Project Title:	Development of sex pheromone trap and evaluation of insecticides for control of blackcurrant leaf midge
Project Number:	SF 012 (GSK222)
Project Co-ordinator:	Mr Rob Saunders
Customers:	GlaxoSmithKline blackcurrant research fund
Project Leader:	Prof J V Cross, EMR
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Report:	Annual Report, 2009
Previous reports:	None
Date Project commenced:	1 April 2009
Expected completion date:	31 March 2010
Date of issue of report:	7 December 2009

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

AUTHENTICATION

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

Signature .... Date ....

Report authorised by:

Signature .... Date ....

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CONTENTS

GROWER SUMMARY

Headline

- Of seven plant protection products tested for control of blackcurrant leaf midge, only a novel product from Bayer showed promise for replacing Brigade (bifenthrin).

Background and expected deliverables

Blackcurrant leaf midge, *Dasineura tetensii*, has increased in importance in recent years and better methods of managing it are needed for UK growers. Currently one or more sprays of bifenthrin (Brigade) or chlorpyrifos (various products) are applied when midge galling damage is seen. This strategy results in less than optimum control. Furthermore, bifenthrin and chlorpyrifos are broad spectrum insecticides which are harmful to many important natural enemies of blackcurrant pests. Accurate timing of insecticide application is essential for control of this pest.

EMR and NRI have identified the sex pheromone of blackcurrant leaf midge and demonstrated that it is useful for monitoring male midge numbers and flight periods. Intensive work in 2008 resulted in the development of an optimised lure (a rubber septum loaded with 5 µg of the C stereoisomer of the pheromone) and a prototype trap design (red delta trap with excluder grids at the entrances and deployed at 3 cm above the ground).

The objectives of the work done in 2009 were to:

1. Field test the efficacy of the red delta trap prototype with and without excluder grids in comparison to a standard white delta trap.
2. Examine the relationship between trap catches and numbers of galls formed in different commercial crops to establish a trap threshold.
3. Identify alternative chemical treatments to Brigade for the control of blackcurrant leaf midge. Seven alternative chemicals (mostly applied as foliar sprays) were compared to Brigade and an untreated control including abamectin (Dynamec), thiacloprid (Claypso), acetamiprid (Gazelle), spinosad (Tracer), Bayer novel product and chlorpyrifos (Equity as a foliar or soil treatment).

4. Evaluate the efficacy of different timings of application of a novel Bayer product, Brigade and Equity for control of blackcurrant leaf midge utilising the sex pheromone trap. A single or double spray programme was compared to an untreated control.

For objectives 3 and 4, the first spray application was timed when the number of midges in the sex pheromone trap exceeded 30/trap.

Summary of the project and main conclusions

Objective 1

Red delta traps with excluder grids at their entrances and held at a height of 3 cm above the ground on integral legs, were optimal for trapping blackcurrant leaf midge using sex pheromone lures. Red delta traps without excluder grids caught more male blackcurrant leaf midges but were subject to the highest numbers of midge losses through predation and higher amounts of debris and non-target insect contamination. Red delta trap with excluder grids and integral legs are not currently commercially available but can be readily constructed (DIY) in small numbers. White delta traps did catch midges, but were much less effective than the red delta traps, which may delay the detection of midges early in the flight period. The poorer performance of this trap may have been because it was positioned higher in the crop where fewer midges are flying.

Objective 2

For non-cut down bushes, pheromone trap calibration showed weak positive relationships between numbers of gall per shoot and the total and peak catches of midge for the corresponding generation. Taking the worst case data, a total catch of 100 midges led to an average of about 90 galls per 100 shoots. A peak catch of 100 midges per trap led to an average of about 180 galls per shoot. For cut down bushes there was no relationship for either total or peak catches. It is suspected that females may have been attracted over long distances to the lush shoot growth in the small plots. There was considerable variability and more data is required over several years in a wider range of plantations to establish more robust nominal thresholds and to determine how these might be affected by variety.

Objective 3

Dynamec, Gazelle, Equity, Brigade and the novel Bayer product gave at least some curative activity against existing infestations of semi-mature and mature larvae in galls. However, only the Bayer coded product performed reliably throughout the trial equalling Brigade in its level of midge control. The Bayer coded product may be a suitable replacement for Brigade (and other bifenthrin products). It is a selective product and was able to kill larvae inside galls whereas Brigade is disruptive and probably did not kill more mature larvae in galls. None of the products produced any visual symptoms of phytotoxicity

Objective 4

The timing of the spray applications was critical for the control of blackcurrant leaf midge. To be effective, products needed to be applied early in the generation of the midge (oviposition or early stage larvae). Brigade was the most effective of the products tested when applied early (when cumulative trap catches reached 30 midges per trap). The second and third spray applications did not have any effect on the numbers of galled leaves or larvae in the galls. The second application of Calypso was beneficial at reducing the numbers of larvae within the galls (although this was too late to reduce the numbers of galls themselves). The Bayer coded product offered the best protection against the midge as it was equally as effective as Brigade at reducing the numbers of larvae, but also appeared to have a larger window of opportunity for treatment application. None of the treatments had any effect when applied at the end of the generation, probably because the larvae had completed development and left the gall, and/or because the gall had become tough and necrotic, limiting any trans-laminar effects of the insecticides. None of the products produced any visual symptoms of phytotoxicity.

Financial benefits

Losses due to blackcurrant leaf midge in blackcurrant plantations in the UK have not been quantified. However, the midge is a widespread and important pest. Severe attacks cause stunting of new growth (by > 30%).

Action points for growers

- Blackcurrant leaf midge sex pheromone delta traps should be used to direct and time insecticide sprays at the most vulnerable life stages of the blackcurrant leaf midge resulting in a significantly improved control.

- Brigade is the most effective insecticide of those available currently, but chlorpyrifos and Calypso are also partially effective. A novel selective product from Bayer appears highly effective but further work is needed before it can be made available to growers.

- The timing of sprays active against blackcurrant leaf midge is critical. First applications should be made a few days after the start of the first generation midge flight in spring as indicated by pheromone trap catches when egg hatch is commencing and larvae are most vulnerable.

