Project title: **Pheromone technology for management of capsid pests to reduce pesticide use in horticultural crops – 2 year extension – final report**

Project number: HL0184 (PC/SF 276)

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Report: Annual report, year 2 extension (issued 20 April 12)

Date commenced: 1 April 2010

Expected completion date: 31 March 2012

Key words: *Lygus rugulipennis*, strawberry, blackcurrant, blackberry, raspberry, trap, monitor, threshold, cucumber, *Lygocoris pabulinus,* capsid

Horticultural
Development
Company

Grower summary

PC/SF 276

Pheromone technology for management of capsid pests to reduce pesticide use in horticultural crops – 2 year extension

Final report

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If you would like a copy of the full report, please email the HDC office (hdc@hdc.org.uk), quoting your HDC number, alternatively contact the HDC at the address below.

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Headlines

Traps are available from Agralan Ltd. to monitor European Tarnished Plant Bug and Common Green Capsid in a range of crops

Background and expected deliverables

- Capsid bugs are important pests of several high-value horticultural crops in the UK and many more worldwide. In the UK, the common green capsid, *Lygocoris pabulinus,* and the European tarnished plant bug, *Lygus rugulipennis* are the most important species. *L. pabulinus,* traditionally a pest of apples, pears and blackcurrants is an increasingly important pest of strawberries, blackberries and raspberries. *L. rugulipennis* is an important pest of late season strawberries and of various glasshouse salad crops, notably cucumber.
- Crop invasion by capsids is sporadic and unpredictable, and, in the absence of effective control measures, capsid bugs cause severe economic losses. They cause damage at low population densities and are difficult to detect at such levels in normal crop inspections.
- In conventional crops capsids are controlled by sprays of broad-spectrum insecticides, organophosphorus insecticides being the most effective and frequently used in strawberry while the anti-feedant, pymetrozine, is the most commonly used in cucumber. Neonicotinoids and other modern insecticide groups are only partially effective against capsids and insect growth regulators are totally ineffective. In the future chlorpyrifos and thiacloprid, two of the main control methods for capsids, are likely to be withdrawn from use in many edible crops. In organic crops the pests cause high levels of damage. The available insecticides (eg natural pyrethrins) have very short persistence and provide no residual effect. Capsids have few natural enemies and effective biocontrol methods have not been developed.
- Without accurate monitoring information, growers are forced to use remedial applications of broad spectrum insecticides. Although these treatments can be effective against capsids, they disrupt the biological control of other pests and can lead to the application of further sprays. The recent outbreaks of pesticide-resistant western flower thrips on strawberry are probably due, at least in part, to routine spraying against capsids.

- The need to use broad spectrum insecticides for control of capsid bugs is a major bottleneck to the implementation of IPM and the quest towards pesticide-free foods.
- Effective monitoring systems for capsid pests would help to ensure that pesticides are only used where necessary, so reducing routine applications of broad-spectrum pesticides that disrupt IPM of these and other pests. They would also enable the use of more selective insecticides and biological approaches for which timing of sprays is critical.

Summary of project and main conclusions

Progress on each objective of the project is summarised below;

1. Improve and test the lure for *L. rugulipennis* so that it is long lasting and practical for use by growers (Yr 1)

The life and release rate of pheromone components from the pipette tip lure have been enhanced. The lure now lasts over 4 weeks in the field having been shielded from sunlight and the use of larger pipette tips is giving a more consistent release rate. Wrapping the pipette tips in duct tape has provided effective screening from sunlight in the field.

In the laboratory windtunnel the 1 ml pipette tips proved much more reliable than the 0.2 ml tips, releasing a blend very similar to that loaded into the dispenser for up to 2 months at 27°C and 8 km/h windspeed. They also released at a higher rate than the 0.2 ml pipette tips. Furthermore, the 1 ml pipettes were easier to load with the pheromone blend and to seal with the crimp cap. The results have confirmed that disposable pipette tips are suitable dispensers for the three candidate pheromone components of the mirid bugs.

The Agrisense sachets proved unsatisfactory for dispensing the pheromone components. The components diffuse through a polyethylene disc such that release of the KA is proportionately faster than the HB and E2HB. This results in a very high relative amount of KA initially which dropped to a very low level within 10 days under windtunnel conditions. Thus, in the field the sachet performed well in comparison with the pipette tip during the first 5 days but much less well subsequently.

The pipette tip lure was also shown to be as attractive as live female *L. rugulipennis*.

Improvements have been confirmed using field trapping tests.

The trap was further tested by adding Fluon to the cross vanes. This increased the catch by more than a third in week one, but catches of males decreased subsequently – probably because of contamination by debris on the cross vanes over time (enables the insects to grip the surface more easily). Products such as Teflon should be considered as an alternative coating for the cross vanes.

2. Calibrate the trap for *L. rugulipennis* for use in pest monitoring to establish a treatment threshold for its use in late season strawberry and/or cucumber (Yrs 1 and 2)

Extensive trapping in both cucumber and strawberry crops by growers, advisers and science staff has proven the *L. rugulipennis* monitoring trap to be an excellent early warning system of invasion into the crops. The pest was detected in high numbers in pheromone traps 7-10 days before detection on cucumber plants and 4 weeks in strawberry compared to using traditional monitoring methods. In strawberry, it is suggested that treatments targeted at the pest are applied 2 weeks after a significant rise in trap catches of capsids – typically 10 per trap. It is recommended that 2 traps per plantation are placed at the ends of strawberry beds in areas considered vulnerable from immigrating capsids. The study in 2011 highlighted the importance of counting only *L. rugulipennis* in the traps and not confusing the species with other similar sized insects. The traps in strawberry should be placed on the ground. Traps placed higher are less sensitive to numbers of *L. rugulipennis*. Pheromone baited traps positioned outside cucumber greenhouses provided useful prior warning of crop invasion by *L. rugulipennis*. However, informed interpretation of the size and timing of the catch, relative to the growth stage of the crop, was required to predict the risk of crop damage. In contrast, traps placed within the greenhouse were of little value regardless of their position within the crop canopy.

The species specificity of the synthetic pheromone lures was tested using standard sticky stake traps (*L. pabulinus* is known not to be attracted into green cross vane bucket traps). The specificity was good for *L. pratensis*, however, this lure also attracted *Capsus ater* (feeds on grasses) early on in the season (June), indicating that these two species may have similar ratios of pheromone components. *L. rugulipennis* and *L. pabulinus* were equally attracted to the lure of either species. No *L. tripustulatus* were captured on the baited traps even though they were known to be in the surrounding nettles.

Traps that combined the lures of *L. rugulipennis* and/or *Anthonomus rubi* with either white or green cross vanes showed that white cross vanes cannot be used as they reduce the catch of *L. rugulipennis* in the traps. In addition, the grid designed for preventing capture of bees attracted to white cross vanes prevents the *Lygus* bugs falling into the bucket of the trap. Any future combined monitoring/mass trap for *L. rugulipennis* and *A. rubi* should have green cross vane, no grid and both pheromone lures.

3. Develop an effective lure and trap for *L. pabulinus* with associated data for pest monitoring (Yrs 1 and 2)

Trap design is of major importance and the green cross vane and delta traps were found to be ineffective at catching males. The lure was more attractive than caged virgin females at attracting males to sticky stake traps. These traps are not practical for use by growers. Sticky platform and water traps were also tested, but were not found to be more effective than sticky stake traps. In 2011, we tested 18 trap designs, including bucket traps and various sticky traps with wet and dry glue. The most successful trap, and indeed better than the sticky stake trap, was a dry glue blue sticky card trap. This was 12.25 x 10 cm and the lure was suspended from a twist tie pointing downward so that the tip was in the centre of the card.

Using remote cameras (wide angle and macro) and a hard drive recorder a series of experiments was set up to observe the behaviour of male *L. pabulinus* approaching pheromone lures. Only one adult *L. pabulinus* was observed attracted to the synthetic *L. pabulinus* sex pheromone lure. There was also significant attraction of *L. rugulipennis/pratensis* to the lure. This supports data found in the 4 species test in Objective 2.

4. Encourage commercial production of traps and lures and produce grower information sheets on the use of the traps for monitoring capsids

Agralan Ltd. will be collaborating to take up commercial production of traps and lures in 2012. An information sheet for growers on the use of the traps for pest monitoring will be developed. An instruction sheet was developed by the HDC, EMR and Agralan to be included in the trap package for sale by Agralan.

Future research

Although this project has come to an end the scope to use the synthetic sex pheromones in IPM for control of capsid bugs is worth consideration. Future research should concentrate on mass trapping (in combination with *A. rubi* traps) or mating disruption techniques.

Financial benefits

The financial benefits for growers will be realised in more accurate predictions of a capsid attack and more focused, not prophylactic, control measures.

Action points for growers

- Target sprays of insecticides active against capsids 2 weeks after the population shows a sharp increase in number or if more than 10 capsids per trap per week are observed.

- Growers interested in monitoring for European Tarnished Plant Bug or Common Green Capsid in their crops should contact Michelle Fountain at (michelle.fountain@emr.ac.uk). Traps and lures are available from Mike Abel at Agralan (www.agralan.co.uk, sales@agralan.co.uk).

SCIENCE SECTION

The research done in 2010 is detailed in the summary (see the previous years report for experimental details). This section will detail trials carried out in the growing season of 2011.

The final year of the project focused on;

A. Determining the best height for the traps in strawberry and cucumber crops
B. Determining a trap threshold for *L. rugulipennis*
C. Comparing the trap catch of the 4 species simultaneously
D. Combining the *A. rubi* and *L. rugulipennis* trap
E. Filming the behaviour of *L. pabulinus* around the synthetic lure
F. Investigating grower convenient trap designs for monitoring *L. pabulinus*

Objective 1. Improve and test the lure for *L. rugulipennis* so that it is long lasting and practical for use by growers.

<u>Introduction</u>

In previous work, the four species studied, *Lygus rugulipennis, Lygocoris pabulinus, Liocoris pustulatus* and *Lygus pratensis,* were shown to use different blends of hexyl butyrate (HB), (*E*)-2-hexenyl butyrate (E2HB) and (*E*)-4-oxo-2-hexenal (KA) as female sex pheromones. These compounds present a considerable challenge to formulate in a controlled-release dispenser because of the markedly different volatility and polarity of the KA relative to the other two compounds.

In work during 2010, 1 ml pipette tips containing the pheromone blend as a 10% solution in sunflower oil impregnated onto a cigarette filter were found to be suitable dispensers. These released the three compounds in a similar blend to the blend loaded into the dispenser and maintained release of the blend for at least one month in a wind tunnel at 27°C. In the field the translucent pipette tips were wrapped in tape to prevent degradation of the KA in sunlight.

During 2011, lures supplied for field tests were checked for release rates in the laboratory windtunnel and data is shown for lures used in comparison of the attractiveness of the blends used by the four different species.

<u>Materials and Methods</u>

Lures were prepared as previously using a 10% solution of the pheromone blend in sunflower oil (100 µl). This was impregnated onto a cigarette filter and inserted into a 1 ml plastic pipette tip which was sealed with a crimp seal septum.

In the laboratory, lures were exposed in a windtunnel (27°C, 8 km/hr windspeed). At intervals the volatiles emitted were collected on Porapak. Individual lures were placed in a glass vessel (12 cm x 3 cm) and air drawn in (2 litre/min) through a charcoal filter and out through a collection filter made from a Pasteur pipette (4 mm i.d.) filled with Porapak Q (50-80 mesh, 200 mg). Trapped volatiles were eluted with dichloromethane (3 x 0.5 ml) and decyl acetate (2 µg) added as internal standard.

The solutions were analysed by gas chromatography using a fused silica capillary column

(30 m x 0.32 mm i.d.) coated with polar DB Wax, oven temperature held at 50°C for 2 min then programmed at 10°C/min to 240°C.

Results

Table 1 shows the target blends for each species, the blend loaded in the lures and the composition of the initial blend released. Blends released from the lures were similar to the blends loaded with the relative amount of KA slightly higher in the blend released. The release rate of HB was approximately 1 µg/hr which is four times that typically released by a calling female insect.

Table 1. Target blends, blend loaded in the lures, composition of the initial blend released and release rate for pipette tip lures for four species of *Lygus* bug (means of 2 replicates; blends express relative to HB = 100).

	Target blend (HB=100)		Blend loaded (HB=100)		Blend released (HB=100)		Release rate HB
Species	E2HB	KA	E2HB	KA	E2HB	KA	(µg/hr)
L. rugulipennis	3.1	15.8	3.4	18.8	2.9	20.7	1.1
L. pabulinus	3.8	8.2	3.7	9.3	3.3	8.1	1.1
L. tripustulatus	7.2	13.9	7.2	16.7	6.3	18.2	1.0
L. pratensis	23.9	25.7	25.6	25.7	22.0	32.5	1.1

Figure 1 shows changes in blends released with time of exposure at 27°C and 8 km/hr windspeed. The blend for *L. pabulinus* was maintained remarkably constant during the 60 d of the experiment. For *L. rugulipennis* and *L. tripustulatus*, blends were maintained close to the target blend for approximately 40 d. for *L. pratensis* the relative amount of KA started to decrease after 30 d. These results reflect the fact that KA is released slightly faster than the other two components so that the relative amount in the blend released decreases with time, the effect being greater the higher the relative amount of KA in the blend.

During 2011, attempts were made to improve the synthesis of KA in terms of speeding up the process and increasing the yield. As a result, some experimental batches were not as pure as others, and this decreased the lifetime of the lures, as shown in data for an early batch of lures in Figure 2.

<u>Conclusions</u>

The pipette tip lures provide a convenient dispensing system for blends of HB, E2HB and KA. Although the KA differs markedly in volatility and polarity from the other two components, they are released at similar rates from the pipette tips such that the blend released is similar to that loaded. In fact the KA is still released slightly faster than the other two components so that the proportion of this in the blend decreases over time. The change in blend is more marked the higher the proportion of KA in the starting blend.

Nevertheless, the blends released are maintained within the target range for at least 1 month at 27°C and for much longer in the field where temperatures are generally lower. It is important to ensure purity of the KA used.

