Toxicity of selected agrichemicals to clover root weevil and its parasitoid *Microctonus aethiopoidea*

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Abstract White clover (*Trifolium repens*) crops are attacked by various insect pests including *Sitona obsoletus* (= *S. lepidus*) (CRW). Laboratory experiments were conducted to measure the toxicity of eight agrichemicals used against white clover insect pests or for weed control on CRW (parasitised and non-parasitised) and adults of its parasitoid *Microctonus aethiopoidea*. Laboratory experiments evaluated insect toxicity through direct contact with the agrichemical spray or via exposure to residues on clover foliage. At field rates, pymetrozine had the lowest impact on CRW biocontrol but had poor activity against non-parasitised CRW. Taufluvalinate provided 60% control of CRW, while having reduced impact on *M. aethiopoidea* adults (0–60% mortality), and was considered the best option in the field over the summer period. Lambda-cyhalothrin and diazinon were the most detrimental to CRW and its biocontrol agent when applied directly and through exposure to residues. Diquat and an adjuvant caused some mortality to CRW and parasitoid. Field studies are needed to corroborate these results.

Keywords insecticides, pesticides, biological control, *Sitona obsoletus*, integrated pest management, pesticide residues, white clover seed production.

INTRODUCTION

White clover (*Trifolium repens* L.) is a keystone legume in New Zealand's pastoral ecosystem (Caradus et al. 1995). The arrival, spread and impacts of the invasive clover root weevil (CRW), *Sitona obsoletus* (Gmelin) (= *S. lepidus*) (Coleoptera: Curculionidae) (Löbl and Smetana 2013) on white clover production and persistence in pastures have been well documented (e.g. Phillips et al. 2007, 2010; Gerard et al. 2007; McNeill et al. 2012), but the impacts are still being felt as the weevil disperses through the South Island. Adult CRW prefers white clover to other clover species, with high adult densities leading to extensive defoliation of the leaves and clover

yield losses, particularly in late-spring-summer when adults are maturing their flight muscles and reproductive system. However, it is the larvae that do the most damage, firstly attacking the nitrogen-fixing nodules then the root system as they mature. Under high larval densities the plant is unable to compensate for the root damage, leading to a significant reduction in plant growth and ultimately, plant death. In Canterbury, adult CRW are found almost all year round with a major peak in late spring (December) followed by a smaller peak in autumn (May). CRW females lay eggs throughout most of the year, with the bulk of egg laying lasting from mid-autumn into

spring, with larval peaks in spring (October) and autumn (April).

As part of a national programme aimed at reducing the impacts of CRW, the parasitoid wasp (*Microctonus aethiopoidea* Loan) (Hymenoptera: Braconidae) was released at several sites in the South Island including Canterbury (Phillips et al. 2010; Ferguson et al. 2012). In conjunction with field releases, it is anticipated that the parasitoid will spread naturally to eventually cover the Canterbury Plains. This parasitoid attacks the adult weevil, and more than one larva can survive to maturity in a host. Female weevils are sterilised once parasitised so they cease oviposition. The weevil eventually dies when the parasitoid larva emerges from the weevil to pupate in the soil litter. Depending on latitude, there are 1–2 CRW generations and 3–4 generations of the parasitoid per year in New Zealand. With time, it is anticipated that biological control by *M. aethiopoidea* will lead to a decline in CRW larval populations below damaging levels.

In the absence of the parasitoid, CRW impacts have also extended to white clover crops with reports by Canterbury farmers of dry matter production losses and reduced seed yields, particularly in 2–3 year old stands (R. Chynoweth, The Foundation for Arable Research, personal communication). White clover seed production is a major industry in New Zealand, covering some 6000 ha, with the majority of production (ca 90%) occurring in Canterbury. The use of insecticides in clover seed crops to control pests, such as potato mirid (*Calocoris norvegicus*), aphid (*Acyrtosiphon* spp.), wheat bug (*Nysius huttoni*) and grass grub (*Costelytra zealandica*), may have a detrimental effect on the biocontrol of CRW.

