Project Title:	Evaluation of insecticides for control of selected apple and pear pests 2003-2004
Project Number:	TF 145
Report:	Final report, 20 December 2004
Previous reports:	TF145: Year 1 annual report 2003
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Date Project commenced:	1 April 2003
Date completion due:	31 December 2004
Key words:	Evaluation, insecticides, pesticides, control, apple, pear, pests, pear midge, *Contarinia pyrivora*, woolly aphid, *Eriosoma lanigerum*, *Blastobasis decolorella*, codling, *Cydia pomonella*.

CONTENTS

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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.

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GROWER SUMMARY

Headline

Six replicated orchard experiments in 2003 and 2004 screened insecticides for control of pear midge, woolly aphid, *Blastobasis*, codling moth and summer fruit tortrix moth.

For woolly aphid, post blossom spray application was found to be more effective than pre-blossom application. Chlorpyrifos (Lorsban, Dursban) and Aphox controlled woolly aphid effectively. Calypso was ineffective and Aztec gave mixed results. A higher volume (500 l/ha) spray of Lorsban admixed with the adjuvant LI-700, applied pre-blossom in 2004, also gave significant control of woolly aphid but the adjuvant alone or especially in admixture with the Lorsban, caused significant fruit russeting to Cox. No adverse effects were found on populations of key natural enemies.

For *Blastobasis*, in 2003, Dursban, Runner and Tracer applied in early June, gave good control. In 2004, a programme of three insecticide sprays, the first of Insegar, the second and third of Lorsban, gave the best control of first generation codling moth.

For pear midge, no meaningful results were obtained.

Background and deliverables

Effective pesticide products need to be identified for control of several pome fruit pests, including pear midge, woolly aphid and caterpillars of the moth *Blastobasis decolorella*. Since the withdrawal of HCH and carbaryl, no effective treatment has been identified for pear midge, which is a localised pest in some pear orchards, notably of the variety Comice. Woolly aphid was a serious problem in 2002 and many growers struggled to control it. Comparisons of the efficacy of existing approved products are needed, including the benefits of pre- versus post blossom treatment and possible harmful effects on the key natural enemies of woolly aphid, earwigs and the parasitoid *Aphelinus mali*. *Blastobasis* is a localised but very damaging pest of apple, particularly Bramley and Egremont Russet and other short-stalked varieties. Growers have relied on routine sprays of chlorpyrifos (Dursban etc) to control this pest. The efficacy of the newer Insect Growth Regulators Insegar and Runner needed to be investigated as well as optimum timing for spraying.

The expected deliverables from this project are:

- Identification of appropriate pesticide treatments for control of pear midge, woolly aphid, *Blastobasis* and the most effective insecticides for codling moth

Approval may be needed for some of the products identified.

Summary of the project and main conclusions 2003/2004

During 2003/2004, various insecticide products were tested for control of pear midge, *Blastobasis*, codling and tortrix moths and woolly aphid in orchard experiments. Three experiments were conducted each year, one against each pest group. The effects of the treatments on the natural enemies of woolly aphid were also investigated.

Pear midge

Talstar, Dursban, Tracer, Calypso, Derris, Toppel 10, XL-All 95% Nicotine and Hallmark were tested against pear midge in two replicated experiments done in Comice pear orchards in Kent and Worcestershire in 2003 and 2004, respectively. In the experiments two sprays of each product were applied at the green bud and white bud stages respectively, shortly before flowering. Unfortunately, significant pest attacks failed to develop in both experiments, even though the two orchards had been heavily infested the previous season. It is suspected that weather conditions in the pre-blossom period when oviposition occurs were poor and did not favour the pest. Therefore, the two trials yielded insufficient results to draw conclusions about the efficacy of the treatments.

Experiences from other countries suggest that Calypso applied pre-bloom is highly effective for control of pear midge. Calypso is not approved for use on pear in the UK. Further trials are needed to support the case for a SOLA, justified by efficacy against pear midge. It is likely that residue data would also need to be generated. In addition, experimental work to elucidate the pear midge sex pheromone would provide a valuable means of monitoring attacks by this pest.

***Blastobasis*, Codling moth and Summer Fruit Tortrix moth**

In 2003, *Bacillus thuringiensis* (Dipel), Runner, Insegar, Tracer and Insegar were evaluated for control of *Blastobasis decolorella* in a large plot, replicated experiment in an infested Bramley orchard in East Kent. Single sprays were applied either on 19 June during the egg-hatch period or on 4 August when caterpillars were semi-mature before harvest. All treatments had some effect but the early spray timing in June was consistently more effective than the later application in August. Dursban and Runner and Tracer were the most effective products.

In 2004, a good site for a *Blastobasis* experiment could not be found. After agreement with the HDC, it was decided to evaluate three different programmes of insecticide sprays for control of a range of caterpillar pests including codling moth, summer fruit tortrix moth and, if it occurred, *Blastobasis*. A large-scale replicated orchard trial was done in a Bramley orchard in Kent. The spray programmes evaluated as treatments were three sprays of Runner, three sprays of Tracer or a spray of Insegar followed by two sprays of Lorsban. The spray programmes were applied against the first generations of codling and summer fruit tortrix moth, at fortnightly internals in June using appropriate timings as indicated by pheromone trap catches.

Despite a very heavy flight of codling moth (peak catch 104 moths between May 26 and June 2) very little codling moth and almost no tortrix moth damage could be found at the end of the first generation attack in July. It was decided not to apply any sprays against the second generation so that differences in control in the first generation could be exposed and magnified in the second generation. This tactic was effective and statistically significant differences between treatments in the levels of damage by codling moth and summer fruit tortrix moth were found at harvest.

The Insegar/Lorsban/Lorsban treatment was most effective, with a second generation codling attack of 5% compared to 14% on the control. Runner and Tracer gave intermediate results.

This work provides a useful reminder that the second generation codling moth attack can be very damaging as the fruit is more susceptible when it is more mature. A comparatively small flight of moths can cause seemingly disproportionate damage. Growers need to place more emphasis on control of the second generation.

Woolly aphid

There has been an increased incidence of woolly aphid outbreaks in recent years, which might be explained by the decline in use of chlorpyrifos. The aim therefore was to evaluate pre and post blossom sprays of approved insecticides, to examine the benefits of adjuvants and to determine effects of treatments on the two key natural enemies of woolly aphid: the parasitic wasp *Aphelinus mali* and the common European earwig. Two replicated orchard experiments, one in 2003 and one in 2004, were done in different areas of an infested Cox orchard near Faversham, Kent.