SCIENCE SECTION

Introduction

The blackcurrant leaf midge, *Dasineura tetensi*, is an important pest of blackcurrants in the UK. Larvae form leaf galls in the shoots and if attacks are severe, shoot growth can be severely stunted. Previously the pest was controlled by routine sprays of fenpropathrin (Meothrin) applied principally for the control of blackcurrant gall mite and reversion virus disease. However, Fenpropathrin (Meothrin) was withdrawn in 2008. Optimisation of spray applications need to be researched in order to apply insecticides at the most effective time.

Previous published research into chemical control of blackcurrant leaf midge

Four research papers on chemical control of blackcurrant leaf midge have been published since 1973. A summary of them is as follows:

<u>Goncharova & Samosudov (1979):</u> A spray of 0.3% malathion was recommended for application to bushes and the soil beneath them. A second spray was recommended if leaf infestation remained above 15-20%.

<u>Labanowska, Bera & Suski (1983)</u>: It was shown in various experiments in Poland that fenitrothion, methidathion and malathion provided satisfactory control of *Dasineura tetensi* on blackcurrant when applied as foliar sprays at standard dosages in high- and low-volume sprays but that up to eight applications were necessary. Soil insecticides (chlorfenvinphos at 80 kg/ha of 10% granules, diazinon at 60-100 kg/ha of 10% granules, or lindane at 80 kg/ha of 2% granules) applied around the bases of the bushes before blossom time (at the time of emergence of the 1st generation adults) to control the emerging adults or the stages in cocoons gave excellent results, providing protection for 4-6 weeks, which included the blossom period and a large part of the pre-harvest period.

<u>Harris and Wardlow (1984):</u> The effectiveness of sprays of 11 insecticides for the control of larvae of *Dasineura tetensi* on blackcurrant was evaluated in laboratory and field tests in the United Kingdom in 1983. Although many of the insecticides were effective in the laboratory, only a combination of azinphos-methyl and demeton-S-methyl sulphone at 0.75 and 0.23 g a.i./litre, respectively, fenitrothion at 0.94 g (with or

without cypermethrin at 0.04 g) and demeton-S-methyl at 0.44 g gave more than 81% larval mortality in the field.

Wardlow & Nicholls (1986): Fenpropathrin in sprays at 50 and 100 g a.i./ha controlled *Dasineura tetensi* on blackcurrants in south-eastern England by protecting the plants against oviposition and apparently also by killing the larvae inside small convoluted leaves.

Unpublished reports of previous research funded by GlaxoSmithKline/HDC

R A Umpelby, S J Corbett (1989-1993). A series of single experiments in 1989, 1990 and 1991 and a two year experiment in 1992-1993 by R A Umpelby, S J Corbett and co-workers at ADAS Worcester investigated the use of phosalone (Zolone) for control of blackcurrant leaf midge in comparison with other organophosphate (OP) treatments including azinphos-methyl (Gusathion), demeton-S-methyl (Metasystox) and fenitrothion (Dicofen). Phosalone was found to be an effective treatment which could be used during flowering as it was comparatively safe to bees. However, it is no longer available in the UK.

Cross and Harris (2002). In a single field trial at Oxhouse Farm, Shobdon, Leominster, Hereford in 2002, the efficacy of single foliar sprays (1000 l/ha) of triazamate (Aztec), thiacloprid (Calypso), chlorpyrifos (Dursban), deltamethrin (Decis), rotenone (Derris), diflubenzuron (Dimilin), fenpropathrin (Meothrin), spinosad (NAF 85), bifenthrin (Talstar) and nicotine (XL-All 95% Nicotine) were tested for control of existing larval infestations of the blackcurrant leaf midge, *Dasineura tetensi*, on blackcurrant cv Ben Lomond. The effects of the treatments were assessed by counting the number of galls and the number of live larvae contained in galls 7 and 14 days after treatment.

Deltamethrin, fenpropathrin and bifenthrin were the most effective products, reducing numbers of new galls that formed over a two week period after treatment and greatly reducing the number of live larvae contained in galls. By 14 days after treatment, the estimated number of live larvae per bush were reduced by 98, 99 and 97% by these treatments respectively compared with the untreated control. Chlorpyrifos, nicotine, triazamate, thiacloprid, rotenone and spinosad were partially effective. By 14 days after treatment, these treatments reduced numbers of live larvae per bush by 86, 57, 56, 84, 65 and 72% respectively compared with the untreated control. Diflubenzuron had little effect. All the effective products were broad-spectrum insecticides that were likely to be harmful to the naturally occurring enemies of blackcurrant leaf midge, including the parasitic wasp *Platygaster demades* and anthocorid bugs.

<u>Cross and Harris (2006).</u> In a single field trial at Upper Horton Farm, Bridge, Kent in 2005 the efficacy of single foliar sprays (500 l ha^{-1}) of chlorpyrifos (Lorsban WG), fenpropathrin (Meothrin), thiacloprid (Calypso), spinosad (Tracer), acetamiprid (Gazelle), acrinathrin (Acrinathrin), pymetrozine (Plenum WG) and formetanate (Dicarzol) were tested for control of existing larval infestations of the blackcurrant leaf midge, *Dasineura tetensi*, on blackcurrant cv Ben Lomond. Sprays were applied on 10 May 2005 in the middle stages of the first generation larval attack when semi-mature and some mature larvae were present in galls. The effects of the treatments were assessed by counting the number of galls and the number of live larvae contained in galls 7 and 14 days after treatment.

The results indicated that none of the treatments had a worthwhile degree of efficacy when applied at this late stage in the larval attack and none of the products tested were more effective than Meothrin. The standard product Meothrin had the lowest mean numbers of larvae at the second assessment but this did not differ significantly from the untreated control.