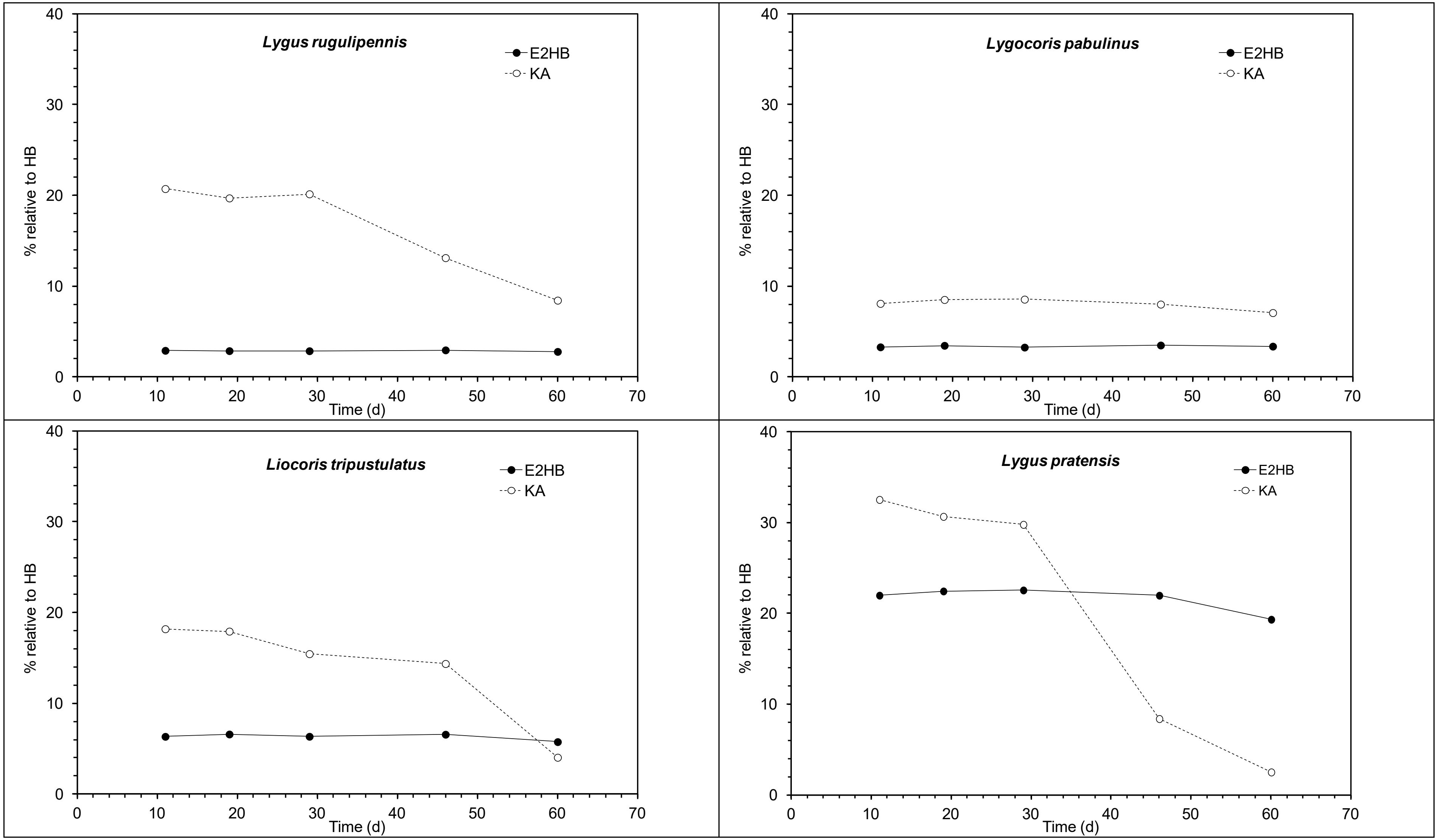


Figure 2. Changes in blends released by pipette tip lures for four species of *Lygus* bug over time at 27°C (% relative to HB).

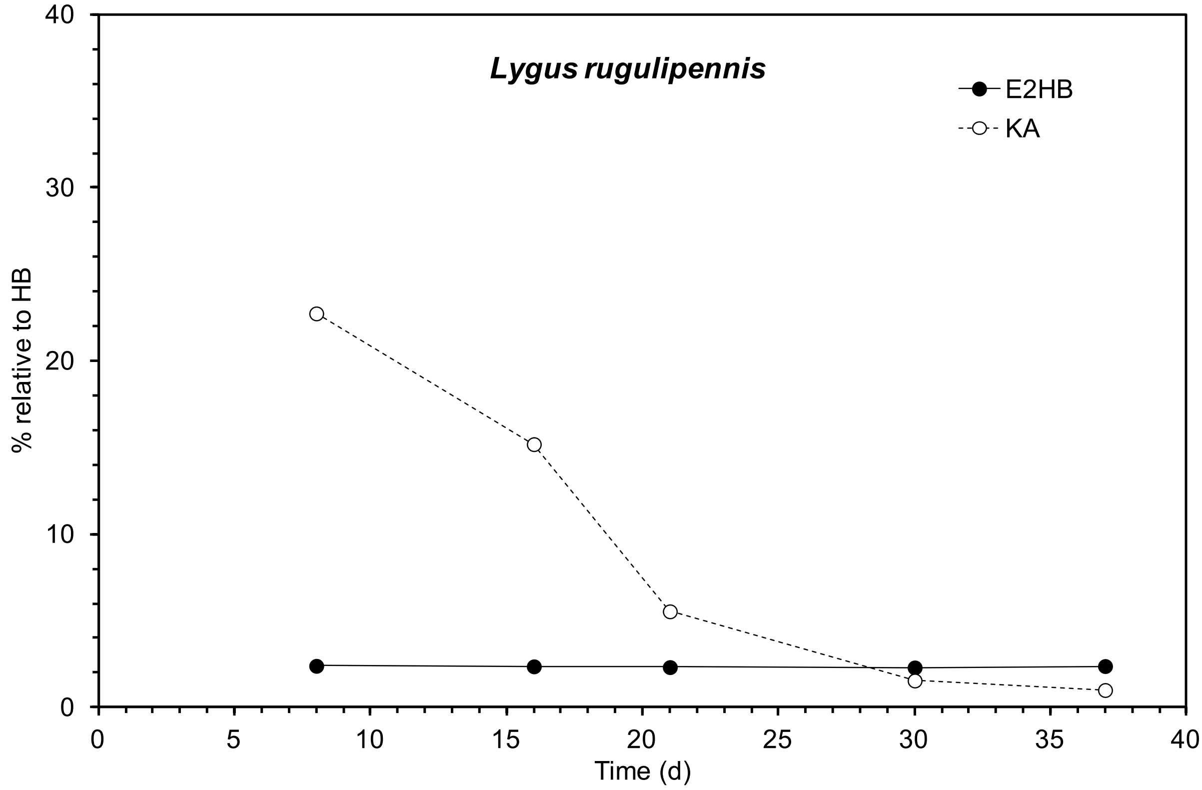


Figure 2. Change in blend released by pipette tip lures for *Lygus rugulipennis* over time at 27°C (% relative to HB).

Objective 2. Calibrate the trap for *L. rugulipennis* for use in pest monitoring to establish a treatment threshold for its use in late season strawberry and cucumber.

A. Determining the best height for the traps in strawberry and cucumber crops

<u>Materials and Methods</u>

Strawberry:

The trial was set up (14 Aug) in a strawberry plantation (cv. 'Finesse') at EMR 'Ditton Rough' field with kind permission of Graham Caspell. Treatments were green cross vane bucket traps (Agralan) with water and detergent as a trapping agent at different heights from the ground. Traps were wired in position at ground level (L), 1.25 m (bracing bar, M) and 4 m (centre top ridge pole, H). The synthetic sex pheromone lures of *L. rugulipennis* were used as bait. The traps were checked on 3 occasions (30 Aug, 19 and 26 Sep) and the number of male *L. rugulipennis* counted. A randomised complete block design with 5 replicates was used and the traps were arranged around the edge of the plantation (Fig 2.A.1) more than 10 m apart.

Cucumber:

The cucumber trial was done at Stubbins Marketing, Fen Drayton (Cambridgeshire) with kind permission of Mr Steve Clarkson. The experiment started in week 33 when the monitoring results from Experiment B showed an increase in *L. rugulipennis* numbers which was attributed to the summer generation. The traps were placed at three heights (Fig. 2.A.2):

- 0.5m from the ground
- hanging at mid crop height (c1.5 m from ground)
- hanging just above the crop support wire (c2.5m from ground)

The layout of the treatments is shown in Figure 2.A.3. The plants had just been placed in the production house at the start of the experiment. By week 35, the crop had grown above the mid-height traps. The highest traps remained above crop height throughout the experiment. The traps were examined weekly and numbers of *L. rugulipennis* recorded over a five week period.

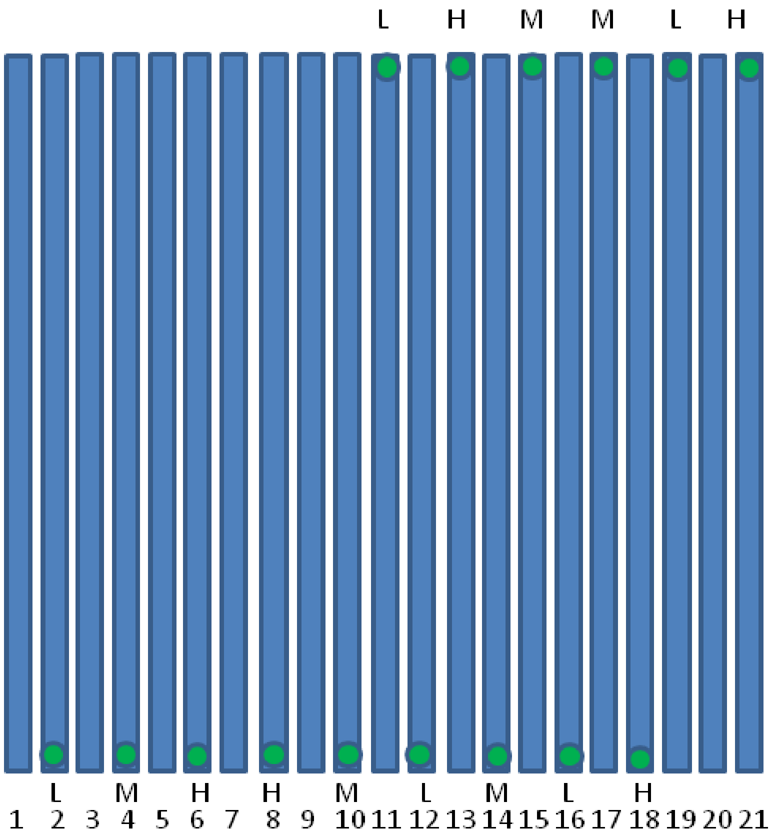


Figure 2.A.1. Plan of trap layout at 'Ditton Rough' strawberry plantation L = low, M = middle and H = high elevation.

Figure 2.A.2. Examples of the three height positions of traps at start of experiment.

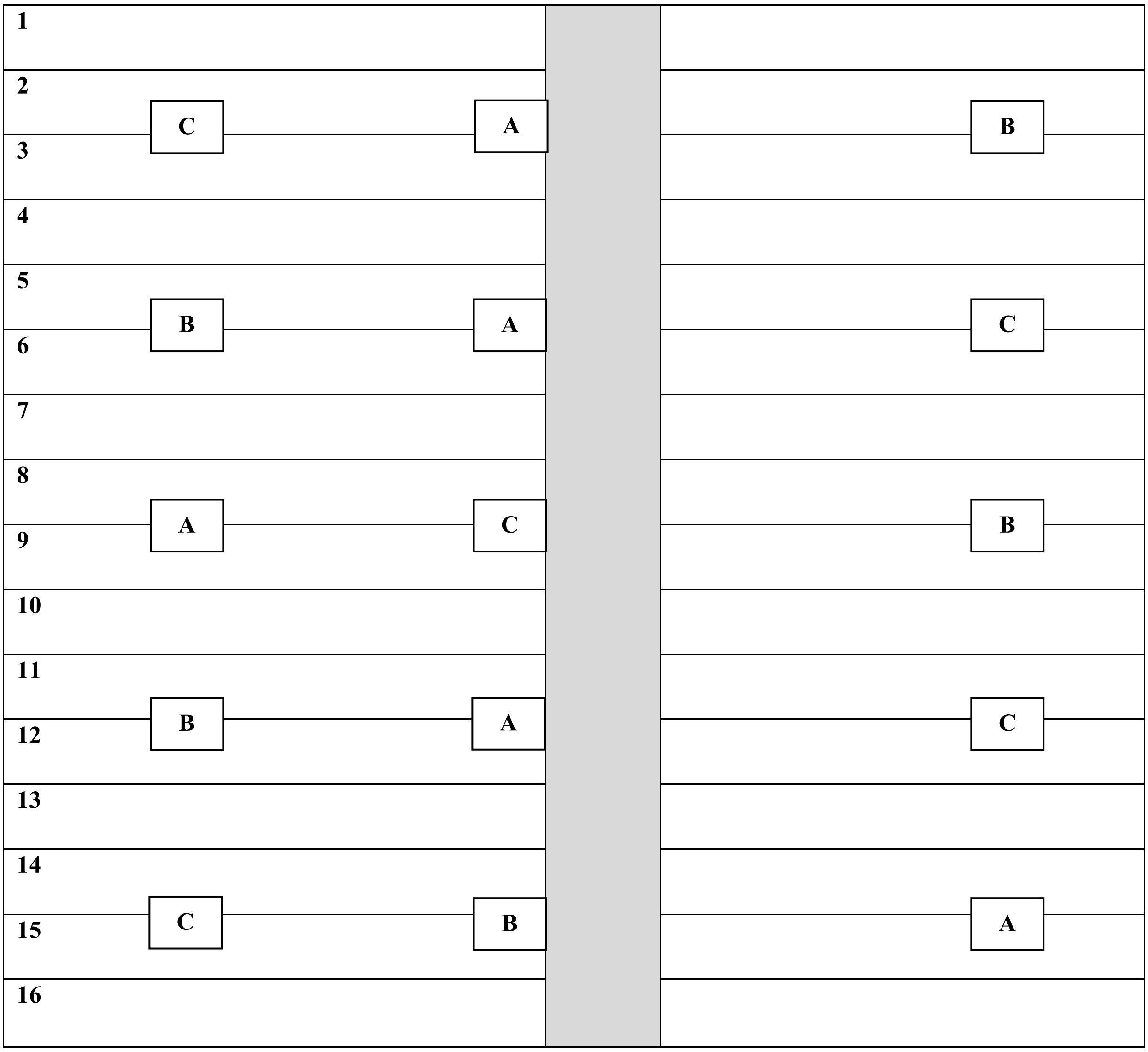


Figure 2.A.3. Experimental layout in Experiment A with treatments allocated in a randomised complete block design within the one hectare glasshouse. [A = Low, B = Medium, C = High]

Results

Strawberry:

There were significantly more male *L. rugulipennis* males in the traps placed on the raised beds within the strawberry (22.2) than the traps wired to the bracing bar (1.0) or the ridge pole (0.2) of the tunnel (P = 0.002, sed = 4.49, lsd = 10.36).

Cucumber results:

The numbers of male *L. rugulipennis* in each trap on each assessment date can be seen in Figure 2.A.4. Very few insects were caught compared to the traps positioned outside the greenhouse. Those caught were always in traps positioned above the crop canopy (*i.e.* treatment B to week 35 and treatment C throughout the experiment). The overall mean catch in traps above crop height was 0.3 per trap per week. Trapping inside the glasshouse proved to be less informative than observations of *L. rugulipennis* on plants made by crop workers while performing their routine crop work.

ROW	HEIGHT	Week number 2011			
		34	35	36	38
15	A	0	0	0	0
	B	1	0	0	0
	C	0	0	0	1
12	A	0	0	0	0
	B	0	0	0	0
	C	0	0	1	1
9	A	0	0	0	0
	B	0	0	0	0
	C	0	0	0	0
6	A	0	0	0	0
	B	0	0	0	0
	C	0	1	1	0
3	A	0	0	0	0
	B	1	0	0	0
	C	1	0	0	0

Figure 2.8.4. Numbers of male *L. rugulipennis* in each trap on each assessment date in the cucumber crop in Experiment A

B. Determining a trap threshold for *L. rugulipennis*

EMR staff and growers monitored *L. rugulipennis* in strawberry and cucumber crops using observational data and sex pheromone trap catches. The objective was to investigate correlations between catches of male capsids in pheromone traps and capsid populations in strawberry and cucumber crops. Trap catches with lures containing synthetic pheromone compounds were compared to crop sampling (tap samples).

