TOXICITY OF TWO PESTICIDES TO *PHYTOSEILUS PERSIMILIS*

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SUMMARY

Populations of two-spotted mite *Tetranychus urticae* (TSM) and its predator *Phytoseiulus persimilis*, were established on dwarf beans and sprayed with either water, phosmet (112.5 mg ai/litre), or pirimiphos-methyl (475 mg ai/litre)/permethrin (25 mg ai/litre). Phosmet was non-toxic but pirimiphos-methyl/permethrin caused high mortality of *P. persimilis*. When *P. persimilis* were placed on bean leaves 4 h after spraying with pirimiphos-methyl/permethrin 92% died, but 72 h after spraying there was little mortality on leaves kept at either 20 °C or 30 °C. All *P. persimilis* were killed when sprayed directly with pirimiphos-methyl/permethrin, but 99% of the eggs hatched, and 69% of the nymphs survived for 6 days.

INTRODUCTION

The spraying of bean plants colonized with *Tetranychus urticae* (TSM), and its predator, *P. persimilis*, was proposed by Coulan and Barres (1976) as a method to test the toxicity of pesticides to the predator. This semi-field test imitates better than many other methods the situation where a crop is sprayed in the field (Overmeer 1985).

The toxicity of phosmet and pirimiphos-methyl/permethrin to *P. persimilis* was examined in such a semi-field test. Both pesticides are registered for use in kiwifruit orchards and *P. persimilis* has been extensively released in areas where kiwifruit are grown to control TSM on susceptible shelter species (Steven pers. comm.). For effective control of TSM by the predator, pesticides harmful to *P. persimilis* should be avoided.

To investigate age the way in which *P. persimilis* recolonized plants treated with pirimiphos-methyl/permethrin, the effect of temperature on the persistence of residues of this treatment was examined. The mortalities of *P. persimilis* adults and eggs after direct spraying with each pesticide under a Potter tower were also assessed.

METHODS

(a) Semi-field test: Dwarf bean plants (*Phaseolus vulgaris* cv. 'Topcrop') were thinned to four plants per pot (150 mm diameter) when the primary leaves had expanded, and the plants were restricted to primary leaves throughout the trial. Each plant was infested with 25 TSM. Seven days later five female *P. persimilis* were placed on each plant and after a further 7 days, when all stages of the predator were present, the plants were allocated to three treatments and sprayed with phosmet (Imidan 45F) at 112.5 mg ai/litre, pirimiphos-methyl/permethrin (Attack) at 500 mg ai/litre or water (untreated control). Each pot of beans was sprayed individually to the point of run off using two Potter tower spray nozzles directed at the upper or lower surfaces of the leaves, with each nozzle delivering 5 ml of spray at 138 kPa. Treatment units consisted of two pots of beans touching each other and standing in a tray of water. The eight replicates of each treatment were arranged in blocks, with five replicates in one glasshouse unit and three in another. Mite populations were assessed prior to treatment and 1, 3, 7 and 14 days after spraying. Each assessment was based on one leaf per unit (eight leaves per treatment). The numbers of eggs, live juveniles and adult mites of both species, and the number of dead *P. persimilis* were recorded.

(b) The effect on *P. persimilis* of pirimiphos-methyl/permethrin residues at 20 °C and 30 °C: The lower surfaces of eighty primary dwarf bean leaves were each sprayed with pirimphos-methyl/permethrin (500 mg ai/litre), and water (untreated) using the

Potter tower (2 ml spray at 68.9 kPa). The sprayed leaves were divided into groups of 10 and stood in 600 ml, water-filled plastic containers with holes in the lids. Equal numbers of water and pesticide sprayed leaves were put in two temperature-controlled chambers and kept at either 20 °C or 30 °C. TSM were established on the bean leaves 2 days prior to infestation of *P. persimilis*. A group of ten leaves from each treatment was removed from each temperature controlled chamber 4, 24, 72 and 168 h after spray application. These leaves were placed, sprayed surface-uppermost, on saturated cottonwool held in separate 10 cm × 10 cm aluminium foil dishes (Bryham 1985). Ten adult female *P. persimilis* were transferred onto each leaf (100 per treatment), and their mortality assessed after 24 and 48 h. Extra TSM were added if necessary when the predators were transferred or at the 24 h assessment.

