Project title:	Efficacy of insecticides, times using the blackberry leaf midge sex pheromone trap, to control the pest on raspberry
Project number:	SF 141
Project leader:	Michelle Fountain, East Malling Research, Kent, ME19 6BJ
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DISCLAIMER

The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

Project leader

Signature: ……. Date: 21/07/14

Report authorised by:

Signature: ……. Date: 21/07/14

CONTENTS

GROWER SUMMARY

Headline

Early applications of chlorpyrifos or deltamethrin, timed using sex pheromone monitoring traps, reduced levels of damage by blackberry leaf midge

Background and expected deliverables

Blackberry leaf midge (*Dasineura plicatrix*), not only attacks blackberry and loganberry, but is an increasing problem in raspberry under polythene, with up to four generations per year. Adult midges are so small that they are difficult to detect. It is therefore difficult to time sprays effectively to coincide with the first generation and prevent galling, which results in stunting of cane growth and subsequent loss of yield. The most effective time to spray is at egg laying/egg hatch when the larvae are most vulnerable. The newly developed blackberry leaf midge sex pheromone trap is now available commercially for monitoring blackberry leaf midge emergence, but the timing of the sprays has not been investigated. This project aims to find the most effective timing of sprays in year one (this report) and screen a range of approved products for blackberry leaf midge control in protected raspberry (subsequent years).

Summary of the project and main conclusions

A replicated field trial was conducted to examine the effects of single applications of chlorpyrifos or deltamethrin to control blackberry leaf midge. The sprays were applied 1, 3, 7 and 14 days after a sex pheromone trap catch of 10 male midges per trap per week was exceeded. The 1, 3 and 7 day applications of both insecticides reduced the numbers of larvae and the resultant leaf galling.

Blackberry leaf midge sex pheromone monitoring traps proved a useful tool for timing applications of chlorpyrifos and deltamethrin. Early applications (within 7 days of the trap threshold of 10 midges per trap being exceeded) gave good levels of control of blackberry leaf midge in raspberry crops. Where applications were made more than 7 days after the threshold was exceeded, control of midge larvae and subsequent leaf damage was reduced resulting in higher numbers of larvae and resultant galling of leaves.

Financial benefits

A leading grower estimated that attacks of blackberry leaf midge could reduce blackberry yield by 10% which would lead to losses of up to £3,000 per ha on a typical 15t/ha crop. The pest is more serious on raspberry and can cause 60% loss in cane height in some modern primocane varieties. If the pest was not controlled and this occurred, 40% crop losses could be expected, amounting to a loss of £12,000 per ha.

Action points for growers

- Sex pheromone traps for blackberry leaf curling midge are commercially available and should be used to monitor midge populations in vulnerable raspberry and blackberry crops to improve the timing of insecticide applications.
- Traps should be checked at least every 7 days, but twice weekly is recommended for the first generation, to give a larger window of opportunity to apply plant protection products.
- Chlorpyrifos and deltamethrin both provide effective control but they are broad spectrum and have persistent adverse effects on natural enemies and biocontrol agents including *Phytoseiulus persimilis*.
- Effective insecticides should be applied within 7 days of a trap catch of 10 midges per trap and targeted at the emerging primocane leaf tips.
- Product label recommendations should be followed.

SCIENCE SECTION

Introduction

Blackberry leaf midge, *Dasineura plicatrix*, is a damaging pest of blackberry and loganberry, and has now spread to raspberry (Sinclair et al. 2009) in the UK and elsewhere in Europe. Larvae feed in primocane leaf tips, causing them to twist, turn brown and wither (Fig. 1). The growing point can be killed, causing stunting or branching of the canes. Cane growth of raspberry can be reduced by 30%. Growers consider that it significantly affects yields. Adult midges are only 1.5-2.0 mm long and difficult to find in the crop by conventional visual inspection. There are typically two generations in outdoor crops, up to four overlapping generations in protected crops. The pest pupates in the soil, where it also overwinters. More detail of the biology can be found in HDC factsheet 10/12 and HDC report for project SF 102.