Materials and Methods

EMR staff monitored capsid populations in 3 strawberry crops.

- Site 1: Strawberry: Protected everbearer cv. Finesse at EMR 'Ditton Rough' plot.
- Site 2: Strawberry: June bearer Driscolls trial varieties at EMR 'Newgates'. 'Palmers Rough', opposite, had a large area of fathen and mayweed.
- Site 3: Strawberry: Park West strawberry plantation (Cv Albion) at Robert Boucher and Son, Newlands Farm, Teynham, Sittingbourne, Kent ME9 9JQ by kind agreement of Hugh Boucher. The plantation was located at NGR TQ 956 622. Plots contained cv. Elsanta.

Two traps per plantation were placed at the end of the rows at least 10 m apart.

In addition growers and advisers used the traps in their plantations and reported back with monitoring results (Table 2.D.1). 16 farms kindly volunteered to help with the testing. All recorders were supplied with the traps lures, wires for pinning traps downs, a white tray for tap sample monitoring and the instruction/record sheet (Appendix 1).

Rob Jacobson monitored capsid populations in 3 cucumber crops.

- Site 4: Cucumber: Hedon Salads, Burstwick (east of Hull) by kind agreement of Mr Phil Clarkson.
- Site 5: Cucumber: Halsham Farms, Cottingham (west of Hull) by kind agreement of Mr Les Deeley.
- Site 6: Cucumber: Stubbins Marketing, Fen Drayton (Cambridgeshire) by kind agreement of Mr Steve Clarkson.

At each cucumber site two traps were placed inside the glasshouse 0.5m from the ground at the end of the row (where they were easily visible) and two traps were placed on the ground outside the glasshouses in separate weedy areas which were at least 30m apart. All the traps were positioned and activated in mid-May and lures were replaced at recommended intervals throughout the summer.

Table 2.D.1. Traps sent out to advisers and growers for testing.

Name	Farm	County	No. traps	Traps given to
Steve Greenaway	1. G Charlton & Son	Kent	4	Steve Greenaway, 42 Oak Drive, Larkfield, Aylesford, ME20 6NU
Charles Kidson	2. Lower Reule Farm Ltd.	Staffordshire	4	Tom Deards, The Pastures, Preston Wynne, Hereford, HR1 3PE
N J Cockburn	3. Pennoxstone Court	Herefordshire	4	
Paul Hamlyn	4 Clock House Farm Ltd	Kent	4	Paul Hamlyn, Clock House Farm Ltd, Clock House Farm, Coxheath, Maidstone Kent ME17 4BG
Jon Regan (Production Director) Lance Mansell (Manager)	5. Hugh Lowe Farms Ltd	Kent	2	
John Busby	6. A J Busby & Son	Staffordshire	2	Simon Beasley, 50 Julian Road, Ludlow, Shropshire, SY8 1HD
Stephen McGuffie	7. New Farm	Staffordshire	2	
Jon Lowe (Farm Manager) John Blazey (Growing Manager)	8. Place UK Ltd	Norfolk	2	Jon Marcar, Place UK Ltd, Church Farm, Tunstead, Norwich, Norfolk NR12 8RQ
Paul Kelsey	9. Quaives Farm	Kent	4	Steven Kember, Lower Ladysden Farm, Summer Hill, Goudhurst, Tonbridge Kent TN17 1JX
Peter Thomson (Managing Director) Simon Harris (Manager)	10. Thomas Thomson (Blairgowrie) Ltd	Perthshire	2	Trelawney Greaves, (Blairgowrie) Ltd, Packhouse, Haugh Road, Blairgowrie, Perthshire, PH10 7HY
Adam Whitehouse	11. EMR	Kent	2	Adam Whitehouse, East Malling Research, New Road, East Malling Kent ME19 6BJ
Harriet Duncalf	12. Maltmas Farm	Cambridgeshire	4	Harriet Duncalfe, Maltmas Farm, Friday Bridge, Wisbech, Cambs PE140HS
Alice MacLeod	13. Maelor Forest Nurseries Ltd.	Hampshire	4	Alice MacLeod, Maelor Forest Nurseries Ltd., Fields Farm, Bronington, Whitchurch SY13 3HZ

The lures were a 3-component mix 10% in sunflower oil of hexyl butyrate ('HB') : (*E*)-2-hexenyl butyrate ('E2HB') : (*E*)-4-oxo-2-hexenal ('KA') deployed in pipette tip dispensers. The release rate of HB was approximately 1.2 µg/h from the 1 ml pipettes. The traps were Agralan green cross vane bucket traps containing water and a drop of detergent with a pheromone lure suspended under the lid.

Assessments;

- Strawberry: The contents of the pheromone traps were sieved and numbers of male *L. rugulipennis* counted. In addition, 40 strawberry plants from each plot were tap sampled over a white tray. Capsids landing on the tray were identified in the laboratory to instar (N1-N5) and adults sexed by EMR staff. Other recorders counted the total number of *L. rugulipennis* on the tray.

- Cucumber: The traps were monitored at approximate weekly intervals. On each occasion, the contents were sieved and the numbers of adult *L. rugulipennis* recorded separately per trap. There is no established method of monitoring capsid numbers in a cucumber crop that will provide a reliable indication of the size of the population or the risk of plant damage. Crop workers usually look for the insects and / or damage symptoms while doing their routine crop work and immediately report any sightings to the nursery manager. It was therefore decided that any damage or *L. rugulipennis* sighted during a 10 minute period during a routine crop inspection would be recorded. In addition, Mr Derek Hargreaves, who is the Cucumber Growers' Association (CGA) Technical Officer and the principal cucumber crop consultant in the UK, alerted CGA members when the pest became active in his clients' crops. In recent years, this warning has instigated more widespread precautionary treatments.

The results of the monitoring were plotted. Growers spray regimes against insects and any reports of capsid damage were also gathered for data interpretation. The results were correlated to determine when the population increase is apparent in the pheromone traps so that insecticidal sprays can be targeted in the future.

Results

- EMR Strawberry monitoring

Monitoring data collated over the past 2 years by EMR staff is shown in Fig 2.D.1. Tuesley Farm and Newlands Farm were also monitored, but numbers were too low to give reliable readings.

In 2011 the first male capsid was caught on 4 March. The adult overwintering generation from the previous year persisted for up to 4 weeks before presumably mating, laying eggs and dying. A lag phase is observed between the overwintering generation and the summer generation (Fig 2.D.1) because eggs are hatching and nymphs maturing (not attracted to sex pheromone).

At Langdon Manor the summer population began to rise in the pheromone traps at the 24 Jun recording. Numbers of *L. rugulipennis* sampled by tap sampling (economic threshold) were only evident from 22 Jul; 4 weeks later.
At Middle Pett Farm the summer population began to increase in the pheromone traps at the 8 Jul recording. Numbers of *L. rugulipennis* sampled by tap sampling were only evident from 12 Aug; 4 weeks later.
At East Malling Research the summer population began to increase in the pheromone traps on 6 Jul recording. Numbers of *L. rugulipennis* sampled by tap sampling were too low to detect by tap sampling 40 plants.
At Middle Pett Farm the summer population began to grow in the pheromone traps on 17 Jun

recording. Numbers of *L. rugulipennis* sampled by tap sampling were only evident from 22 Jul; ~4 weeks later.

- Grower/Adviser Strawberry monitoring

The following is a short summary of the most noticeable and significant findings for the data collected by growers and advisers (see Appendix 2 for record sheets).

1. G Charlton & Son
There were low numbers of *L. rugulipennis* captured in traps. However, the tap sampling revealed increasing numbers of *L. pabulinus* from July onwards. On 4 Aug a spray of Chess (pymetrazine) was applied reducing numbers in subsequent weeks.

2. Lower Reule Farm Ltd.
One plantation at this farm had a severe infestation of *L. rugulipennis*. Trap catches on 21 Jul reached 67 and 75, but significant numbers of males were being trapped from 23 Jun. An application of Tracer (spinosad) on 23 Jul reduced the numbers by two thirds, but it is speculated that an earlier treatment, 2 weeks after numbers began to rise (07 Jul) would have controlled the pest more effectively. After applications of Calypso (thiocloprid) and then Hallmark (llambda cyhalothrin) helped to bring the pest under control.

3. NJ Cockburn
Once the trap catch exceeded 10 males per trap the grower applied a spray of Calypso (thiocloprid). This kept numbers under control in the following weeks (usually 0-3 males per trap). However, in one trap on 8 Aug there were 60 males captured. A treatment of Hallmark (llambda cyhalothrin) was applied, bringing capsids under control once more. Generally the two traps on each plantation gave similar trap catches. However, on this occasion the second trap on the plantation only caught 16 males showing that it is important to have 2 monitoring traps per plantation.

4. Clock House Farm Ltd
Very few *L. rugulipennis* were captured in the pheromone monitoring traps at the two plantations on this farm.

Unfortunately the results for the following farms are unavailable due to a member of the advisory staff leaving (5. Hugh Lowe Farms Ltd, 6. A J Busby & Son, 8. Place UK Ltd, 9. Quaives Farm).

7. New Farm,
Very few capsids were found in the traps on both plantations, hence, no action to control was required.

10. Thomas Thomson (Blairgowrie) Ltd
No *L. rugulipennis* were captured in the pheromone monitoring traps or tap samples on the Jubilee plantation at this farm. However, some *L. pabulinus* were sampled in one area of the field.

11. EMR (student project)
According to the data collected there was a significant rise in capsid numbers on 15 Apr. However, this is unlikely as the timing was between generations of adult *L. rugulipennis*. The numbers were quite erratic (not seen in other experiments). After conversations with the recorder it is suspected that total numbers of invertebrates in the traps were being recorded and no distinction of *L. rugulipennis* males was being made. This highlights the importance of accurate identification of capsids from other insects. However, numbers reached 36 in the traps on 24 Jun and a spray of Hallmark (llambda cyhalothrin) on 30 June reduced numbers of insects trapped so it is likely there were some *L. rugulipennis* amongst the insects.

12. Maltmas Farm
Very few *L. rugulipennis* captured, however, there were some *L. pabulinus* present.

13. Maelor Forest Nurseries Ltd.
The final farm was a pine a sitka plantation where capsids were initially thought to be causing damage to the shoot tips. However, it was later identified as damage by *Adelges abietis* (spruce pineapple gall adelges). Hence, *L. rugulipennis* was probably feeding on the understory of weeds. In addition, many of the sprays detailed (Appendix 2) were applied against other pests, such as, aphids and cutworm.

Conclusion
In 2010 and 2011 the sex pheromone traps gave a 4 week warning of when economic damage was likely to occur (1 capsid / 40 plants). Hence, to achieve maximum control and reduced fruit damage a treatment to control adults and nymphs should be applied 2 weeks after the trap catch begins to rise or after a threshold of 10 individuals per trap.

- Cucumber crops

The mean numbers of male *L. rugulipennis* caught per trap inside and outside cucumber greenhouses at the three sites between week numbers 20 and 38 2011 are shown in Figure 2.D.2. Comparable results were obtained from sites 5 and 6; both sites recording a sharp peak of 10-15 males per trap outside the glasshouse in week 33 with much smaller numbers (< 2 / trap) within the crops. Crop monitoring revealed traces of damage and only rare sightings of capsids on the plants. Very small numbers of *L. rugulipennis* were recorded in traps at Site 4.

The size and timings of the catches differed at each site compared to 2010:
- At Site 6, the peak catch in 2011 was <20% of 2010. Furthermore, it was 2-3 weeks later than in 2010 and spread over a much shorter time.
- Very few males were caught in the traps at Site 4, which was in complete contrast to 2010 when there was a very marked peak between weeks 31 and 33.
- The reverse of this was seen at Site 5, where the peak catch was more than 4x greater than the relatively small catch recorded in 2010.

In summary, the overall numbers of *L. rugulipennis* were smaller and the summer generation about two weeks later than in 2010. Many of the replanted cucumber crops had passed the most vulnerable stage before this generation appeared and were thus spared serious damage. These results reinforce the need for accurate local monitoring and further demonstrate the value of the pheromone system being developed by this consortium. However, they also illustrate the need to base decisions on informed interpretation of the size and timing of the catch relative to the growth stage of the crop.

It is worth mentioning that pheromone traps were placed in and around an additional crop in Kent where they were managed by the grower throughout the season. At that site, capsid bugs were first recorded on plants in January and serious damage occurred during spring. Those individuals must have overwintered within the glasshouse and then developed more quickly than if they had been outside. As a consequence, treatments with broad spectrum insecticides were required very early in the season. This situation was unusual and should serve to remind growers that pests do not always follow the normal trend.