In this project we used a combination of the newly discovered blackcurrant leaf midge sex pheromone combined with a prototype trap design to time applications of a number of plant protection products for the control of the pest. There were four main objectives;

1. Field test the efficacy of the red delta trap prototype with and without excluder grids in comparison to a standard white delta trap;
2. Examine the relationship between trap catches and numbers of galls formed in different commercial crops to establish a trap threshold;
3. Identify alternative chemical treatments to Brigade for the control of blackcurrant leaf midge. Seven alternative chemicals (mostly applied at foliar sprays) were compared to Brigade and an untreated control (abamectin (Dynamec), thiacloprid (Claypso), acetamiprid (Gazelle), spinosad (Tracer), Bayer novel product, chlorpyrifos (Equity as a foliar or soil treatment);
4. Evaluate the efficacy of different timings of application of a novel Bayer product, Brigade and Equity for control of blackcurrant leaf midge utilising

the sex pheromone trap. A single or double spray programme was compared to an untreated control.

Materials and methods

Objective 1

The experiment was done in two rows of a commercial blackcurrant plantation, cultivar Ben Alder, at Brenchley, Kent by kind permission of Tom Maynard. The spacing between the rows was 3.0 m, and the bushes (~1.0-1.5 m tall), were spaced 0.44 m apart in the rows (7575 bushes/ha). Three trap design treatments were deployed (Table 1.1);

Standard white delta trap (WDT) suspended on two fibre glass canes 50 cm from the ground;

Red delta trap on legs (RDT L) 3 cm from the ground;

The same red delta trap but with excluder grids fitted (RDT L+G)

All traps were baited with the same a 5 μg rubber septa sex pheromone lure. The traps contained a removable sticky base to catch the adult male midges.

Table 1.1. Specifications of the three trap designs used.

Trt. No.	Colour	Excluder grid	Legs (height†)	Photograph of trap
1	Red	Yes	Yes (3 cm)	
2	Red	No	Yes (3 cm)	
3	White	No	No (50 cm)	

† deployment height above ground

A randomised block design with six replicates of the three treatments was used. Thus, there were 18 plots arranged in blocks of three; three blocks in each row with seven guard rows between them (21 m). Each plot consisted of a single trap separated from its nearest neighbour by at least 20 m.

The traps were deployed on 22 April. The effects of the treatments were assessed on 29 April, 7 May and 14 May. On each sampling occasion, the sticky base was removed from the trap, labelled and transferred to the laboratory. Sticky bases were examined under a microscope and the species and sex of midges checked. Numbers of male blackcurrant leaf midges, other insects and contamination from leaf litter (percentage debris) were recorded. The midges have been shown to struggle and free themselves from sticky bases, often leaving behind legs and wings. Birds are also known to feed on the trapped midges, so these incidences were recorded separately as, “lost midges”.

Temperature and humidity were recorded for the duration of the trial with a USB 500 data logger. Counts of the total numbers of midges were subjected to analysis of variance using GenStat. Data was $\log_{10}$+1 transformed and percentage cover data was angular transformed.

Objective 2

Six commercial blackcurrant crops, three on each of two farms in Kent, were selected for the trial (Table 2.1). The sites used for the trial were Burr Farm, Brenchley (NGR TQ 684 405) by kind permission of Mr Ian Overy and Macknade Farm, Faversham (NGR TQ 025 598) by kind permission of Mr Steven Holmes. Three plantations were used at each site (Table 2.1).

Two prototype, red delta blackcurrant leaf midge sex pheromone traps with exclusion grids were deployed in each plantation (12 and 16 March respectively) and monitored weekly by the grower for the first two generations of the midge (mid-April to early June). The traps were deployed on the ground within the row of the crop. Each trap had four legs mounted on each corner which were pushed into the soil raising the trap to 3 cm above ground level. The traps were baited with a 5 μg rubber septa lure of the C enatiomer of the blackcurrant leaf midge pheromone. The lure life is much greater than one season so the lures were not refreshed.

In each plantation a 10 m length of row between the two traps was cut to the ground prior to the study to encourage new shoot growth. The plots at Burr Hill Farm were cut down on 12 March and at MacKnade 16 March.

Full maintenance programmes of fungicide (and PGR programme) were applied as for the rest of the plantation. The specific aphicide pirimicarb was applied as required. A temperature and humidity data logger was deployed at each site. Detailed weather data was available from the East Malling weather station.

Table 2.1. Trap locations at each farm. All traps were spaced >10 m apart

Farm	Plantation	Variety	Year	Trap No.s
Burr Farm	House Meadow	Ben Alder	2001	1, 2
Burr Farm	12 acres	Ben Tirran	1997	3,4
Burr Farm	Beet Field	Ben Gairn	2001	5,6
Macknade Farm		Ben Avon		7,8
Macknade Farm		Ben Hope		9,10
Macknade Farm		Ben Lomond		11,12

Each week the sticky bases were changed by the grower and collected by EMR staff for identification and counting of the male blackcurrant leaf midge. At the peak of galling damage for each generation, a count was made of the numbers of galls present on 100 of the re-growth shoots and on 100 of the non-cut down bushes to establish the numbers of galls per unit area in each situation.

Data was collated and subject to regression analysis to determine the relationships between peak catches and the gall density that results for that generation. The aim was to establish a preliminary trap threshold.

Objective 3

See *Objective 1* for details of plantation. Treatments were two foliar sprays of eight different pesticide products, including a standard treatment with Brigade, and an untreated control (Table 3.1). Sprays were timed by counting the numbers of midges caught in two pheromone traps situated in the crop. When the total numbers of midges in the two traps exceeded 30 midges the first spray was applied. The sprays were applied on 14 April and nine days later on 23 April at the B1 and E1 growth stages respectively (Anon., 1984).

Table 3.1. Products evaluated against the first generation of blackcurrant leaf gall midge.

Trt. No.	Active substance & formulation	Product	Product dose rate/ha	Application methods
1	novel	Bayer product†	1.5 l	foliar spray
2	abamectin 18 g/l EC	Dynamec†	500 ml	foliar spray
3	thiacloprid 480 g/l SC	Calypso	125 ml	foliar spray
4	acetamiprid 20% w/w SP	Gazelle†	375 g	foliar spray
5	spinosad 480 g/l EC	Tracer†	250 ml	foliar spray
6	bifenthrin 80 g/l SC	Brigade	500 ml	foliar spray
7	chlorpyrifos 480 g/l EC	Equity	1.5 l	foliar spray
8	chlorpyrifos 480 g/l EC	Equity	1.5 l	soil surface spray
9	Untreated			

† not approved on blackcurrant

A randomised block experimental design with eight pesticide treatments, an untreated control and with four replicates was used. Thus the experiment had 36 plots and these were arranged in blocks of nine, two blocks in each row with a guard row between them. Each plot consisted of an 8 m length of row. The middle 6 m was used for the assessments leaving a 1 m guard at the end of each plot.

