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Authentication

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

....
J V Cross

Date ....

East Malling Research is an Officially Recognised Efficacy Testing Organisation (Certification No. ORETO 0150)

Grower Summary

SF 59

Raspberry: Alternative insecticides for raspberry cane midge and raspberry beetle control

Year 3 (final report)
31 March 2006

SF 59

Raspberry: Alternative insecticides for raspberry cane midge and raspberry beetle control

Headline

- Calypso was found to be highly effective for raspberry beetle control, and was more effective than the standard insecticide chlorpyrifos.

- A single spray of Calyspso at first flower or at the green fruit growth stage greatly reduced larval infestation. Two sprays at these times virtually eliminated the pest. Calypso is comparatively safe to bees and can be applied to raspberries during flowering. A single spray might give optimal control but reduce the risk of the occurrence of residues in harvested fruit above reporting limits.

- Tracer was less effective than Calypso and appeared slightly less effective than chlorpyrifos. It is a shorter persistence product and it may be possible to use it nearer to harvest without leaving reportable residues. It may be that in practice, a combination of use of Calyspso before or during flowering and Tracer after flowering may give optimal results. The relationships between timing of spraying and the incidence of reportable residues need to be investigated.

- Calypso has a SOLA on outdoor raspberry.

- Chlorpyrifos gave excellent cont5rol of raspberry cane midge but none of the other treatments tested were sufficiently effective for commercial purposes and most were completely ineffective.

- Further work on insecticide controls for raspberry cane midge will be needed if chlorpyrifos is to be lost.

Background and deliverables

Raspberry beetle and raspberry cane midge are two of the most damaging pests of raspberry. Either pest can render production uneconomic in the absence of effective control measures. There is a virtual zero tolerance of raspberry beetle in fruit for the fresh market. Growers in the UK rely currently on a narrow range of broad-spectrum insecticides to control these pests. Chlorpyrifos (Dursban etc), deltamethrin (Decis etc) and rotenone (Derris) are approved for use currently for control of raspberry beetle. Chlorpyrifos (Dursban etc) is the only insecticide approved for control of raspberry cane midge. Alternative chemical control treatments need to be identified for both these pests. The activities of a range of alternative insecticides, including existing products approved for use on raspberry or other crops and novel compounds under development for use on UK horticultural crops, need to be evaluated for control of each pest. No trials screening modern pesticides are reported in the literature.

The expected deliverables from this project are:

- Identification of appropriate pesticide treatments for control of raspberry beetle and raspberry cane midge

Approval may be needed for some of the products identified.

Summary of the project and main conclusions

Replicated field experiments were conducted in 2003, 2004 and 2005 to screen alternative products for control of raspberry beetle and raspberry cane midge.

Raspberry beetle

In 2003, single sprays of Dynamec, Tracer , Talstar and Trigard applied at first pink fruit were tested in comparison with an untreated control and the approved products Dursban, Decis and Rotenone in an abandoned organic raspberry plantation in Kent. Raspberry beetle proved comparatively easy to kill with insecticides and all the products tested were effective

In 2004, programmes of three sprays (500 l/ha) of Aztec, Calypso, Decis, Dynamec, Lorsban, Plenum or Talstar were applied at fortnightly intervals at first flower, mid-flowering and the end of flowering to replicated plots in a heavily infested blackberry plantation near Norwich. A further treatment of two sprays of Tracer at the latter two timings only was also applied. Lorsban, Dynamec, Decis, Calypso, Talstar and Tracer were all highly effective for raspberry beetle control, reducing larval infestations and damage by > 95%. Dynamec, Claypso and Tracer provided three possible alternatives to the standard Lorsban and Decis treatments. The rate of application of Tracer that was tested in this trial was high. Trigard, Aztec and Plenum were at best only partially effective.

In 2005, sprays of Tracer, Calypso or Dynamec applied at first flower and/or at the green fruit growth stage were tested in comparison with a standard 2 spray treatment of Lorsban at both timings and untreated control in a trial in a heavily infested blackberry plantation in Norfolk.

Calypso was highly effective for raspberry beetle control, and was more effective than the standard insecticide Lorsban. A single spray of Calypso at first flower or at the green fruit growth stage reduced larval infestation by approximately 90%. Two sprays virtually eliminated the pest. Calypso is comparatively safe to bees and can be applied to raspberries during flowering. A single spray at this time might give optimal control but reduce the risk of the occurrence of residues in harvested fruit above reporting limits. The relationship between timing and numbers of applications of Calypso sprays and the occurrence of residues at harvest needs to be investigated on protected and open field raspberry crops. This work is needed before the optimal timing of application of Calypso for commercial use can be decided. Tracer (at the lower rate of 200 ml/ha/spray than used in previous trials) was less effective than Calypso and appeared slightly less effective than chlorpyrifos. However, it may still have a place in commercial raspberry beetle control. It is a shorter persistence product and it may be possible to use it nearer to harvest without leaving reportable residues. It may be that in practice, a combination of use of Calypso before or during blossom and Tracer after flowering may give optimal results.

Tracer is harmful to bees and cannot be used during flowering. It is selective to natural enemies, and has a favourable environmental and human safety profile. Dynamec was partially effective, two sprays being better than one. Its high risk to bees would preclude its use during flowering. These results were obtained in small plots surrounded by untreated guard areas where pest pressure was very high. It is likely that treatments would be more effective if applied on a commercial scale.