Figure 1. Larvae in raspberry shoot and damage to shoot tips

During 2010 the Natural Resources Institute and EMR identified the chemical structures of the two components of the female sex pheromone of the blackberry leaf midge as part of an HDC funded PhD Studentship project (CP 73). The components were determined and subsequently synthesised. Lures containing two of the synthesised components attracted male *D. plicatrix* to traps; the single components are virtually unattractive (HDC SF 117, Amarawardana 2008).

Pheromone monitoring traps for this midge are now available from Agralan Ltd. The trap is a red delta trap with a white sticky base card and the septum is made of rubber with the two components incorporated. Traps should be place in the plantation before the first adults

normally appear and maintained until the end of the season (from early April to late September). Traps should be placed within the crop at least 50 m apart, and two traps per two hectares are recommended. Catches should be recorded weekly and the current recommendation is to apply an insecticidal product at a threshold of 10 midges per trap.

Cultural control

The use of polythene and woven ground cover significantly inhibited the pupation of the midge in a pot test, suggesting that such an approach might offer some control benefits in potted crops (HDC SF 102). However, since the whole tunnel floor would need to be covered and intact with no debris for midges to pupate in, this would be prohibitively expensive and impractical in a commercial crop.

Biological control agents

In laboratory and pot tests, the predatory mites *Neoseiulus cucumeris* and *Macrocheles robustulus* fed on blackberry leaf midge eggs and larvae, however, when tested in the field results were variable and did not give consistent reduction in leaf damage by the midge larvae (HDC SF102). Anthocorid bugs (*Anthocoris nemorum* and *Orius* sp.) were seen feeding on the midge larvae in the commercial crop in July and August, but they are not normally present in high enough numbers in the crop to control the pest. It is not known if releases of commercially produced *Anthocoris* could control midge numbers. *Beauveria bassiana* (Naturalis-L) did not reduce numbers of larvae in the leaf tips or in the soil (HDC SF 102, Wenneker 2008). Although biological control may be achievable for low to medium infestations, highly infested crops will inevitably rely on chemical control of the pest.

Control with conventional crop protection products

In the previous HDC project SF 102 applications of thiacloprid and abamectin did not reduce the numbers of midge larvae or the damage to the leaves. However, a leading grower reports that thiacloprid with an added wetter is effective at reducing damage. In the earlier HDC project only chlorpyrifos reduced midge larvae by 87% and infested tips by 92% in an outdoor, unprotected blackberry crop. Although chlorpyrifos is not approved for use in blackberry crops it is approved for use in raspberry.

At the time that this previous trial was done the pheromone trap was not available. However, now that it is available it may be possible to optimise the timing of spray. The applications were not part of a replicated experiment, although they were compared to an untreated control area and in addition, chlorpyrifos does not fit well into IPM programmes during the growing/picking season due to its long harvest interval and effects on bees and other beneficial insects/mites. Because the midge larvae are so well protected in leaf galls caused

by its feeding, the products need to have some vapour, systemic or translaminar activity to kill the larvae.

Objective

To compare control of blackberry leaf midge with different timings (1, 3, 7, 14 days post pheromone trap threshold) of a synthetic pyrethroid vs. chlorpyrifos (Year 1)

Materials and methods

Sites

The raspberry plantation was "10 Acres", located just off Kent Street in Mereworth (National grid reference TQ 667 545) courtesy of Hugh Lowe Farms, Barons Place, Mereworth, Maidstone, Kent ME18 5NF. The commercial plantation was of the variety Maravilla, planted in 2000.

Experimental design and layout

The plots were 8.1 m long (the distance between the posts supporting the wires) and 3.4 m wide; each row was 98 m long. A randomised block experiment with four replicates of nine treatments was used.

Treatments

Treatments were individual sprays of the test products applied at intervals after a trap catch threshold of 10 male midges per trap was exceeded (Table 1).