Sprays were applied at a volume of 500 l/ha with a Birchmier Motorised Knapsack mist blower. The flow rate of the sprayer was restricted to 0.893 l/minute. Each 8 m of row was sprayed for 60 seconds to achieve the required spray volume (each side of the row was sprayed for 30 seconds). The accuracy of each treatment application, calculated as the applied volume divided by the required volume expressed as a percentage, was checked by measuring the volume of spray remaining in the spray tank after treatments had been applied. These measurements showed that the applied volume of spray was between 88 and 116% of the required spray volume. Measurements of wind speed and wet and dry bulb air temperature (taken with a whirling hygrometer) were taken before the treatments were applied and at the end of the application three hours later. The dry bulb air temperature ranged from 15.0-17.5 °C, the wet bulb temperature 15-11 °C and the wind was a constant 4 kph from the south for the first application. The dry bulb air temperature ranged from 12-16 °C, the wet bulb temperature 15-21 °C and there was no wind for the second application. Temperature and humidity were recorded for the duration of the trial with a USB 500 data logger.

The effects of the treatments were assessed on three sampling dates, 21 April, 30 April and 8 May, seven days after each application, with the final assessment 14 days after the last spray application. On the first two occasions, the total numbers of new basal blackcurrant shoots were counted and the total numbers of galled leaves per shoot were counted from a sample of 12 bushes from the middle of each plot. This assessment was done in the field. On the final sampling occasion, 25 shoots per plot were collected and brought back to the laboratory to be examined and the number of galled leaves and the numbers of live and dead larvae counted. New galls were distinguished as being completely green and fresh with no necrotic areas of leaf tissue and were found in or near the growing point. Examination of galls from untreated bushes before the assessment showed these galls contained numerous larvae of a wide range of ages including young (small transparent) larvae. Old galls were distinguished as having brown areas of necrotic leaf tissue in the gall and were usually found on older shoot growth. Pre-assessment inspection revealed that these galls contained fewer larvae, most of which were mature (large and white). On each occasion, all the bushes in the central 6 m of the plot were carefully inspected for visual symptoms of phytotoxicity.

The counts of the numbers of galls per plot and number of larvae per plot at the assessments were subjected to analysis of variance using GenStat. The counts of numbers of larvae were $\log_{10}$+1 transformed.

Objective 4

The experiment was done in alternate two rows (guard rows) of *Objective 3*. Details of the plantation are in *Objective 1*. Treatments were one or two foliar sprays of three different pesticide products, including a standard treatment with bifenthrin, and an untreated control (Table 4.1). Sprays were timed when pheromone trap catches indicated that midge numbers had begun to increase for the second generation. They were applied on 28 May, 4 and 11 June at the F2, I2 and I3 growth stages respectively (Anon., 1984).

A randomised block experimental design with 15 pesticide treatments, an untreated control and with four replicates was used. Thus the experiment had 64 plots and these were arranged in blocks of 16. Two blocks in each row with a guard row between them. Each plot consisted of 5 m length of row. The middle 4 m was used for the assessments, leaving a 0.5 m guard at the end of each plot.

Sprays were applied at a volume of 500 l/ha with a Birchmier motorised knapsack mist blower. The flow rate of the sprayer was restricted to 0.893 l/ minute. Each 5 m of row was sprayed for 50 seconds to achieve the required spray volume (each side of the row was sprayed for 25 seconds). The accuracy of each treatment application (calculated as the applied volume divided by the required volume expressed as a percentage) was checked by measuring the volume of spray remaining in the spray tank after treatments had been applied. These measurements showed that the applied volume of spray was between 96 and 110% of the required spray volume. Measurements of wind speed and wet and dry bulb air temperature (taken with a whirling hygrometer) were taken before the treatments were applied and at the end of the application 2:30 hours later. The dry bulb air temperature ranged from 16-21 °C for the first application, 18-21 °C for the second application and 14-17 °C for the third application and the wind-speed was less than 2 kph at each application. Temperature and humidity were recorded for the duration of the trial with a USB 500 data logger.

The effects of the treatments were assessed on two sampling dates, 10 and 18 June, six days after the second application and seven days after the third. Ten shoots per plot were collected at random, sealed into polythene bags and returned to the laboratory where the number of galled leaves and number of larvae in each gall was recorded. New galls were distinguished as being completely green and fresh with no necrotic areas of gall leaf tissue and were found in or near the growing point. Examination of galls from untreated bushes before the assessment showed these galls contained numerous larvae of a wide range of ages including young (small transparent) larvae. Old galls were distinguished as having brown areas of necrotic leaf tissue in the gall and were usually found on older growth. Pre-assessment inspection revealed that these galls contained fewer larvae, most of which were mature (large and white).

On each sampling occasion all of the bushes were carefully inspected for visual symptoms of phytotoxicity. The counts of the numbers of new galls per plot and number of larvae per plot at the first and second assessments were square root transformed and subjected to analysis of variance using GenStat.

Table 4.1. Products evaluated in the trial against the second generation.