In 2003, single sprays (200 l/ha) with Dursban, Orosorb oil (orange oil), Aphox, Calypso or Aztec were applied pre-blossom on April 15 versus post-blossom on June 18. The pre-blossom sprays did not significantly reduce woolly aphid populations but the post blossom sprays with Aphox and Dursban significantly reduced infestations by over 50%. Aztec, Calypso and Orosorb oil were ineffective.

In 2004, sprays were applied at 500 l/ha and the adjuvant LI-700 was included in combination with the four insecticides or applied alone (Orosorb oil was not tested). Treatments were two sprays of each product, applied before blossom on April 23 and after blossom on June 30. For the pre-blossom spray, best results were obtained with Lorsban. Post-blossom sprays with Aphox or Aztec also gave good results. Calypso was ineffective.

Unfortunately, the LI-700 treatment caused a significant increase in fruit russeting, particularly around the stalk and to a lesser extent around the calyx of the Cox apples. The russeting was exacerbated by the admixture of the LI-700 adjuvant with pesticides, most markedly when mixed with Lorsban.

No adverse effects of the treatments on natural enemies were detected in either experiment. In July 2003, > 50% parasitism by *A. mali* occurred on all plots but the levels of predation by earwigs were very low and the effects of treatments could not be determined.

Financial benefits

Use of ineffective treatments for control of any of these pests could result in substantial losses in yield and quality. In the extreme, the entire crop from a particular orchard might be lost, though typical losses are usually less than 10%. A 10% loss from a 20 tonne/ha Cox crop worth £400/tonne to the grower would cost the grower £800/ha.

Action points for growers

- Runner has been shown to be an effective approved product for the control of *Blastobasis*. Sprays should be applied during egg hatch and the early stages of caterpillar development and not be left until caterpillars are semi-mature in August. Further work to confirm these findings is needed.
- A programme of sprays of Insegar followed by chlorpyrifos, is a most effective treatment strategy for codling moth.
- Chlorpyrifos (Dursban etc) and Aphox are the most effective treatments for control of woolly aphid. Post blossom spraying is more effective than pre-blossom spraying. Higher volume spraying (500 l/ha) and the use of the adjuvant LI-700 are likely to improve efficacy of woolly aphid control. Further work to confirm these findings is needed.

SCIENCE SECTION

I Evaluation of insecticides for control of pear midge 2004

Summary

A single replicated small plot experiment was conducted in a pear orchard at Pullens Farm, Ridgeway Cross, Worcester (courtesy of Mr Nigel Kitney). The pear orchard (cv Comice) had a history of pear midge infestation, against which the following insecticide products were evaluated: Talstar, Lorsban, Tracer, Calypso, Py Insect Killer, Toppel 10, XL-All 95% Nicotine and Hallmark. Two foliar sprays of each product were applied at a volume rate of 500 l/ha at the green and white bud growth stages on 24 March and 8 April 2004, respectively. The numbers of pear fruitlets damaged or infested with pear midge larvae was assessed on 3 June 2004.

Even though the site had been heavily infested in the previous season, a significant pest attack failed to develop. It is suspected that the weather conditions were poor in the pre-blossom period and did not favour the pest. Therefore, the trial yielded insufficient results to draw conclusions about the efficacy of the treatments.

Introduction

The biology and control of pear midge were reviewed in detail in the first report of this work (Cross, 2003). In the first year of this project (2003), two foliar sprays (500 l/ha) of Talstar, Dursban 4, Tracer (spinosad), Calypso, Derris, Toppel, XL All 95% nicotine and Hallmark were applied to a Comice pear orchard in Kent at the green and white bud growth stages on 27 March and 11 April 2003, respectively.

Only a very light infestation of pear midge developed in the 2003 trial, insufficient to test the efficacy of the treatments and draw sound conclusions**.** Derris, Toppel and Nicotine had similar or greater total numbers of infested fruitlets compared to the untreated control**.** The smallest total number of infested fruitlets was found on the plots treated with Calypso.

Objective of this work

Here we report the results of a single replicated orchard experiment done in 2004 to evaluate the efficacy of 8 insecticide products for preventive control of pear midge.

Materials and Methods

The experiment was done in a commercial orchard in 2004 as follows:

Site

Pullens Farm, Ridgeway Cross, Worcester, courtesy of Mr Nigel Kitney. The orchard had alternate rows of the cultivars Comice and Conference. Only the Comice was used for this experiment. The tree density was 1481 trees/ha. The site had a heavy pear midge attack the previous season.

Treatments

Treatments comprised two applications of each insecticide at green and white bud stage on 24 March and 8 April 2004 respectively.

Treatments tested are shown in Table 1.

Table 1. Treatments

Product	Product dose (/ha)	Concentration (/litre)
1. Talstar	0.5 l	1.0 ml
2. Lorsban WG	0.6 kg	1.2 g
3. Tracer †	0.6 l	1.2 ml
4. Calypso	0.125 l	0.25 ml
5. Py insect killer	10.0 l	20 ml
6. Toppel 10	0.35 l	0.7 ml
7. XL- Nicotine 95%	0.665 l	1.33 ml
8. Hallmark	0.09 l	0.18 ml
9. Untreated control	-	-

† Experimental approval only (not requiring crop destruction)

Spray application

Sprays were applied with a Birchmeier motorised air-assisted knapsack sprayer at a volume of 500 l/ha. Measurement of the volume of solution remaining in the tank after spray application showed that application rate was generally within 20% of those required. The Crop Adjustment Factor (CAF) for PACE was estimated at 0.25 for all spray applications

Experimental layout

A randomised block experimental design with 4 replicates was used. Plots each comprised 6 trees.

Meteorological records

Wet and dry bulb temperature and wind speed were measured with a whirling psychrometer and a hand held cup anemometer (at 2m height above ground) before and after spraying. For the first treatment at 24 March, the wind speed was 2-3 km/hr from the North with gusts up to 6 km/hr. At the start of the treatment (9.55 hr) the dry bulb temp was 7°C and the wet bulb temp was 4°C. At the end of the application (14.00 hr) the dry bulb temperature was 12.5°C and the wet bulb temperature was 8°C. On 8 April, the wind speed was 2-3 km/hr from the North. At the start the treatment application (09.15 hr) the dry bulb temperature was 5.5°C and the wet bulb temperature was 3.5°C. At the end of the application (14.30 hr) the dry bulb temperature was 11°C and the wet bulb temperature was 7.5°C.