Table 1. Treatments and timings of applications (days after a cumulative catch of 10 male midges)

Treat No.	Product	Product dose (l/ha)	Days after threshold	Date of application
1	Chlorpyrifos (Equity) 480g/l EC	1.5	1	08 May 13
2	Chlorpyrifos (Equity) 480g/l EC	1.5	3	10 May 13
3	Chlorpyrifos (Equity) 480g/l EC	1.5	7	15 May 13
4	Chlorpyrifos (Equity) 480g/l EC	1.5	14	22 May 13
5	Deltamethrin (Bandu) 25g/l EC	0.6	1	08 May 13
6	Deltamethrin (Bandu) 25g/l EC	0.6	3	10 May 13
7	Deltamethrin (Bandu) 25g/l EC	0.6	7	15 May 13
8	Deltamethrin (Bandu) 25g/l EC	0.6	14	22 May 13
9	Untreated	-		-

Treatment application

Treatments were applied at a volume rate of 1000 l/ha using a Birchmeier B245 air assisted motorised knapsack sprayer. To minimised inter-plot contamination by spray drift the entire plot was sprayed but the first and last 50 cm of each plot were omitted from the assessments. The accuracy of application of each treatment was estimated by measurement of the amount of spray that had actually been applied (calculated from the initial tank volume minus the final volume of sprayate left in the tank, divided by the amount that should have been applied if 100% of the target volume had been applied). Applications were generally within 10% of that required (Table 2).

Table 2. Accuracy of spray application estimated from the amount of sprayate remaining in the spray tank after spray application

Spray round and date	Treatment No:	Days	Accuracy (%)
1. 08 May	1	1	102%
	5	1	99%
3. 10 May	2	3	103%
	6	3	105%
3. 15 May	3	7	99%
	7	7	91%
4. 22 May	4	14	98%
	8	14	103%

Assessments

The effects of the treatments were assessed on 15, 22 and 29 May and 4 June (7, 14, 21 and 28 days after the first spray application). When necessary, assessments were made immediately prior to spray applications. At each assessment 25 shoots per plot were randomly selected and examined in the laboratory. The numbers of blackberry midge damaged leaves and larvae per shoot by were recorded.

Plot maintenance

The growers' normal maintenance regime for fungicides was continued during the trial but insecticide applications detrimental to midge were suspended for the duration of the trial.

Meteorological records

Dry and wet bulb temperature, wind speed and direction were recorded before and after each spray occasion (Table 3). RH% was estimated from the dry and wet bulb temperature

readings. In addition two Lascar USB-502 loggers were deployed inside a Stevenson's screen to take hourly temperature and humidity readings inside the polytunnel (Appendix 1).

Table 3. Weather conditions at the time of spray application**.**
N/A = Not applicable

Date	Time	Air temperature			Wind	
		°C dry	°C wet	% rh	speed (Kmh)	direction
08 May	08:15	11	11	100	0	N/A
10 May	07:51	11	10	88	0	N/A
15 May	09:44	9	7	76	0	N/A
22 May	10:47	13	11	79	0	N/A

Statistical analysis

The data was expressed as a numbers of leaves damaged, and numbers of larvae present. Because this was count data, it required square route transformation prior to undergoing statistical analysis by ANOVA.

Phytotoxicity

Determination of any phytotoxic effects of the treatments was not a central aim of this work. However, plots were inspected for any visual signs of phytotoxicity from the treatments on each sampling occasion.

Results

Midge population

Monitoring of the midge population with pheromone traps showed no midge activity until the first week of May, when the population rapidly increased to above threshold (10 midges per trap) thus triggering the spray applications. The method of deployment of the trap also proved to be important. The trap 10 m into the crop caught higher numbers of male blackberry midges compared the trap on the edge of the crop (Fig. 2).