Trt. No.	Active substance & formulation	Product	Product dose rate /ha	Timing [Days after threshold catch]
1	novel	Bayer product †	1.5 l	0
2	novel	Bayer product †	1.5 l	7
3	novel	Bayer product †	1.5 l	14
4	novel	Bayer product †	1.5 l	0,7
5	novel	Bayer product †	1.5 l	0,14
6	thiacloprid 480 g/l SC	Calypso	125 ml	0
7	thiacloprid 480 g/l SC	Calypso	125 ml	7
8	thiacloprid 480 g/l SC	Calypso	125 ml	14
9	thiacloprid 480 g/l SC	Calypso	125 ml	0,7
10	thiacloprid 480 g/l SC	Calypso	125 ml	0,14
11	bifenthrin 80 g/l SC	Brigade	500 ml	0
12	bifenthrin 80 g/l SC	Brigade	500 ml	7
13	bifenthrin 80 g/l SC	Brigade	500 ml	14
14	bifenthrin 80 g/l SC	Brigade	500 ml	0,7
15	bifenthrin 80 g/l SC	Brigade	500 ml	0,14
16	Untreated			-

†not approved on blackcurrant

Results

Objective 1

The white delta trap caught significantly fewer midges (3,244 total midges), than the red trap with an excluder grid (5,409) or the red trap without grid (10,508 midges) (Table 1.2). Significant losses of midges occurred in the red trap without a grid, However, this was less than 7% of the total trap catch. Contamination by other species of midges was lowest in the design with a grid (only 0.5% of total catch) compared to the red trap without a grid (0.8%) and the white delta trap (3 %), respectively. The percentage area covered by debris (leaf litter) was highest in the red trap with legs and no excluder grid (33.6 % of the sticky base); much more than the other two trap designs (2-4%).

Table 1.2. Results of blackcurrant leaf midge trap design trial comparing white delta traps suspended at 50 cm from ground (WDT); red delta traps 30 cm from ground (RDT L) and red delta traps 30 cm from ground with an exclusion grid (RDT L+G)

Treatment	BCLM	Lost	% of total	Other midges	% of total	Debris (%)
Original data						
WDT	3244	63	1.94	97	2.99	4
RDT L	10508	708	6.74	82	0.78	33.6
RDT L+G	5409	223	4.12	26	0.48	2.3
Transformed data	$\log_{10}(x)$	$\log_{10}(x)$		$\log_{10}(x)$		Ang(x)
WDT	a 2.129	a 0.418		a 0.652		a 2.018
RDT L	c 2.697	b 1.208		a 0.559		b 6.303
RDT L+G	b 2.424	a 0.801		b 0.268		a 1.262
Fprob	<.001	<.001		0.019		<.001
max sed	0.102	0.196		0.136		1.112
max lsd	0.205	0.395		0.274		2.240

Objective 2

Numbers of galls per shoot recorded each generation for each variety and the corresponding total and peak average pheromone trap catches are given in Table 2.2.

Table 2.2. Leaf midge gall densities and total and peak pheromone traps catches for the first and second generations

Site	Variety	Midge generation	Bushes cut down?	No. shoots sampled	No. galls	No. galls/ shoot	Total trap catch	Peak trap catch
Brenchley	Ben Alder	1	yes	120	417	3.5	801	279
Brenchley	Ben Tirran	1	yes	100	198	2.0	518	129
Brenchley	Ben Gairn	1	yes	101	51	0.5	33	13
McKnade	Ben Avon	1	yes	105	138	1.3	738	439
McKnade	Ben Hope	1	yes	124	162	1.3	712	239
McKnade	Ben Lomond	1	yes	107	216	2.0	44	27
Brenchley	Ben Alder	2	yes	103	189	1.8	217	67
Brenchley	Ben Tirran	2	yes	109	298	2.7	260	162
Brenchley	Ben Gairn	2	yes	100	274	2.7	247	101
McKnade	Ben Avon	2	yes	100	603	6.0	549	304
McKnade	Ben Hope	2	yes	101	514	5.1	127	98
McKnade	Ben Lomond	2	yes	107	532	5.0	152	107
Brenchley	Ben Alder	1	no	106	321	3.0	801	279
Brenchley	Ben Tirran	1	no	104	237	2.3	518	129
Brenchley	Ben Gairn	1	no	100	15	0.2	33	13
McKnade	Ben Avon	1	no	103	53	0.5	738	439
McKnade	Ben Hope	1	no	107	44	0.4	712	239
McKnade	Ben Lomond	1	no	111	31	0.3	44	27
Brenchley	Ben Alder	2	no	104	107	1.0	217	67
Brenchley	Ben Tirran	2	no	104	206	2.0	260	162
Brenchley	Ben Gairn	2	no	102	8	0.1	247	101

McKnade	Ben Avon	2	no	106	170	1.6	549	304
McKnade	Ben Hope	2	no	100	85	0.8	127	98
McKnade	Ben Lomond	2	no	100	42	0.4	152	107

Analyses of variance showed large highly significant ($P < 0.001$) differences in mean gall numbers with respect to whether or not the bushes had been cut down, variety and generation. There was a very strong interaction between height and generation, with large differences between generations 1 & 2 (generation 2 > generation 1) for cut down bushes whereas the numbers for not cut down bushes were much lower and there was little difference between the generations (Table 2.3).

Table 2.3. Mean numbers of galls per bush recorded at for the first and second generations on cut down and non-cut down bushes

	Generation 1		**Generation 2**		
	Cut down	**Not cut down**	**Cut down**	**Not cut down**	**Mean**
Ben Alder	3.48	3.04	1.84	1.31	**2.24**
Ben Tirran	1.98	2.27	2.73	1.99	**2.21**
Ben Gairn	0.51	0.15	2.74	0.08	**0.62**
Ben Avon	1.31	0.52	6.03	1.59	**1.93**
Ben Hope	1.31	0.41	5.09	0.85	**1.48**
Ben Lomond	2.02	0.27	4.97	0.42	**1.39**
Mean	**1.77**	**1.11**	**3.90**	**0.99**	**1.65**
Grand mean	**1.33**		**1.96**		

Factor	**LSD (p = 0.05)**
Variety	0.250
Generation	0.144
Cut down	0.153
Variety*generation	0.353
Generation*cut down	0.530

Numbers of galls per shoot were 47% greater in generation 2 than generation 1. Highest numbers of galls occurred on Ben Alder, the most susceptible variety, with lowest numbers on Ben Gairn. Cut down bushes had 1.59 times more galls per shoot than non-cut down bushes in the first generation but 3.94 times more galls in the second generation.

For non-cut down bushes, regression analysis showed at best weak positive relationships between numbers of gall per shoot and the total (r^2 = 0.25) and peak catches (r^2 = 0.10) of midge for the corresponding generation (Figure 2.1.). Taking the worst case data, a total catch of 100 midges would lead to an average of about 90 galls per 100 shoots. A peak catch of 100 midges per trap would lead to an average of about 180 galls per shoot.