Assessment

On 3 June 2004, when fruitlets had developed sufficiently to show damage or infestation symptoms (damage was clearly visible at that time on garden trees), an inspection of the orchard was made. The infested fruitlets on each plot were counted.

Results/Conclusion

No infested fruitlets were found in any of the plots. A very small number of infested fruitlets were found in another area of the orchard. This is surprising as a heavy attack occurred in the orchard the previous season and small numbers of ovipositing midges were observed at the time of spray application. It is suspected that the weather conditions were poor in the pre-blossom period and did not favour the pest.

Therefore, the trial yielded insufficient results to draw conclusions about the efficacy of the treatments.

II Evaluation of insecticides for control of woolly aphid 2004

Summary

A replicated orchard experiment in a Cox orchard in Kent in 2004 evaluated two foliar sprays (500 l/ha) of Lorsban, Aphox, Calypso or Aztec, all in admixture with the adjuvant LI-700, for control of woolly aphid, in comparison with two sprays of the LI-700 adjuvant alone and an untreated control. The two sprays were applied before blossom on 23 April 2004 and after blossom on 30 June 2004 respectively. Woolly aphid infestation built up in June and was assessed two weeks before and two weeks after the second spray. Two bottle refuges for earwigs were provided in each plot and numbers of earwigs in them were counted on three occasions post treatment.

The Lorsban pre-blossom spray gave good control of woolly aphid, reducing numbers of nodes infested to 5% on June 17, compared to 21% for the untreated control. The % nodes infested on the adjuvant treated plots (17%) was not significantly less than the untreated control. The other pre-blossom sprays did not significantly reduce numbers infested compared to the adjuvant.

The post-blossom sprays were more effective. The adjuvant alone significantly reduced infestation by 20% compared to the untreated control. The Lorsban and Aphox (plus adjuvant) treatments both reduced infestation to a very low level (< 1% nodes infested). Aztec plus adjuvant treatment followed closely (2%), but the Calypso plus adjuvant treatment did not reduce infestation significantly compared to the adjuvant alone.

Unfortunately, the LI-700 treatment caused a significant increase in fruit russeting, particularly around the stalk and to a lesser extent around the calyx of the Cox apples. The russeting was exacerbated by the admixture of the LI-700 adjuvant with pesticides, most markedly when mixed with Lorsban. More work is required to identify alternative adjuvants that do not cause russeting.

Earwig numbers in the artificial refuges were small and variable but were not affected significantly by treatments. The occurrence of the parasitoid *Aphelinus mali* was too scarce and patchy for investigation of treatment effects.

Introduction

The biology, natural enemies and control of woolly aphid were reviewed in detail in the first report of this work (Cross, 2003).

In the first year of this project, single foliar sprays (200 l/ha) of Dursban 4, Orosorb oil, Aphox, Calypso or Aztec, were applied either preventively pre-blossom on 15 April 2003 or curatively post blossom on 18 June 2003 when woolly aphid populations were increasing rapidly.

The pre-blossom sprays did not control woolly aphid infestations, probably because the bulk of the population was present in burr knots on the rootstocks above ground level at this time where the colonies were inaccessible. Post blossom applications of

Dursban 4 or of Aphox significantly reduced infestations of woolly aphid by over 50% compared to the untreated control. Aztec, Calypso or Orosorb oil were ineffective.

None of the treatments adversely affected parasitism by *Aphelinus mali*. Levels of parasitism increased markedly on all plots. Pre-blossom application of Orosorb oil significantly reduced numbers of earwigs in artificial refuges but none of the other treatments significantly affected earwig numbers.

Objectives of this work

Here we report the results of a single replicated orchard experiment done in 2004 to evaluate the efficacy of four insecticide products for control of woolly aphid on apple. The insecticides were all tested in admixture with the adjuvant LI-700. An LI-700 adjuvant alone treatment and an untreated control were included for comparison. Preventive treatment before blossom was compared with curative treatment against established infestations in May-June post-blossom. An important additional objective was to determine whether any of the treatments tested adversely affected numbers of earwigs or the proportion of aphids parasitised by the parasitoid *Aphelinus mali*.

Material and Methods

A single replicated experiment was done in a commercial orchard in 2004 as follows:

Site

The experiment was done in 'Unit 6' Cox orchard, Bayfield Farm, Painter's Forstal, Faversham, Kent (by kind agreement with the owner, Mr A.R. Neaves). This experiment was carried out in a different area from the orchard than the experiment in 2003. The orchard was planted ca 25 years ago, with a row spacing of 3.96 m and tree spacing 1.83 m in the row (1380 trees/ha).

Treatments

Treatments were two foliar sprays of Lorsban, Aphox, Calypso, Aztec, all in admixture with the adjuvant LI-700, an adjuvant alone treatment and an untreated control (Table 1). They were applied before blossom on 23 April 2004, and subsequently during fruit development on 17 June 2004.

Table 2. Treatments applied in the woolly aphid trial on 23 April, and repeated 30 June 2004

Treat no.	Active ingredient [1]	Product	Dose (/ha)	Conc (/ml)
1	Chlorpyrifos + adjuvant	Lorsban WG + LI-700	1.20 kg + 2.50 l	2.40 g + 5.0 ml
2	Pirimicarb + adjuvant	Aphox + LI-700	560 g + 2.50 l	1.12 g + 5.0 ml
3	Thiacloprid + adjuvant	Calypso + LI-700	375 ml + 2.50 l	0.75 ml + 5.0 ml
4	Triazamate + adjuvant	Aztec + LI-700	500 ml + 2.50 l	1.0 ml + 5.0 ml
5	Adjuvant	LI-700	2.50 l	5.0 ml
6	Untreated	-	-	-

Spray application

Sprays were applied with a Birchmeier motorised air-assisted knapsack sprayer at a volume of 500 l/ha. Measurement of the volume of spray solution remaining in the tank after spray application showed that application rates were generally within 15% of those required. The first spray application with Aphox was under-applied by 28% because of a partially blocked nozzle. The Crop Adjustment Factor (CAF) for PACE was estimated at 0.25 for the pre-blossom spray applications and at 0.5 for the post blossom applications.