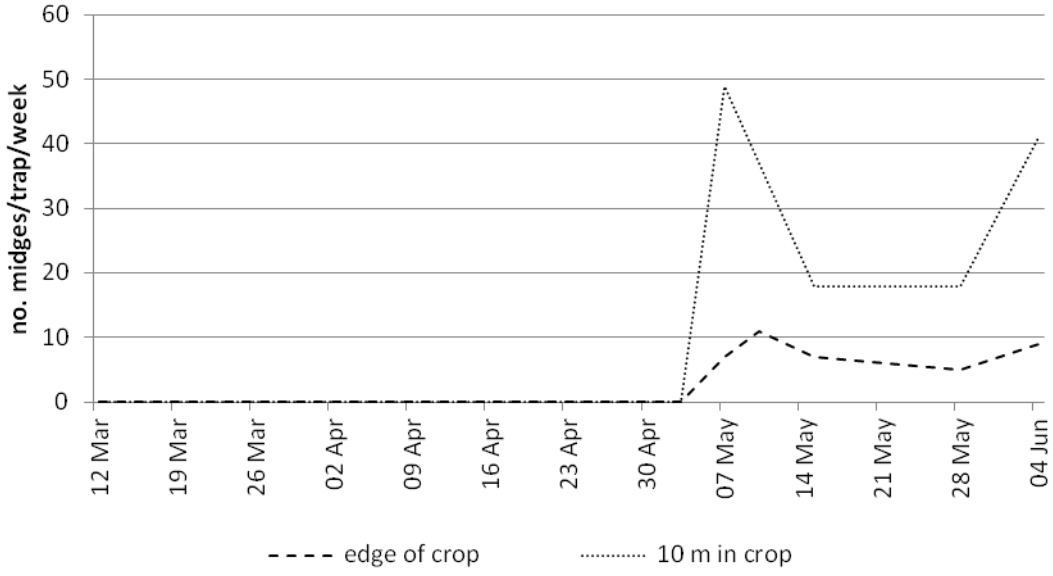

Figure 2. Midge numbers caught per trap per week in two pheromone traps, one 10 m into the crop, the other at the end of the row

First assessment

On 15 May, seven days after the first application, there was no blackberry midge damage recorded on any of the plots.

Second assessment

On 22 May, 14 days after the first application, and immediately prior to the 14 day application there was significantly reduced blackberry midge damage and numbers of larvae (Table 4). The 7 day application of chlorpyrifos also had a significant effect, reducing the numbers of larvae to the same level as the first two sprays, but was not as effective as the earlier treatments in the reduction of damage. The 7 day deltamethrin application had no significant effect on the amount of damage (Fig. 3) but did significantly reduce the number of larvae (Fig. 4).

Table 4. Actual and square route transformed mean numbers of blackberry leaf midge galled leaves and larvae on 22 May 2013, one week after the first spray application

Treatment	Interval after threshold (Days)	Galls		Larvae	
		mean	√mean	mean	√mean
Chlorpyrifos	1	5.75	1.64 c	2.00	0.71 c
Chlorpyrifos	3	1.75	0.91 c	0.25	0.25 c
Chlorpyrifos	7	19.00	4.10 c	7.75	1.86 c
Chlorpyrifos	14				
Deltamethrin	1	2.25	1.01 c	0.25	0.25 c
Deltamethrin	3	15.25	3.69 b	4.25	1.58 c
Deltamethrin	7	86.00	8.81 a	30.00	4.59 b
Deltamethrin	14				
Untreated	-	60.50	7.67 a	48.5	6.78 a
Fprob			<0.001		<0.001
SED (24 df)			0.770		0.989
LSD (P = 0.05)			1.589		2.041

