INSECT CONTROL ON APPLES WITH RH-5992 A NOVEL INSECT GROWTH REGULATOR

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SUMMARY

RH-5992 is a new class of insect growth regulator which acts as a highly specific ecdysone agonist in larval Lepidoptera. It was evaluated in programmes for codling moth and leafroller control on apples over two seasons. In the first season, when three rates were evaluated at two-weekly spray intervals, high levels of control of these pests were achieved but control of homopterous pests was poor. In the second trial insect control was based on RH-5992 and strategic applications of chlorpyrifos. Control of all pests was excellent and approached levels comparable to a programme based on azinphos-methyl.

Keywords: apples, codling moth, leafrollers, insect growth regulator

INTRODUCTION

Important pests of apples in New Zealand include codling moth and several species of leafrollers. These pests are presently controlled by organophosphorous (OP) insecticides (azinphos-methyl and/or chlorpyrifos) but current levels of control may not continue. Resistance to azinphos-methyl has been found in Nelson populations of the lightbrown apple moth *Epiphyas postvittana* (Suckling *et al* 1989). There are also overseas reports of OP insecticides failing to control either codling moth (*Cydia pomonella*) (S. Welter, unpublished data) or leafrollers (Reissig, pers. comm.). Effective alternatives to OP insecticides for lepidopterous pest control in New Zealand orchards are therefore desirable.

First generation insect growth regulators (IGRs) possess activity against target pests by disrupting insect juvenile hormone biosynthesis (e.g. methoprene), by mimicing juvenile hormone activity (fenoxycarb) or by inhibiting chitin synthesis during cuticle formation (e.g. dimilin). A new class of nonsteroidal IGR's, ecdysone agonists, has been developed which act by inducing a premature moult in larval stages of Lepidoptera (Wing *et al* 1988). Larval exposure induces apolysis which results in head capsule slippage; feeding activity is terminated within a few hours and larvae die within a few days. In this paper we report on two of these moulting accelerator compounds (MAC), RH-5849 and RH-5992, which were evaluated in field trials to determine their efficacy against apple pests.

METHODS

The trials were at the DSIR Research Orchard, Havelock North. Trial 1 was conducted on the apple cultivar "Red Delicious" in 1988-89 and Trial 2 was on "Braeburn" in 1989-90.

Trial 1

There were eight treatments, namely two MAC compounds (RH-5849 and RH-5992) each applied at three rates, a standard programme based on chlorpyrifos, and an untreated control (Table 3). All MAC treatments received ten applications which were applied at two-weekly intervals from "full bloom". There were nine chlorpyrifos applications which commenced 2 weeks later, at "petal-fall". No insecticides were applied to the trees before bloom.

Trial 2

In this study all trees received oil (2.5%) and chlorpyrifos (40 g/100 litres) at bud burst. This was followed by six insecticidal treatments: four RH-5992 treatments, one

TABLE 1: The experimental treatments in Trial 2.

Trt	Products	Trade Name	Rates ai/100 litres	No. of sprays
1.	RH-5992	nil	6g	10
2.	RH-5992 + chlorpyrifos	nil, Lorsban	3g + 25g	7 + 2
3.	RH-5992 + chlorpyrifos	nil, Lorsban	6g + 25g	7 + 2
4.	RH-5992 + chlorpyrifos	nil, Lorsban	12g + 25g	7 + 2
5.	chlorfluazuron	Attabron	1g	10
6.	azinphos-methyl	Gusathion	38g	10
7.	untreated		—	—

chlorfluazuron treatment (an alternative IGR comparison), a standard programme based on azinphos-methyl, and an untreated control. Treatments 1, 5 and 6 (Table 2) were applied every 2 weeks starting at "petal-fall" (November 3, 1989). In Treatments 2, 3, and 4 RH-5992 was applied during bloom (October 10, 1989), at "petal-fall', on December 15 and January 30 followed by three further sprays at two-weekly intervals. In addition, chlorpyrifos (25 g/100 litres) sprays were inserted on November 30 and January 15.