Experimental design and layout

A randomised block design with six replicates was used. However, there were two missing plots, one an untreated control plot, the other an adjuvant only (treatment 5) plot. Plots consisted of 10 adjacent trees in a row. The whole experiment was arranged in two rows.

Meteorological records

Wet and dry bulb temperature and wind speed were measured with a whirling psychrometer and a hand held cup anemometer (at 2m height above ground) before and after spraying. For the first treatment at 23 April 2004, the wind speed was 3 km/hr from the NW. At the start of treatment application (1300 hr) the dry bulb temperature was 18.0°C and the wet bulb temperature was 13.5°C. On 30 June 2004, wind speed initially was 3 km/hr from the South, increasing at the end of treatment application to 8 km/hr with gusts up to 11 km/hr. The start temperatures at 11.30 hr were 17.5°C (dry bulb) and 15°C (wet bulb). At the end of treatment application at 15.30 hr, temperatures were 23.0°C (dry bulb) and 16.0°C (wet bulb) respectively.

Assessments

Populations of woolly aphid, percentage of parasitism by *Aphelinus mali* and numbers of earwigs were assessed on 12 May (3 weeks after the pre blossom spray), on 16-18 June (2 weeks before post blossom treatment), and again 14 July (two weeks after last treatment). For woolly aphid, the total numbers of nodes and the numbers of nodes infested with woolly aphid were counted on eight of the current years extension shoots (chosen at random) emanating from the main trunk of each of the middle six trees in each plot.

For *Aphelinus mali*, one woolly aphid colony containing roughly 50 aphids was selected on each assessed tree. After blowing away the wax, the number of mummified aphids from which the parasite had emerged was counted.

For assessment of populations of the common European earwig, two trees in each plot (the fourth and sixth tree) were fitted with a bottle refuge, which was taped to the trunk. Each refuge consisted of a plastic drinks bottle with the base cut away and was loosely filled with a roll of corrugated cardboard. The number of earwig males, females and nymphs in each refuge were counted on each assessment date. After counting, the earwigs were returned to the tree.

Each time a pest and natural enemy assessment was made, the trees were also inspected for visual symptoms of phytotoxicity. Additionally, the effect of the treatments on the degree of russeting of the fruits was assessed on 17 August 2004. For this assessment, three apples were chosen at random from each of the eight central trees in each plot. The severity of russet on skin of the fruit round the stalk, on the cheek and round the eye was scored on a scale of 0-3, where 0 = no russeting, 1 = slight russeting, 2 = moderate russeting and 3 = severe russeting.

Statistical analysis

The percentage of nodes infested with woolly aphid on each assessed tree was calculated. Analysis of variance was done on the percentage of infested nodes or on the angular transformed values from this data.

For the phytotoxicity data two analyses were done. A Generalised Linear Model with binomial error and logit link function was fitted to the numbers of fruits without russet, taking account of the different totals within each plot. Estimates of the overall proportions without russet for each treatment were calculated, along with tests of statistical significance between treatments, particularly for comparison with the untreated control. The percentage **with** any russeting can be calculated by subtraction from 100, with the significance of differences remaining the same.

For the second analysis, scores were estimated using ordinal (logistic) regression. In this process, the cut-points between the ordered categories (here 0, 1, 2 and 3) were estimated by the model on an underlying linear scale. The actual positioning on the linear scale is somewhat arbitrary so results are presented as differences on that scale from the untreated control (also for other treatments from the adjuvant alone)

Results

Woolly aphid infestation

The overall variance ratio test for treatments at the 16-18 June assessment was highly significant (p<0.001). In comparison with the untreated, three of the treatments showed a statistically significant reduction in infestation. Lorsban appeared to be the most effective treatment (p<0.001), with Aphox and Calypso also giving significant reductions (p<0.05) (Table 3, Figure 1). The mean values for adjuvant alone for the adjuvant in admixture with Aztec were lower than the untreated control, but not significantly so. In comparisons with the adjuvant alone, only the reduction for Lorsban was statistically significant (p<0.001).

All treatments showed a reduction in % infestation from the 16-18 June assessment to14 July assessment (all differences June - July were positive) (column 3 of Table 3). The overall treatment variance ratio test had an F-probability of 0.069 and was therefore of borderline significance. However, it did appear that the reduction for Aztec plus adjuvant treatment was significantly greater than for the untreated (p<0.05). Although the Aztec + adjuvant treatment did not appear very effective at the 16-18 June assessment, it did have an effect in reducing infection between the June and July assessments. For a reduction to be significantly greater than zero, it would have needed to be at least 5.41 (5.92 for untreated or adjuvant) which implied that the reductions for the Aphox and Aztec plus adjuvant treatments between June and July are likely to be real reductions.

The analysis of variance of the 14 July showed highly significant treatment effects. However, the July analysis needs to be treated with caution as it is not independent of the analyses of the June assessment and of the June–July difference. The residual variance was not homogeneous so the statistical conclusions were based on the analysis on the angular scale. All treatments showed a significant reduction in infestation compared to the untreated, including the adjuvant alone treatment. Compared to the adjuvant alone treatment, all except Calypso showed a statistically significant reduction. Surprisingly, Aztec appeared to work well as a post blossom spray, but the pre-blossom spray was ineffective.

Table 3. Percentage of nodes infested with woolly aphid

Treatment	16-18 June % infection	Difference in % infection from June to July	July % infection (raw means)	July % infection – angular transformed
Lorsban + adj	4.71	4.50	0.21	0.76
Aphox + adj	11.37	10.78	0.59	2.10
Calypso + adj	12.96	5.30	7.66	12.23
Aztec + adj	16.53	14.49	2.04	5.27
adjuvant	16.92	7.01	9.91	15.43
untreated	21.40	4.57	16.83	22.39
*SED(23 df)	3.166	3.875		3.105
*LSD(p=0.05)	6.55	8.02		6.42