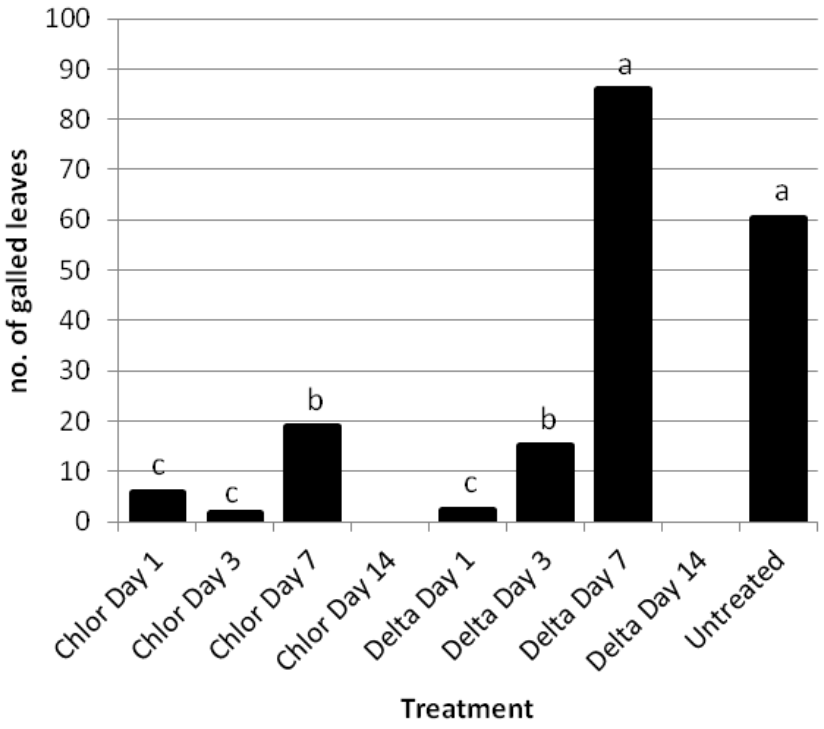

Figure 3. Mean number of leaves with gall damage on 22 May after three timings (days) of applications of chlorpyrifos (Chlor) and deltamethrin (Delta). Letters indicate significant difference. Note the 14 day treatments had not yet been applied.

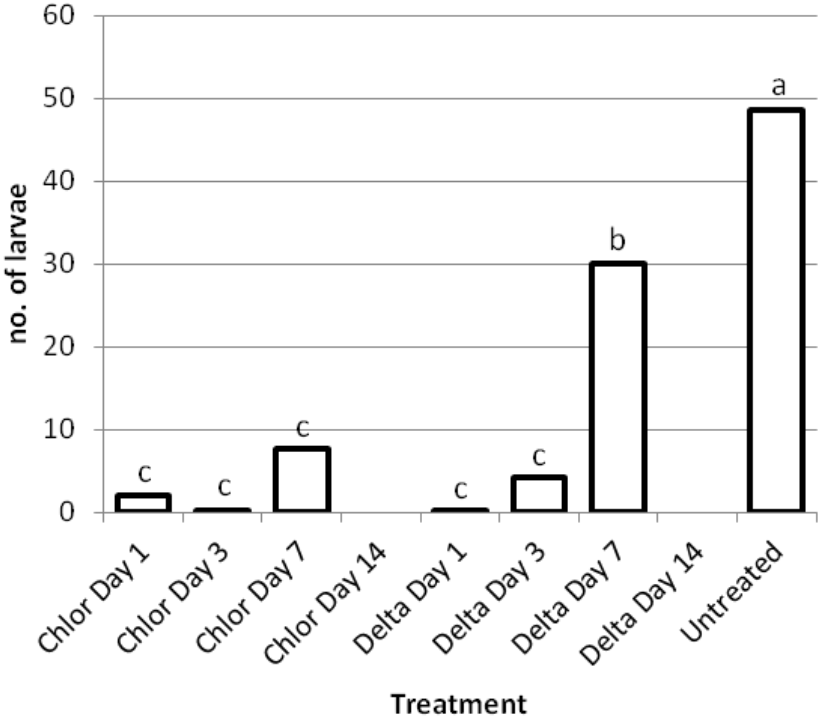

Figure 4. Mean number of larvae within 25 shoot tips on 22 May after three timings (days) of applications of chlorpyrifos (Chlor) and deltamethrin (Delta). Letters indicate significant difference. Note the 14 day treatments had not yet been applied.

Third assessment

The 14 day treatments for both insecticides did not have significantly different damage or numbers of larvae compared to the untreated control, i.e. control of the midge had been lost after 7 days post trap catch threshold (Table 5). The 7 day treatments significantly reduced the number of larvae but some of the damage had already occurred so the levels of leaf damage were significantly reduced when compared to the untreated control. However the earlier treatments (day 1 and 3 chlorpyrifos and day 1 deltamethrin) were significantly better at reducing the amount of damage (Fig. 5). The 1, 3 and 7 day insecticide treatments reduced the numbers of larvae compared to the untreated control (Fig. 6).

