke.) Aderh., apple scab, diuron for weed control and either cyclosulfyne, phenisobromolate, chlordimeform or azaform to temporarily suppress *T. urticae* (Koch) populations if necessary.

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