Project Title:	Efficacy of insecticides, timed using the blackberry leaf midge sex pheromone trap, to control the pest on raspberry
Project Number:	SF 141
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Authentication

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

Signature (project leader) ………………………………………………………….……..

Date ………………………………………………………………...

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GROWER SUMMARY

Headlines

- Well-timed applications of insecticides using the sex pheromone traps reduce levels of damage by blackberry leaf midge.
- The dose of products can be reduced by 50% with the addition of Silwet L-77 without compromising efficacy.

Background and expected deliverables

Blackberry leaf midge, *Dasineura plicatrix,* attacks blackberry, loganberry and raspberry and is an increasing problem in raspberry under polythene, with up to four generations occurring per year. Because adult midges are so small they are difficult to detect at the first generation and, therefore, it is difficult to time effective sprays against them to control leaf galling. The galling causes damage to primocane shoot tips, causing cane branching, which can have adverse effects on yields. The most effective time to spray is at egg laying/egg hatch when the larvae are most vulnerable. The newly developed species specific sex pheromone trap is now available commercially for monitoring blackberry leaf midge emergence, but the timing of the sprays had not been investigated. This project aimed to find the most effective timing of sprays (year 1) and identify the most efficacious products in admixture with wetters for blackberry midge control in protected raspberry (year 2).

Summary of the project and main conclusions

In the first year of the project (2013) a replicated field trial examined 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. After 7 days, control of midge larvae and subsequent leaf damage was reduced resulting in higher numbers of larvae and resultant galling of leaves.

In year 2 (2014) a replicated field experiment compared applications of chlorpyrifos and deltamethrin versus thiacloprid at full rate and half rate, with and without Silwet L-77. Applications of chlorpyrifos, deltamethrin or thiacloprid (made within 7 days of the trap catch threshold), reduced numbers of midge larvae and levels of damage by blackberry leaf midge. Reducing the insecticide dose by 50% when using the products in admixture with Silwet L-77, was as effective as the full dose applied alone and increased the duration of efficacy of thiacloprid from 13 to 20 days.

Financial benefits

A leading grower estimated that attacks of blackberry 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 on some modern primocane varieties. If the pest were 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 identify the optimum time to apply plant protection products.
- Traps should be checked at least every 7 days, but we would recommend twice weekly for the first generation to give a larger window of opportunity to apply plant protection products.
- Chlorpyrifos, deltamethrin and thiacloprid were all effective products giving >80% control, but chlorpyrifos and deltamethrin 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.
- The dose of active can be reduced by 50% by mixing with Silwet L-77 at the recommended rate without compromising efficacy.
- The addition of Silwet l-77 can increase the longevity of thiacloprid in the crop by up to seven days.
- Product label recommendations should be followed.

SCIENCE SECTION

Introduction

Background

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 60%. 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 and 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 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 then these components were synthesised. Lures containing two of the synthesised components attracted male *D. plicatrix* to traps but the single components were 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 card base and the septum is made of rubber with the two components incorporated. Traps should be placed 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.

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 reductions 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 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 HDC project only chlorpyrifos was effective, this 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 and now that it is available it may be possible to optimise the timing of spray application. In addition the applications were not part of a replicated experiment, although they were compared to an untreated control area. Also, chlorpyrifos does not fit well into IPM programmes during the growing/picking season due to its long harvest interval and negative effects on bees and other beneficial insects/mites. As midge larvae are well protected in leaf galls caused as a result of feeding, the products need to have some vapour, systemic or translaminar activity to kill the larvae.

Objective

To compare the efficacy of insecticidal products with or without a silicone wetter

Materials and methods

Sites

The raspberry plantation, Jubilee II, Hugh Lowe Farms, Barons Place, Mereworth, Maidstone, Kent, ME18 5NF

Experimental design and layout

The tunnels were approximately 140 m long with two rows of canes. Two tunnels were used for the trial. Plants were potted cv. Maravilla and were planted in 2011. The posts were 8.1 m apart and the rows 3.4 m apart. Plots were 8.1 m long and arranged end to end with two blocks of treatments in each of the target tunnels

Treatments

Treatments were individual sprays of the test products applied five days after a trap catch threshold of 10 male midges per trap was exceeded (17 April).

Two standard blackberry leaf midge sex pheromone traps (red delta trap with white sticky) were placed in the control areas of the trial (within 50 cm of the ground) and monitored twice weekly for catches of adult blackberry leaf midges from early March.