For cut down bushes there was no relationship for either total or peak catches (r^2 < 0.02). It is suspected that females may have been attracted over long distances to the lush shoot growth in the comparatively small (10 m single row) plots.

There is clearly considerable variability and more data is required over several years in a wider range of plantations to establish more robust nominal thresholds and to determine how these might be affected by variety.

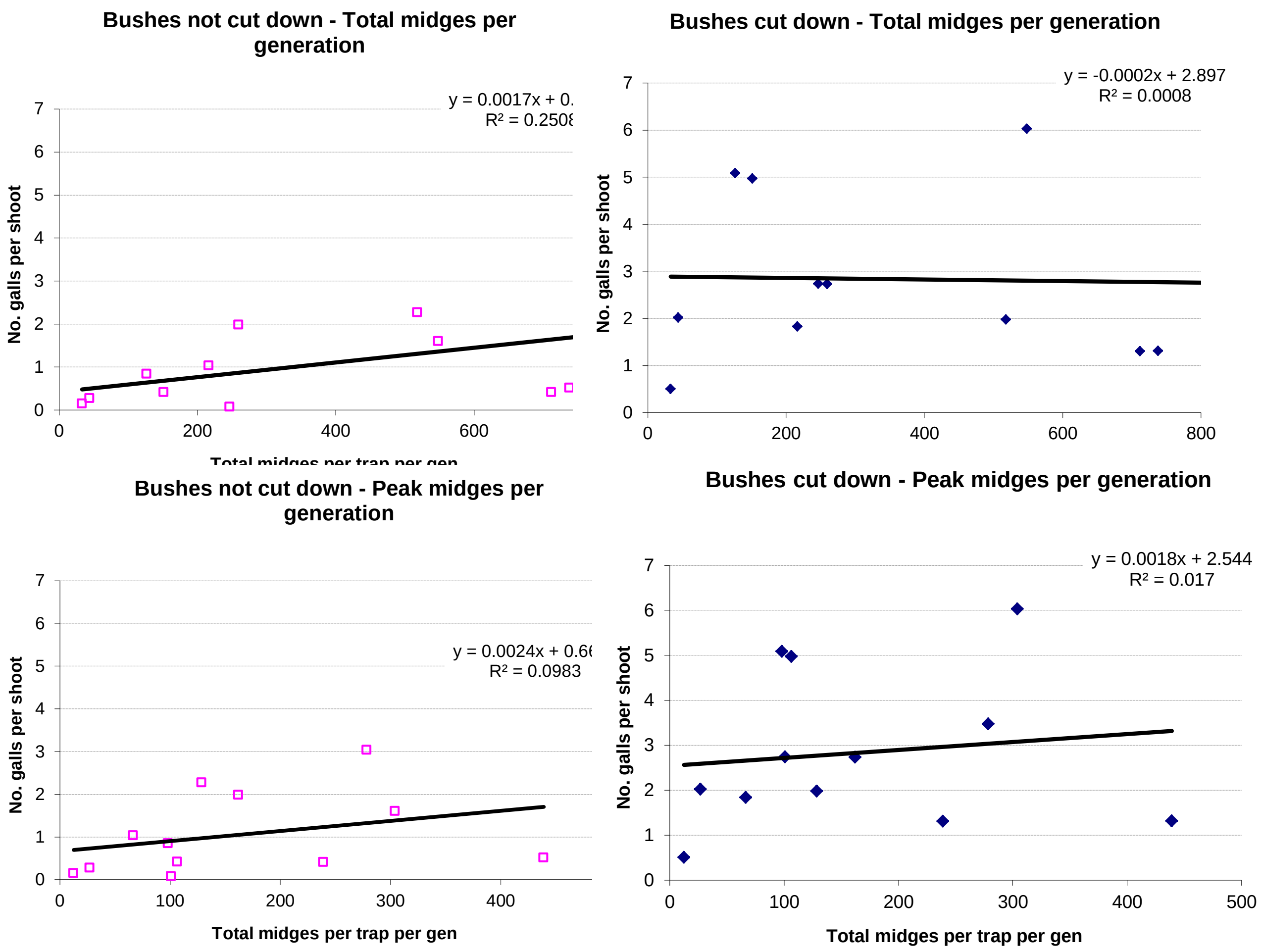

Figure 2.1. Linear regressions between the numbers of galls per shoot and the average peak and total numbers of midges per trap for that generation for the six varieties.

Objective 3

The monitoring traps (Fig. 3.1) showed two distinct flights of the male blackcurrant midge - the first in mid to late April and the second in mid June.

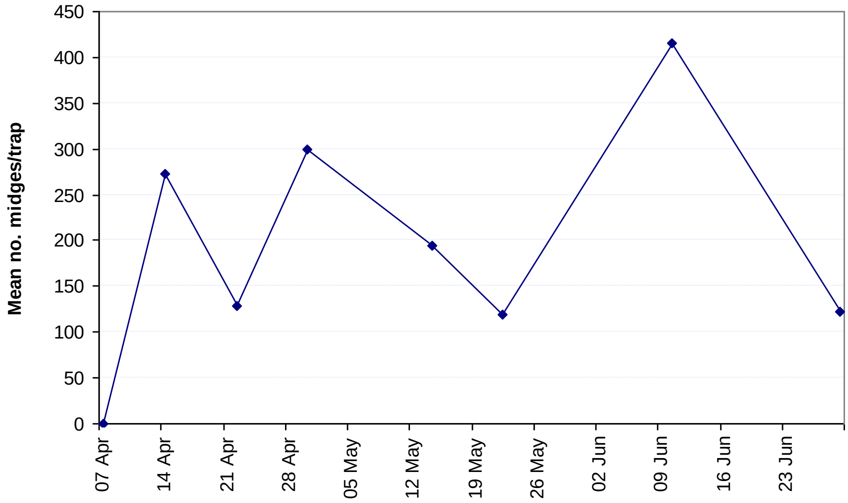

Figure 3.1. Mean number of male blackcurrant leaf midge caught in two sex pheromone traps (red design with grids, 5 µg sex pheromone rubber septa). Traps were deployed on 1 April.