In both trials the treatments were applied to single tree plots, each replicated four times and arranged in randomised complete block designs. The surfactant, Triton B-1956, was included (15 mls/100 litres) in all applications of insect growth regulators. No surfactants were added to the OP treatments. All applications were made by hand, using high pressure spray equipment; trees were sprayed to run-off (10 litres/tree). In both trials a standard fungicide programme was applied using an airblast sprayer.

The effectiveness of each treatment was assessed using random samples of 100 fruit per replicate at harvest (Trial 1 — March 13, 1989; Trial 2 — April 3, 1990). Fruit were examined for insect damage or infestation. Results were analysed using SAS for ANOVA of arc-sin transformed percentages of fruit damage. Analyses were not performed on data for which values in all treatments were either very low or zero. Significant differences cited in the results are at $P<0.05$.

RESULTS

The results are presented in Table 2 (Trial 1) and Table 3 (Trial 2).

Trial 1

Codling moth control was excellent with no deep "entries" in any of the insecticidal treatments while relatively high levels of damage occurred in the control trees. Minor codling moth feeding injury or "stings" were present in all RH-5849 treatments at levels similar to that in the chlorpyrifos treatment. Leafroller damage in all treatments was significantly lower than that in the untreated trees but control at the lowest rate of RH-5849 was significantly inferior to all other insecticidal treatments.

TABLE 2: The untransformed percentages of insect damage or infestation of fruit at harvest in Trial 1. Numbers with the same letter are not significantly different (i.e. $P>0.05$).

Trt	Product	Rate ai/100 litres	Codling moth Sting	Codling moth Entry	Leafroller Damage	Leafroller Larvae	Mealy bug	Scale	WAA
1.	RH-5849	10g	0.5	0.0a	4.4b	0.3	34.4 b	14.8bc	35.4 b
2.	RH-5849	20g	0.5	0.0a	1.5 a	0.8	24.8 b	4.5abc	34.8 b
3.	RH-5849	40g	0.8	0.0a	0.6 a	0.0	37.0 b	20.3bc	58.8 c
4.	RH-5992	3g	0.0	0.0a	0.9 a	0.5	65.4 c	22.6c	53.3 bc
5.	RH-5992	6g	0.3	0.0a	0.3 a	0.0	22.1 b	3.0ab	40.6 bc
6.	RH-5992	12g	0.0	0.0a	0.8 a	0.0	27.6 b	9.9abc	38.0 b
7.	chlorpyrifos	25g	0.8	0.0a	1.3 a	0.0	2.0 a	0.5a	2.5 a
8.	untreated		0.3	4.2b	34.0 c	4.7	97.4 d	23.0c	58.3c

All RH-5849 treatments, and the two highest rates of RH-5992, had similar levels of mealybug (*Pseudococcus* spp.) infested fruit. All MAC treatments were significantly better than the untreated control but all were also inferior to the chlorpyrifos programme. The interpretation of scale control was difficult due to a high between-tree variation in San Jose scale (*Quadraspidiotus perniciosus*) population densities. There was no consistent insecticidal effect on scale or woolly apple aphid (WAA) (*Eriosoma lanigerum*) with either MAC compound whereas control of all homopterous pests was high in the chlorpyrifos programme.

Trial 2

Extended spray intervals were used in Trial 2 to exploit opportunities for reducing sprays for leafroller control in early summer (Suckling *et al* 1990). Chlorpyrifos applications were added to the RH-5992 programme to improve the poor control of homopterous pests achieved with RH-5992 in Trial 1.