Table 5. Actual and square route transformed mean numbers of blackberry leaf midge galled leaves and larvae on 28 May 2013, two weeks after the first spray application

	Interval after threshold	Galls		Larvae	
Treatment	**(Days)**	**mean**	**√mean**	**mean**	**√mean**
Chlorpyrifos	1	13.75	3.62 c	0.75	0.60 c
Chlorpyrifos	3	14.00	3.45 c	2.50	0.79 c
Chlorpyrifos	7	28.50	5.20 b	6.75	2.35 c
Chlorpyrifos	14	73.00	8.51 a	58.00	7.32 a
Deltamethrin	1	15.75	3.85 bc	1.25	0.75 c
Deltamethrin	3	31.25	5.40 b	11.50	3.02 bc
Deltamethrin	7	29.75	5.29 b	2.75	1.31 c
Deltamethrin	14	72.50	8.22 a	38.75	4.69 ab
Untreated	-	73.75	8.40 a	45.25	6.53 a
Fprob			<0.001		<0.001
SED (24 df)			0.770		0.989
LSD (P = 0.05)			1.589		2.041

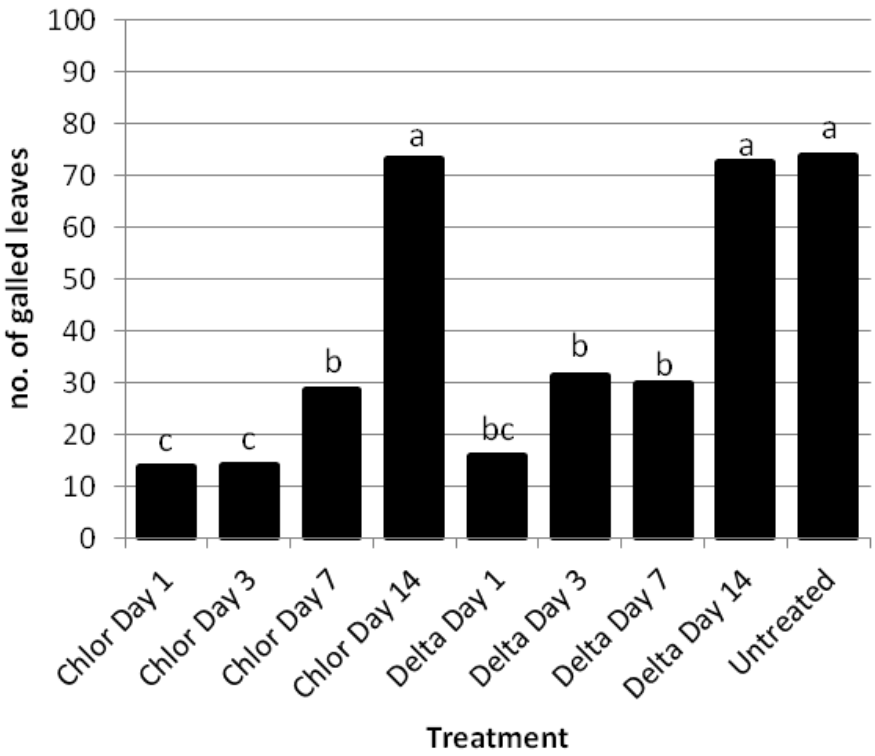

Figure 5. Mean number of leaves with gall damage on 28 May after four timings (days) of applications of chlorpyrifos (Chlor) and deltamethrin (Delta). Letters indicate significant difference.