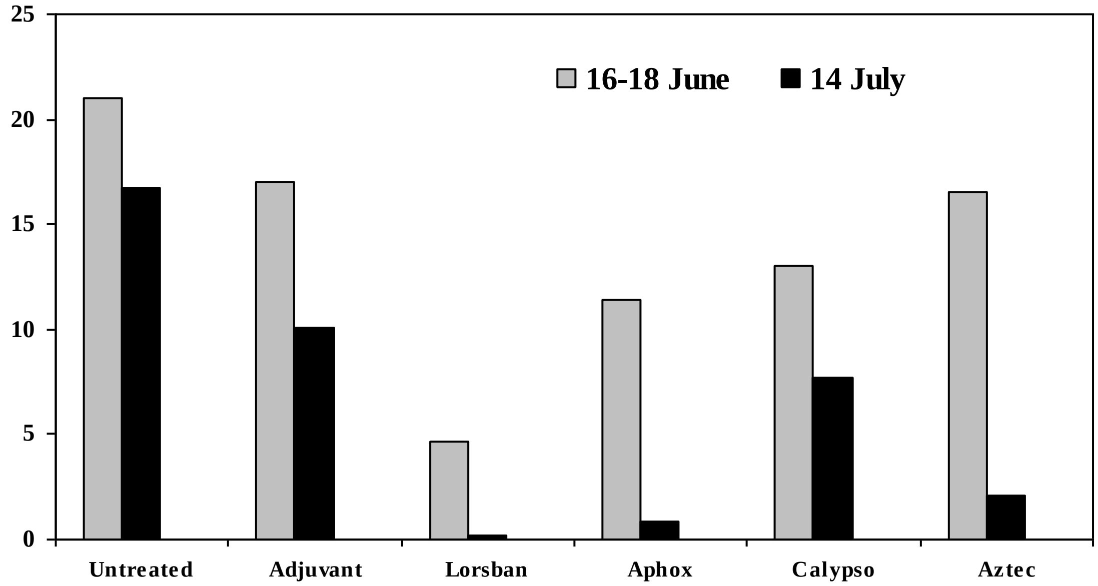

Figure 1. Percentage nodes infested with woolly aphid at the first assessment on 16-18 June, approximately 7 weeks after the pre-blossom spray, and on 14 July, 2 weeks after the second spray

Effects on natural enemies

Numbers of earwigs found in the refuges were low and variable (Table 4). There was strong evidence of increasing variability with increasing mean; a $\log_e$(count+1) transformation was found to be best for giving reasonable variance homogeneity. There was no evidence of any differences in earwig numbers between the different treatments (F-prob=0.844).

Parasitism of the aphids by *Aphelinus mali* did occur, but in very low numbers. *A. mali* was only found in 13 of the colonies on 204 trees assessed.

Table 4. Mean numbers of earwigs found in bottle refuges on 12 May, 16-18 June and 14 July*

Treatment	**Total numbers of earwigs counted in artificial refuges in 2004**		
	May 12	June 16/18	July 14
Lorsban + adj	7	6	39
Aphox + adj	15	3	22
Calypso + adj	6	9	21
Aztec + adj	6	9	29
adjuvant	23	0	15
untreated	8	8	21

*12 bottle refuges/treatment for Lorsban, Aphox, Calypso and Aztec, 10 for Adjuvant and Untreated.

Phytotoxicity

Stalk russet: The statistical analysis of the percentages of fruits not russeted showed strong overall evidence for differences present (p=0.003); as well as significant reductions from the untreated control for all treatments except adjuvant alone, which none-the-less was close to standard significance level (Table 5). The Lorsban + adjuvant treatment also had a % fruits not russeted significantly lower than adjuvant alone (p=0.021).

The statistical analysis of the russet scores (Table 6) showed that all treatments had a significantly greater score than the untreated control, with the Lorsban + adjuvant treatment also significant higher than adjuvant only (p=<0.001). The Calypso + adjuvant treatment bordered on being greater than adjuvant alone (p=0.055).

Cheek russet: There was no evidence for differences in the percentages of fruits with no russet. There was some overall evidence of significant differences present in the russet scores (p=0.002), but with the untreated control and adjuvant alone in the middle of the range, these significant differences were not generally in comparison with control or adjuvant (Aztec + adjuvant possibly significantly lower than both).

Calyx russet: The statistical analysis of the percentages of fruits not russeted showed strong overall evidence of treatment differences present (p=0.006)) (Table 5). Lorsban + adjuvant reduced the percentage without russeting compared to untreated control. The % fruits not russeted for this treatment was also significantly smaller than adjuvant alone (p=0.001), as was the Aphox + adjuvant treatment (p=0.030).

In the analyses of the scores the Lorsban + adjuvant (p<0.001) and Aphox + adjuvant (p=0.024) treatments showed a significant increase in russet severity compared to the untreated control (Table 6). Both these treatments also showed a significant increase compared to adjuvant alone (p<0.001, 0.002 respectively).

Conclusions

- A Lorsban + LI-700 spray pre-blossom on 23 April 2004 gave good control of woolly aphid, reducing numbers of nodes infested to 5% on June 17, compared to 21% for the untreated control.
- Pre-blossom sprays with Aphox, Calypso or Aztec, all in admixture with LI-700, did not significantly reduce woolly aphid numbers compared to a pre-blossom LI-700 spray alone.
- Sprays applied on 30 June during fruitlet development, were more effective than the pre-blossom sprays.
- Lorsban + LI-700, Aphox + LI-700 and Aztec + LI-700 sprays on 30 June reduced infestation on 14 July to a very low level (to < 1%, < 1% and 2% nodes infested respectively).
- Calypso + LI-700 on 30 June did not reduce infestation significantly compared to LI-700 alone.
- LI-700 alone also appeared to reduce infestation, the reduction being statistically significant after a second spray.
- The LI-700 treatment caused a significant increase in russeting, particularly around the stalk and calyx of the Cox apples
- The russeting was exacerbated by the admixture of the LI-700 with pesticides, notably by Lorsban
- Earwig numbers in the artificial refuges were low and variable but were not affected significantly by treatments.
- The parasitoid *Aphelinus mali* was too scarce and patchy for investigation of treatment effects.