(c) Direct spraying of *P. persimilis* under the Potter tower: Thirty primary dwarf bean leaves heavily infested with TSM were placed in aluminium foil dishes, (see method b) and 10 adult female *P. persimilis* transferred to each leaf (100 per treatment). Eighteen hours later the leaves were divided between three treatments, as in (a), and sprayed under the Potter tower. The leaves were then held at 25 °C and the mortality of *P. persimilis* was assessed after 24 and 48 h. Leaves sprayed with pirimiphos-methyl/permethrin were also assessed for 6 days after treatment and the survival of *P. persimilis* emerging from eggs laid prior to spraying was recorded.

RESULTS

(a) In the semi-field test a high proportion of the active stages of *P. persimilis* was killed in the pirimiphos-methyl/permethrin treatment, reducing the average number of predators from 27.4 *P. persimilis* per leaf in the pre-spray sample to 3.2/leaf 24 h after spraying (Fig. 1). There was little mortality of *P. persimilis* on plants sprayed with phosmet or in the untreated control but the number of predators in these treatments decreased as the numbers of TSM fell. As few dead *P. persimilis* were seen on these treatments, the decrease can be explained by emigration in response to the decreasing availability of TSM. After the initial high mortality (18 dead/leaf) on the pirimiphos-methyl/permethrin treatment, the predator re-established and although numbers per leaf remained low they were still sufficient to nearly eliminate TSM after 14 days.

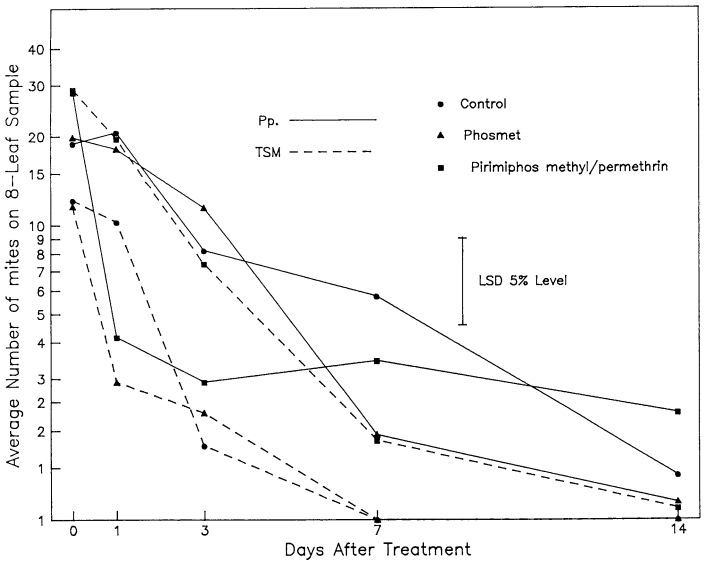

Fig. 1: Average number of live two-spotted mites (TSM) and *P. persimilis* (Pp) per leaf (scale $\log_e (\times + 1)$)

Pirimiphos-methyl/permethrin may have been partly responsible for this decrease in TSM but it was not possible to distinguish TSM killed by the pesticide and those killed by the predator. The low numbers of TSM became a limiting factor for *P. persimilis* populations in all treatments, and the difference between the two pesticides would have shown more clearly if higher numbers of TSM had been established. The high glasshouse temperatures also meant that the predator/prey interaction proceeded at a faster rate than anticipated.