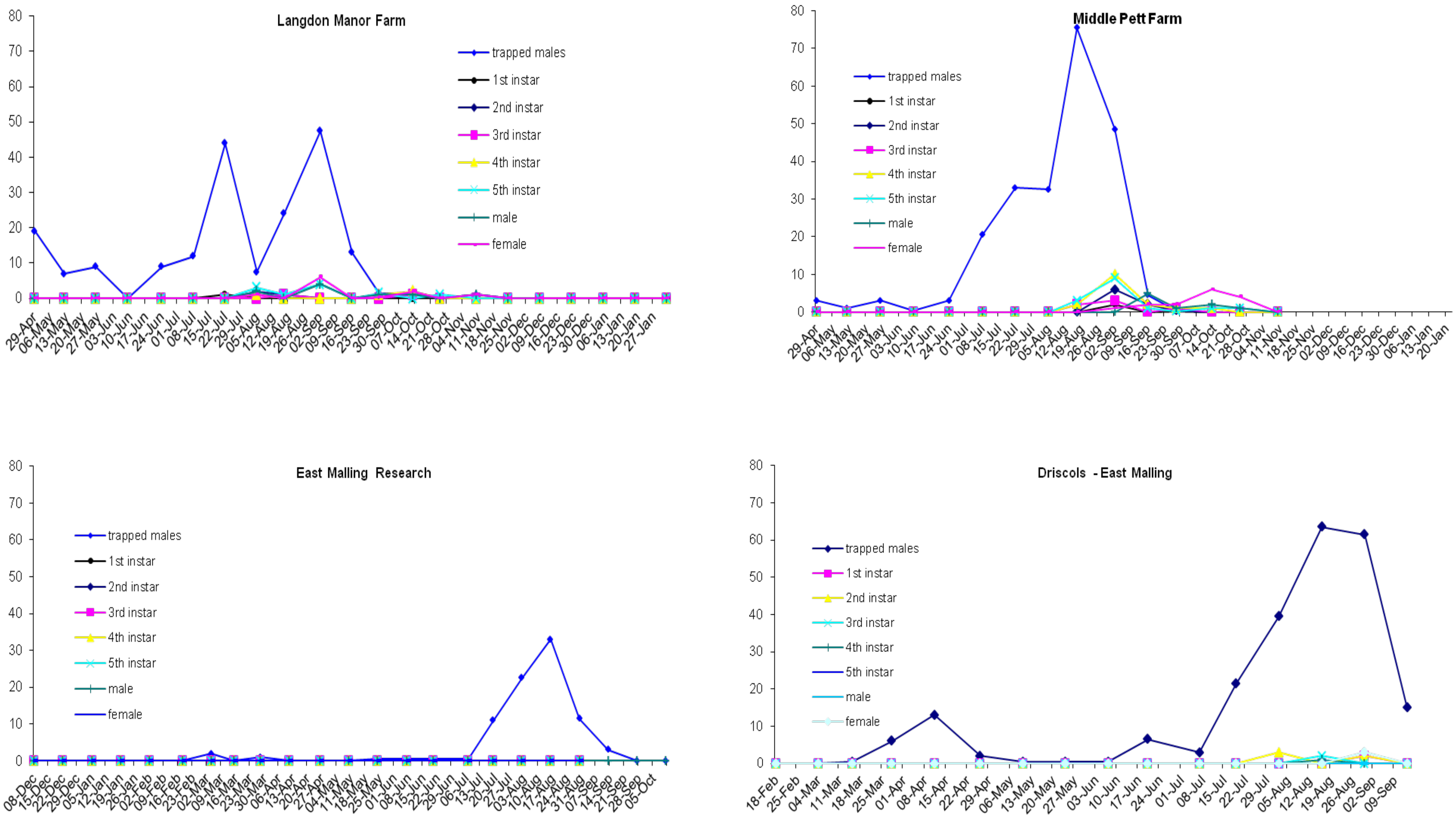
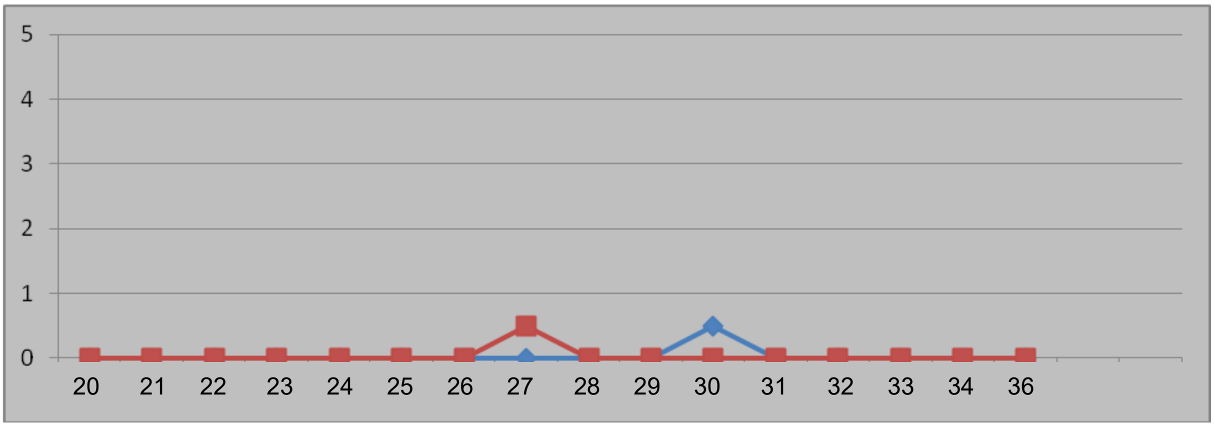
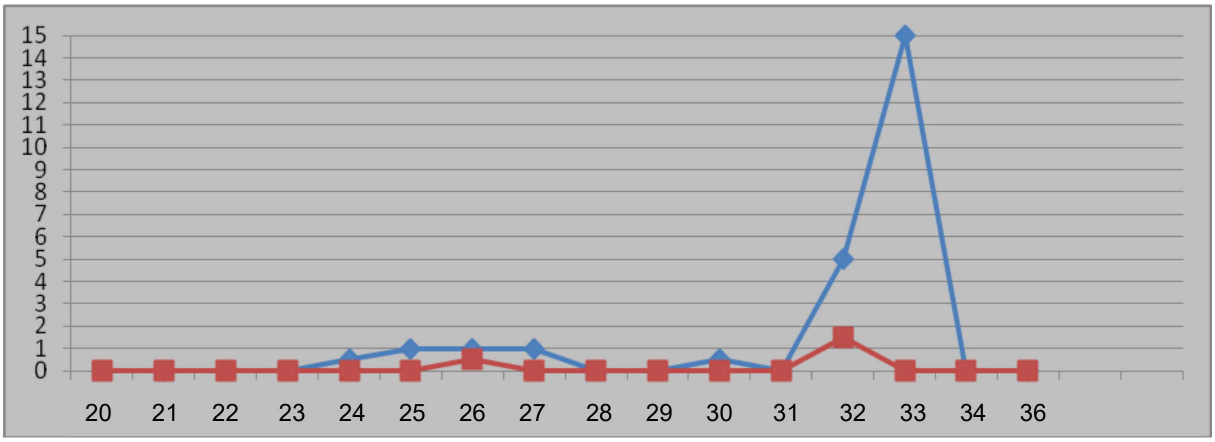


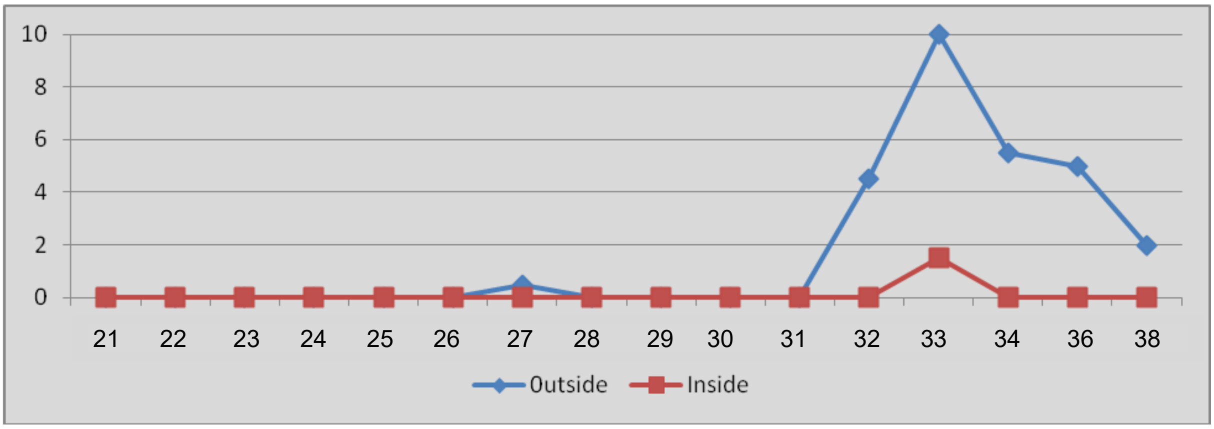
Figure 2.D.1. Sex pheromone trap catches from 2010 and 2011



Site 4. Hedon Salads



Site 5. Halsham Salads



Site 6. Stubbins Marketing

Figure 2.D.2. Mean numbers of *Lygus rugulipennis* caught per trap inside and outside cucumber greenhouses at three sites between week numbers 20 and 38 2011

C. Comparing the trap catch of the 4 species simultaneously

Materials and Methods

This experiment was to investigate the specificity of the synthetic sex pheromone blends for the 4 species of capsid studied in the project (*L. rugulipennis, L. pratensis, L. pabulinus* and *L. tripustulatus*) in attracting males of the intended species.

The trial was done at:

a) Nettle area on the border of the organic apple field at East Malling Research. The site was situated between the hedgerow and a wire fence along a public footpath towards East Malling village, west of Great East Hostel (location NSRQ705 570). *L. rugulipennis, L. pratensis, L. pabulinus* and *L. tripustulatus* were known to exist at this site.
b) EMR blackcurrant plantation (Baldwin, Ben Gairn, Ben Hope, Ben Lomond and Ben Tirran), CE179. Row spacing 3 m and plant spacing 0.5 m, 10 4x4 Latin squares (2 of each variety). The plot was planted in March 2002. *L. rugulipennis, L. pratensis* and *L. pabulinus* were known to exist on this site.
c) Ben Alder blackcurrant plantation at Stonebridge, Horsmonden, Location NGR TQ 719 399 (Kind permission of Tom Maynard). *L. rugulipennis, L. tripustulatus* and *L. pabulinus* were known to exist on this site.

Four small scale field trials using synthetic sex pheromone lures (1 ml pipette tips) of all 4 species on sticky stake traps were done. The experimental design was a randomised complete block design with 4-5 replicates, and the traps were arranged in rows at least 10 m apart.

Results

Data were square root transformed to normalise for variances.

Test 1: 2-27 June - Site A - blackcurrant

Significantly more *Capsus ater* (P <.001, sed = 0.329, lsd = 0.697) were captured on the *L. pratensis* lure baited traps than the other species lures or the unbaited control traps, indicating that these two species may have similar ratios of pheromone components.

More *L. pabulinus* (P = 0.037, sed = 0.686, lsd = 1.455) were captured all 4 species lures compared to the control. There was no difference between the species of lure used. Either this species is less precise about the ratio it is attracted to or the blend is not optimum for *L. pabulinus.*

No *L. tripustulatus* were captured although they are known to be in the nettles surrounding the plantation. *L. pratensis* numbers are generally low at this site and *L. rugulipennis* were between generations (Fig. 2.C 1).

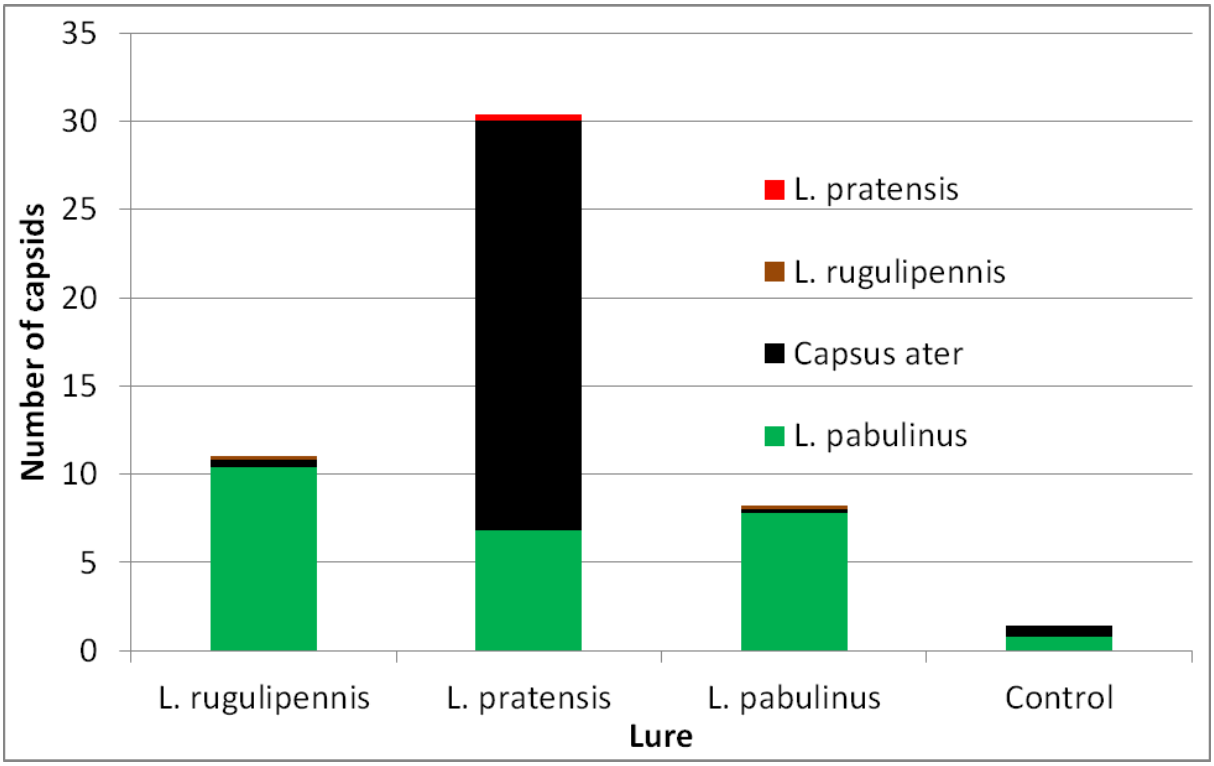


Figure 2.C.1. Mean numbers of capsids trapped in Test 1: 2-27 June - Site A - blackcurrant

Test 2: 2-27 June - Site A - nettle
Numbers of mirids captured on this site were much lower, however, significantly more *C. ater* (P =0.022, sed = 0.468, lsd = 0.992) were captured on the *L. pratensis* lure baited traps than the other species lures or the unbaited control traps.

Heterogaster urticae were captured on the *L. pabulinus, L. tripustulatus* and *L. pratensis* but the results were not quite significant (P=0.06).

More *L. pabulinus* (P = 0.035, sed = 0.414, lsd = 0.879) were captured on *L. rugulipennis* and *L. pabulinus* lures (Fig. 2.C.2).

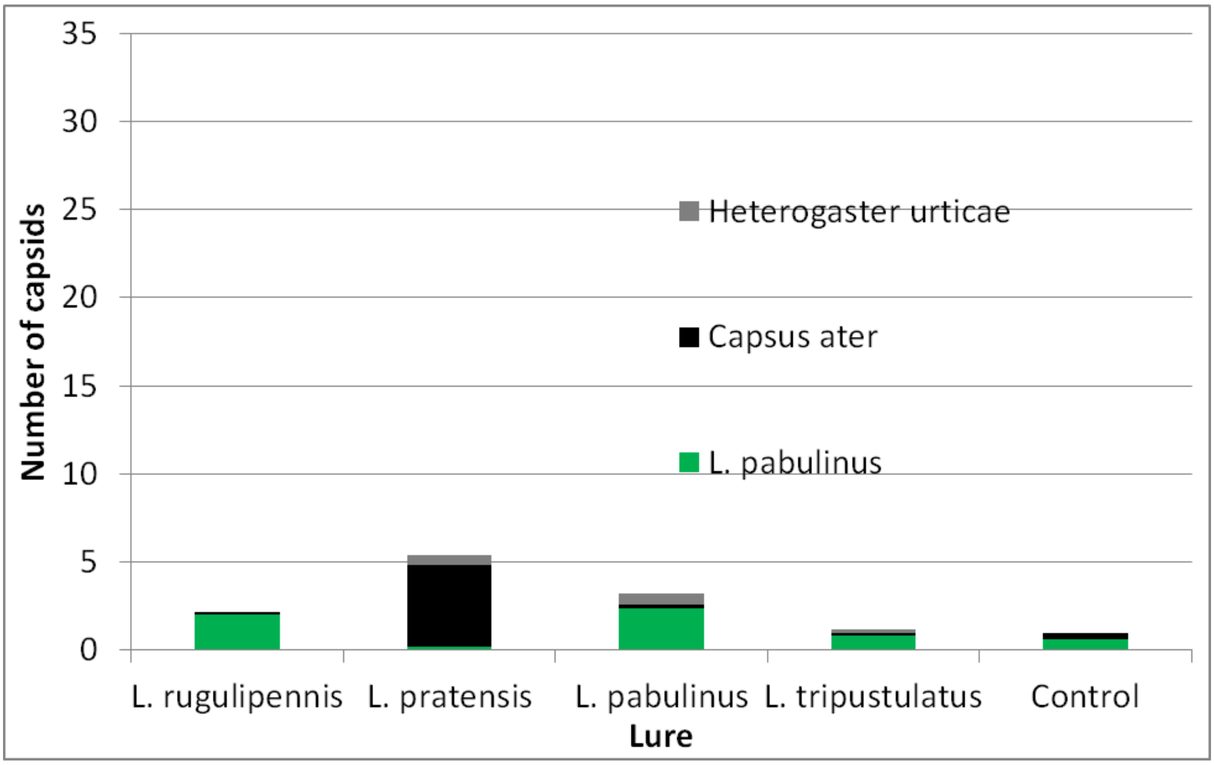


Figure 2.C.2. Mean numbers of capsids trapped in Test 2: 2-27 June - Site A - nettle

Test 3: 5 August-7 September - Site B - Blackcurrant

Once again, numbers of capsids captured were low over the 4 weeks of the trial. This time there was no significant difference in the number of *L. pabulinus* trapped on the sticky stakes with different species lures or the control. The numbers of *L. pratensis* were higher on the *L. pratensis* baited traps compared to the other species synthetic pheromones (P =0.007, sed = 0.339, lsd = 0.739). Numbers of *L. rugulipennis* (P =0.025, sed = 0.403, lsd = 0.877) were higher on all pheromone baited traps compared to the control (Fig. 2.C.3).