Raspberry cane midge

In the 2003 trial, two sprays of Decis, Dursban, Dynamec, Tracer (contains spinosad), Calypso, Mavrik, Trigard (contains cyromazine) and 60145C (contains fipronil) were sprayed against second generation cane midge attack on 24 June and 3 July 2003. Untreated controls were included. Only the standard product Dursban was effective. None of the other treatments gave a satisfactory standard of control though Mavrik significantly reduced larval numbers. It is assumed that Dursban is effective as it was able to kill the larvae inside the splits as well as kill adults and possibly prevent egg laying. Dursban contains particularly effective wetting agents and this may have aided penetration into the splits.

The trial in 2004 was unsuccessful because populations of the pest failed to develop despite an extended effort to provide artificial splits for oviposition. Sprays were applied at the appropriate time. The reason for this is unknown. The site was very heavily infested in 2003 and a successful trial conducted there. An additional site was sought for 2005 and the 2004 trial was repeated at the best site.

In 2005, two experiments were conducted in a commercial plantation of Glen Lion at Belks farm, Otham, Kent to test sprays of Lorsban WG, Talstar + LI700, Mavrik + LI700, NI25 (contains acetamprid), acrinathrin, Plenum or Dicarzol (contains formetanate) for control of raspberry cane midge. A sex pheromone trap for raspberry cane midge males (the first to be deployed in a commercial crop) was used to monitor midge activity through the season. For the first experiment done against the second generation of cane midge, artificial splits were made in canes on 21 June 2005 and single spray treatments were applied on 1 July 2005. The second experiment repeated the first experiment .but with two applications of the treatments. Artificial splits were made on 2 August 2005 and spray applications were made on 5 and 11 August.

The Lorsban treatment was effective reducing numbers of midge larvae by 95% and the results indicate that until an alternative is found it should remain the standard for commercial treatment for raspberry cane midge. Treatment with Talstar + LI700 (adjuvant) also reduced larval populations by 93%.. Synthetic pyrethroids have persistent harmful effects on natural enemies and their use is incompatible with IPM. However, adverse effects may be mitigated by directing sprays to the base of canes only. Use of adjuvants like LI700, which possibly aid penetration of insecticides into splits, needs further investigation. Though the reduction in cane midge larval infestation from the treatment with Talstar was not significant statistically, further investigation of this product is needed. None of the other products tested showed promise. Mavrik, which was partially effective in the 2003 trials was ineffective in the 2005 trials.

Financial benefits

Chlorpyrifos is relied on currently for control of raspberry beetle and cane midge in the UK but it is loosing its approval for use on the crop in 2008. If these pests cannot be controlled effectively, raspberry production would become uneconomic in the UK. Finding alternative treatments is crucial to the raspberry industry. This work has identified a highly effective treatment for raspberry beetle, the most important pest.

Action points for growers

Calypso should be used for raspberry beetle control in place of chlorpyrifos. Two sprays, at first flower and green fruit, should be used where raspberry beetle populations are high. A single spray should be sufficient in normal circumstances. The relationship between timing of spraying and occurrence of residues needs to be investigated.

No alternative to chlorpyrifos for raspberry cane midge control was identified in this work. However, the new raspberry cane midge sex pheromone traps available from EMR and NRI should be used by growers to improve spray decisions.

Introduction

Raspberry beetle *(Byturus tomentosus)* and raspberry cane midge (*Resseliella theobaldi*) are two of the most damaging pests of raspberry.

Either pest can render production uneconomic in the absence of effective control measures. Raspberry beetle has little effect on yield but there is a virtual zero tolerance of the presence of larvae or damage in ripe fruit in the market place. Raspberry cane midge does not attack the fruits directly and low populations may not cause significant crop damage and may go unnoticed. However, the pest can build up rapidly and cause severe damage weakening and killing canes which results in crop loss.

Growers in the UK rely currently on a narrow range of broad-spectrum insecticides to control these pests.

Chlorpyrifos (Dursban etc) (harvest interval = 14 days), deltamethrin (Decis etc) (harvest interval = zero days) and rotenone (Derris) (harvest interval = zero days) are approved for use currently for control of raspberry beetle. Derris is used mainly in organic production as it is of short persistence and hence is considered to be less effective. A sprays of one of these insecticides is applied at the green fruit or first pink fruit stage and may be repeated 10-14 days later. Such applications are uncomfortably close to harvest. If persistent broad-spectrum insecticides are sprayed onto raspberries close to harvest it is inevitable that residues will be detected on the harvested produce. If harvest intervals are observed, the residue should be below the MRL, but now all reportable residues, including those below the MRL are undesirable. Chlorpyrifos (Dursban etc), an OP insecticide, is not favoured by users, markets or consumers. It has a 14-day harvest interval and a maximum of two sprays per annum on raspberry. All these products, but especially deltamethrin (Decis), are harmful to biocontrol agents including *Phytoseiulus persimilis* predatory mites introduced to control two-spotted spider mite.

Chlorpyrifos (Dursban etc) is the only insecticide approved in the UK for control of raspberry cane midge. It is normal practice to apply a spray against the first generation of midges in spring according to the time of emergence predictions supplied by ADAS. The aim is to control the first generation adequately in order to prevent the second and third generation from being sufficiently numerous to cause significant damage. Sprays are directed to the base of the canes where most of the splits, and hence infestation, occurs.

Chlorpyrifos is due to lose its approval on raspberry in the UK in 2008 under the EU review of pesticides. Alternative chemical control treatments need to be identified for both of these pests.