The threshold date (day 0) 17 April was the day when an average cumulative catch of 10 midges was recorded. Sprays were targeted against egg laying females. Treatments were individual sprays of the test products at different rates with or without the addition of Silwet L-77 applied five days after the trap threshold had been exceeded (22 April) (Table 1).

Table 1. Treatments and timings of applications 22 April (five days after a cumulative catch of 10 midges)

Treat No.	Product	Product dose (l/ha)
1	Chlorpyrifos (Equity) 480g/l EC	1.5 ml/l
2	Deltamethrin (Bandu) 25g/l EC	0.6 ml/l
3	Deltamethrin (Bandu) 25g/l EC+Silwet L-77	0.6 + 0.05 ml/l
4	Deltamethrin (Bandu) 25g/l EC+Silwet L-77	0.3 + 0.05 ml/l
5	Thiacloprid (Calypso)	0.750
6	Thiacloprid (Calypso) + Silwet L-77	0.750 + 0.05 ml/l
7	Thiacloprid(Calypso) + Silwet L-77	0.375 + 0.05 ml/l
8	Silwet L-77	0.05 ml/l
9	Untreated	-

Treatment application

Treatments were applied at 1000 l/ha using a Birchmier 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 7% 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

Treatment No.	Accuracy (%)
1	105%
2	103%
3	99%
4	104%
5	106%
6	104%
7	107%
8	93%

Assessments

The effects of the treatments were assessed on 29 April, 5 May and 12 May (seven, 13 and 20 days after the spray application). At each assessment 25 shoots per plot were collected at random across the plot and brought back to the laboratory, they were assessed for the number of leaves per shoot damaged by blackberry midge. Damaged shoots were dissected so that the numbers of larvae per gall could be counted.

Plot maintenance

The grower's 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). Relative humidity (RH)% was estimated from the dry and wet bulb temperature readings. In addition 2 lascar USB-502 loggers were deployed inside a Stevenson's screen within the crop 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	
		dry (^oC)	wet (^oC)	RH(%)	speed (Kmh^{-1})	direction
22 Apr	08:44	12	12	100	0	N/A
22 Apr	12:40	14	13	89.4	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 last week of March after which the population rapidly increased to above threshold in the second week of April triggering the spray applications (Fig. 2).

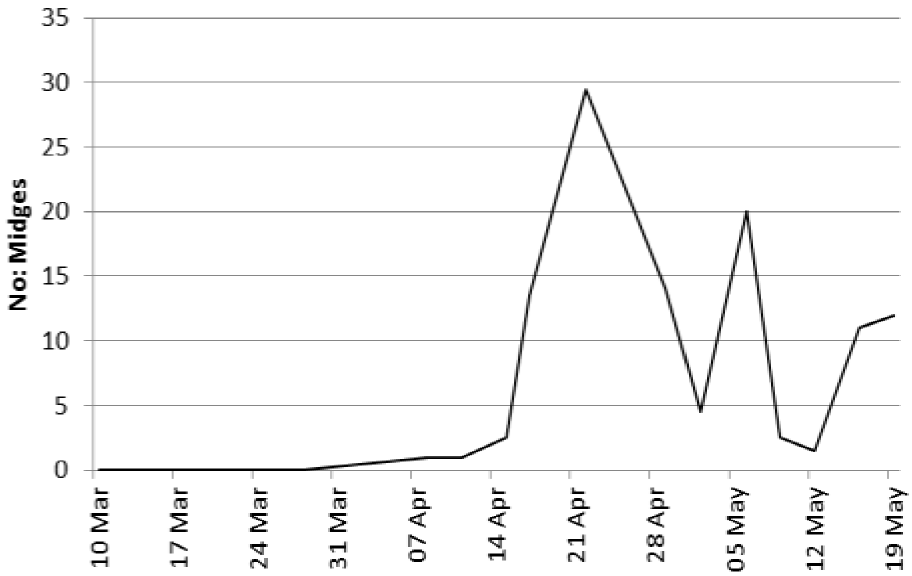

Figure 2. Mean numbers of male blackcurrant leaf midge caught on two pheromone traps placed in the crop

First assessment

On 29 April, seven days after the first spray application there was no damage to be recorded on any of the plots.