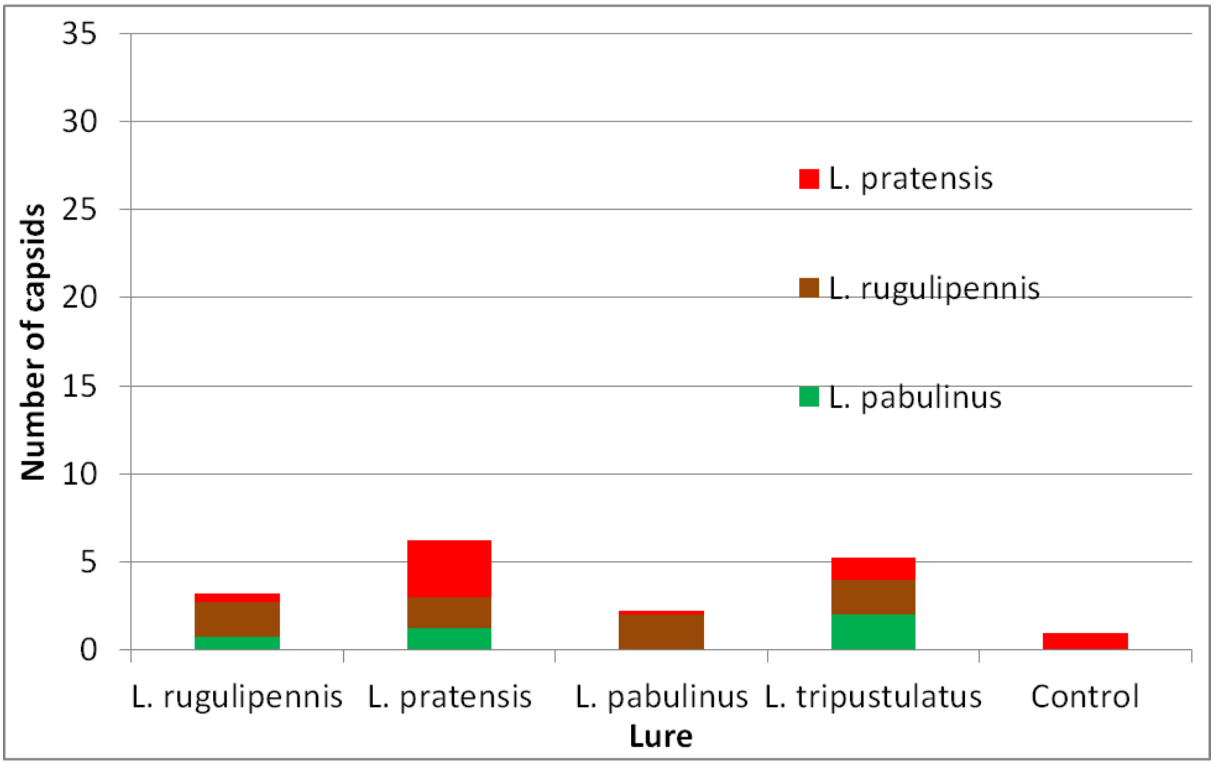


Figure 2.C.3. Mean numbers of capsids trapped in Test 3: 5 August-7 September - Site

B - Blackcurrant

Test 4: 5 August-7 September - Site A - Nettles
The numbers of capsids captured were low. There was no significant difference in the number of any of the 4 species between the species synthetic pheromone lures or the control (Fig. 2.C.4).

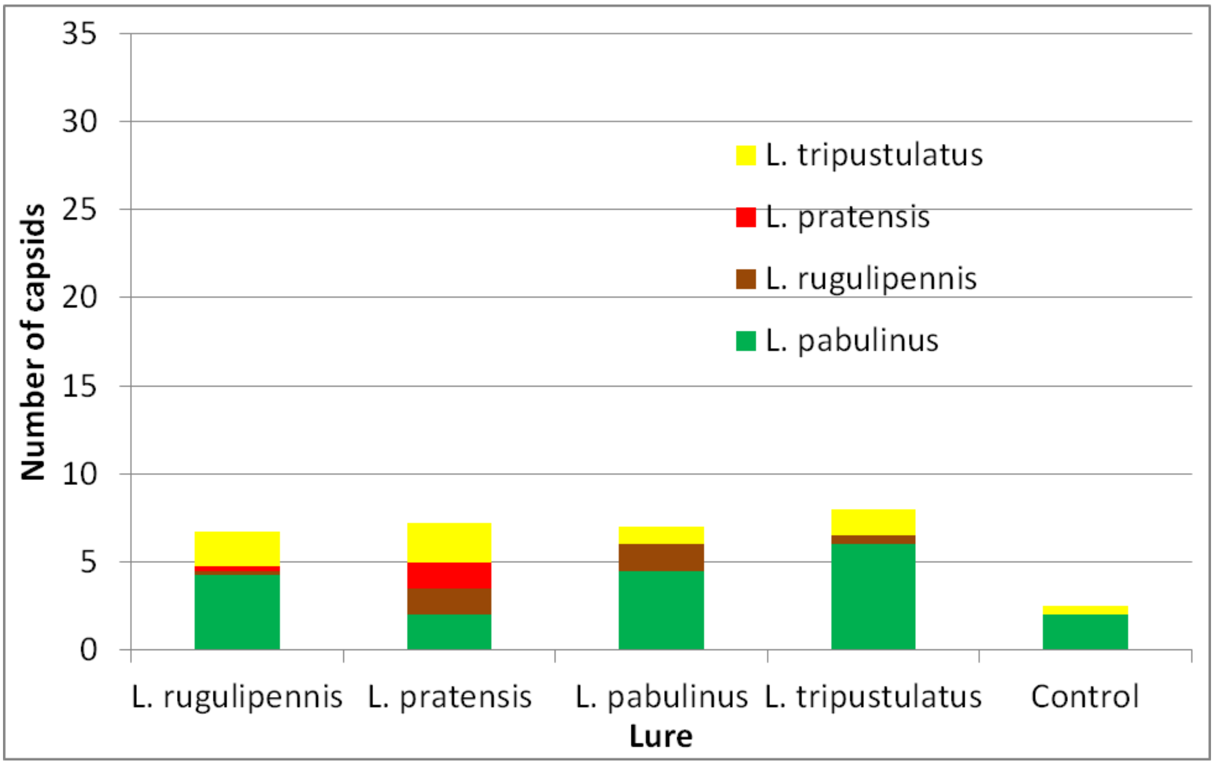


Figure 2.C.4. Mean numbers of capsids trapped in Test 4: 5 August-7 September - Site A - Nettles

<u>Conclusions</u>

Although it was previously demonstrated that virgin females of the four species of *Lygus* bug produce remarkably well-defined blends of the three pheromone components, the results of these experiments show that there is considerable cross-attraction of other species by lures containing these specific blends. In particular, there were no obvious, consistent differences between the blends for *L. pabulinus* (low E2HB, low KA), *L. rugulipennis* (low E2HB, medium KA) and *L. tripustulatus* (medium E2HB, medium KA). The blend for *L. pratensis* (high E2HB, high KA) showed some differences, generally attracting fewer *L. pabulinus* than the other lures and more *L. pratensis*. It was also interesting that the *L. pratensis* lures also attracted significant numbers of a new species, *Capsus ater*.

In scientific terms, these results indicate that other mechanisms must be acting to ensure species-specificity of mating. For instance, it was shown that females of *L. rugulipennis* produce pheromone early in the morning and those of *L. pabulinus* produce pheromone in the late afternoon and evening.

In practical terms, these results mean that one could probably use a generic lure containing an intermediate blend that would attract significant numbers of all the four species investigated here.

D. Combining *A. rubi* and *L. rugulipennis* trap

Methods

The objective was to determine whether pheromone traps for *L. rugulipennis* and the strawberry blossom weevil (*Anthonomus rubi*) could be effectively combined into one. We aimed to determine whether the lures for the two species interacted and which of the trap designs used is effective at catching both species.

The trial was done at Haygrove Ltd, Redbank Farm, Little Marcle Rd, Ledbury, Hereford HR8 2JL by kind agreement of Graham Moor in 'Southfield' (treated) organic plantation. The plantation had moderate levels of blossom weevil, and was planted with cv. Evie 2, an everbearer variety, in March 2010. The experimental plot consisted of 12 tunnels. The tunnels were 7.4 m wide. Each tunnel contained 4 beds (each containing 3 rows of strawberries). The trail was repeated in 2010 and 2011.

The treatments were a factorial comparison of trap design (2 levels), and lure composition (3 levels) (Table 2.D.1). A Latin square design comprising 6 replicates of the 6 treatments was used. Plots were single traps deployed in a square grid, spaced 2 tunnels (= 14.8 m) apart in the leg rows of the Spanish tunnel protected strawberry field.

Table 2.D1. Treatments

Treatment no.	Factor 1: Trap design	Factor 2 Lure(s)
1. GA	Green cross vane no grid	*A. rubi*
2. GL	Green cross vane no grid	*L. rugulipennis*
3. GLA	Green cross vane no grid	*A. rubi* + *L. rugulipennis*
4. WA	White cross vane with grid	*A. rubi*
5. WL	White cross vane with grid	*L. rugulipennis*
6. WLA	White cross vane with grid	*A. rubi* + *L. rugulipennis*

Traps were Agralan funnel traps with either white or green cross vanes. The white cross vane traps were deployed with a bee excluder grid over the funnel. This is because the white cross vane traps attract non-target insects, such as, honeybees and bumblebees. This was not necessary with the green cross vane traps because they do not attract bees. Lures were either the standard *Anthonomus rubi* sachet containing 100 µl of the normal 1:4:1 blend of Grandlure I: Grandlure 2: lavandulol plus 1 g of the strawberry flower volatile 2, 4-dimethoxybenzene, provided by International Pheromone Systems Ltd. or *L rugulipennis* pipette tips containing 100 µl of the standard blend of hexyl butyrate, (*E*)-2-hexenyl butyrate and (*E*)-4-oxo-2-hexenal (10% in sunflower oil). Plots were single traps deployed in a square grid, spaced 2 tunnels (= 14.8 m) apart in the leg rows of the Spanish tunnel protected strawberry field.

The traps were stood on the ground and held in place with a wire hoop, and contained water plus a few drops of detergent to break the surface tension. *L. rugulipennis* lures were renewed on each visit.

The grower was requested to avoid spraying the field for the two target pests for as long as possible. A temperature/humidity data logger was deployed in a Stevenson's screen in the field to take half hourly records.

Counts of the number of male *L. rugulipennis* and *Anthonomus rubi* in each trap were made.

Results

Square root transformed data was analysed using a split plot design. Both trap type and lure species were significantly different in the numbers of insects captured (p<0.001). The same general pattern was observed in both years, although *A. rubi* numbers were lower in 2011.

More *L. rugulipennis* males were captured in green cross vane traps than white cross vane traps (ANOVA P<0.001). More were caught in traps baited with *L. rugulipennis* pheromone than *A. rubi* pheromone baited traps (ANOVA, P<0.001). The *A. rubi* lures did not interfere with catches of *L. rugulipennis* or *vice versa*. In a previous HortLINK project HL0184 (PC/SF 276), *L. rugulipennis* was less attracted to white cross vane traps and, in addition, impeded by the grids used as bee excluders (Figure 2.D.1). Also fewer non target insects, includeing bees, were captured in green cross vane traps.

A. rubi numbers were not affected by cross vane colour. Significantly more were found in the traps baited with *A. rubi* pheromone (P<0.001) than the *L. rugulipennis* pheromone.

Any future combined monitoring/mass trap for *L. rugulipennis* and *Anthonomus rubi* should have green cross vane, no grid and both pheromone lures (Figure 2.D.2).

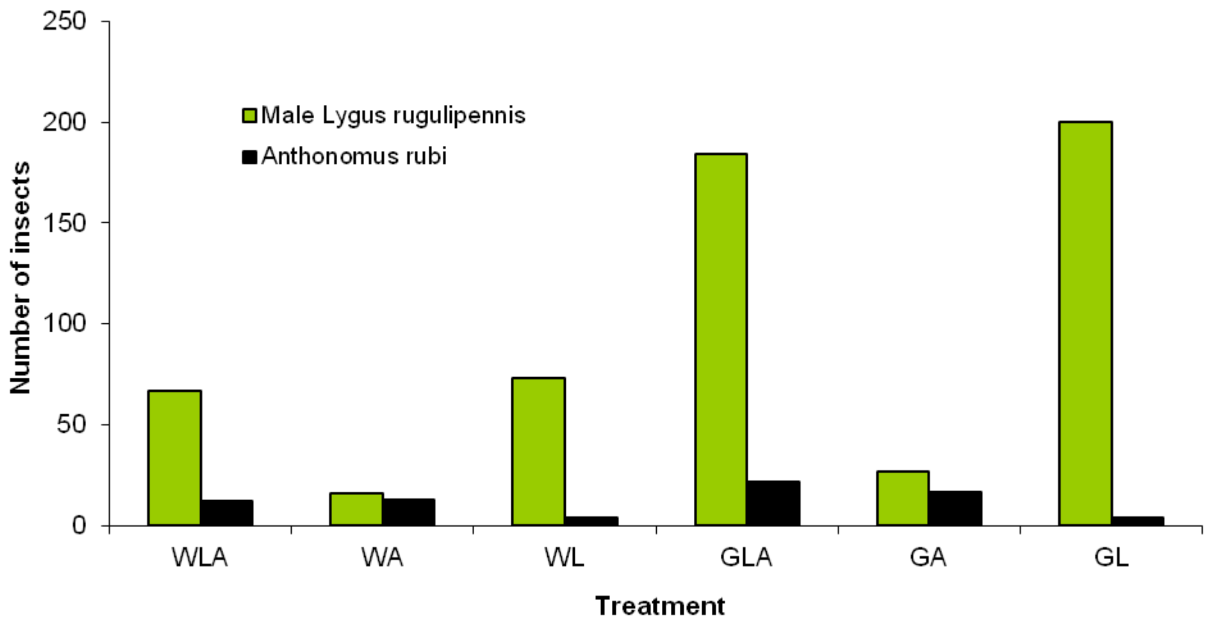


Figure 2.D.1. Mean number of male *L. rugulipennis* and *A rubi* trapped in green (G) or white (W) cross vane traps with *Lygus* (L) and/or *Anthonomus* (A) lures (n=6)

Figure 2.D.2. Recommended monitoring/mass trapping device for *L. rugulipennis* and *A rubi*

Objective 3. Develop an effective lure and trap for *L. pabulinus* with associated data for pest monitoring.