In 2003, two replicated field experiments were conducted to screen alternative products for control of raspberry beetle and raspberry cane midge (Cross, 2003; Cross & Gordon, 2003). For raspberry beetle, single sprays of Dynamec, Tracer contains spinosad), Talstar (bifenthrin) and Trigard (cyromazine) applied at first pink fruit were tested in comparison with an untreated control and the approved products Dursban, Decis and Rotenone. Raspberry beetle proved comparatively easy to kill with insecticides and all the products tested were effective. For raspberry cane midge, two sprays of Decis, Dursban, Dynamec, Tracer (spinosad), Calypso (thiacloprid), Mavrik (tau-fluvalinate), Trigard and 60145C (fipronil) were sprayed against second generation attack on 24 June and 3 July 2003. Only the standard product Dursban was effective. None of the other treatments gave a satisfactory standard of control. It is assumed that chlorpyrifos is effective as it was able to kill the larvae inside the splits as well as kill adults and possibly prevent egg laying. Dursban contains particularly effective wetting agents and this may have aided penetration into the splits.

In 2004, two further replicated field experiments were conducted, one to screen alternative products for control of raspberry beetle and one for raspberry cane midge (Cross, 2005). For the raspberry beetle trial, programmes of three sprays (500 l/ha) of Aztec (triazamate), Calypso, Decis, Dynamec, Lorsban, Plenum (pymetrozine) or Talstar were applied at fortnightly intervals at first flower, mid-flowering and the end of flowering to replicated plots in a heavily infested blackberry plantation at Church farm, Tunstead. A further treatment of two sprays of Tracer at the latter two timings only was also applied. Lorsban, Dynamec, Decis, Calypso, Talstar and Tracer were all highly effective for raspberry beetle control, reducing larval infestations and damage by > 95%. The rate of application of Tracer that was tested in this trial was high. However, only two sprays were applied compared to three for the other treatments. Trigard, Aztec and Plenum were at best only partially effective and further investigation is not warranted. The raspberry cane midge experiment in 2004 was unsuccessful because populations of the pest failed to develop despite an extended effort to provide artificial splits for oviposition. The reason for this is unknown. Sprays were applied at the appropriate time. The site was very heavily infested in 2003 and a successful trial was conducted there.

The results of three further pesticide screening trials conducted in 2005, one evaluating insecticides for raspberry beetle control and the two evaluating insecticides for raspberry cane midge control are reported here.

Screening trial for products active against raspberry beetle, 2005

Methods and materials

In 2005, a single replicated field experiment was done to evaluate insecticides for control of raspberry beetle in a heavily infested blackberry plantation as follows:

Site

The trial was located in rows 1-6 of ‘No. 335’ blackberry plantation, at Grange Farm, Tunstead, Norfolk owned by Place UK Ltd.. The plantation was at National Grid Reference TG 2819 8465 (Landranger sheet 134). No. 335 is a blackberry plantation, cv Bedford Giant but with the eastern-most 2 rows (i.e. rows 1 and 2) of cv Loch Ness, which was planted 1993/94. The row spacing was 9’ = 2.75 m and the plant spacing in the row was 4’ = 1.22m. Posts and wirework are provided to support plants. Posts were after every 4 plants. The site was chosen because it was exceptionally heavily infested with raspberry beetle in 2004.

Treatments

Treatments were sprays of Tracer, Calypso or Dynamec at early flower on 14 June and/or at first green fruit on 14 July 2005 as shown in Table 1. A standard treatment with Lorsban at both timings and an untreated control was included.

Table 1. Treatments for the raspberry beetle trial in a blackberry plantation at Church Farm, Tunstead in 2005

Treat no.	Active substance and formulation	Product	Dose (/ha)	Timing (growth stage) of applications†
1	spinosad 480 g/l SC	Tracer	200 ml	FF
2				GF
3				FF+GF
4	thiacloprid 480 g/l SC	Calypso	250 ml	FF
5				GF
6				FF+GF
7	abamectin 18 g/l EC	Dynamec	500 ml	FF
8				FF+GF
9	chlorpyrifos 75% w/w WG	Lorsban WG	0.6 kg	FF+GF
10	Untreated			

†FF=first flower on 7 June 2005, GF=early green fruit on 14 July 2005

Spray application

Sprays were applied at a volume rate of 500 l/ha using a Birchmeier B 7014 air assisted knapsack sprayer fitted with a pink micron flow restrictor. Calibration of the sprayer before treatment application showed the sprayer delivered spray at a flow rate of 3.13 l/min. Measurement of the volume of sprayate in the tank before and after spraying each insecticide treatment showed that the volumes actually applied (and hence the doses) were generally within 10% of the required volume of 500 l/ha (Table 2).

Table 2. Accuracy of spray applications in the raspberry beetle trial†

Treatment	Accuracy of spray applications (%)†	
	7 June	14 July
Tracer FF	100	N/A
Tracer GF	N/A	90
Tracer FF+GF	96	90
Calypso FF	96	N/A
Calypso GF	N/A	102
Calypso FF+GF	96	102
Dynamec FF	94	N/A
Dynamec FF+GF	96	100
Lorsban FF+GF	96	96

†Values given relate to each spray tank filling required to complete the corresponding treatment(s)

Meteorological conditions

Records of dry and wet bulb temperature and of wind speed at 2 m height in the crop were taken immediately before and at the end of spray application, which took 3-4 hours, as shown in Table 3.