Previous studies in the laboratory and field have shown that the parasitoid *M. aethiopoidea* is highly susceptible to insecticides both at the adult and immature stages inside the host weevil, with the degree of susceptibility dependent on the type of insecticide, mode of exposure as well as the development stage (e.g. larvae inside host, cocoon or adult) at which exposure occurred (e.g. Dumbre & Hower 1976, 1977; Ascerno et al. 1980; Frampton et al. 1987; McNeill & Chapman 1989; McNeill et al. 1996). Therefore, a non-target consequence of insecticide use is the

elimination of *M. aethiopoidea* at the paddock scale. This potentially can lead to a temporary resurgence of damaging CRW through reinvasion by the more mobile non-parasitised cohort of the weevil population. Clover seed growers require information as to the non-target field impacts of the agrichemicals they use to control crop pests on the CRW biocontrol agent.

Two laboratory experiments were conducted to determine the toxicity of six insecticides used in white clover seed production, a herbicide and an adjuvant commonly used in spray mixes, to CRW and *M. aethiopoidea*, through either direct application or exposure to residues on clover leaves. Based on these results, a ranking of the agrichemicals tested was developed that would be used by growers to determine the most appropriate products to use against white clover pests.

MATERIALS AND METHODS

Eight agrichemical products were selected, based on recommendations from white clover growers, and these represented the main agrichemical compounds used in white clover cropping environments. The products were prepared at both half and full recommended field rates resulting in 17 treatments including water as a control (Table 1). One litre of each treatment was sufficient to spray the clover and insects in both the direct application and residue experiments.

The adjuvant Li700 (hereafter referred to as 'adjuvant') is a penetrating surfactant and was included as it is representative of the compounds often added to insecticides to enhance spray coverage and activity.

The active ingredient of Beaugenic™ (hereafter referred to as 'biopesticide') is a combination of *Lecanicillium lecanii* (Zare and Gams) and *Beauveria bassiana* (Bals.-Criv.) Vuill. (Hypocreales: Clavicipitaceae), eNtomate (sticker, spreader) and Ncapture (stimulant/food source for the fungal products). The biopesticide treatment was a ready-to-use solution, with instructions that it be applied within a day or two of arriving, before the live spores germinated. As the other agrichemicals were yet to arrive, this treatment along with a water control was applied to CRW and to clover in the residue trial 4 days before all other treatments, requiring

the microbial insecticide data to be analysed separately. For the direct application bioassay involving the parasitoid adults, a second batch of biopesticide was used allowing this treatment to be analysed alongside the other treatments.

Insect collection and rearing

Approximately 7,000 CRW adults were collected from a parasitoid-free field site near Invermay (Otago) throughout January and February 2012. Half were then parasitised in the laboratory at a ratio of three parasitoid adults to 100 CRW for 72 h to provide parasitised CRW of a uniform parasitoid stage and age. Following exposure, the parasitoid-exposed weevils were held at 20°C and fed on white clover for 3 weeks. Based on development rate data, this would provide weevils for assays containing immature parasitoids at an advanced stage of development (3rd to 4th instar). A further 1,000 weevils collected from a biocontrol release site were used to provide the bulk of the *M. aethiopoulos* adults required for the adult parasitoid bioassays. These were augmented with adults obtained from healthy parasitoid larvae that emerged from CRW used in the experiments.

Direct application

Adult CRW, either 60 parasitised or 60 non-parasitised, were placed in a 500 ml square plastic container for each treatment. An antistick fluoropolymer resin (PTFE-30) compound was painted around the container rim to confine the weevils and filter paper lined the base to absorb spray droplets. Weevils were sprayed with the test solution using a moving belt sprayer set to deliver 200 litres/ha.

Once the spray residue had dried, weevils were separated out into 250 ml vented cages with 10 weevils per cage and six replicate cages per treatment. Each cage contained filter paper, 3–4 fresh excised white clover leaves and a dental wick moistened with water. Weevil mortality was observed daily for 5 days.

Parasitoids were confined in 250 ml containers then immobilised by cooling in a 4°C fridge for 30 min prior to being sprayed with the test solution. The containers were covered with a plastic mesh with 1 mm square holes to retain

the wasps while allowing the spray to pass through. Filter paper was used to completely line the containers to absorb spray droplets and prevent drowning. Approximately 20 min post treatment, the parasitoids were transferred using a fine touch paint brush to individual 250 ml vented cages containing a 5 mm length of dental wick moistened with sugar solution. There was one parasitoid per replicate and 12 replicates per treatment. During the 5-day bioassay, insects were held at 20°C and 14:10 h light:dark.