E. Filming the behaviour of *L. pabulinus* around the synthetic lure

Materials and Methods
Using a remote security camera and hard drive recorder a series of experiments was set up to observe the behaviour of males *L. pabulinus* approaching pheromone lures (Fig. 3.D.1). The objectives were to; 1. Determine what time of day males are attracted to females and 2. Record approach behaviour of male to female to help in trap design.

Synthetic *L. pabulinus* sex pheromone lures were used as bait. The recordings were done on a blackcurrant plantation at EMR (see site b in Obj. 1).

The pipette tip synthetic lure was placed under the centre of a piece of white square Correx (50x50 cm). Two cameras were employed;

1. A security camera for observing the long range attraction of the male capsid to the bait. The camera (Swamm digital wireless security camera, ADW-300^{TM}, up to 50 m wireless) was sourced from CCTV direct (200 Selby Road, Leeds, West York LS15 0LF 08453701999).
2. A macro camera for observing the approach behaviour of the male at close range to the bait. The camera (CCD box cctv camera with Sony super HAD CCD sensor) fitted with a V6x17 17-102mm Canon tv zoom lens. Connected to a "Digisender" DG-300 Signal Extender 100m RF transmitter and receiver system were sourced form Farnell CPC (150 Armley Road, Leeds, LS12 2QQ 08447 88 00 88).

Both cameras were connected to a hard disk recorder (HDD 500GB KillerCam Corp., 4Ch, LAN, USB B/up-VGA Mon) also sourced from CCTV direct (200 Selby Road, Leeds, West York LS15 0LF 08453701999). Recordings were made and then watched at x 5 speed on a computer monitor.

Figure 3.D.1. Photograph of camera and lure set up in field to record male *L. pabulinus* behaviour

Results

Recordings were made of one *L. pabulinus* adult on the morning of 1 Jul. A nymph was recorded walking up the stake on 5 Jul, also in the morning. All of the other recordings were of *L. rugulipennis/pratensis* being attracted to the lure (Table 3.D.1). This is an interesting finding as it confirms the data from sticky traps catches in the 4 species test carried out later in the year (Obj. 2). It would appear that there is some long range attraction of, particularly *L. pabulinus* and *L. rugulipennis*, to the same synthetic pheromone lures.

Table 3.D.1. Activity and attraction of capsid bugs to L. pabulinus synthetic sex pheromone lure

Date	Time	Notes
30/06/2011	16:51:30	Can see thrips on macro camera, so quality good enough for capsid i.d.
01/07/2011	09:02:32	brown/red insect hovering in front of lure
	10:25:38	L. pab - walked up from behind stake and round to front No footage of approach. Walked down stake to leave Remained stationary, but out of view of macro
	10:26:15	L. pab - left
	11:35:29	brown/red insect walked up and down lure (v. blurred)
	11:43:34	L. rug landed on lure, tapped abdomen and flew off
	12:07:11	L. rug - crawled up and down stake
	12:11:31	L. rug - flew away
	12:12:13	L. rug - on lure
	12:16:17	L. rug - crawling up and down stake
	12:17:20	L. rug - stationary underneath lure
	12:17:20	L. rug - on lure
	12:27:19	L. rug - walking up and down stake and visiting lure
	17:39:23	L. rug - walking up stake
05/07/2011	08:47:36	L. pab nymph - walking up stake
	08:52:57	L. pab nymph - on lure
	15:38:13	L. rug/ L. prat - around lure
	15:43:12	L. rug/ L. prat - left
07/07/2011	21:38:49	L. rug - walking down stake
	21:39:08	L. rug - on lure (walking up and down)
	21:40:06	L. rug - walking down stake
	21:40:48	L. rug - on lure (walking up and down)
	21:56:08	L. rug - remained on lure and stake
		Too dark to observe night recordings
08/07/2011	04:08:12	L. rug - on lure
	04:40:43	L. rug - continued to walk up and down stake and visit lure until this time
	06:15:55	L. rug - on lure
	06:24:46	L. rug - on lure - then flew away
	07:58:52	L. rug - walking up stake
	07:59:22	L. rug - on lure
	08:10:42	L. rug - continued to walk up and down stake and visit lure then flew away
	12:12:05	L. rug - walking up and down stake and visiting lure
	12:15:20	L. rug - continued to walk up and down stake and visit lure then flew away
09/07/2011	10:00:00	**END**

F. Investigating grower convenient trap designs for monitoring *L. pabulinus*

In 2008, from 9-30 June, three males were captured in three female baited traps and 1 male was captured in 1 male baited trap. Three of the four males were captured in clear plastic delta traps. The attraction of males to females was not very successful, was probably due to trap design. In 2010 significantly more male *L. pabulinus* were trapped on the sticky stake traps compared to clear delta traps, or green cross vane traps, sticky platform or water traps.

The objective of the tests done in 2011 was to find an effective trap design for *L. pabulinus*.

<u>Materials and methods</u>
The sites used were:

a. Ben Alder blackcurrant plantation at Stonebridge, Horsmonden, Location NGR TQ 719 399 Windmill Hill, Ticehurst, East Sussex TN5 7HQ by kind permission of Tom Maynard.
b. Blackberry at A. Belks, Belks Farm, Otham, Maidstone, Kent ME15 8RL (Loch Ness No. 19) by kind permission of Tim Chambers.
c. Blackberry (outdoor, cv Crakerblack) at Salman's Ltd at Cheveney Farm, Lughorse Lane Yalding by kind permission of Adam Shorter.

Small scale field trials using synthetic sex pheromone lures of *L. pabulinus* in various trap designs were done.

The treatments included 18 types including; VARL traps, VARb3 traps, white Rebell® bianco sticky traps, McPhail traps mounted on a cane or the control sticky stake trap (Figs. 3.E.1a-d, Tables 3.E.1a-d).

The traps were suspended or hammered into the soil beneath the crop and checked every 7 days. Lures were replaced every 4 weeks. Counts of the number, sex and species of mirids caught on the traps were made.

Table 3.E.1.a. Trap designs (treatments)

Code	Trap	Capture agent
A	VARL traps	water with detergent
B	VARb3 traps	water with detergent
C	Rebell® bianco vertical white sticky traps	Glue
D	McPhail traps mounted on a cane	water with detergent
E	Sticky stake trap	Ecotoc

Table 3.E.1.b. Trap designs (treatments)

Code	Trap	Capture agent
A	Clear cross vane bucket trap	Square of sticky base
B	VARb3 with lid	Square of sticky base
C	Rebell® bianco vertical white sticky traps	Glue
D	Square of green Correx®	Ecotoc
E	Square of red Correx®	Ecotoc
F	Sticky stake trap	Ecotoc

Table 3.E.1.c. Trap designs (treatments)

Code	Trap	Capture agent
A	Red Delta trap with window	Square of sticky base
B	Green cross vane trap (no lid)	Water and detergent
C	Stake trap	Sticky band - Agralan
D	Sticky stake trap	Ecotoc

Table 3.E.1.d. Trap designs (treatments)

Code	Trap	Capture agent
A	Orange Rebell trap	wet glue
B	White Rebell trap	wet glue
C	Yellow sticky trap 12.5 x 10 cm (medium card cut in half)	wet glue
D	Blue sticky trap 12.25 x 10 cm (medium card cut in half)	dry glue
E	Yellow sticky trap 12.25 x 10 cm (medium card cut in half)	wet glue
F	Standard sticky stake trap	Ecotoc

A randomised complete block designs with 4-5 replicates were done. The traps were arranged in a row at least 10 m apart, at the peaks of adult emergence (June and August). Data were square root transformed for analyses.

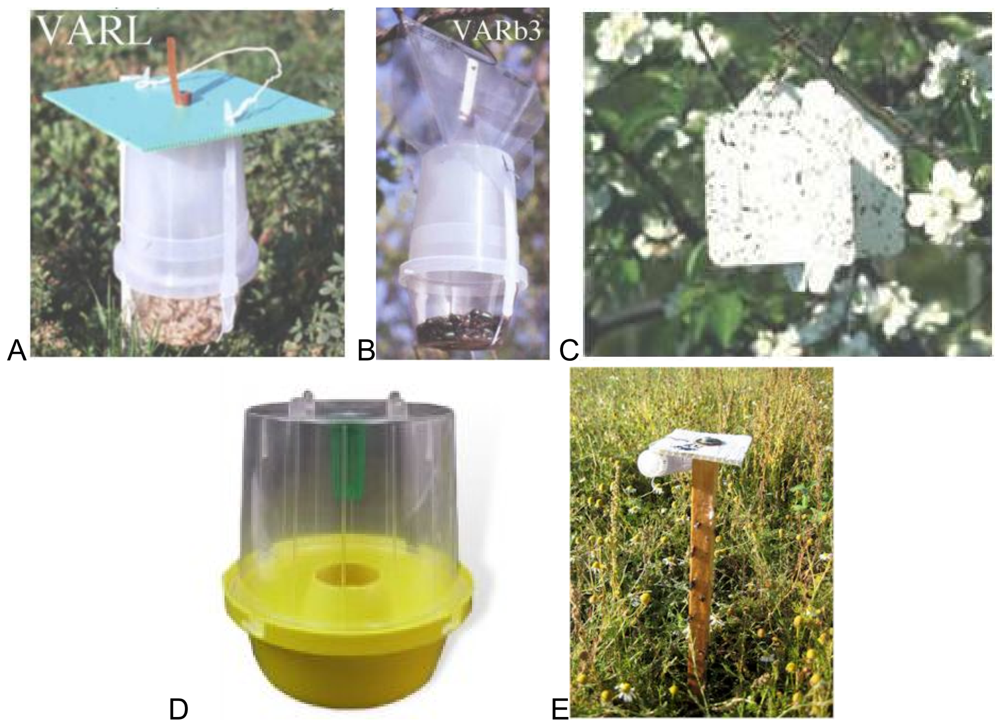
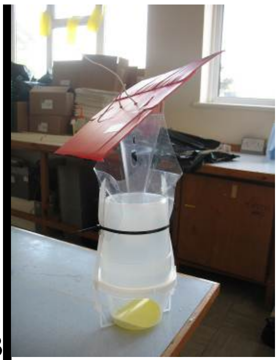


Figure 3.E.1a. Test 1a. Trap designs used in first field test. A VARL trap, B VARb3 trap, C white Rebell® bianco sticky trap, D McPhail trap, and E control sticky stake trap


A

B

C

F

Figure 3.E.1b. Test b. Trap designs used in second field test. A Clear cross vane bucket trap, B VARb3 with lid, C white Rebell® bianco sticky trap, and F control sticky stake trap


A

Figure 3.E.1c. Test c. Red delta trap with window


A

C&E

D

Figure 3.E.1d. Test d. Trap designs used in second field test. A Orange Rebell trap C&E Yellow sticky trap, D Blue sticky trap

Results

Test a

There were significantly more *L. pabulinus* males captured on sticky Rebel and sticky stake traps than the Var traps (18 May – 7 June, p <0.001, sed = 0.344, lsd = 0.729, Fig 3.E.2) in the blackberry crop. No capsids were captured in the McPhail trap.

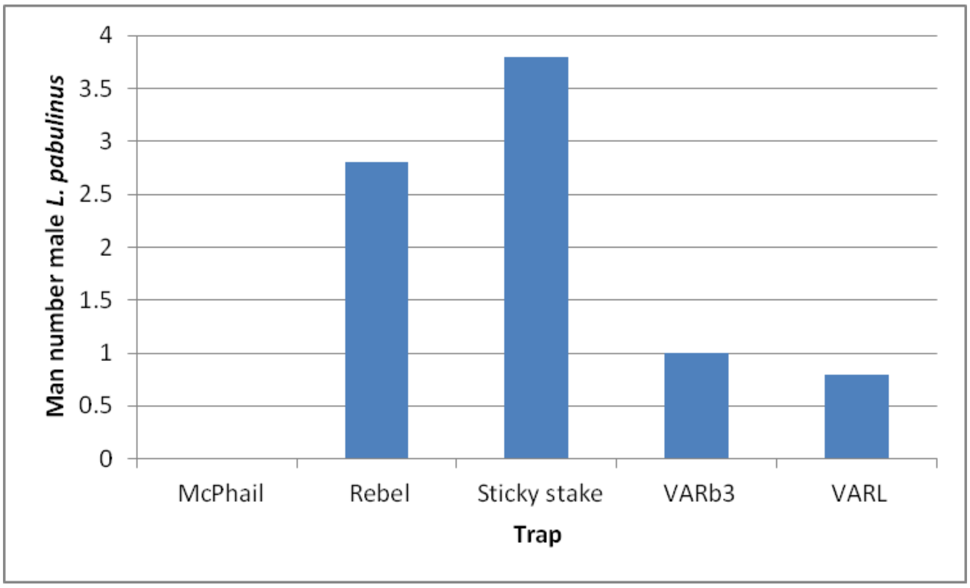


Figure 3.E.2. Mean numbers of *L. pabulinus* males captured on traps of differing designs (18 May – 7 June)

Test b

There were more *L. pabulinus* males captured on sticky red or green Correx squares or sticky stake traps than clear cross vane traps, Rebel traps or Var traps (2 – 27 June, p = 0.011, sed = 0.428, lsd = 0.894, Fig 3.E.3) in the blackcurrant crop.

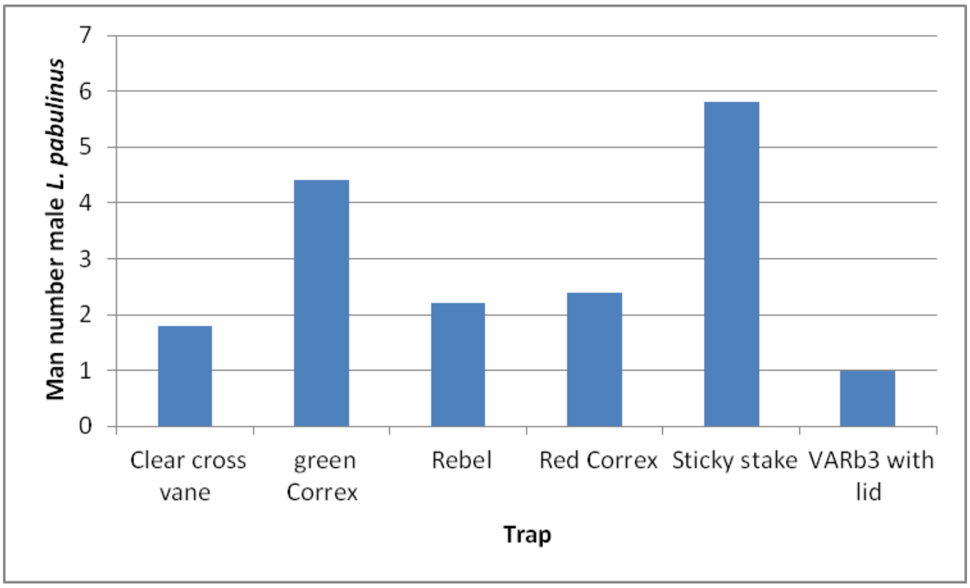


Figure 3.E.3. Mean numbers of *L. pabulinus* males captured on traps of differing designs (2 – 27 June)

Test c

There were more *L. pabulinus* males captured on sticky stake traps than the cross vane or red window delta trap (23 Aug – 28 Sep, p <0.001, max. sed = 0.2107, max. lsd = 0.4189, Fig 3.E.4) in the blackberry crop. However, the green sticky tree banding often came away from the stake.