Codling moth "stings" were absent in all RH-5992 treatments except the 12 g/100 litre rate. No deep "entries" were found in any RH-5992 treatment. An entry was found in the chlorfluazuron treatment but this damage level was low compared with that in the untreated trees (7.25%). Fruit in all treatments had significantly less leafroller damage than did the untreated trees. The highest level of leafroller control was achieved with azinphos-methyl but this was not significantly different from two of the RH-5992 plus chlorpyrifos treatments (Treatments 2 and 4, 3 g and 12 g/100 litres respectively). Inclusion of chlorpyrifos in Treatment 3 did not enhance leafroller control compared with RH-5992 alone (Treatment 1). Leafroller control with all RH-5992 treatments was significantly better than in the chlorfluazuron treatment where leafroller damage reached 8.5%. Low numbers of leafroller larvae were present in all IGR treatments (Tables 2 and 3) but all were dead at the time of assessment.

TABLE 3: The untransformed percentages of insect damage or infestation of fruit at harvest in Trial 2. Numbers with the same letter are not significantly different (i.e. P >0.05).

Trt	Product	Rate ai/100 litres	Codling moth		Leafroller		Mealy bug	Scale	WAA
			Sting	Entry	Damage	Larvae			
1.	RH-5992	6g	0.00	0.00b	2.25c	1.25ab	1.25a	5.50ab	3.75bc
2.	RH-5992	3g	0.00	0.00b	0.25ab	0.25ab	0.00a	1.50bc	1.75bc
3.	RH-5992	6g	0.00	0.00b	1.84bc	1.07ab	0.00a	0.00c	1.07bc
4.	RH-5992	12g	0.75	0.00b	1.49abc	0.75ab	0.25a	1.75bc	0.50c
5.	chlorflua-zuron	1g	0.00	0.25b	8.50d	2.25ab	0.25a	5.50ab	11.00b
6.	azinphos-methyl	38g	0.00	0.00b	0.00a	0.00b	0.25a	0.00c	1.75bc
7.	untreated	—	0.00	7.25a	20.25e	2.25a	2.25a	7.25a	27.75a

Mealybug levels in Trial 2 were low with only 2.25% of the fruit infested in the untreated trees. In the RH-5992 and chlorfluazuron treatments where chlorpyrifos was not applied (1 and 5), scale control was not significantly different from that in the untreated control. The percentages of fruit infested with WAA were significantly lower in all insecticidal treatments than in the untreated trees. WAA control in the RH-5992 treatments improved where chlorpyrifos was applied and was similar to that in the azinphos-methyl programme.

DISCUSSION

In these trials RH-5849 and RH-5992 showed considerable promise as alternative insecticides for codling moth control. Leafroller control with the lowest rate of RH-5992 was significantly better than the lowest rate of RH-5849. At middle and higher rates both compounds provided a high level of control, approaching that given by either a chlorpyrifos or an azinphos-methyl programme at the recommended rates. Leafroller

control with RH-5992 was superior to chlorfluazuron applied at 1 g 100/litres. In Trial 2, low numbers of dead leafroller larvae were found in all IGR treatments at harvest, but their presence would not represent a quarantine problem under current export requirements.

Control of homopterous pests with either RH-5849 or RH-5992 was consistently inferior to chlorpyrifos in Trial 1. No evidence was found of either RH-5849 or RH-5992 having any insecticidal activity against mealybug, scale or WAA. In Trial 2, application of chlorpyrifos and oil at "bud-burst" and two strategic post-flowering chlorpyrifos sprays ensured that control of homopterous pests in the RH-5992 programmes was similar to full season use of azinphos-methyl.

MAC compounds, and in particular RH-5992, are an interesting new class of insecticides for the control of lepidopterous larvae on apples. They have no direct effect on adult Lepidoptera but may decrease adult oviposition (Carlson, pers. comm.). RH-5992 is highly specific to Lepidoptera and would be well suited to use in IPM programmes as it exhibits no toxicity to bees, phytoseiid mites or other beneficial species.

The high selectivity of RH-5992 against Lepidoptera requires the development of complementary strategies to control the range of other pests found in orchards, especially homopterous pests. These trials have shown that acceptable control of the pest complex on apple can be achieved with strategic use of chlorpyrifos in combination with RH-5992. This concept requires further development before commercial implementation and illustrates the need for an integrated approach to pest control as the chemical industry develops increasingly selective compounds.

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