

# SCEPTREPLUS

## Final Trial Report

<b>Trial code:</b>	SP 58
<b>Title:</b>	Efficacy trial testing candidate IPM-compatible control measures for leafhopper on herbs.
<b>Crop</b>	Protected sage. Trial data also applicable to other protected and outdoor herbs and herb species grown as ornamentals.
<b>Target</b>	Chrysanthemum leafhopper (commonly known as the 'sage leafhopper'), <i>Eupteryx melissae</i> .
<b>Lead researcher:</b>	Jude Bennison & Peter Seymour
<b>Organisation:</b>	ADAS Horticulture
<b>Period:</b>	March 2020 – December 2020
<b>Report date:</b>	2 December 2020
<b>Report authors:</b>	Pete Seymour & Jude Bennison
<b>ORETO Number: (certificate should be attached)</b>	409

I the undersigned, hereby declare that the work was performed according to the procedures herein described and that this report is an accurate and faithful record of the results obtained

2.12.20  
Date

  
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# Trial Summary

## Introduction

The quality of herb crops, including sage, can be reduced by feeding damage caused by chrysanthemum or 'sage' leafhopper (*Eupteryx melissae*). There are currently limited available effective options for controlling this pest.

## Methods

Sage plants were planted from seed on 7 August 2020 and grown in insect-proof cages in a polytunnel to exclude leafhoppers and other pests. The trial was designed with seven treatments and six replicates. The treatments consisted of conventional insecticides and bio-pesticides. Each plot consisting of four pots of sage in an insect-proof cage and was infested with 20 adult leafhoppers. All treatments were applied using a knapsack Oxford precision sprayer fitted with 02F110 nozzles in 600l/ha water. Each treatment was applied at the rates and timings recommended by the manufacturer. Assessments of leafhopper numbers, phytotoxicity and percentage leaf area damaged were made on days 4, 8, 15 and 22 after the first treatment application. Damage assessments were carried out on 24 marked leaves per plot.

A pilot experiment was undertaken to compare the numbers of leafhopper adults trapped on red, yellow or blue sticky traps in a polytunnel. 'Sage' leafhopper adults (250) were released over potted sage plants in an insect-proof tent with four replicate blocks of the three types of coloured trap around the sides. Numbers of leafhopper adults on the traps were recorded after two 6-day periods.

## Results

- The industry standard conventional insecticide Gazelle SG (applied once) performed well as the positive control, giving statistically significant reductions in both leafhopper numbers and damage compared with the untreated control on all assessment dates. Gazelle SG was the most effective treatment in reducing numbers of leafhoppers on days 15 and 22 and the most effective in reducing damage on all dates.
- The botanical biopesticides AHDB 9920 & AHDB 9919 (both applied three times at five-day intervals) gave significant reductions in both leafhopper numbers and damage on all assessment dates.
- The botanical biopesticide AHDB 9967 (applied three times at seven-day intervals) gave a significant reduction in leafhopper numbers on all assessment dates from eight days after the first application but not on the day 4 assessment. However, it significantly reduced leafhopper damage on all dates.
- The conventional insecticides AHDB 9966 (applied twice at 14-day intervals) and AHDB 9921 (applied twice at seven-day intervals) did not significantly reduce leafhopper numbers on days 4 and 8 but significantly reduced numbers on days 15 and 22. Both treatments significantly reduced damage on all assessment dates.
- All treatments mixed and sprayed well. There were no phytotoxic effects.
- Significantly more leafhopper adults were caught on yellow traps than on red or blue traps in the first 6-day period but lower numbers were caught in the second 6-day period and there were no significant differences between colours.

## Take home message:

- Gazelle SG used as the industry standard was the most effective treatment.
- All treatments significantly reduced leafhopper numbers on sage compared with the untreated control, although some treatments acted faster than others.
- All treatments significantly reduced damage on all assessment dates.
- No treatments caused phytotoxic effects
- In a pilot experiment, yellow traps caught significantly more leafhoppers than red or blue but when leafhopper numbers were lower, similar numbers were caught on traps of all three colours.