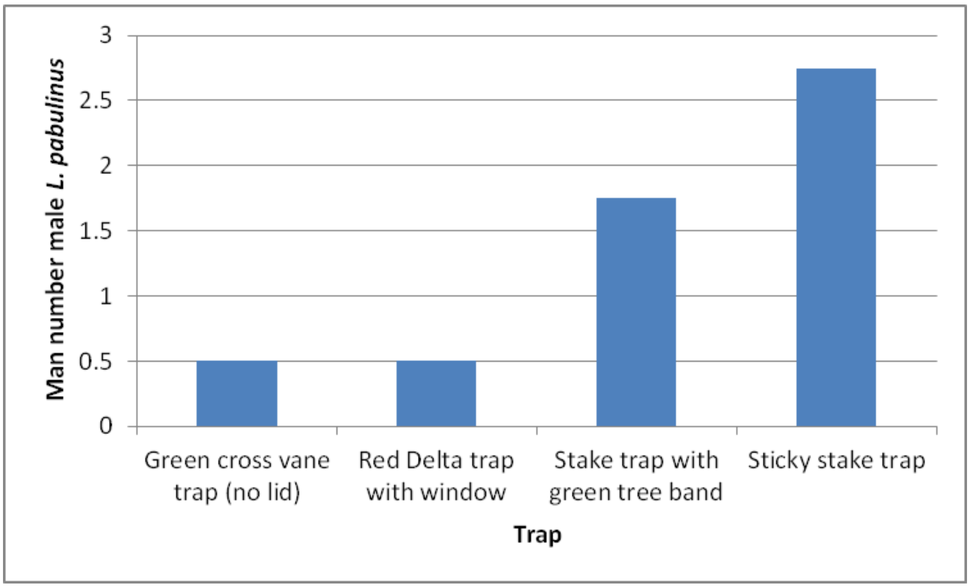


Figure 3.E.4. Mean numbers of *L. pabulinus* males captured on traps of differing designs (23 Aug – 28 Sep)

Test d

There was no significant difference in trap catch between the dry blue sticky traps and the white Rebel trap. However, the blue sticky trap captured significantly more *L. pabulinus* males than the yellow sticky traps, the orange Rebel trap and the standard sticky stake trap (21 Sep - 17 Oct, p = 0.015, sed = 0.480, lsd = 0.981, Fig 3.E.5) in the blackberry crops.

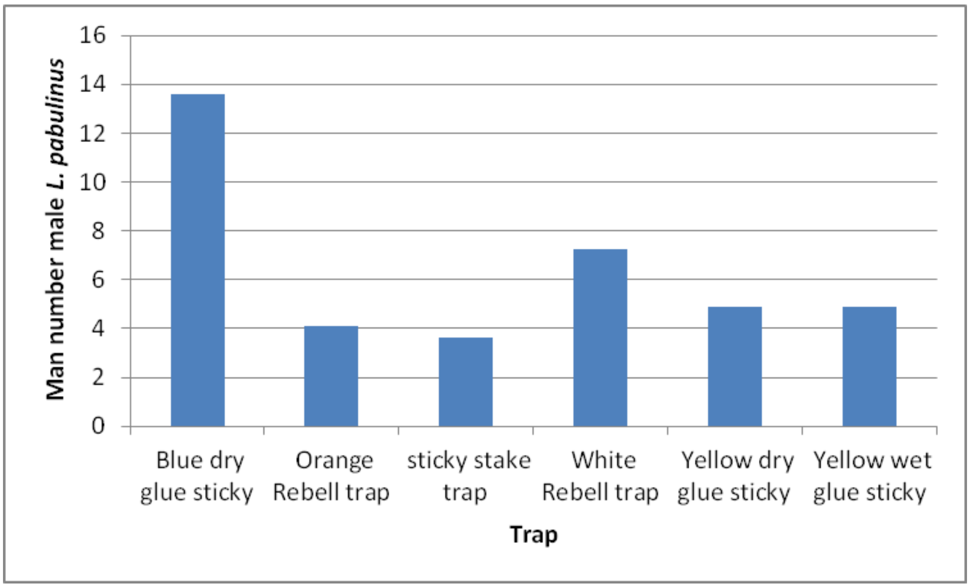


Figure 3.E.5. Mean numbers of *L. pabulinus* males captured on traps of differing designs (21 Sep - 17 Oct)

Liz Johnson, a celery grower, tested the blue sticky traps in crops being damaged by capsids. She compared them to a standard white delta sticky insert. More *L. pabulinus* were captured on the blue sticky cards (Table 3.E.2).

Table 3.E.2. Numbers of *L. pabulinus* males captured on white delta sticky inserts and dry glue blue sticky traps in a celery crop

	Field A		Field B		Field C	
	Blue sticky	**Delta**	**Blue sticky**	**Delta**	**Blue sticky**	**Delta**
1 Sep	2	0	2	0	-	-
8 Sep	9	0	6	0	-	-
15 Sep	1	3	6	0	0	2
23 Sep	removed	removed	2	0	1	0

<u>Conclusion</u>
Blue dry glue sticky cards are effective at capturing male *L. pabulinus*

Objective 4. Encourage commercial production of traps and lures and produce grower information sheets on the use of the traps for monitoring capsids

Agralan will be collaborating to take up commercial production of traps and lures. An information sheet for growers on the use of the traps for pest monitoring will be developed. Information sheets have been developed for sale with the traps and lures.

SIX MONTHLY REPORT TO HORTICULTURE LINK PROGRAMME MANAGEMENT COMMITTEE

Project Number:	HL0184 (PC/SF 276)
Project Title:	Pheromone technology for management of capsid pests to reduce pesticide use in horticultural crops – 2 year extension
Project Partners:	*SCIENCE BASED PARTNERS* East Malling Research Natural Resources Institute East Malling Research Associate (Mr R Jacobson) *INDUSTRY PARTNERS* Horticultural Development Company (GlaxoSmithKline Blackcurrant growers research fund) GlaxoSmithKline East Malling Trust East Malling Ltd Agrisense Cucumber Growers Association K G Growers Ltd Donald J Moor, Nichol Farm, Teynham
Report Written by:	Michelle Fountain and Jerry Cross
Project Start/Completion Dates:	Project extension: (1 April 2010 - 31 March 2012)
Reporting Period:	24
Number of Months Since Commencement:	1 April 2010 – 31 March 2011 24
Date of Last Management Meeting:	13 December 2011

1. Project objectives: (from project proposal, or other more recently approved planning document)

Objectives Proposed in the Extension

1. Improve and test the lure for *L. rugulipennis* so that it is long lasting and practical for use by growers.
2. Calibrate the trap for *L. rugulipennis* for use in pest monitoring to establish a treatment threshold for its use in late season strawberry and cucumber.
3. Develop an effective lure and trap for *L. pabulinus* with associated data for pest monitoring.
4. Encourage commercial production of traps and lures and produce grower information sheets on the use of the traps for monitoring capsids.

2. Table showing overview of progress against milestones for project as a whole (from project proposal, or other more recently approved planning document)

Milestone	Target year	Title	
P1	1	Lure for *L. rugulipennis* developed which lasts for at least one month under field conditions	Y
P2	2	Action thresholds developed and validated for monitoring *L. rugulipennis*	Y
P3	2	Trap and lure for *L. pabulinus* developed and validated	Y
P4	2	Information on use of traps for monitoring capsids available to growers	Y

3. Milestones for the six month period: (from project proposal, or other more recently approved planning document)

NA

4. Research report: (concise account including comments on whether targets are being met)

1. Improve and test the lure for *L. rugulipennis* so that it is long lasting and practical for use by growers (Yr 1)

2. Calibrate the trap for *L. rugulipennis* for use in pest monitoring to establish a treatment threshold for its use in late season strawberry and/or cucumber (Yrs 1 and 2)

3. Develop an effective lure and trap for *L. pabulinus* with associated data for pest monitoring (Yrs 1 and 2)

4. Encourage commercial production of traps and lures and produce grower information sheets on the use of the traps for monitoring capsids

5. Project changes: (proposed or agreed with the LINK programme, and including any changes to expected profile of grant claims)

No changes have been made to the proposed extension milestone and objectives.

6. Publications and technology transfer outputs: (including public presentations/talks given. Indicate additions since last report by use of bold type)

Technology transfer activities

15 – 20 Nov-2009; Developing an effective trap and lure to monitor mirid pests in UK horticultural crops. “Semio-chemicals without Borders Joint Conference of the Pheromone Groups of IOBC WPRS and IOBC EPRS Budapest, Hungary. Travel award from Worshipful Company of Fruiterers

29 Jun-2010; EMRA/HDC Strawberry Walk, Talk on capsid LINK project to develop new management and control systems for different capsid species (PC/SF 276)

17 Nov2010; BGG Autumn Growers' Meeting and Technical Conference, Poster presentation: Monitoring and Control of Capsid Bugs

24 Nov-2010; EMRA/HDC Soft Fruit Day, Technical Up-Date on Soft Fruit Research, East Malling Research, Kent. Talk: Novel technology for controlling capsids in soft fruit 12 Jan-2011 BIFGA Bewl Water. Talk: Pest control on top fruits

14 June-2011; EMRA/HDC Walk – gave talk on monitoring capsids in strawberry crops

08 June-2011; HDC Protected Ornamentals Panel – gave brief summary of research in Entomology

5 Jul-2011; HDC Annual studentship Conference – Explained discovery of insect sex pheromones
EUFRIN WG "zero residues" activities and next meeting – 24 Jan – use of trap in crops

6 March 2012; HDC Fruit Agronomists Day on Tuesday– trap demonstration to agronomists

Publications

Future publications

Preparation of a paper reporting the important scientific findings of this work is in progress for submission to the Journal of Chemical Ecology after the end of the project once the lures are commercially available. A definitive experiment comparing the attractancy of the lures for all the species is being done in 2011 to provide a straight forward data set for the publication.

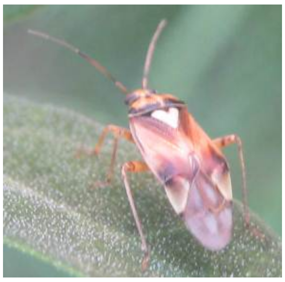
7. Exploitation plans: (give an update on perceived exploitation opportunities and future plans.)

Agralan will be collaborating to take up commercial production of traps and lures. An information sheet for growers on the use of the traps for pest monitoring has been developed.

Appendix 1

European tarnished plant bug sex pheromone monitoring trap

An early warning system of crop invasion by *Lygus rugulipennis*



BACKGROUND

The trap has been used successfully to predict European tarnished plant bug (ETPB) populations in field grown strawberries and glasshouse cucumber. The aim of this information and recording sheet is to give growers the opportunity to use the trap and help us determine a trap threshold.

How does the trap work?

The trap is a cross vane funnelled bucket trap (Agralan). The male insects are attracted to the sex pheromone baited lure placed just under the lid of the trap. They fly towards the lure into the green cross vanes and then drop through the funnel into the bucket which contains water and a drop of detergent. The insects become trapped enabling counting and assessment of population size.

Agralan green cross vane, funnelled, bucket trap in strawberry crop

Lure in top of bucket trap, just under the lid

Benefits

More sensitive detection of ETPB and easier to use compared to conventional methods, e.g. tap sampling

Monitors population build-up of ETPB and is selective for this damaging species of capsid

Decisions can be made on spray timing and targeting on the basis of reliable estimates of capsid numbers

Estimating pest levels is an essential part of Integrated Pest Management

Trap assembly, placement and maintenance

Attach cross vanes and lid to funnel section of trap. Pour approximately 5 cm of water into bucket and add a drop of detergent. Use a stiff wire through hole in top of cross vane to pin trap into ground/strawberry bed. Alternatively the trap can be suspended using the hooks on the lid, but the base of the trap should be positioned at ground level.

Attach lure using a paperclip or twist tie so that it hangs point downwards in the space in the cross vanes. Lures should be changed every 4 weeks and stored in a refrigerator (preferably freezer) to ensure a long life. Ensure cross vanes are free from foliage to allow the insects to fly and hit the cross vanes.

In strawberry the trap should be placed within the crop. For cucumber the trap should be placed in a weedy area outside the glasshouse.

Maintenance of trap

Renew the water and detergent each week to enable viewing of the capsids and prevent rotting. Keep cross vanes clear of dirt to maintain effectiveness (insects are able to walk on soiled surfaces). Traps should be labelled with field name/number.

WHAT WE NEED FROM YOU

1. Trap records

Check traps each week on the same day from the beginning of March. Either sieve the contents of the trap through a tea strainer or tip into a white bowl to count the number of ETPB. Record date and trap catches on appropriate record sheet (attached, white columns). Discard dead insects and detritus.

ETPB in water in bottom of trap

2. Crop sampling

At the same time as checking traps please can you also tap sample 40 strawberry plants over a white tray/bowl or search shoots of cucumber plants for 10 minutes. This can be done in the vicinity of the trap in strawberry or centre of crop in cucumber. Record capsid adults and nymphs found on the record sheet (grey columns).

Identification

Male ETPB are 5-6 mm long, broad bodied and can be variable in colour, from dark brown/red to almost black. Just behind the head there is usually a white V-shaped marking which can vary in size and intensity. The underside of the male ETPB has a broad dark stripe with the sides of the abdomen being yellowish green.

Male ETPB sieved through tea strainer

Male European tarnished plant bug. Note the variation in colour and V-shape behind the head

Capsid nymphs, with characteristic spots on back. They move faster than aphids.

'Contact your advisor for advice on choice of pesticide treatments'

Use

Initial studies show that the traps give a 3-4 week warning of field grown strawberry invasion by ETPB, and a 2 week warning of invasion into cucumber glasshouses, compared to conventional methods of determining populations, e.g. tap sampling and looking for feeding damage.