Table 3. Meteorological conditions at the times of spray application

	7 June 2005		14 July 2005	
	Start	End	Start	End
Air temp (°C)	12.2	14.6	27	22
RH (%)	65	61	71	90
Wind speed (kmph)	0	1	0	2

Experimental design

A randomised complete block experiment design with 4 replicates was used. Plots consisted of 8 adjacent plants in a row and were 9.8 m long. They were guarded on each side by an unsprayed guard row. Although all the plants in each plot received the appropriate treatment, assessments were only done on the central 4 plants in each plot.

Assessments

On 28 July and 3 August 2005, 2 and 3 weeks respectively after the last sprays had been applied, samples of approximately 200 ripe fruits were taken per plot, approximately 50 berries from each of the four plants in the centre of each plot. Each sample of approximately 50 berries was held in a small plastic punnet itself in an individual plastic bag to prevent larvae from escaping. The samples were transported to East Malling Research where they were held overnight at 4 ºC in a cold store. The following day, each individual fruit was examined for infestation and or damage by raspberry beetle. Damage on the calyx, plug and flesh were recorded separately. Thus for each punnet of fruit sampled from each plant on each sampling occasion, the following records were taken

Total number of berries
Number of berries infested by larvae
Number of berries with calyx damaged by raspberry beetle
Number of berries with plug damaged by raspberry beetle
Number of berries with flesh damaged by raspberry beetle
Number of berries damaged by raspberry beetle

Statistical analysis

The percentages of berries infested or damaged by larvae in each category were calculated for each of the two pick dates and for the totals of both picks. A generalised linear model with binomial distribution and logit link function was fitted to the count data for numbers of fruits assessed. Each treatment was thus compared to the untreated control and a t-test calculated for the estimated differences. An approximate F-probability was calculated from the treatment deviance ratio from the subsequent analysis of deviance.

Results

Larval infestation of berries

The analyses of deviance revealed highly significant treatment effects at both the first and second pick dates and for the mean data for both picks (Table 4). The Calypso treatments consistently gave the greatest reductions in the percentages of berries infested. Single applications of Calypso either at first flower or at green fruit reduced the mean percentages of berries infested by 87-94% (Table 4, Figure 1). Treatment with two sprays of Calypso at these timings virtually eliminated larval infestation and was more effective than the standard two spray treatment with Lorsban which reduced the percentage fruits infested by 87% (from 4.7% to 0.6% fruits infested) compared to the control. The two Tracer spray treatment reduced the larval infestation significantly but appeared less effective than the Calypso of Lorsban treatments, although differences between these treatments were not statistically significant. Other reductions compared to the untreated control (e.g. from the Tracer FF and Dynamec FF+GF treatments) were smaller and only significant at the $0.1 < p > 0.05$ level. These treatments were thus only partially effective.

Damage to berries

Treatment effects on the percentages of berries which had damage to the calyx, plug or flesh due to raspberry beetle larval infestation showed similar trends to those on larvae (Table 4, Figure 1). The Calypso treatments were the most effective, performing better than the standard two Lorsban spray treatment. The two Calypso spray treatment was again the most effective but it did not totally eliminate damage in this small plot trial situation. The Tracer and Dynamec treatments were considerably less effective than the Calypso or Lorsban treatments.

Discussion

In this experiment, the plots were relatively small and were each surrounded by untreated guard rows which were heavily infested with raspberry beetle adults. Raspberry beetle is highly dispersive and the plots were continuously under strong re-infestation pressure from ingress of beetles from the untreated adjacent rows. It is likely that treatments would have been more effective if applied to large areas. Thus, the very good results with the Calypso treatments in this situation indicate this product is highly effective against raspberry beetle. Less good results with the other treatments do not necessarily indicate that they would not be satisfactory for control in commercial crops on a larger scale or with lower pest pressure.

The likelihood of occurrence of reportable residues in fruit at harvest is an important consideration in choice of raspberry beetle treatment for commercial crops. The current standard treatment with chlorpyrifos at the green to pink fruit stage results in chlorpyrifos residues above the reporting limit of 0.01 mg/kg in > 20% of UK produced raspberry fruit samples. One important reason for seeking alternative treatments to chlorpyrifos for raspberry beetle control is to reduce the incidence of reportable pesticide residues, as is being increasingly demanded by the market. The residues that result from treatment with Calypso before and/or after flowering need to be investigated. This work indicates that a single treatment with Calypso at first flower gives good control of raspberry beetle. It would be fortunate if pre-flowering application did not result in detectable residues. Calypso is classified as not harmful to bees. It may be possible to improve efficacy slightly by making applications during flowering if necessary. This may be preferable to application of two sprays one before and one after flowering.

Tracer gave good control of raspberry beetle in the trial conducted as part of this project in 2004 where it was used at the higher rate of 600 ml/ha/spray. In the 2005 trial, it was used at a rate of 200 ml/ha/spray, as advised by the parent company, Dow AgroSciences. It performed less well at this lower rate. However, though less effective than either Calypso or Lorsban, it may still have a place in commercial raspberry beetle control. It is a shorter persistence product and it may be possible to use it nearer to harvest without leaving reportable residues. It may be that in practice a combination of use of Calypso before or during blossom and Tracer after flowering may give optimal results. However, Tracer is harmful to bees and cannot be used during flowering. The protracted flowering period of some varieties may make it difficult to use. Raspberries are highly attractive to both honey bees and bumble bees and use of pesticides harmful to bees during flowering must be avoided.