At the first assessment on 21 April, seven days after the first treatment application, Dynamec, Gazelle and Brigade reduced the numbers of galled leaves but Brigade was most effective (Table 3.2).

At the second assessment on 30 April 2009, seven days after the second application, there was no longer any evidence for the activity of Dynamic or Gazelle. The Bayer coded product, Equity (applied as a soil drench) and Brigade all reduced the numbers of galls on the shoots. The latter treatment was the most effective.

At the final assessment, 14 days after the second application, the Bayer coded product had reduced the level of infestation but Brigade was still significantly more effective.

Four of the products significantly reduced the number of larvae in the galls on the final assessment. Brigade and the Bayer product were equally effective, and were more effective than the two Equity treatments (foliar sprays or soil drenching), which also reduced the numbers of larvae in galls.

The new Bayer product and Brigade consistently gave the best control of blackcurrant midge larvae and their leaf galls, although the newer product was a little slower to act.

The analysis of the number of larvae per gall gave the most robust conclusions with both the Bayer coded product and Brigade significantly reducing the number of larvae. No visual symptoms of phytotoxicity were observed on any of the bushes at either assessment.

Table 3.2. Results of blackcurrant leaf midge insecticides screening trial 2009. First spray applied 14 April, second spray applied 10-14 days later on 23 April 2009 (N=4) *significantly less than control P≤0.05; **significantly less than control P≤0.01

Date	**21 April**		**30 April**		**8 May**					
Measure	**Galls/shoot**		**Galls/shoot**		**Galls/25 shoots**		**Larvae/25 shoots**		**Larvae/gall**	
Date	**n**	**$Log_{10}(100n+1)$**	**n**	**$Log_{10}(100n+1)$**	**n**	**$Log_{10}(100n+1)$**	**n**	**$Log_{10}(100n+1)$**	**n**	**$Log_{10}(100n+1)$**
Bayer product	0.15	1.148	0.51	1.687*	9.0	2.30*	0.3	0.501**	0.03	0.354**
Dynamec	0.10	0.987*	0.74	1.789	33.0	3.37	77.5	3.744	2.43	2.380
Calypso	0.28	1.201	0.84	1.858	38.5	3.51	75.3	3.718	2.08	2.212
Gazelle	0.11	1.008*	0.53	1.710	16.3	3.18	15.8	3.116	0.91	1.938
Tracer	0.26	1.426	1.01	1.979	30.8	3.43	64.0	3.731	2.01	2.301
Brigade	0.06	0.695**	0.10	1.032**	1.3	1.15**	0.5	0.576**	0.25	0.780**
Equity foliar	0.44	1.529	0.53	1.702	9.3	2.88	8.3	2.752*	0.83	1.875
Equity soil	0.39	1.338	0.54	1.680*	17.5	2.98	11.5	2.925*	1.06	1.947
Untreated	0.58	1.554	1.12	2.021	40.8	3.56	98.3	3.921	2.34	2.367
Fprob		0.036		<0.001		0.001		<0.001		<0.001
SED (24 df)		0.2511		0.1557		0.490		0.435		0.2627
LSD(P=0.05)		0.5182		0.3214		1.011		0.897		0.5463
LSD(P=0.01)		0.7022		0.4355		1.370		1.216		0.7438

Objective 4

At the first assessment, 10 June, six days after the first treatment application, six of the spray programmes had significantly reduced the numbers of galls (Table 4.2), even though the numbers of midges in the pheromone traps at the time of spraying were high (see Fig 3.1). Of the six, only programmes which included either an early and/or intermediate spray of the Brigade or the Bayer product were effective. An intermediate spray of Calypso did seem to give good control, but this result is conflicting because two sprays, one early and one intermediate, did not control the midge larvae. Treatments that consisted of only a last spray were not effective at controlling the midge larvae. An early and intermediate spray of Brigade was the most effective treatment at this date (treatment 14). The Bayer coded product was slower acting than Brigade and did not halt the production of galls, but did kill the larvae. All four of the treatment programmes that had the Bayer coded product applied and the three Brigade programmes that consisted of early sprays were effective at reducing the number of larvae in the galls (p=0.001). A single intermediate application of Calypso also significantly reduced the number of larvae in galls (p=0.001). (Table 4.2).

At the second assessment on the 18 June, seven days after the final application, none of the treatments reduced the numbers of galls per shoot though it should be noted that the treatments including the Bayer product had no or very larvae in the galls (Table 4.2).

No visual symptoms of phytotoxicity were observed on any of the bushes at either assessment.

Table 4.2. Mean and mean square root transformed numbers of blackcurrant leaf midge galls and larvae per 10 shoots on 10 and 18 June, six days after the second and seven days after the third spray application, of UKA385a, Calypso or Brigade as indicated by the shaded cells (N=4). *,**,*** significantly less than control at P≤0.05, 0.01,0.001

Trt	Product	Spray date			10 June 2009				18 June 2009			
					Galls		Larvae		Galls		Larvae	
		28 May	4 Jun	11 Jun	n	√n	n	√n	n	√n	n	√n
1	Bayer product				8.8	4.12	0.0	0.00***	11.8	3.28	0.0	0
2	Bayer product				7.8	2.76*	0.5	0.50***	12.0	2.90	0.3	0.25
3	Bayer product				26.3	5.05	10.5	2.62*	14.8	3.67	0.0	0.00
4	Bayer product				11.3	2.92*	0.0	0.00***	31.8	5.27	0.0	0.00
5	Bayer product				12.0	2.65*	0.0	0.00***	9.5	3.02	0.3	0.25
6	Calypso				32.5	5.60	30.5	5.17	13.0	3.20	21.8	3.78
7	Calypso				19.5	4.14	1.8	0.66***	14.8	3.72	15.8	3.20
8	Calypso				20.5	4.32	20.0	3.79	15.3	3.67	3.5	1.57
9	Calypso				29.5	5.40	54.3	6.68	41.8	5.81	42.5	5.65
10	Calypso				25.0	4.92	19.0	3.37	15.3	3.60	7.5	2.23
11	Brigade				9.8	2.75*	1.0	0.85***	11.5	3.20	45.0	6.09
12	Brigade				38.7	6.14	30.8	4.22	8.3	2.46	5.5	1.17
13	Brigade				44.0	6.59	34.0	5.61	15.0	3.65	11.3	2.99
14	Brigade				5.3	0.87**	0.3	0.25***	8.8	2.90	12.0	3.41
15	Brigade				15.3	2.73*	0.0	0.00***	11.3	3.14	23.8	4.35
16	Untreated				25.8	4.87	52.0	6.10	12.3	3.05	10.8	2.47
				FProb		<0.001		<0.001		0.171		<0.001
				SED(45 df)		0.880		1.468		1.018		1.281
				LSD(P=0.05)		1.771		2.956		2.050		2.580