Please send completed forms to Dr Michelle Fountain
East Malling Research, New Road, East Malling, Kent ME19 6BJ · UK
Tel: 01732 843833, Fax: 01732 849067, michelle.fountain@emr.ac.uk

emr east malling research

European Tarnished Plant Bug record sheet for strawberry

Farm:			**Post code:**
Address:		**Crop/variety:**	**Area (ha):**
Trap No.	Plantation name	Plantation location (NGR)	Date set up
1			
2			
3			
4			

Trap	**1**		**2**		**3**		**4**		Threshold exceeded	Treatment date	Treatment	Dose
Date	Trap record	40 plants tap samples	Trap record	40 plants tap samples	Trap record	40 plants tap samples	Trap record	40 plants tap samples				

Please send completed forms to Dr Michelle Fountain
East Malling Research, New Road, East Malling, Kent ME19 6BJ · UK
Tel: 01732 843833, Fax: 01732 849067, michelle.fountain@emr.ac.uk

emr
east malling research

European Tarnished Plant Bug record sheet for cucumber

Farm:			**Post code:**
Address:		**Crop/variety:**	**Area (ha):**
Trap No.	Plantation name	Plantation location (NGR)	Date set up
1			
2			
3			
4			

Trap	**1**		**2**		**3**		**4**		Threshold exceeded	Treatment date	Treatment	Dose
Date	Trap record	10 minute search	Trap record	10 minute search	Trap record	10 minute search	Trap record	10 minute search				

Please send completed forms to Dr Michelle Fountain
East Malling Research, New Road, East Malling, Kent ME19 6BJ · UK
Tel: 01732 843833, Fax: 01732 849067, michelle.fountain@emr.ac.uk

emr
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Appendix 2

European Tarnished Plant Bug record sheet for strawberry

Farm: G Charlton & Son			**Post code:**
Address: Rumwood Green Farm, Maidstone		**Crop/variety: ELSINORE**	**Area (ha):**
Trap No.	Plantation name	Plantation location (NGR)	Date set up
1	MOB (Table top 2nd YR Elsinore)	** LURES CHANGED	31.03.11
2	MOB (Table top)		31.03.11
3	SEYMOURS (Table top Planted 01.03.11)		31.03.11
4	SEYMOURS (Table top)		31.03.11

Trap	**1**		**2**		**3**		**4**		Threshold exceeded	Treatment date	Treatment	Dose
Date	Trap record	40 plants tap samples	Trap record	40 plants tap samples	Trap record	40 plants tap samples	Trap record	40 plants tap samples				
08.04.11	0	0	0	0	0	0	0	0				
14.04.11	0	0	0	0	0	0	0	0				
20.04.11	0	0	0	0	0	0	0	0	Blossom Weevil/ Aphid	21.04.11 MOB	Starion 80 & Calypso	300 ml 250 ml
28.04.11 **	0	0	0	0	0	0	1	0	Blossom Weevil	29.04.11 Seymours	Starion 80 & Calypso	300 ml 250 ml
05.05.11	0	0	0	0	0	0	0	0				
12.05.11	0	0	0	0	0	0	0	0				
19.05.11	0	0	0	0	0	0	0	0				
26.05.11	0	0	0	0	0	0	0	0				
02.06.11 **	0	0	0	0	0	0	0	0				
09.06.11	0	0	0	0	0	0	0	0				
16.06.11	0	0	0	0	1	0	0	0				
23.06.11	0	1	0	0	0	0	0	0	Blossom Weevil	23.06.11 Seymours	Calypso	250 ml
30.06.11 **	0	0	0	1	0	0	0	0				
07.07.11	0	0	0	0	0	0	0	0				
14.07.11	0	1	0	0	0	0	0	1				
21.07.11	0	3	0	0	0	8	0	3				
28.07.11 **	0	0	0	12	0	10	0	4	All Common Green capsid (CGC)	All Traps moved to ends of Table tops		
04.08.11	0	4	0	17	0	12	0	0	CGC	04.08.11 (evening)	Chess WG	400 g

11.08.11	1	2	0	6	0	0	2	2	CGC			
18.08.11	0	1	0	4	0	0	0	4	CGC			
25.08.11 **	2	4	3	9	0	3	1	3	CGC			
01.09.11	0	1	0	0	0	1	0	0	CGC			
08.09.11	1	0	3	0	0	2	0	1	CGC			
15.09.11	0	0	4	0	0	2	0	0	CGC			

2

European Tarnished Plant Bug record sheet for strawberry

Farm: Gr63 Lower Reule Farm, Gnosall, Staffs			**Post code:**
Address:		**Crop/variety:**	**Area (ha):**
Trap No.	Plantation name	Plantation location (NGR)	Date set up
1	Towlers Everbearer A	Shropshire	10/04/2011
2	Towlers Everbearer B	Shropshire	10/04/2011
3	Woods Maincrop Elsanta then Everbearer A	Shropshire	10/04/2011
4	Woods Maincrop Elsanta then Everbearer B	Shropshire	10/04/2011

Trap	**1**		**2**		**3**		**4**		Threshold exceeded	Treatment date	Treatment	Dose
Date	Trap record	40 plants tap samples	Trap record	40 plants tap samples	Trap record	40 plants tap samples	Trap record	40 plants tap samples				
19-Apr	0	0	0	0	0	0	0	0				
26-Apr	0	0	4	0	1	0	1	0				
03-May	2	0	1	0	0	0	0	0		06-May	Equity	1 litre
10-May	2	0	0	0	2	0	0	0				
19-May	0	0	2	0	0	0	0	0				
24-May	0	0	0	0	0	0	0	0				
02-Jun	1	0	1	0	0	0	0	0				
07-Jun	1	0	1	0	0	0	0	0				
14-Jun	1	0	1	0	0	0	0	0				
23-Jun	17	2	3	1	0	0	0	0				
29-Jun	21	2	6	1	0	0	0	0				
05-Jul	39	5	16	1	0	0	0	0				
12-Jul	50	5	48	4	0	0	0	0				
21-Jul	67	6	75	5	1	0	1	0		23-Jul	Tracer	150ml
26-Jul	23	2	25	1	0	0	0	0		28-	Calypso	250ml

										Jul		
03-Aug	15	1	20	1	0	0	0	0				
09-Aug	2	0	0	0	0	0	0	0		05-Aug	Hallmark	75ml
16-Aug	0	0	0	0	0	0	0	0				
30-Aug	0	0	0	0	2	0	0	0				
06-Sep	0	0	0	0	0	0	0	0				
13-Sep	0	0	0	0	0	0	0	0				
21-Sep	0	0	0	0	0	0	0	0				

3

European Tarnished Plant Bug record sheet for strawberry

Farm: Gr88 NJ Cockburn, Pennoxstone Cour, King'sCaple, Hereford		**Post code:**	
Address:		**Crop/variety:**	**Area (ha):**
Trap No.	Plantation name	Plantation location (NGR)	Date set up
1	Old Sward Everbearer A	Herefordshire	09/04/2011
2	Old Sward Everbearer B	Herefordshire	09/04/2011
3	Windmill Everbearer A	Herefordshire	09/04/2011
4	Windmill Everbearer B	Herefordshire	09/04/2011

Trap	**1**		**2**		**3**		**4**		Threshold exceeded	Treatment date	Treatment	Dose
Date	Trap record	40 plants tap samples	Trap record	40 plants tap samples	Trap record	40 plants tap samples	Trap record	40 plants tap samples				
18-Apr	0	0	0	0	0	0	0	0				
05-May	3	0	8	0	0	0	0	0				
09-May	0	0	0	0	0	0	2	0				
16-May	0	0	4	0	0	0	0	0				
23-May	2	1	1	1	2	1	1	1				
06-Jun	0	0	1	1	13	2	6	1		Calypso applied		250ml
13-Jun	2	0	2	0	2	0	2	0				
20-Jun	2	1	2	1	2	1	2	0				
27-Jun	11	2	2	1	6	2	5	1				
04-Jul	2	0	0	0	2	1	1	0				
11-Jul	17	5	3	1	3	0	0	1		Calypso applied		250ml
18-Jul	1	0	0	0	2	1	3	0				
25-Jul	0	0	0	0	3	0	3	1				
01-Aug	7	2	0	0	9	2	4	2				

08-Aug	60	13	16	6	10	0	19	1		Hallmark applied		75ml
15-Aug	1	0	0	0	8	1	9	1				
29-Aug	3	0	0	0	10	1	12	1				
05-Sep	0	0	0	0	0	0	0	0				
12-Sep	0	0	0	0	0	0	0	0				
19-Sep	2	1	2	1	1	0	0	0				

4

European Tarnished Plant Bug record sheet for strawberry

Farm: Clockhouse Farm			**Post code:**
Address: Yalding, Kent		**Crop/variety:**	**Area (ha):**
Trap No.	Plantation name	Plantation location (NGR)	Date set up
1	2nd Tunnel (table tops)	BG Trials site	7.04.2011
2	2nd Tunnel (zero residue table tops)	Clockhouse Farm	7.04.2011
3	6th Tunnel (table tops) top	Yalding, Clockhouse Farm	7.04.2011
4	2nd Tunnel (table tops) bottom	Yalding, Clockhouse Farm	7.04.2011

Trap	**1**		**2**		**3**		**4**		Threshold exceeded	Treatment date	Treatment	Dose
Date	Trap record	40 plants tap samples	Trap record	40 plants tap samples	Trap record	40 plants tap samples	Trap record	40 plants tap samples				
14.04	1	0	0	0	0	0	0	0				
21.04	0	0	1	0	1	0	0	0				
28.04	0	1	0	0	0	0	0	0				
5.05	0	0	2	0	0	1	1	1				
12.05	2	0	0	0	0	0	0	0				
26.05	0	0	0	0	0	0	0	0				
3.06	0	0	0	0	0	0	0	0				
9.06	0	0	0	0	0	0	0	0				
17.06	0	0	0	0	0	0	0	0				
23.06	0	0	0	0	0	0	0	0				
7.07	0	0	0	0	2	0	0	0				
14.07	0	0	0	0	1	0	0	0				
21.07	0	0	0	0	0	0	0	0				
28.07	0	0	2	1	0	0	1	0				
4.08	0	0	0	0	0	0	1	0				
11.08	0	0	0	0	0	0	0	0				
30.08	4	0	0	0	4	0	0	0				
6.09	1	0	0	0	3	0	0	0				
27.09	0	0	0	0	0	0	0	0				

European Tarnished Plant Bug record sheet for strawberry

Farm: Simon Beasley			**Post code:**
Address: J R Clarke, Hints, Staffordshire		**Crop/variety: Camarillo Everebearer**	**Area (ha): 3**
Trap No.	Plantation name	Plantation location (NGR)	Date set up
1	Road Field Camarillo	Hints, Staffordshire	
2	Road Field Camarillo	Hints, Staffordshire	
3			
4			

Trap	**1**		**2**		**3**		**4**		Threshold exceeded	Treatment date	Treatment	Dose
Date	Trap record	40 plants tap samples	Trap record	40 plants tap samples	Trap record	40 plants tap samples	Trap record	40 plants tap samples				
20/06/2011	1	0	0	0					No		None	
27/06/2011	0	0	0	0					No		None	
04/07/2011	2	0	1	0					No		None	
11/07/2011	0	0	0	0					No		None	
18/07/2011	0	0	0	0					No		None	
25/07/2011	0	0	0	0					No		None	
01/08/2011	0	0	0	0					No		None	
08/08/2011	0	0	0	0					No		None	
15/08/2011	0	0	0	0					No		None	
22/08/2011	2	0	1	0					No		None	
29/08/2011	0	0	1	0					No		None	
05/09/2011	0	0	0	0					No		None	
12/09/2011	0	0	0	0					No		None	

European Tarnished Plant Bug record sheet for strawberry

Farm: Simon Beasley		**Post code:**	
Address: New Farm Produce		**Crop/variety: Evie 2, Everbearer**	**Area (ha): 2**
Trap No.	Plantation name	Plantation location (NGR)	Date set up
1	B 1 Evie 2	WoodShoot Nursery, Kings Bromley, Staffordshire	
2	B 1 Evie 2	WoodShoot Nursery, Kings Bromley, Staffordshire	
3			
4			

Trap	1		2		3		4		Threshold exceeded	Treatment date	Treatment	Dose
Date	Trap record	40 plants tap samples	Trap record	40 plants tap samples	Trap record	40 plants tap samples	Trap record	40 plants tap samples				
20/06/2011	0	0	0	0							N/A	
27/06/2011	2	0	1	0							N/A	
04/07/2011	2	0	0	0							N/A	
11/07/2011	0	0	0	0							N/A	
18/07/2011	0	0	0	0							N/A	
25/07/2011	0	0	0	0							N/A	
01/08/2011	2	0	0	0							N/A	
08/08/2011	0	0	0	0							N/A	
15/08/2011	0	0	0	0							N/A	
22/08/2011	1	0	1	0							N/A	
29/08/2011	2	0	0	0							N/A	
05/09/2011	0	0	0	0							N/A	
12/09/2011	0	0	0	0							N/A	

European Tarnished Plant Bug record sheet for strawberry

Farm: East Malling Research			**Post code: ME19 6BJ**
Address: New Road, East Malling, Kent		**Crop/variety: Everbearers**	**Area (ha):**
Trap No.	Plantation name	Plantation location (NGR)	Date set up
1	DR216 S END	TQ 712573	01/04/2011
2	DR216 N END	TQ 711575	01/04/2011
3			
4			

Trap	**1**		**2**		**3**		**4**		Threshold exceeded	Treatment date	Treatment	Dose
Date	Trap reocord	40 plants tap samples	Trap reocord	40 plants tap samples	Trap reocord	40 plants tap samples	Trap reocord	40 plants tap samples				
08-Apr	1		1									
15-Apr	7		6									
21-Apr	5		0									
28-Apr	4		0					changed lure				
06-Apr	0		1									
13-May	7		7									
20-May	3		7									
27-May	9		3					changed lure				
03-Jun	8		4									
10-Jun	9		3									
17-Jun	19		8									
24-Jun	36		11					changed lure		30-Jun	Hallmark	
01-Jul	17		14									
08-Jul	1		1									
15-Jul	13		23									
22-Jul	8		26					changed lure				
29-Jul	12		31									
05-Aug	4		5									
12-Aug	6		16									
19-Aug	12		17					changed lure				
26-Aug	18		18									
02-Sep	14		10									
09-Sep	20		5									
16-Sep	7		6					changed				


lure

Trap No.	Plantation Name
1	F3 Pine crop
2	F3 Pine headland
3	F4 Sitka crop
4	F4 Sitka headland

* X-month= pheromone replaced with new one

	1			2		3			4		
Date	Trap record	40 tap sample record	Insecticide applications	Trap record	40 tap sample record	Trap record	40 tap sample record	Insecticide applications	Trap record	40 tap sample record	Insecticide applications
08-Feb								Apollo 0.4 l/ha			
13-Apr								Toppel 100 EC 0.25 l/ha			
20-Apr			Toppel 100 EC 0.25 l/ha								
08-May								Toppel 100 EC 0.25 l/ha			
11-May			Danadim Progress 0.84 l/ha					Danadim Progress 0.84 l/ha			
20-Jun	0	0		0	0	1	0		0	0	
27-Jun								Majestik 2 l/ha			
29-Jun	17	1		3	0	15	0		3	0	
04-Jun	8	0		0	0	12	0		2	0	
04-Jul								Toppel 100 EC 0.25 l/ha			
08-Jul			Cyren 2 l/ha					Cyren 2 l/ha			
11-Jul	2	0	Danadim Progress 0.84 l/ha	2	0	2	0		1	0	
18-Jul	0	0		1	0	4	0		2	0	
25-Jul	3	0		0	0	6	0(1)		4	0	
01-Aug	7	0		1	0	10	0		4	0	
02-Aug			Masai 0.25 kg/ha								
05-Aug			Toppel 100 EC 0.25 l/ha					Toppel 100 EC 0.25 l/ha			
08-Aug	10	0		8	0	5	0		3	0	
15-Aug	8	0		0	0	0	1		5	0	
22-Aug	7	0		1	1	2	0		2	0	
25-Aug			Danadim Progress 0.84 l/ha					Danadim Progress 0.84 l/ha			
30-Aug	3	0		1	0	2	0		1	0	
05-Sep	0	0		0	0	1	0		0	0	
12-Sep	1	0		0	0	2	0		3	0	
19-Sep	0	0		0	0	0	0		1	0	
23-Sep								Sequel 1 l/ha			
26-Sep	0	0	Masai 0.25 kg/ha	0	0	0	0	Cyren 2 l/ha	0	5	
03-Oct	0	4		0	4	0	2		0	15	