Exposure to pesticide residues

The residue experiment examined the toxicity of either 2 h or 48 h-old residues to CRW and *M. aethiopoulos*. Eighty-five white clover plants were grown in potting mix in pots (12 mm diameter) from stolon cuttings in the glasshouse for 3 months prior to the experiment. Five plants per treatment were sprayed using a moving belt CO₂ powered precision sprayer at an application rate of 200 litres/ha. Plants were then air-dried for 2 h at approximately 20°C in a glasshouse. The foliage was cut randomly from each of the five plants in each treatment and mixed in a container. Ten healthy weevils (either parasitised or non-parasitised) were confined in 90 mm × 20 mm Petri dishes with four trifoliate leaves. For the parasitoid bioassay, a single adult parasitoid was caged with one trifoliate leaf. After 24 h, weevils or parasitoids were transferred to clean Petri dishes containing a dental wick moistened with water or 20% sucrose solution and were provided fresh, untreated clover as required. This experiment was repeated at 48 h post treatment where further foliage was cut from the treated clover plants and presented to another cohort of parasitised or non-parasitised CRW or parasitoid adults for 24 h to determine the impact of older residues on CRW and its parasitoid. This was replicated six times for each treatment. Insect mortality was recorded daily for 5 days, although observations of surviving insects continued past that point.

Assessment

Insect mortality was determined by observation with moribund individuals (unable to maintain a normal posture) classified as dead. Parasitoid

larvae that emerged from weevils were monitored for pupation and survival to maturity. For CRW, mortality through exposure by direct contact with residues or ingestion of treated foliage was not determined.

Statistical analysis

Weevil mortality data were analysed using logistic regression, with each day analysed separately. The fixed model included a treatment effect, a parasitoid effect (i.e. either parasitised or non-parasitised) and their interaction. In order to test for consistent chemical and rate effects, a second analysis was conducted reparameterising the treatment effect as Treated/(Rate*Chemical), where the factor "Treated" specifies whether the treatment was an agrichemical or the water control. On day five, the effect of residue exposure time (24 or 48 h) on mortality was analysed by inclusion of exposure time into the logistic regression. The parasitoid mortality data were also analysed using logistic regression.

For the parasitised weevil component of the study, parasitoids began to emerge from the fungal culture treatments and their corresponding controls 4 days post-treatment. As the other agrichemical treatments were set up 4 days later, the parasitoid larvae were further developed and emergence was observed 1 day following

treatment. Because weevil mortality resulting from direct toxicity was confounded by parasitoid emergence, the results are reported in relation to observations of mean number of parasitoid larvae that emerged from the parasitised weevils. Mortality of parasitised weevils is not presented. Parasitoid larval emergence from treated CRW was used as an indicator of agrichemical toxicity to the immature stage of the parasitoid. Parasitoid emergence data were analysed using ANOVA. However, as daily data were sparse, the total number emerged over all 5 days was analysed. To normalise the data, the total number emerged was square root transformed prior to analysis. All analyses were conducted using GenStat version 15.

RESULTS

Direct application

Although insect mortality was assessed daily, only the day 1 and day 5 data are presented. This approach covers the period where treatments may have an initial knockdown effect, to treatments that may take longer to kill the insect.

Non-parasitised CRW

Weevil mortality is shown in Figure 1. Diazinon at both half and full rates resulted in 100% mortality after 1 day, while lambda-cyhalothrin (λ -cyhalothrin), diquat, the full rate of

Table 1 Agrichemicals tested in the direct application and residue experiments at field and half rate.

Trade name	g ai/litre	Active ingredient	Product class
control	-	-	water
Karate®	0.025 0.05	lambda-cyhalothrin	synthetic pyrethroid
Maverick® Aquaflo	0.091 0.18	taufluvalinate	synthetic pyrethroid
Chess® WG	0.25 0.50	pymetrozine	pyridine azomethine
Pirimor®	0.315 0.625	pirimicarb	carbamate
Diazinon 800 EC®	1.60 3.20	diazinon	organophosphate
Beaugenic™	- -	fungal culture	organic insecticide
Reglone®	1.50 3.00	diquat	bipyridyl desiccant herbicide
Li 700®	1.25 2.50	various ingredients	adjuvant

taufluvallinate and half rate of adjuvant resulted in significantly ($P<0.05$) higher mortalities than the untreated controls (7-28% after day one and 27-85% by day five). The half rates of lambda-cyhalothrin and taufluvallinate had significantly less mortality ($P<0.05$) compared to their full rates at day five.