Conclusions

Objective 1

- Red delta traps with excluder grids at their entrances and held at a height of 3 cm above the ground on integral legs were optimal for trapping blackcurrant leaf midge using sex pheromone lures. Red delta traps without excluder grids caught about twice as many male blackcurrant leaf midges but were subject to the highest numbers of midge losses through predation and higher amounts of debris and non-target insect contamination.
- Red delta traps with excluder grids and integral legs are not commercially available currently but can be readily DIY constructed in small numbers.
- White delta traps did catch midges but were less effective than the red delta traps, which may delay the detection of midges early in the flight period when spray applications are critical for control. The poor performance of this trap may have been because it was positioned higher in the crop where fewer midges are flying.

Objective 2

- For non-cut down bushes pheromone trap calibration showed weak positive relationships between numbers of gall per shoot and the total and peak catches of midge for the corresponding generation. Taking the worst case data, a total catch of 100 midges would lead to an average of about 90 galls per 100 shoots. A peak catch of 100 midges per trap would lead to an average of about 180 galls per shoot.
- For cut down bushes there was no relationship for either total or peak catches. It is suspected that females may have been attracted over long distances to the lush shoot growth in the small plots.
- There was considerable variability and more data is required over several years in a wider range of plantations to establish more robust nominal thresholds and to determine how these might be affected by variety.

Objective 3

- Five of the plant protection products tested gave at least some curative activity against existing infestations of larvae in galls (Dynamec, Gazelle, Equity, Brigade and Bayer product).
- Only the Bayer coded product and Brigade gave consistently reliable results.
- The Bayer coded product was as effective as Brigade, for which it may be a suitable replacement. It is a selective product and was able to kill larvae inside galls whereas Brigade is disruptive and probably did not kill more mature larvae in galls.
- None of the products produced any visual symptoms of phytotoxicity.

Objective 4

- Timing of pesticide applications was critical in the control of blackcurrant leaf gall midge. To be effective insecticides needed to be applied early in the generation of the midge (oviposition or early stage larvae).
- Brigade and the Bayer coded product were effective at controlling the midge, but only if applied at the beginning of the generation (within a few days of a threshold catch of 30 midges/trap).
- The third spray application did not have any effect on the numbers of galled leaves or larvae.
- Calypso applied on the second application appeared to reduce the numbers of larvae within the galls (although this was too late to reduce the numbers of galls themselves).
- The Bayer coded product seemed to offer the best protection against the midge as it was equally as effect as Brigade in reducing the numbers of larvae, but also seemed to have a larger window of opportunity to apply the treatment.
- None of the treatments had any effect when applied at the end of the generation, probably because the larvae had completed development and left the gall, but also because the gall had become tough and necrotic, limiting any trans-laminar effects of the insecticides.
- None of the products produced any visual symptoms of phytotoxicity.

Acknowledgements

We are grateful to the GlaxoSmithKline blackcurrant grower research fund for funding this work and especially Rob Saunders for his support and advice. We would also like to thank Tom Maynard, Ian Overy and Steven Holmes for provision of the experimental sites. Gillian Arnold helped and gave advice on the statistical analyses. Gloria Endredi and Willy Couanon assisted with the experimental work.

References

Anonymous. 1984. EPPO Crop Growth Stage Keys. Blackcurrant. EPPO/OEPP 1988 No. 8, 577-579

Cross, J.V. & Harris, A.L. 2006. IPM methods for blackcurrant gall mite and leaf midge: synthesis, validation and implementation in UK commercial blackcurrant production. Report to GSK blackcurrant grower's research committee issued December 2006, 30-31 pp.

Cross, J.V. & Harris, A.L. 2002. Evaluation of insecticides for control of blackcurrant leaf midge 2002. Report to GSK blackcurrant grower's research committee issued July 2002, 13 pp.

Goncharova, N.G. Samosudov, V.N. 1979. Protection of black currant from the leaf gall-midge. *Zashchita Rastenii.* 1979. No. 10, 38-39*.*

Harris, P.G.W. & Wardlow, L.R. 1984. The efficacy of insecticides against blackcurrant leaf midge (*Dasineura tetensi*). *Annals of Applied Biology.* 1984. 104: Supplement, 8-9.

Labanowska, B.H. Bera, B. & Suski, Z.W. 1983. Control of the blackcurrant leaf midge (*Dasyneura tetensi*). *10th International Congress of Plant Protection 1983. Volume 3. Proceedings of a conference held at Brighton, England, 20-25 November, 1983. Plant protection for human welfare. British Crop Protection Council, Croydon, UK: 1983.* 1013.

Umpelby, R.A. & Corbett, S.J. 1991. Chemical control and biology of blackcurrant leaf midge 1989-1990. ADAS Report for Beecham Group Plc.

Umpelby, R.A. & Corbett, S.J. 1992. Chemical control and biology of blackcurrant leaf midge 1991. ADAS Report for Beecham Group Plc.

Umpelby, R.A. & Corbett, S.J. 1992. Chemical control and biology of blackcurrant leaf midge. ADAS Report for SmithKline Beecham.

Umpelby, R.A. & Corbett, S.J. 1993. Chemical control and biology of blackcurrant leaf midge. ADAS Report for SmithKline Beecham.

Wardlow, L.R. & Nicholls, R.F. 1986. Chemical control of blackcurrant leaf midge using fenpropathrin. 1986 British Crop Protection Conference. Pests and diseases. Volume 1. Proceedings of a conference held at Brighton Metropole, England, November 17-20, 1986. British Crop Protection Council, Thornton Heath, UK: 1986, 359-362.