Conclusions and recommendations (raspberry beetle)

- Calypso was highly effective for raspberry beetle control and was more effective than the standard insecticide chlorpyrifos (Lorsban). A single spray of Calypso at first flower or at the green fruit growth stage reduced larval infestation by ~90%. Two sprays virtually eliminated the pest.
- Calypso is comparatively safe to bees and can be applied to raspberries during flowering. A single spray at this time might give optimal control and reduce the risk of the occurrence of residues in harvested fruit above reporting limits.
- The relationship between timing and numbers of applications of Calypso sprays and the occurrence of residues at harvest needs to be investigated on protected and open field crops. This work is needed before the optimal timing of application of Calypso for commercial use can be decided.
- Tracer (at the lower rate of 200 ml/ha/spray than used in previous trials) was less effective than Calypso and appeared slightly less effective than chlorpyrifos. However, it may still have a place in commercial raspberry beetle control. It is a shorter persistence product and it may be possible to use it nearer to harvest without leaving reportable residues. It may be that in practice a combination of use of Calypso before or during blossom and Tracer after flowering may give optimal results. However, Tracer is harmful to bees and cannot be used during flowering.
- Dynamec was partially effective, two sprays being better than one. Its high risk to bees would preclude its use during flowering.

- These results were obtained in small plots surrounded by untreated guard areas where pest pressure was very high. It is likely that treatments would be more effective if applied on a commercial scale.

Table 4. Mean % blackberry fruit infested and damaged by raspberry beetle.

Treatment	% berries infested	% berries damaged		
		calyx	plug	flesh
1st pick				
Tracer FF	2.2*	5.4	4.4†	10.2
Tracer GF	4.6	17.2	12.2	26.1
Tracer FF+GF	1.0*	9.2	6.9	14.7
Calypso FF	0.3*	2.0†	1.1*	3.5†
Calypso GF	1.0*	1.3*	1.6*	5.4†
Calypso FF+GF	0.0*	0.5*	0.3*	1.5*
Dynamec FF	1.5*	11.1	8.8	18.9
Dynamec FF+GF	2.6†	5.4	5.4	9.6
Lorsban FF+GF	1.0*	4.1	3.2†	6.4
Control	7.4	13.1	13.0	17.2
Fprob	0.002	0.010	0.019	0.012
2nd pick				
Tracer FF	1.5	8.7	4.6	12.5
Tracer GF	0.9	9.0	6.2	16.1
Tracer FF+GF	0.9	7.0	3.6	12.4
Calypso FF	0.4†	1.9*	1.2†	2.5**
Calypso GF	0.2†	2.5*	1.3†	4.8*
Calypso FF+GF	0.0*	0.1*	0.1†	1.0**
Dynamec FF	3.0	14.2	9.8	24.2
Dynamec FF+GF	1.0	4.8	5.3	12.7
Lorsban FF+GF	0.3†	3.3†	2.7	7.4†
Control	1.7	11.5	8.1	17.7
Fprob	0.003	0.005	0.025	<0.001
Average				
Tracer FF	1.9†	7.0	4.5	11.4
Tracer GF	2.7	13.1	9.2	21.1
Tracer FF+GF	0.9*	8.2	5.3	13.5
Calypso FF	0.3*	2.0*	1.2*	3.0*
Calypso GF	0.6*	1.9*	1.5*	5.1*
Calypso FF+GF	0.0**	0.3**	0.2**	1.1**
Dynamec FF	2.2	12.6	9.2	21.5
Dynamec FF+GF	1.8†	5.1	5.4	11.1
Lorsban FF+GF	0.6*	3.7†	3.0	7.0†
Control	4.7	12.3	10.6	17.4
Fprob	0.003	0.007	0.014	0.002
Significantly less than control † = P<0.1 *= P<0.05, ** = P<0.01				