Pymetrozine, pirimicarb, biopesticide, the half rate of taufluvallinate and the full rate of adjuvant had the least effect on weevils by day five, with no difference in mortality compared with the untreated controls (Figure 1). The half rate of adjuvant caused greater mortality than the full rate at both assessment dates ($P<0.05$).

Parasitised CRW

Rearing out parasitoids from a subsample of 20 untreated weevils from the rearing cages revealed high parasitism levels ($>75\%$). Parasitoid larvae emerged from weevils exposed to all treatments except for diazinon (Figure 2), where no parasitoid larvae emerged, while the majority of larvae that emerged from the lambda-cyhalothrin treatments died before pupation. The numbers of parasitoid larvae that emerged from the agrichemicals were generally less than the control with the overall difference

between treatments being statistically significant ($P<0.001$). At field rates, larval emergence was highest for pymetrozine, followed in decreasing order by diquat, biopesticide and pirimicarb (Figure 2). Multiple parasitism was common, with more than one parasitoid emerging from single weevils, and parasitoids continuing to emerge from surviving weevils beyond the day 5 assessment. An average of at least one healthy parasitoid larva emerged and survived through to adults per dead weevil, indicating that their development could continue post-chemical exposure.

Microctonus aethioides adults

Treatment of parasitoid adults with diazinon caused 100% mortality after 1 day. Half and full rates of lambda-cyhalothrin caused significant mortalities (42% and 50%, respectively) to parasitoid adults on day one compared to the untreated control (8%) ($P<0.05$) (Figure 3). By day five, the full rate of taufluvallinate had also caused significant mortality (58%) compared with the untreated controls (17%) ($P<0.05$). No significant rate effects were found with any of the agrichemicals tested. Pymetrozine, pirimicarb, diquat, adjuvant and biopesticide

Figure 1 Percentage mortality of non-parasitised adult CRW, 1 and 5 days after direct contact with agrichemical sprays. Biopesticide treatments were tested separately from the rest and so have a separate control (b). An asterisk indicates treatments significantly different to the control ($P<0.05$).

had no significant effect on parasitoids at either day one (0% mortality) or day five (17% to 42% mortality) compared to the untreated control.

Agrichemical residues

Non-parasitised CRW

Exposure to 2-h-old residues of the insecticides diazinon, lambda-cyhalothrin and taufluvalinate caused significant weevil mortality compared

to the control after 5 days ($P < 0.05$) (Figure 4). Mortality due to the other agrichemicals was not significantly different from the controls. Rate effects were seen with the half rates of pirimicarb, diazinon and adjuvant causing significantly less weevil mortality compared to their full rates ($P < 0.05$).

After exposure to 48-h-old residues, both rates of diazinon and lambda-cyhalothrin, and the full

Figure 2 Average number of parasitoid larvae emerged from parasitised CRW for each treatment after direct contact with agrichemicals. For clarity, means are back transformed from the square root value.

Figure 3 Percentage mortality of adult *M. aethiopoulos*, 1 and 5 days after direct contact with agrichemical sprays. An asterisk indicates treatments significantly different to the control ($P < 0.05$).

rate of taufluvinate had caused significant weevil mortality compared to the control ($P < 0.05$) (Figure 4). Rate effects were seen with half rates of taufluvinate and diazinon, both having less mortality compared to their full rates ($P < 0.05$) at day five. For all agrichemicals, weevil mortality when exposed to 48-h-old residues generally declined significantly compared to exposure to 2-h-old residues ($P < 0.001$). Clover treated with the herbicide diquat had burnt off by the 48 h post treatment bioassay so these treatments could not be tested.

Parasitised CRW

For parasitised weevils exposed to 2-h-old residues, diazinon had the greatest negative impact on parasitoid larval emergence followed by lambda-cyhalothrin (Figure 5). Overall, there was a highly significant difference ($P < 0.001$) in the ability of parasitoid prepupae to emerge from exposed weevils. Emergence from weevils treated with pirimicarb, diquat, adjuvant and taufluvinate was generally high, with an average of 6.3 to 8.3 larvae recovered per treatment (Figure 5). In addition to reduced emergence from diazinon and lambda-cyhalothrin treatments, survival of larvae that did emerge

from these treatments was significantly affected as few ($< 40\%$) developed into adults. Both rates of biopesticide had very low emergence of parasitoid larvae but the difference was significant compared to the control where no larvae emerged during the 5 day bioassay (Figure 5).