Table 5. Percentage fruits with no russet and statistical significance of differences from untreated and from adjuvant

Treatment	Stalk			Cheek			Calyx		
	%	Sig. from Untreated	Sig. from Adjuvant	%	Sig. from Untreated	Sig. from Adjuvant	%	Sig. from Untreated	Sig. from Adjuvant
Lorsban + adj	11.9	<0.001	0.021	92.2	0.364	0.469	36.7	0.005	0.001
Aphox + adj	20.7	0.006	0.374	98.0	0.402	0.257	48.4	0.121	0.030
Calypso + adj	18.1	0.002	0.190	98.0	0.409	0.262	58.9	0.861	0.381
Aztec + adj	26.0	0.042	0.980	99.5	0.159	0.115	60.0	0.982	0.469
adjuvant	26.2	0.056	-	94.9	0.794	-	65.3	0.508	-
untreated	41.0	-	-	95.8	-	-	60.2	-	-
Overall F prob		0.003			0.100			0.006	

Table 6. Differences and statistical significances from the untreated and from adjuvant in the russet scores

Treatment	Stalk				Cheek				Calyx			
	Diff. from Untr.	Sig	Diff. from Adj.	Sig	Diff. from Untr.	Sig	Diff. from Adj.	Sig	Diff. from Untr.	Sig	Diff. from Adj.	Sig
Lorsban + adj	+1.56	<0.001	+0.95	<0.001	+0.64	0.217	+0.43	0.341	+1.18	<0.001	+1.41	<0.001
Aphox + adj	+0.80	<0.001	+0.19	0.443	-0.76	0.256	-0.97	0.123	+0.52	0.024	+0.75	0.002
Calypso + adj	+1.10	<0.001	+0.49	0.055	-0.75	0.265	-0.96	0.128	+0.07	0.751	+0.30	0.215
Aztec + adj	+0.68	0.006	+0.07	0.798	-2.12	0.053	-2.33	0.033	+0.08	0.726	+0.31	0.205
adjuvant	+0.61	0.017	-	-	+0.21	0.710	-	-	-0.23	0.380	-	-
Overall χ^2 prob	<0.001				0.002				<0.001			

III Evaluation of insecticides for control of caterpillar damage 2004

Summary

A replicated orchard experiment was carried out in a Bramley orchard at Amsbury Farm, Coxheath in 2004 to evaluate the efficacy of foliar sprays (300 l/ha) of Runner, Tracer and Insegar/Lorsban against the first generation caterpillars of codling, tortrix and *Blastobasis* moths. Three applications were given on fortnightly intervals, with timing of first spray principally based on the trap catches of codling moth.

Very little damage was found in July. Therefore, it was decided not to spray for the second generation in August so that differences in control in the first generation could be exposed and magnified in the second generation. This strategy worked and caused significant attack. Damage, primarily caused by codling moth (*Cydia pomonella*) caterpillar was assessed between 25 August and 2 September 2004.

- The Insegar/Lorsban treatment was most successful, with 5% damage compared to 13% for the control. The Tracer and Runner treatments gave intermediate results. Only the damage reduction by the Insegar/Lorsban treatment was statistically significant.
- The damage was exaggerated by the second generation attack (against which plots were not sprayed) and growers would be well advised to put more emphasis on this period when fruit is more susceptible to attack.

Introduction

In 2004, a good site for a *Blastobasis* experiment could not be found. After agreement with the HDC it was decided to evaluate three different programmes of insecticide sprays for control of a range of caterpillar pests, including codling moth, summer fruit tortrix and, if it occurred, *Blastobasis*. The major pest was expected to be codling moth.

The codling moth is an important pest of apples and pears in the UK and appears to have been increasing in importance and causing greater damage in recent years. The pest has one complete generation per annum in May-July and often a partial second generation in July-September in the warm summers of recent years. The biology, pest status and control of codling moth have been reviewed by Van der Geest and Evenhuis (1991). A range of insecticides is currently approved for control of the pest in the UK including chlorpyrifos (Lorsban etc), cypermethrin, deltamethrin, diflubenzuron (Dimilin) and methoxyfenozide (Runner). A number of other insecticides are recommended for control of other pests, including tortrix moth and other caterpillars, that also have activity against codling moth, notably fenoxycarb and fenpropathrin. Pyrethroid insecticides are rarely used in UK apple orchards nowadays as they are harmful to natural enemies. Chlorpyrifos, fenoxycarb, methoxyfenozide and diflubenzuron are the most widely used products for codling moth control. Spinosad (Tracer) is also expected to receive approval for control of codling moth on apple.

Objectives of this work

The objective of the work reported here was to conduct one field experiment in 2004 to evaluate three different insecticide programs, applied during the egg hatch period of the first generation, for control of caterpillar pests, particularly codling moth, summer fruit tortrix moth and *Blastobasis decolorella*.

Materials and Methods

A single replicated experiment was done in a commercial orchard in 2004 as follows:

Site

The experiment was done in '10 Acre West' Bramley orchard at Amsbury Farm, Hunton, Maidstone, Kent (by kind agreement with Mr Clive Baxter). The orchard consisted of 11 rows of apple trees. The rows were spaced 5.5 m apart and the trees 5.5 m apart in the rows (Tree density 330/ha). The rows were approximately 330 m long. 10 of the rows were Bramleys Seedling with a central pollinator row of cv Howgate Wonder. The orchard was approximately 30 years old and was on a south-facing slope. The area is well known for its high risk of codling moth.

Moth flight monitoring

Three delta sex pheromone traps, one for codling moth, one for fruit tree tortrix moth and one for summer fruit tortrix moth were set in the northern central part of the orchard. Numbers of moths captured were recorded weekly from 5 May to 25 August 2004.

Treatments

Treatments (Table 7 and 8) were programmes of three foliar sprays of insecticides applied against the first generation of codling moth between 25 May and 2 July.

The first sprays of Runner and Insegar for treatments 1 and 2 respectively were applied at the start of egg laying of codling moth on 25 May, six days after the first significant pheromone trap catch of the first generation of codling moth. Subsequent insecticide applications for these treatments, of Runner and Lorsban respectively, were applied at approximately two-week intervals. The first spray of Tracer for treatment 3 was applied at the approximate start of egg hatch on 4 June 2004, two weeks after the first significant codling moth pheromone trap catch. Subsequent sprays were also applied at fortnightly intervals. An untreated control was included for comparison.