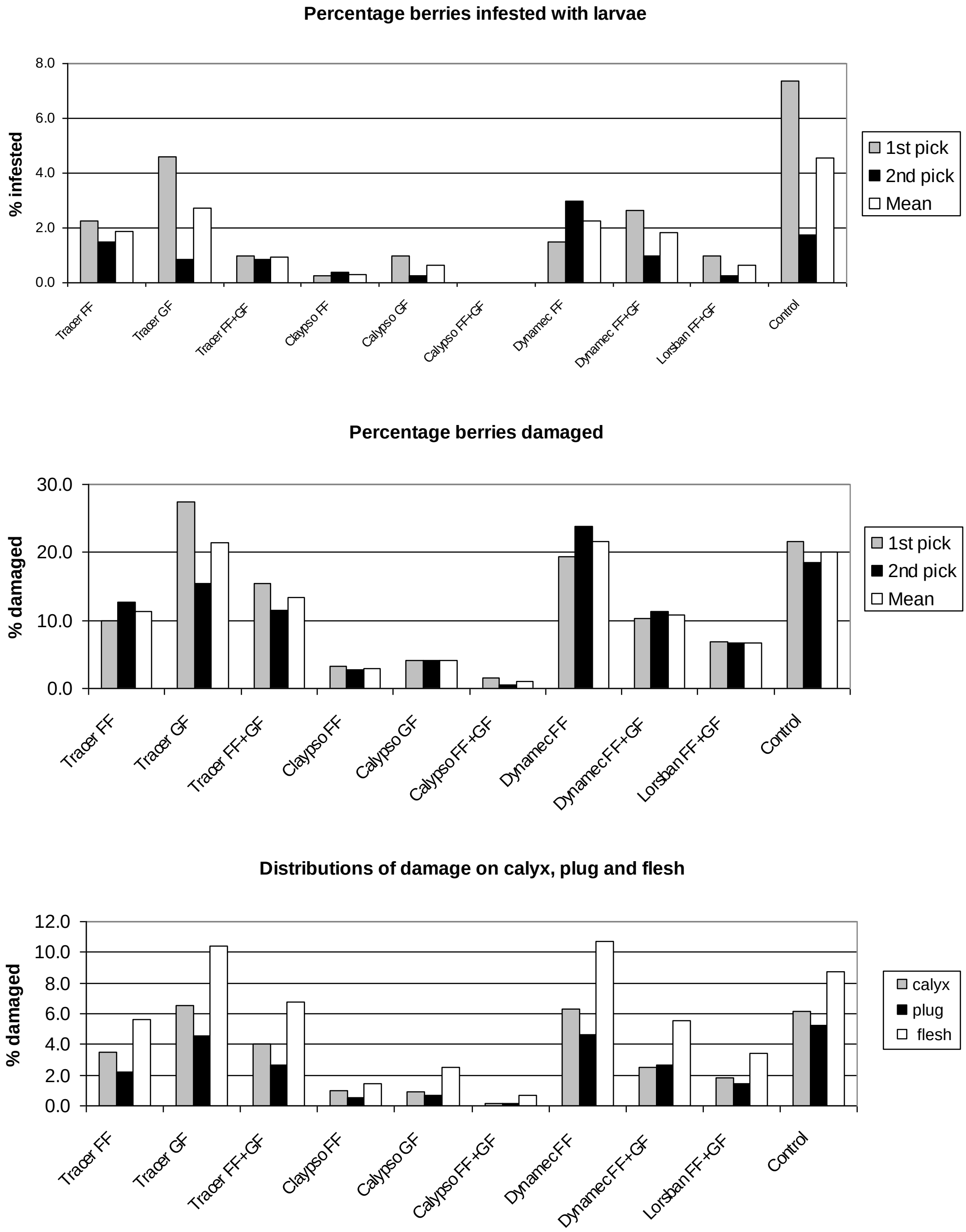


Figure 1. % Berries infested and damaged by raspberry beetle and distribution of % damage on calyx, plug and flesh of berries

Screening trials for products active against raspberry cane midge, 2005

Methods and materials

Site

The experiment was located in a Glen Lion raspberry plantation at Belks Farm, Otham, Maidstone, Kent. The plantation consisted of 15 rows of raspberries, 40 m long. The row spacing was 1.2 m. The plantation was chosen because the variety is susceptible to cane midge and the plantation had been heavily infested with raspberry cane midge in 2004. The fruiting canes were removed from the plantation in April before the trial commenced as they were not needed for the experiment which was done on the current season's primocanes.

Monitoring midge populations

ADAS midge warnings issued by Stuart Bennett, ADAS Wolverhampton, based on air temperature interpolated from local met stations predicted first emergence of the first generation to be on 5 May 2005.

Pheromone trap: A raspberry cane midge sex pheromone trap (standard white delta trap with a polythene dispenser containing 100 µg of a blend of the racemic major component of the raspberry cane midge sex pheromone and the three c11 minor components each at 30% of the major component) was deployed in the centre of the experimental plot at a height of 0.5 m above the ground on 11 May 2005. The number of males captured each week was recorded (Fig. 2).

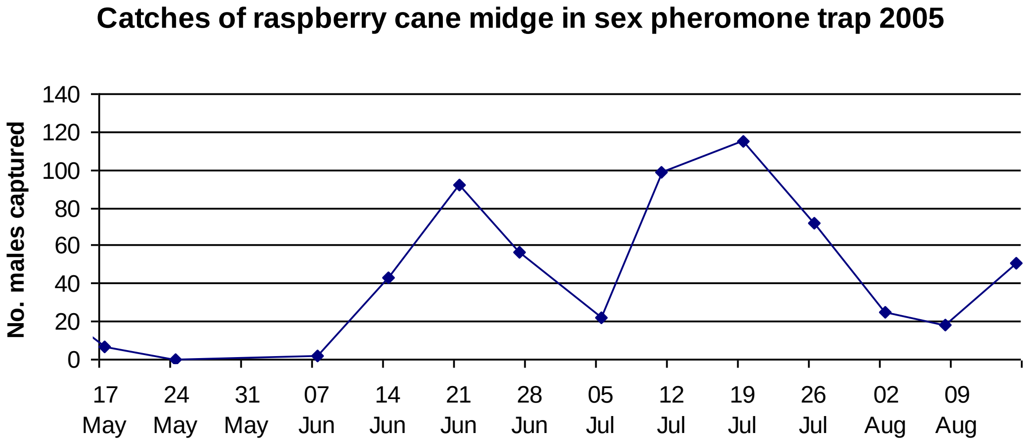


Figure 2. Sex pheromone catches of male? raspberry cane midge males in the experimental plantation. The trap was first deployed on 11 May 2005.

Oviposition in artificial splits: At least weekly from 21 April to 2 August 2005, artificial splits were made in 10 canes in each of three well separated areas of the experimental area. Splits from the previous week were collected and examined in the lab under a binocular microscope for raspberry cane midge eggs. Unfortunately, no eggs were found throughout the period of the first generation in May. It was therefore decided to delay the application of treatments until the second generation. Weekly monitoring was continued seeking the second generation attack for application of treatments. On 26 July, small numbers of eggs and young larvae were found in about 10% of the artificial splits. This prompted application of treatments at the earliest opportunity the following week

Treatments

On 11 May 2005, shortly after the predicted start of the first generation flight, an artificial split approximately 3-5 cm long was made in each of 20 primocanes per plot. No eggs or larvae were found subsequently in these splits so the experiment was delayed until the second generation.