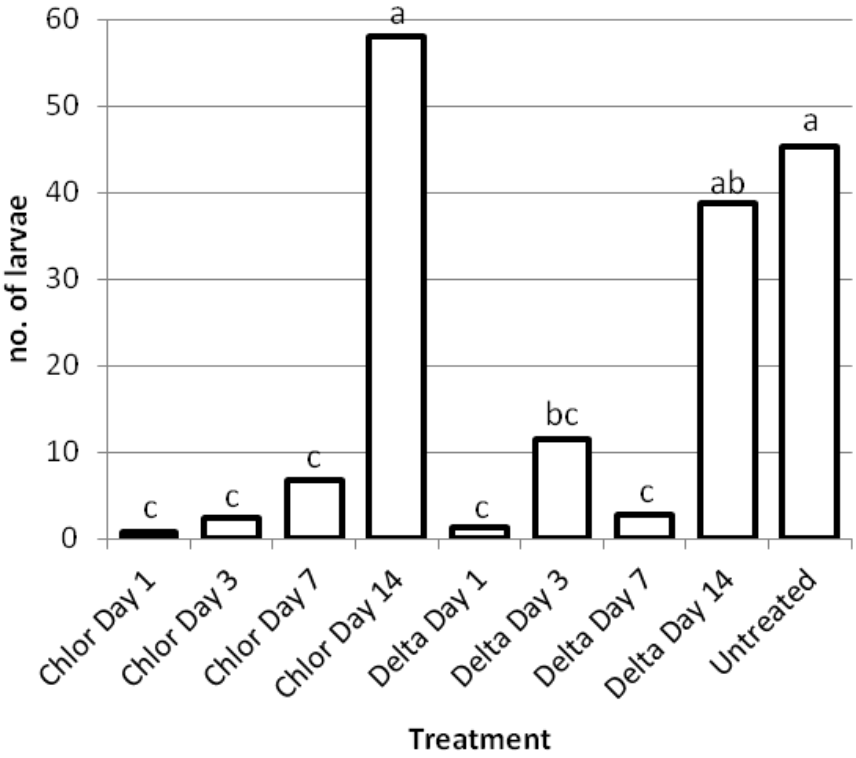

Figure 6. Mean number of larvae within 25 shoot tips on 28 May after four timings (days) of applications of chlorpyrifos (Chlor) and deltamethrin (Delta). Letters indicate significant difference.

Fourth assessment

The final assessment on 4 June, two weeks after the final application, showed that levels of leaf damage remained similar to the previous assessment, however, the damage on the 1 day chlorpyrifos treatment was increasing (Table 6). The numbers of larvae per plot were lower than at previous assessments (mean 5.4 Compared to 15.9) and it appeared that this generation was coming to an end (Fig. 7). However in the 1, 3 and 7 day post sex pheromone trap threshold timed insecticide application plots there were still good levels of control (Fig. 8).

Table 6. Actual and square route transformed mean numbers of blackberry leaf midge galled leaves and larvae on 04 June 2013, three weeks after the first spray application

Treatment	Interval after threshold (Days)	Galls		Larvae	
		mean	√mean	mean	√mean
Chlorpyrifos	1	36.25	2.80 b	4.00	1.37 b
Chlorpyrifos	3	13.00	1.77 c	2.00	0.71 b
Chlorpyrifos	7	17.50	1.60 c	0.00	0.00 b
Chlorpyrifos	14	96.50	6.61 a	10.50	2.93 a
Deltamethrin	1	16.25	1.69 c	2.25	1.06 b
Deltamethrin	3	31.00	2.59 c	2.25	1.06 b
Deltamethrin	7	27.00	1.62 c	1.50	0.87 b
Deltamethrin	14	60.75	4.26 b	7.25	2.09 ab
Untreated	-	87.25	5.89 a	19.00	3.89 a
Fprob			<0.001		<0.001
SED (24 df)			0.770		0.989
LSD (P = 0.05)			1.589		2.041