(b) The mortality of *P. persimilis* caused by pirimiphos-methyl/permethrin residues decreased rapidly at both 20 °C and 30 °C (Table 1). Of the 100 *P. persimilis* placed on the pirimiphos-methyl/permethrin sprayed leaves 4 h after treatment, 92% were killed (Table 1). The only difference in mortality of *P. persimilis* between the leaves kept at different temperatures occurred when the predator was placed on residues 24 h after spraying, with the leaves kept at 20 °C causing 34% mortality and those at 30 °C, 9.4%. After 72 h the mortalities of the predators on residues from both temperatures were similar to that on the untreated control.

(c) All *P. persimilis* were killed within 48 h when sprayed with pirimiphos-methyl/permethrin under the Potter tower. Phosmet caused low mortality (15.6%) which was similar to that in the untreated control (9.3%). However, the pirimiphos-methyl/permethrin spray did not kill *P. persimilis* eggs that had been laid in the 18 hours prior to treatment. Of the 205 eggs on the leaves sprayed with pirimiphos-methyl/permethrin 99% had emerged 3 days after treatment. Six days after spraying 63.9% of nymphs had survived with many reaching maturity and laying eggs.

TABLE 1: Percentage mortality of *P. persimilis* after 48 h exposure on leaves sprayed with pirimiphos-methyl/permethrin or water.

Treatment	Time after spraying at which *P. persimilis* was placed on treated leaves (h)			
	4	24	72	168
pirimiphos methyl/permethrin leaves kept at 20 °C	92	34	3.1	6.9
pirimiphos methyl/permethrin leaves kept at 30 °C	92	9.3	0	3.3
water leaves kept at 20 °C	8.6	5.1	4.5	4.3
water leaves kept at 30 °C	0	0	0	3.0

DISCUSSION

Survival of some *P. persimilis* in the semi-field test on plants sprayed with pirimiphos-methyl/permethrin was unexpected as both components of this pesticide are known to be toxic to the predator (GCRI 1975). The results of spraying *P. persimilis* using the Potter tower and tests on pirimiphos-methyl/permethrin residues suggest a number of reasons for the predator persisting in this treatment.

First, there was incomplete spray coverage in the semi-field test. This is indicated by adult survivors in the semi-field test 24 h after spraying with pirimiphos-methyl/permethrin whereas direct spraying using the Potter tower with this material killed all adult *P. persimilis*.

Secondly, the toxic effect of the pirimiphos-methyl/permethrin residues rapidly decreased with time. This would have allowed the survival of *P. persimilis* which migrated onto sprayed leaves soon after the plants had been treated. *P. persimilis* is known to disperse aerially (Sabelis 1984), and the control and phosmet treatments would have provided a source of migrating predators.

Thirdly, in the Potter tower test, *P. persimilis* eggs were not harmed by direct spraying with pirimiphos-methyl/permethrin. *P. persimilis* takes 3 days to hatch at 25 °C by which time the effects of the residue had decreased sufficiently to allow the

survival of a large percentage of emerging nymphs. A high proportion of predators alive in the semi-field test on days 1 and 3 were juveniles (87.1% and 97.7% respectively), which suggests that survival of eggs was a major factor in the persistence of the predator.

The value of the semi-field test is shown by the pirimiphos-methyl/permethrin treatment. Toxicological methods, such as slide dip, which test only the active stages of the predator would indicate that this pesticide was more harmful to *P. persimilis* than is actually the case. Although complete spray coverage had been intended, the results indicate that this was not achieved. However spray coverage is also variable in the field. The difference in toxicity of the two pesticides would have been demonstrated more clearly if the numbers of TSM had not been a limiting factor to survival of *P. persimilis*. This could be overcome if higher numbers of TSM were used to infest the beans and if the plants were kept at lower temperatures to slow down predation.

Phosmet, because of its low toxicity to *P. persimilis*, as demonstrated in the semi-field test and in the Potter tower spraying, is very compatible with the use of the predators to control TSM in kiwifruit orchards. Pirimiphos-methyl/permethrin on the other hand is highly toxic to the active stages of *P. persimilis*, and even though eggs are able to survive this treatment, frequent use of this pesticide would be very disruptive to predator populations and predation of TSM.

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