Experiment 1 was done against the second midge generation, artificial splits were made in 25 canes per plot on 21 June 2005. The spray treatments were applied on 1 July 2005. Treatments were a single spray of a range of 7 insecticides as shown in Table 5.

Experiment 2 repeated Experiment 1 on the same plots with the same allocation of treatments to plots as in experiment1. Artificial splits were made in 30 canes (Different to those in Exp 1) per plot on 2 August 2005 and spray applications were made on 5 and 11 August. Treatments were thus two sprays of the same range of 7 insecticides as shown in Table 5.

Table 5. Treatments applied in Experiment 1 and 2 at Belks Farm, Otham in 2005. Note in the first experiment, sprays were applied once on 1 July and in the second experiment they were applied twice on 5 August and 15 August 2005.

Treat no.	Active substance and formulation	Product	Product dose (/ha)
1	Chlorpyrifos 75% w/w WG	Lorsban WG	0.6 kg
2	Bifenthrin 100 g/l EC + Li700	Talstar+LI700	0.5 litres+2.5 l
3	Taufluvalinate 240 g/l EW + Li700	Mavrik+LI700	200 ml+2.5 l
4	Acetamprid	NI25	250 g
5	Acrinathrin 75 g/l EW	Acrinathrin	1.2 l
6	Pymetrozine 50% w/w WG	Plenum	300 g
7	Formetanate	Dicarzol	2000 g
8	Untreated	-	-

Spray application

Sprays were applied in a volume of 1000 l/ha using a Birchmeier B 7014 air assisted knapsack sprayer fitted with a pink micron flow restrictor delivering 3.13 l/min. Plots were sprayed for 24 seconds each (12 seconds/side) to deliver 1.25 litres of spray per plot.

Experiment design

A randomised block experiment design was used with 4 replicates. Plots were 10m lengths of single row, arranged end to end in a block, and were guarded on each side by an unsprayed guard row.

Assessments

For the first experiment, 20 primocanes each bearing at least one artificial split were sampled from the central area of each plot on 14 July 2005. They were held in a fridge in the laboratory at EMR until 18-19 July when the numbers of larvae and eggs in each split were counted under a binocular microscope. The length of each split was also measured to the nearest 0.5 cm so that the densities of larvae and eggs per 10 cm length of split could be calculated.

For the second experiment, sampling was done on 15 August 2005 and the same procedure followed for counting egg and larval densities in the laboratory.

Statistical analyses

The total number of eggs and larvae per 10 cm of split were calculated and analyses of variance were done on the data after $\log_{10}(n+0.1)$ transformation to stabilise variances. As the smallest value in the second experiment was 0.082, the addition of an increment to allow for logging zero depended on the size of the smallest non-zero data value. An increment of 1 would have been appropriate for counts where the smallest value was 1, but for these analyses a more appropriate increment was 0.1. This had the disadvantage of giving some negative means on the transformed scale, but the statistical tests were more appropriate using this scale. Back-transformed densities were calculated for information.

Results

Experiment 1

Numbers of eggs and larvae were small (overall average of 1.87 larvae and 0.03 eggs per 10 cm of split) (Table 6, Fig 3a). No statistically significant treatment differences were revealed by the analyses of variance of the $\log_{10}(n+0.1)$ transformed numbers of larvae plus eggs. However, it should be noted that the lowest numbers occurred in the Lorsban and Mavrik treatments.

Table 6. Mean numbers of larvae per 10 cm of cane split in the first raspberry cane midge experiment on 18 July 2005, 17 days after treatment application.

	Larvae	Eggs	Total
Lorsban	0.97	0.05	1.02
Talstar+LI700	3.09	0.00	3.09
Mavrik+LI700	1.16	0.00	1.16
NI25	2.02	0.03	2.05
Acrinathrin	2.28	0.00	2.28
Plenum	2.02	0.06	2.08
Dicarzol	1.38	0.01	1.39
Control	2.06	0.05	2.11

Experiment 2

There was an average of 2 larvae per 10 cm of split when the second experiment was assessed on 15 August 2005, and very few eggs (Table 7, Fig 3b). Analysis of variance of the $\log_{10}(n+0.1)$ transformed data showed significant treatment effects ($P < 0.05$) (Table 8). The Lorsban treatment reduced numbers of larvae + eggs significantly (by 95%) compared to the untreated control. The reduction by Talstar+LI700 was only significant at the $p<0.10$ level. The reduction by acrinathrin was not statistically significant.

Table 7. Mean numbers of larvae per 10 cm of cane split in the second raspberry cane midge experiment on 15 August 2005, 10 days after first spray application and 3 days after the second.