Table 7. Products applied in the caterpillar damage trial, 2004

Product	Active substance	Product dose (/ha)	Conc (/litre)
Lorsban WG	Chlorpyrifos 75% w/w WG	1.2 kg	4.0 g
Runner	Methoxyfenozide 240 g/l SC	0.4 l	1.33 ml
Insegar WG	Fenoxycarb 25% w/w WG	0.4 kg	1.33 g
Tracer	Spinosad 480 g/l SC	250 ml	0.83 ml

Table 8. Treatment in the caterpillar damage trial, 2004

Treatment	Application date:		
	May 25	**June 10**	**June 25**
1. Runner	Runner	Runner	Runner
2. Insegar/Lorsban	Insegar	Lorsban	Lorsban
	June 4	**June 17**	**July 2**
3. Tracer	Tracer	Tracer	Tracer
4. Untreated control	None	None	None

As very little damage to the fruit was apparent on 2 July 2004 due to codling moth, and almost none due to other caterpillar pests, no sprays were applied against the second generation in July an August. The aim was to allow any treatment differences that occurred in the first generation of codling moth to be amplified in the second generation

Spray application

Sprays were applied by David Gossling of Amsbury Farm using a commercial Munckhof axial fan airblast sprayer at a volume of 300 l/ha under supervision of East Malling Research staff. Estimates of the volume of spray solution remaining in the tank after application showed that application rates were within 10% of those required. The Crop Adjustment Factor (CAF) for PACE was estimated at 1.0 for all spray applications.

Experimental design and layout

A randomised complete block experimental design with three replicate was used. Each plot consisted of 50 trees, arranged in five rows of 10 trees. Only trees in the central area of the centre row of each plot were assessed, the remaining acting as guards.

Meteorological records

Wet and dry bulb temperature and wind speed were measured with a whirling psychrometer and a hand held cup anemometer (at 2m height above ground) before and after spraying. See Table 9 for details:

Table 9. Meteorological conditions during spray applications

Date	**Time**	**Wind speed** (km/hr)	**Wind direction**	**Temp dry bulb (°C)**	**Temp wet bulb (°C)**	**Application**
25/05	12:00	0	W	20.4	14.2	Runner, Insegar
	14:40	0	W	22.0	14.5	
04/06	14:45	0-1	N	21.0	17.5	Tracer
	15:15	0-1	N	21.5	18.0	
10/06	10:45	0-1	S	20.0	18.0	Runner, Lorsban
	12:50	0-1	S	22.0	20.0	
17/06	09:10	1-2	S	17.0	15.0	Tracer
	09:50	1-2	S	17.0	15.0	
25/06	10:15	2-4	E	18.0	14.0	Runner, Lorsban
	12:00	2-4	E	21.0	16.0	
02/07	10:45	7-11	NE	18.5	14.0	Tracer
	11:15	7-11	NE	18.5	14.0	

Assessments

The untreated control plots were inspected for damage on 2 July 2004. On each of the three control plots codling damage was assessed by counting the numbers of damaged fruits from each of five trees on a random selection of 10 apples on the tree and 10 apples under the tree.

Between 25 August and 3 September 2004, three trees, each with 300-400 fruits, were selected in each plot, and all the fruits were picked and assessed for damage by codling moth or tortrix moth or Blastobasis. In addition, the fallen fruit from two trees in each plot were collected and assessed.

Statistical analysis

The percentages of fruits damaged by codling and tortrix caterpillars were calculated. Analyses of variance were done on these percentages, after angular transformation ($\sin^{-1}x^{½}$) where necessary.

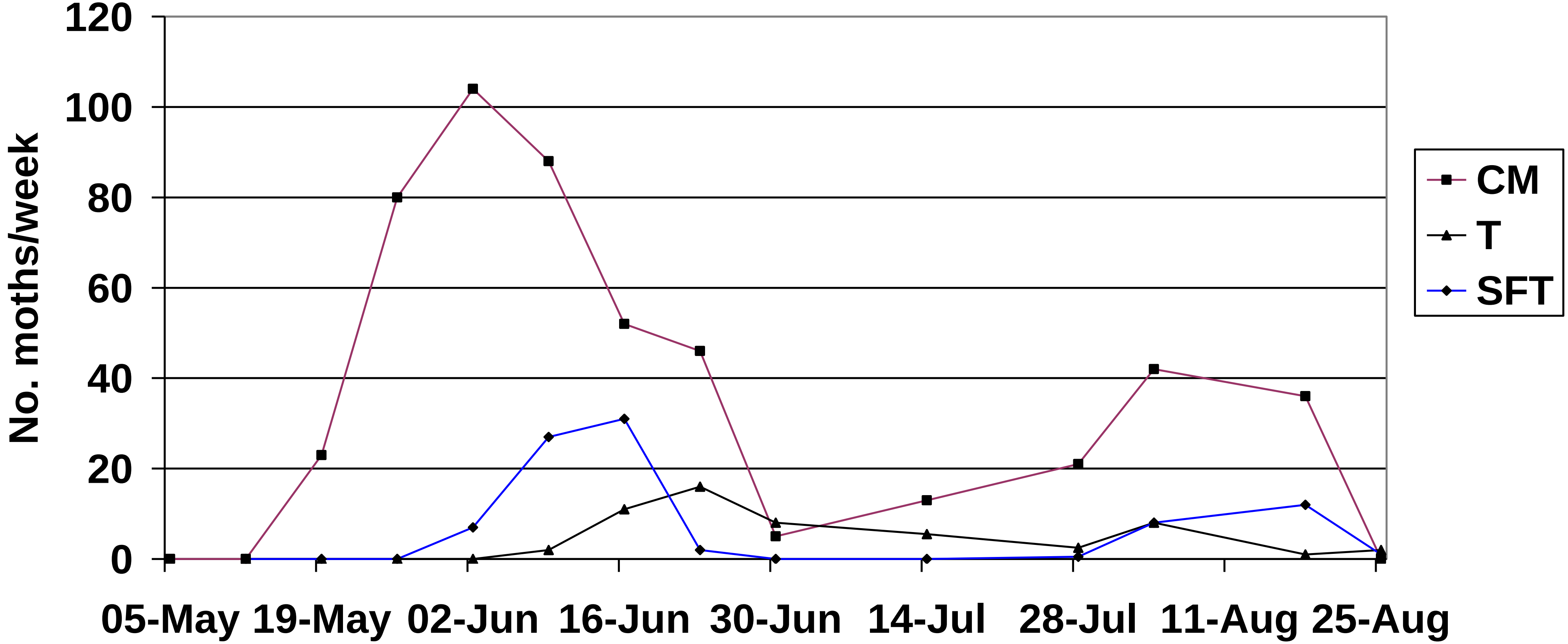

Figure 2. Trap catches counted in ‘10Acre West’ of codling moth (CM), summer fruit tortrix (SFT) and fruit tree tortrix (T) moth.