## Objectives

- To evaluate the effectiveness of novel conventional insecticides and bio-pesticides applied against chrysanthemum ('sage') leafhopper on herbs, as measured by numbers of live adults and nymphs per plant and percentage damaged leaf area.
- To monitor the treated crop for phytotoxicity.
- To test adult leafhopper preference for trap colour (pilot additional test, non ORETO).

## Trial conduct

UK regulatory guidelines were followed but EPPO guidelines took precedence. The following EPPO guidelines were followed:

Relevant EPPO guideline(s)		Variation from EPPO
EPPO PP1/135(4)	Phytotoxicity assessment	None
EPPO PP1/152(4)	Guideline on design and analysis of efficacy evaluation trials	None
EPPO PP1/225(2)	Minimum effective dose	None
EPPO PP1/181(4)	Conduct and reporting of efficacy evaluation trials including good experimental practice	None
EPPO PP1/214(3)	Principles of acceptable efficacy	None
EPPO PP1/224(2)	Principles of efficacy evaluation for minor uses	None
EPPO PP1/312(1)	Green leafhoppers on peach	Assessed leafhoppers on all leaves per plot instead of on 5 shoots per tree.
EPPO PP1/316(1)	Leafhoppers and planthoppers on grapevines	Assessed leafhoppers on all leaves per plot instead of on 25 leaves per plot.

Deviations from EPPO guidance: as in table above.

ADAS has Efficacy Testing Certificate No. ORETO 409.

## Test site

Item	Details
Location address	ADAS Boxworth, Boxworth, Cambridge, CB23 4NN
Crop	Sage
Cultivar	N/A
Soil or substrate type	Levington M2 growing media
Agronomic practice	See Appendix A
Prior history of site	Research polytunnels used for evaluating control methods for pests and diseases on various crops

## Trial design

Item	Details
Trial design:	7* Treatments, randomised block
Number of replicates:	6
Row spacing:	Four 9cm pots in two rows of two.
Plot size: (w x l)	50x50cm thrips-proof cage
Plot size: (m <sup>2</sup> )	0.25
Number of plants per plot:	Four
<i>Leaf Wall Area calculations</i>	N/A

\*8 treatments were planned but one treatment did not arrive after being requested from the manufacturer, so was omitted from the trial.

## Treatment details

AHDB Code	Active substance	Product name/ manufacturer s code	Formulation batch number	Content of active substance in product	Formulation type	Adjuvant
Untreated	N/A	N/A	N/A	N/A	N/A	N/A
N/A	Acetamiprid	Gazelle SG (+ve control)	199467	200g/ Kg	Water Soluble Granule	N/A
AHDB 9966	N/D	N/D	N/D	N/D	N/D	N/A
AHDB 9921	N/D	N/D	N/D	N/D	N/D	N/A
AHDB 9920	N/D	N/D	N/D	N/D	N/D	N/A
AHDB 9967	N/D	N/D	N/D	N/D	N/D	N/A
AHDB 9919	N/D	N/D	N/D	N/D	N/D	N/A

Rain water was used with the fatty acids product as recommended by the manufacturer. An additional novel bio-pesticide treatment was planned however it had to be removed from the trial as it did not arrive in time from the manufacturer.

## Application schedule

Treatment number	Treatment: product name or AHDB code	Rate of active substance (ml or g a.s./ha)	Rate of product (l or kg/ha)	Application code
1	Untreated Control	N/A	N/A	Untreated Control
2	Gazelle (+ve control)	50g a.s./ ha	250g/ha	A
3	AHDB 9966	24g a.s./ha	200ml/ha	A & E
4	AHDB 9921	120g a.s./ ha	1L/ha	A & C
5	AHDB 9920	6.12kg /ha	12L/ha (2% concentration)	A, B & D
6	AHDB 9967	N/D	3.6L/ha (0.6% concentration)	A, C & E
7	AHDB 9919	7.1kg a.s. /ha	12L/ha (2% concentration)	A, B & D