Second assessment

On 5 May, 13 days after the treatment application, blackberry midge damage and numbers of larvae (Table 4) were significantly reduced compared to the untreated control plots. All treatments (chlorpyrifos, deltamethrin and thiacloprid (the latter with or without Silwet), with the exception of Silwet L-77 applied alone gave significantly reduced the numbers of galled leaves (P ≤0.001), (Fig. 3) and the larvae within those leaves (P ≤0.001), (Fig. 4).

Table 4. Actual and square route transformed mean numbers of blackberry leaf midge galled leaves and larvae on 5 May, 13 days after the spray application. Different letters indicate significant difference

		Galls		Larvae	
Treatment	**Day**	**mean**	**√mean**	**mean**	**√mean**
Chlorpyrifos	1.5 ml/l	3	1.14 B	7.2	1.65 BC
Deltamethrin	0.6 ml/l	2	1.21 B	2.5	1.37 BC
Deltamethrin + Silwet L-77	0.6 + 0.05 ml/l	1.5	0.85 B	2.2	1.05 BC
Deltamethrin + Silwet L-77	0.3 + 0.05 ml/l	2.5	1.00 B	0.7	0.60 C
Thiacloprid	0.750	6.8	2.55 B	16.5	3.94 BC
Thiacloprid + Silwet L-77	0.750 + 0.05 ml/l	4.3	1.72 B	6.7	2.16 BC
Thiacloprid + Silwet L-77	0.375 + 0.05 ml/l	4	1.41 B	6.7	1.84 BC
Silwet L-77	0.05 ml/l	31.5	5.36 A	81.2	8.54 A
Untreated		37.5	5.42 A	54.5	6.80 A
Fprob			<0.001		<0.001
SED (24 df)			1.123		1.434
LSD (P = 0.05)			2.318		2.959

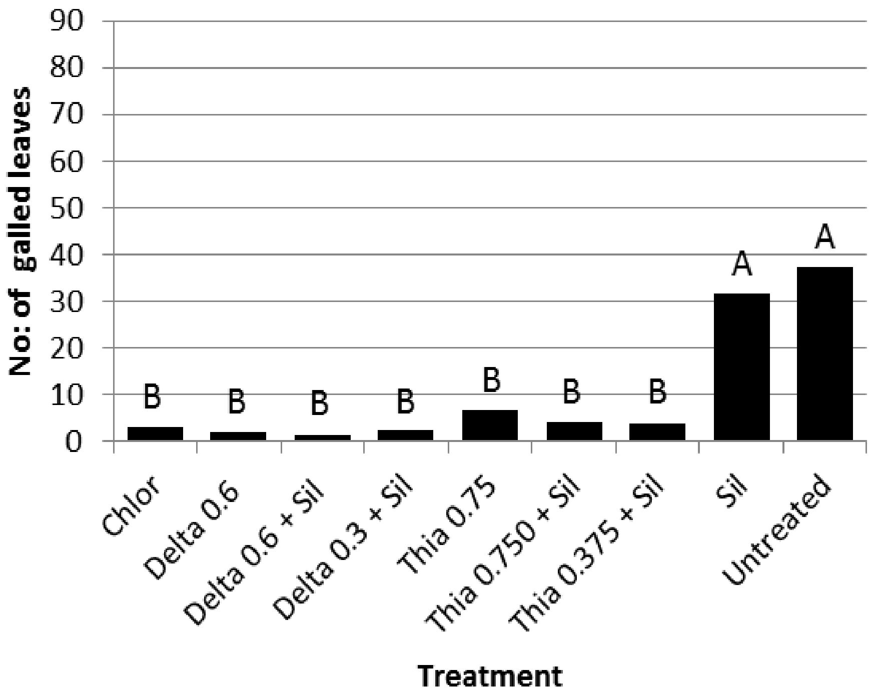

Figure 3. Mean numbers of leaves with gall damage on the 5 May, 13 days after the application of different rates of chlorpyrifos (Chlor), deltamethrin (Delta), thiacloprid (Thia) and Silwet L-77 (Sil). Different letters indicate significant difference