In the 48-h-old residue bioassay, larval emergence was generally less than that recorded for the 2-h-old residue bioassay (Figure 5), with the overall differences between treatments just failing significance ($P = 0.054$). There did not seem to be any consistent pattern compared to the 2-h-old residues, with the average larval emergence highest for the field rate of diazinon (average of 4.7 larvae) followed in decreasing order by the field rates of pymetrozine (4.2), adjuvant (3.4), lambda-cyhalothrin (3.3) and taufluvinate. Lambda-cyhalothrin and diazinon were the most detrimental to immature stages of the parasitoid in weevils exposed to 48-h-old residues, as only those larvae that emerged within 1-2 days of weevil exposure to the residues, successfully pupated and developed into adults (T.M. Eden, AgResearch, unpublished data). Thereafter, the majority of later emerged parasitoid larvae ($> 80\%$) died before pupation. Both rates of taufluvinate, adjuvant and biopesticide along

Figure 4 Percentage mortality of non-parasitised adult CRW, 5 days after contact with 2-h- and 48-h-old agrichemical residues. Biopesticide treatments were tested separately from the rest and so have a separate control (b). An asterisk indicates treatments different to the control ($P < 0.05$).

with the full rates of pymetrozine and pirimicarb had greater weevil mortality than the control. However, on average, 1-2 healthy larvae were able to successfully emerge and pupate from dead weevils, with the majority successfully eclosing as adults (data not shown).

Microctonus aethiopoies adults

After exposure to 2-h-old residues, diazinon was the only agrichemical to cause 100% mortality after only 1 day (data not shown). By day five, all treatments caused significant mortalities to parasitoid adults compared to the controls ($P < 0.001$), except taufluvallinate and the half rates

Figure 5 Average number of parasitoid larvae emerged from parasitised CRW 5 days after contact with 2-h- and 48 h-old agrichemical residues. Biopesticide treatments were tested separately from the other treatments and so have a separate control (b). For clarity, means are back transformed from the square root value.

Figure 6 Percentage mortality of adult *M. aethiopoies* 5 days after contact with 2-h- and 48-h-old agrichemical residuals. An asterisk indicates treatments different to the control ($P < 0.05$).

of both lambda-cyhalothrin and pymetrozine (Figure 6). Significant rate effects were recorded for both lambda-cyhalothrin and pymetrozine with a 3–4× increase in mortality of parasitoids exposed to the full rate compared to the half rate of insecticide ($P < 0.05$).

For parasitoids exposed to 48-h-old residues, there were highly significant treatment effects ($P < 0.001$) and while there was no significant exposure effect ($P = 0.124$) a significant treatment × exposure interaction was recorded ($P = 0.003$). Both rates of diazinon caused 100% mortality to adults at day 1. By day five, the biopesticide and the full rate of pirimicarb also reduced parasitoid survival compared to the control ($P < 0.05$). No sporulation was seen on cadavers from the biopesticide treatments, so it is possibly the additives not the fungi (*L. lecanii* and *B. bassiana*) that affected adult survival. By day five, exposure to the half rate of pirimicarb caused 33% mortality of parasitoid adults compared with 83% in the full rate ($P < 0.05$). For lambda-cyhalothrin there was no mortality after exposure to 48-h-old residues, but for field rates of taufluvinate and pirimicarb, there was greater mortality of adult parasitoids exposed to 48-h-old residues than 2-h-old residues. This result was surprising, given that concentration on the foliage would be expected to be higher on foliage after 2 h than 48 h, and mortality therefore lower (e.g. McNeill & Chapman 1989; Williams et al. 2003). As the parasitoids were ca 24-h-old for both 2 and 48 h bioassays, and handled identically, the result can only be attributed to unidentified external factors.

DISCUSSION

The study found that all agrichemicals commonly used in white clover crops had some activity against CRW and *M. aethiopoides* adults, with mortality generally higher for parasitoids than the weevil. The emergence of parasitoid larvae from weevils exposed to the agrichemicals again varied with agrichemical, with diazinon being most lethal to larvae. The fact that toxicity to the parasitoid does vary with the agrichemical is not surprising, as research carried out in the USA in the 1970s on the strain of *M. aethiopoides* introduced to control alfalfa weevil *Hypera postica*

(Gyllenhal) reported a similar effect (Dumbre & Hower 1976, 1977; Ascerno et al. 1980).