	Larvae	Eggs	Total
Lorsban	0.19	0.00	0.19
Talstar+LI700	0.27	0.00	0.27
Mavrik+LI700	4.96	0.02	4.98
NI25	2.27	0.07	2.34
acrinathrin	0.48	0.01	0.50
Plenum	2.40	0.01	2.41
Dicarzol	1.73	0.02	1.75
control	3.74	0.00	3.74

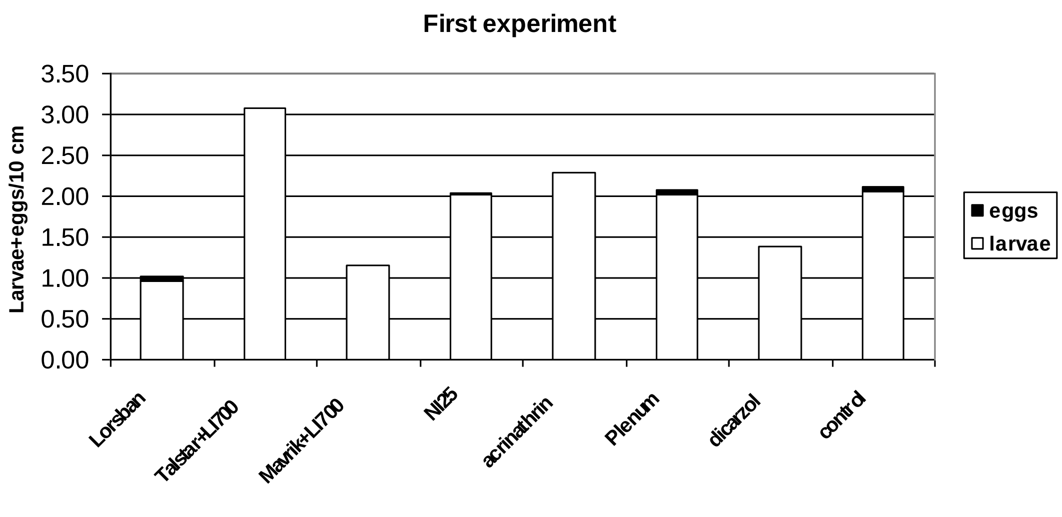
Table 8. Mean $\log_{10}(n+0.1)$ transformed numbers of larvae and larvae plus eggs per 10 cm of cane split in the second raspberry cane midge experiment on 15 August 2005, 10 days after first spray application and 3 days after the second. Back-transformed values are given in parentheses

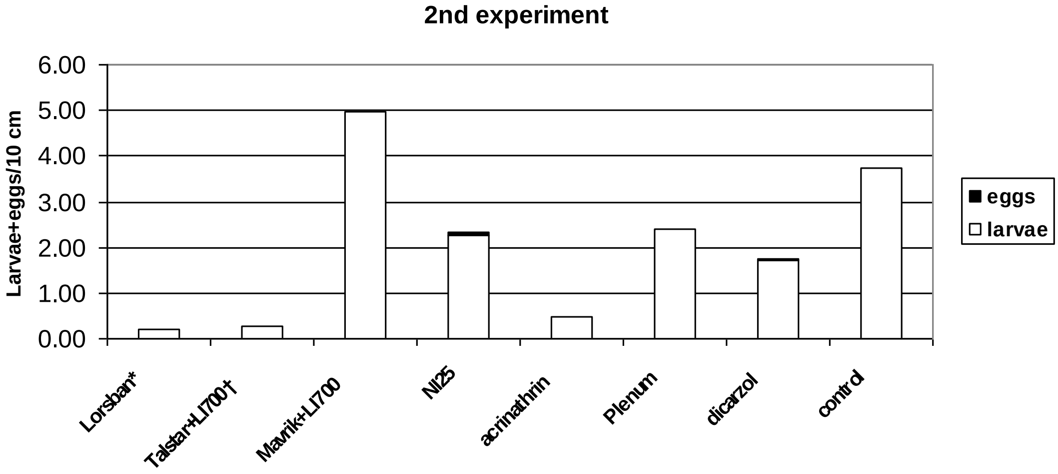
Treatment	Larvae		Total	
Lorsban	−0.711*	(0.095)	−0.771*	(0.095)
Talstar	−0.539	(0.189)	−0.539	(0.189)
Mavrik	0.607	(3.944)	0.612	(3.993)
N125	0.241	(1.642)	0.266	(1.746)
acrinathrin	−0.441	(0.262)	−0.438	(0.265)
Plenum	0.183	(1.426)	0.184	(1.428)
Dicarzol	−0.058	(0.776)	−0.044	(0.804)
Control	0.147	(1.304)	0.147	(1.304)
SED(27df)	0.3528		0.3529	
LSD(P=0.05)	0.734		0.734	
Fprob	0.016		0.015	

* Significantly less than the control P<0.05

Conclusions

- The Lorsban treatment was effective and reduced numbers of midge larvae by 95% and the results indicate that it should remain the standard for commercial treatment for raspberry cane midge until alternatives can be identified.
- Treatment with Talstar + LI700 also reduced larval populations by 93%, but the statistical significance of this effect was lower than the normal P=0.05 threshold accepted. Synthetic pyrethroids have persistent harmful effects on natural enemies and their use is incompatible with IPM. However, adverse effects may be mitigated by directing sprays to the base of canes only.
- Use of adjuvants like LI700, which possibly aid penetration of insecticides into splits, needs further investigation.
- Though the reduction in cane midge larval infestation from the treatment with acrinathrin was not significant statistically, further investigation of this product is needed to validate these results and to explore dose rate and admixture with adjuvants.
- None of the other products tested show promise. Mavrik, which was partially effective in the 2003 trial done as part of this project, was ineffective in these 2005 trials.





Figures 3a&b. Mean numbers of raspberry cane midge larvae + eggs recorded in the first and second experiments in 2005. *= significantly less than control P<0.05 † = significantly less than control P<0.10

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