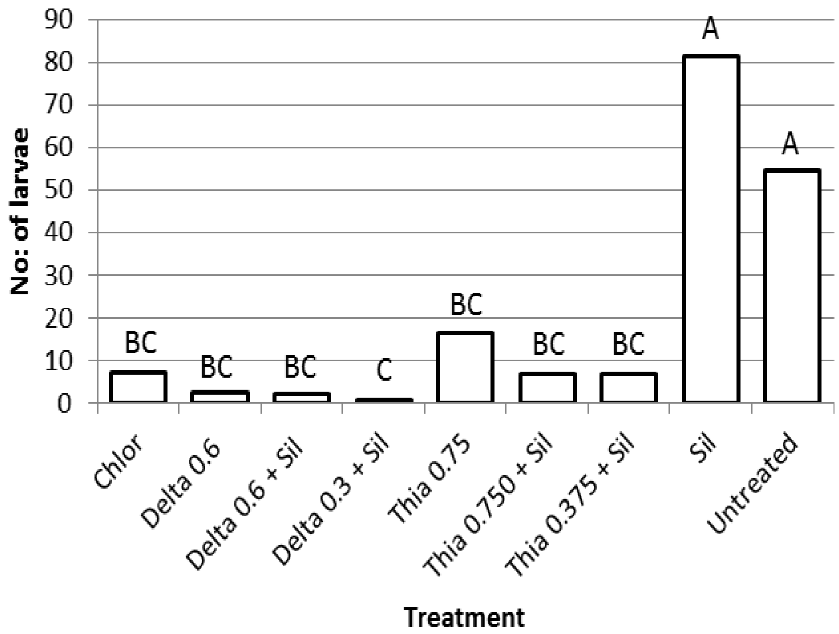

Figure 4. Mean number of larvae within 25 shoot tips on the 5 May, 13 days after the application of different rates of chlorpyrifos (Chlor), deltamethrin (Delta), thiacloprid (Thia) and Silwet L-77 (Sil). Different letters indicate significant difference

Third assessment

On 12 May, 20 days after the treatment applications, thiacloprid was no longer significantly different from the Silwet L-77 and untreated control for the amount of damage or the number of larvae in the leaf galls (Table 5). The deltamethrin treatments significantly reduced the amount of damage (Fig. 5) and the number of larvae in the galls (Fig. 6) with and without Silwet and at half dose deltamethrin with Silwet.

Table 5. Actual and square route transformed mean numbers of blackberry leaf midge galled leaves and larvae on 12 May 2014, 20 days after the spray application. Different letters indicate significant difference

		Galls		Larvae	
Treatment	**Day**	**mean**	**√mean**	**mean**	**√mean**
Chlorpyrifos	1.5 ml/l	11.5	3.35 BCD	25.5	5.00 BCD
Deltamethrin	0.6 ml/l	6.0	2.29 CD	8.0	2.65 CD
Deltamethrin + Silwet L-77	0.6 + 0.05 ml/l	6.8	2.14 CD	7.5	2.23 CD
Deltamethrin + Silwet L-77	0.3 + 0.05 ml/l	4.2	1.72 D	5.3	1.93 CD
Thiacloprid	0.750	38.5	5.97 AB	77.5	8.36 AB
Thiacloprid + Silwet L-77	0.750 + 0.05 ml/l	23.0	4.54 ABC	39.8	5.82 ABC
Thiacloprid + Silwet L-77	0.375 + 0.05 ml/l	24.0	4.80 ABC	46.0	6.61 ABC
Silwet L-77	0.05 ml/l	36.2	5.93 AB	72.2	8.27 AB
Untreated		43.5	6.18 AB	84.8	8.50 AB
Fprob			<0.001		<0.001
SED (24 df)			1.044		1.553
LSD (P = 0.05)			2.156		3.206