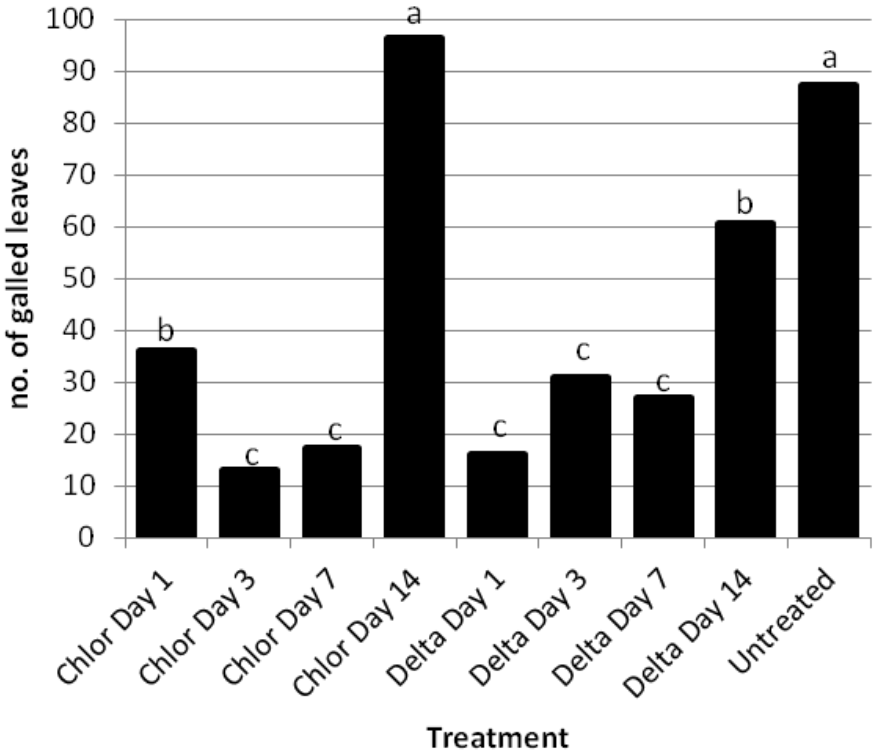

Figure 7. Mean number of leaves with gall damage on 4 June after four timings (days) of applications of chlorpyrifos (Chlor) and deltamethrin (Delta). Letters indicate significant difference.

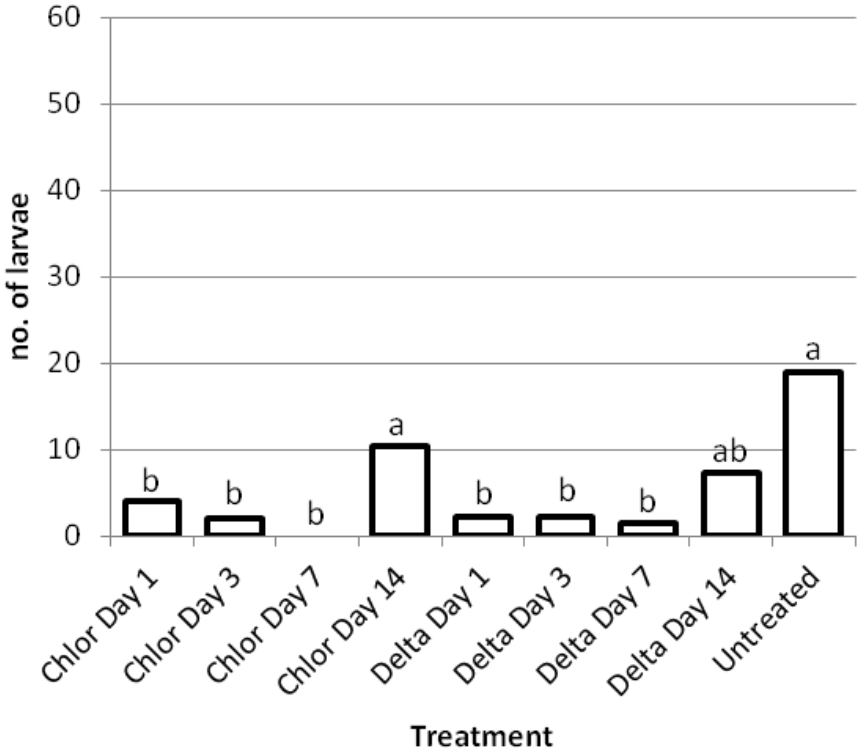

Figure 8. Mean number of larvae within 25 shoot tips on 4 June after four timings (days) of applications of chlorpyrifos (Chlor) and deltamethrin (Delta). Letters indicate significant difference.

Discussion

Chlorpyrifos and deltamethrin were both effective products for the control of blackberry leaf midge but they are broad spectrum and have persistent adverse effects on natural enemies and biocontrol agents, including *P. persimilis.* Sex pheromone traps for blackberry leaf curling midge are commercially available and should be used to monitor midge populations in vulnerable raspberry and blackberry crops to time applications of chlorpyrifos and deltamethrin. Traps should be checked at least every seven days, but we would recommend twice weekly for the first generation to give a larger window of opportunity to apply plant protection products.

Early applications (within seven days of the trap threshold of 10 midges per trap being exceeded) gave good levels of control of blackberry leaf midge in raspberry crops and should be targeted at the emerging primocane leaf tips. After seven days, control of midge larvae and subsequent leaf damage was reduced resulting in higher numbers of larvae and resultant galling of leaves.

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Appendix 1

Weather data for the duration of the trial measured using two Lascar USB-502 data loggers.