When applied directly to insects, both rates of diazinon and lambda-cyhalothrin were the most detrimental to CRW and *M. aethiopoides*. Weevil and parasitoid adult survival were significantly reduced (65–100%) and few emerged larvae successfully pupated and developed as adult parasitoids (<40%). The full rate of taufluvinate also caused significant (58%) adult parasitoid mortality after 5 days. Exposure to 2-h-old residues of diazinon and lambda-cyhalothrin significantly affected survival of emerged parasitoid larvae, with high larval mortality and only a few (<40%) pupae successfully completing development into adult parasitoids. All treatments reduced adult parasitoid survival by day five (<50%) except taufluvinate and the half rates of both lambda-cyhalothrin and pymetrozine. After exposure to 48-h-old residues, diazinon treatments were the most detrimental to the insects causing 100% mortality to parasitoid adults and significantly reducing weevil survival at day one. Survival of emerged parasitoid larvae from both rates of diazinon and lambda-cyhalothrin were low (<50%).

Prepupal emergence from insecticide-treated hosts and successful pupation and adult emergence were observed, a result similar to that reported for the Moroccan strain of *M. aethiopoides* parasitising *S. discoideus* (McNeill et al. 1996) and *M. hyperodae* parasitising *Listronotus bonariensis* (Addison & Barker 2006). However, while not examined, it is assumed that in the field, sub-lethal effects on parasitoid adults can include reduced longevity, decreased reproduction potential and delays in population growth (e.g. Dumbre & Hower 1976; Stark et al. 2007), which potentially cause significant disruption to the effectiveness of biological control.

Based on these laboratory results, there are options that growers could use in an IPM programme to control white clover pests over the summer period. Although pymetrozine, biopesticide, pirimicarb and taufluvinate were toxic to both immature and adult parasitoids, sufficient parasitoids may survive through to adulthood to attack any remaining non-parasitised

CRW in the white clover crop. Taufluvalinate was considered the best option over the summer period targeting both white clover pests and CRW (60% control), while having reduced impact on *M. aethiopoulos* adults (0–60% mortality). Lambda-cyhalothrin and diazinon were the most detrimental to CRW and its biocontrol agent either applied directly or through exposure to residues. In particular, the use of diazinon in autumn to control grass grub will have a highly significant impact on CRW and the parasitoid, because the parasitoid is in diapause inside the weevil. A table was developed for white clover growers that ranked the relative toxicity of the agrichemicals (Table 2). The values presented are an average based on both mortality from direct contact 5 days post-exposure plus exposure to residues on clover foliage (2 and 48 h). The values for parasitised weevils were high because they included mortality due to both agrichemical toxicity and parasitoid larval emergence. Subsequent, dissemination of these results to growers, led to the many electing to use taufluvalinate to control clover insect pests while minimising damage to the CRW parasitoid.

While direct exposure will have some impact on adult *M. aethiopoulos*, timing applications in summer to control clover pests while minimising impacts on the parasitoid could be achieved by delaying applications when the parasitoid adult is less active and pupae are more prevalent. However, the approach requires an understanding of parasitoid phenology, which is currently lacking. While the parasitoid will re-establish in the crop following an insecticide application, the lag between the resurgence of CRW and the re-establishment of its biocontrol could lead to a temporary build-up in damaging CRW larval populations. However, verifying the true impact of these agrichemicals on *M. aethiopoulos* can only be addressed in a field study.

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Table 2 Toxicity ranking of agrichemicals at two rates (1 = full rate, 0.5 = half rate) to CRW (parasitised and non-parasitised) and adult *M. aethiopoulos* (0= no kill, 10= 100% kill). Scores correspond to mortality of insects averaged over the three experiments, with 0 being zero mortality and 10 being 100%.

Active ingredient	Trade name	Rate	Non-parasitised	Parasitised	Parasitoid
			CRW	CRW	adult
pymetrozine	Chess® WG	0.5	0	5	3
		1.0	1	7	5
pirimicarb	Pirimor®	0.5	0	5	4
		1.0	1	6	6
biopesticide	Beaugenic™	0.5	2	3	7
		1.0	1	4	7
taufluvalinate	Maverick®	0.5	2	6	2
		1.0	3	7	4
lambda-cyhalothrin	Karate®	0.5	5	9	5
		1.0	6	9	5
diazinon	Diazinon 800 EC®	0.5	7	9	10
		1.0	9	10	10
diquat (herbicide)	Reglone	0.5	6	6	5
		1.0	6	7	6
adjuvant	Li700	0.5	1	5	5
		1.0	1	6	4

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