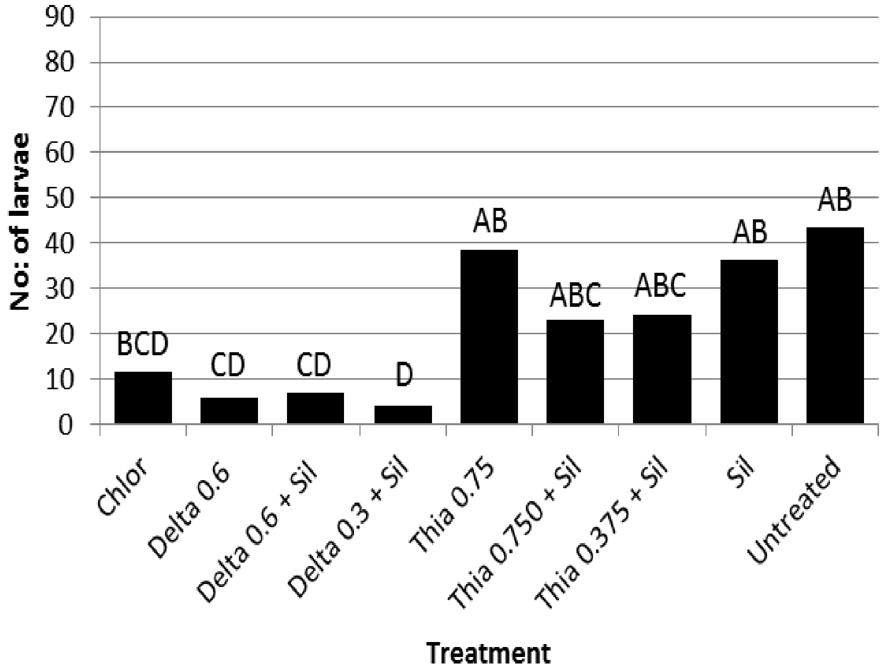

Figure 5. Mean number of leaves with gall damage on the 5 May, 13 days after the application of different rates of chlorpyrifos (Chlor), deltamethrin (Delta), thiacloprid (Thia) and Silwet L-77 (Sil). Different letters indicate significant difference

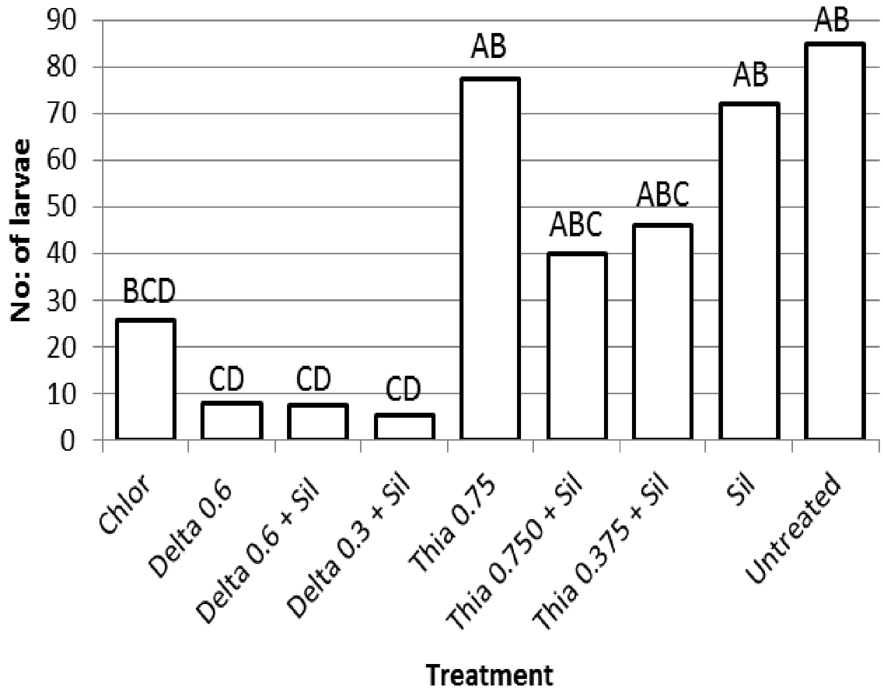

Figure 6. Mean number of larvae within 25 shoot tips on the 12 May, 20 days after the application of different rates of chlorpyrifos (Chlor), deltamethrin (Delta), thiacloprid (Thia) and Silwet L-77 (Sil). Different letters indicate significant difference

Discussion

Chlorpyrifos, deltamethrin and thiacloprid were all effective products for the control of blackberry leaf midge. Chlorpyrifos and deltamethrin are broad spectrum insecticides and have long retention times on the plant. All three products significantly reduced the number of larvae and the number of galls up to 13 days after application. Reduction of the rate of product and the addition of Silwet L-77 did not reduce levels of control. Both chlorpyrifos and deltamethrin significantly reduced the number of larvae and the number of leaf galls up to 20 days after application. Thiacloprid had a shorter persistence of efficacy (still active after 13 days but not after 20 days). The addition of Silwett L-77 to thiacloprid increased the duration of efficacy by seven days with fewer larvae and galls developing in these treatments.

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 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. The use of Silwett L-77 meant that the dose of insecticide applied could be halved with equal or greater efficacy.

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Appendix 1. Weather data for the duration of the trial measured using two lascar USB-502 data loggers