Results\

Damage found at harvest was mainly due to the codling moth with much less damage by tortrix moths. *Blastobasis* was also recorded but at a very low level, insufficient to draw any conclusions about the treatments with respect to this pest.

During July, very little damage developed, even though pheromone trap catches in June had been very high. An initial assessment at 4 July showed one out of 150 apples in the untreated control plots with codling damage. It was therefore decided to wait for assessment until after the second generation caterpillars had developed, the intention with this strategy being that differences in control in the first generation could be exposed and increased in the second generation. This strategy worked and there was a significant attack in August, which was apparent in August/early September at harvest.

The Insegar/Lorsban treatment was the most effective for codling moth, giving only 2.9% damage of fruits on the tree compared to 7.8% for the control (Table 10, Figure 3). Runner and Tracer gave intermediate results which were, however, not significantly different from the control. Similar trends were apparent in the damage results for tortrix (Table 11, Figure 3), though at a lower level.

It has to be borne in mind that most of this damage occurred during the second generation attack, which was not sprayed against. The intention was to expose differences in control during the first generation. Therefore, if proper treatments were applied during July/August, the damage on the treated plots could have been expected to be much lower.

Table 10. Mean percentages of fruits damaged by codling moth between 25 August and 3 September after the second generation attack

Treatment	Total fruits assessed		Codling moth damage			
	picked	fallen	picked fruit %	picked fruit Ang(%)	fallen fruit %	fallen fruit Ang(%)
Runner/Runner/Runner	3233	556	5.27	13.25	25.5	30.1
Insegar/Lorsban/Lorsban	3478	450	2.86	9.72	20.3	26.1
Tracer/Tracer/Tracer	3075	535	5.85	13.76	20.8	26.7
control (untreated)	3018	591	7.76	16.13	32.2	34.5
SED (6df)			1.42	1.68	8.89	6.17
F pr.			0.069	0.045	0.55	0.54

Table 11. Mean percentages of fruits damaged by caterpillars of tortrix moth after second generation attack - assessed between 25 August and 3 September

Treatment	Total fruits assessed		Tortrix moth damage			
	picked	fallen	picked fruit		fallen fruit	
			%	Ang(%)	%	Ang(%)
Runner/Runner/Runner	3233	556	1.46	6.82	1.84	7.63
Insegar/Lorsban/Lorsban	3478	450	0.34	2.63	2.16	7.71
Tracer/Tracer/Tracer	3075	535	1.13	5.96	1.14	6.12
control (untreated)	3018	591	1.41	6.79	0.47	2.27
SED (6df)			0.47	1.55	0.99	2.58
F pr.			0.16	0.10	0.40	0.22

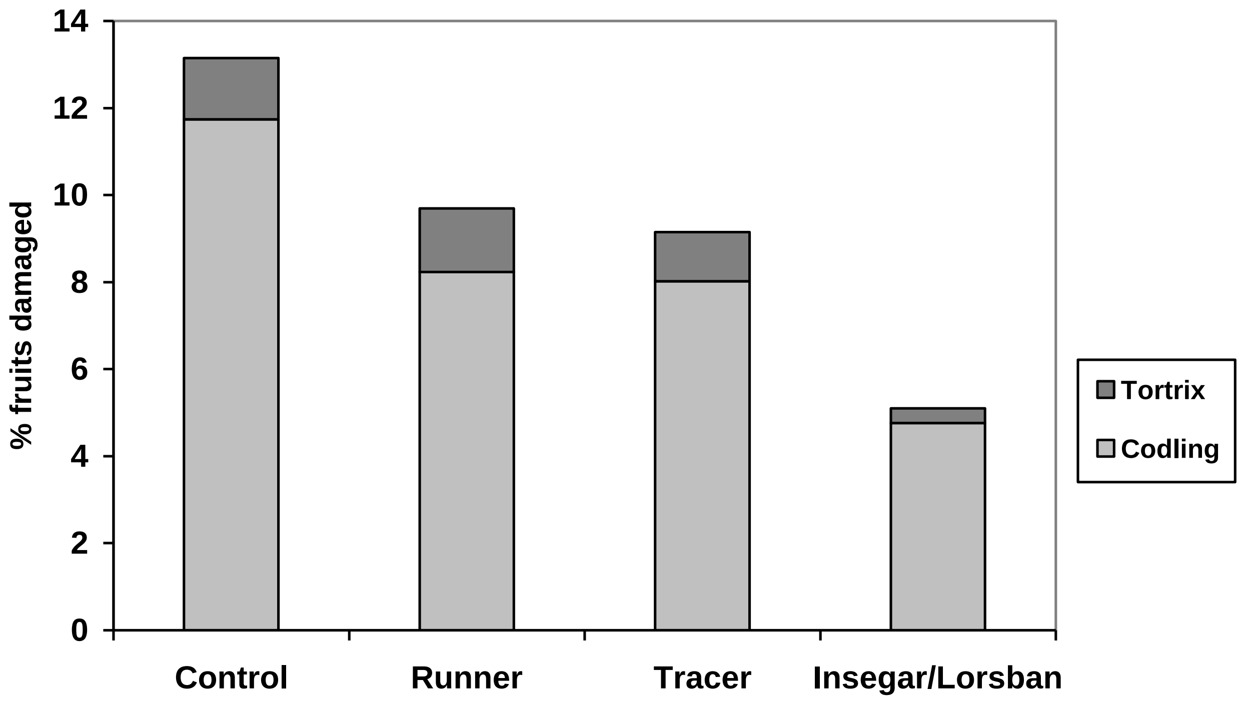

Figure 3. Overall percentage damaged fruit by codling moth and tortrix moth caterpillars – assessed between 25 August and 3 September.

Conclusions

- The Insegar/Lorsban treatment in June gave good control against the first generation caterpillar damage.
- Tracer and Runner gave intermediate results, although not significantly different from the control.
- Most damage was caused by the second generation of caterpillars in August.

Acknowledgements

We are grateful to Richard Carpenter, Nigel Kitney, Clive Baxter, Graham Foat and Martin Harmen for providing sites for the 6 orchard experiments reported and to Graham Waters for his help with locating suitable orchards.

Also thanks to Gillian Arnold for statistical advice and assistance, and to Marc Bohiem, Matthias Daub, Anita Kovacs, Mark Petzer and Jonathan Hall who assisted with this work whilst temporarily employed by East Malling Research.

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