## Application details

	Application A	Application B	Application C	Application D
Application date	11.09.2020	16.9.20	18.9.20	21.9.20
Time of day	13:45	08:30	09:35	09:40
Crop growth stage (Max, min average BBCH)	12	12	12/13	13
Crop height (cm)	10	10	11	14
Crop coverage (%)	N/a	N/a	N/a	N/a
Application Method	Spray	Spray	Spray	Spray
Application Placement	Foliar	Foliar	Foliar	Foliar
Application equipment	Oxford Precision Sprayer	Oxford Precision Sprayer	Oxford Precision Sprayer	Oxford Precision Sprayer
Nozzle pressure	2 Bar	2 Bar	2 Bar	2 Bar
Nozzle type	02F110	02F110	02F110	02F110
Nozzle size	Medium (Yellow)	Medium (Yellow)	Medium (Yellow)	Medium (Yellow)
Application water volume/ha	600L/ha	600L/ha	600L/ha	600L/ha
Temperature of air - shade (°C)	21.2	20.4	21.5	20.4
Relative humidity (%)	49.2	69.6	51.9	65
Wind speed range (m/s)	0 (in closed polytunnel)	0 (in closed polytunnel)	0 (in closed polytunnel)	0 (in closed polytunnel)
Dew presence (Y/N)	N	N	N	N
Temperature of soil - 2-5 cm (°C)	N/A	N/A	N/A	N/A
Wetness of soil - 2-5 cm	Damp	Damp	Damp	Damp
Cloud cover (%)	5	20	10	20

## Untreated levels of pests/pathogens at application and through the assessment period

Common name	Scientific Name	EPPO Code	Infestation level pre-application	Infestation level at start of assessment period	Infestation level at end of assessment period
Chrysanthemum ('sage') leafhopper	<i>Eupteryx melissae</i>	-	0 <sup>1</sup> 0 <sup>2</sup>	6.33 <sup>1</sup> 17.72 <sup>2</sup>	4.50 <sup>1</sup> 26.51 <sup>2</sup>

<sup>1</sup> Mean number of leafhopper adults per plot prior to infestation

<sup>2</sup> Mean percentage leaf area damaged

## Assessment details

Prior to infestation, six leaves per plant were marked with a single black dot with a felt tip pen.

Chrysanthemum ('sage') leafhopper adults were collected from a culture of leafhoppers maintained on sage in insect-proof tents in a polytunnel at ADAS Boxworth and also from sage plants in local gardens. Twenty adults were added to each plot (consisting of a thrips-proof cage 0.5x0.5x0.5 m) one day before the first treatments were applied.

Prior to the application of treatments, water-sensitive paper was used to demonstrate spray coverage, using water. Papers were attached to the upper and lower sides of a top and lower leaf on two representative spare sage plants using paper clips. Water was then applied to the

plants at 600L/ha using the same equipment used for application of all other treatments in the trial. The papers were then assessed to confirm droplet deposition.

Treatments were applied over a 15-day period at time intervals recommended by each manufacturer. These varied from once, twice at 7-day intervals, to three times at 5-day intervals and three times at 7-day intervals. The plants in each plot were sprayed whilst remaining in each respective cage after opening the hinged lid at the top of each cage to allow application whilst minimizing the risk of leafhopper adults escaping from the cages.

Assessments of leafhopper adult and nymph numbers and leaf damage were done one day before the first treatments were applied and then three, six, 14, and 21 days after the first treatments. On each assessment date numbers of live leafhopper adults and nymphs on all the leaves in each cage, numbers of adults on the inside of each cage, and percentage leaf damage caused by leafhoppers on the marked leaves were recorded. Leaf assessments were done by examining both the upper and lower sides of each leaf. The assessments were done *in-situ* after opening the lid of each cage to minimize the risk of leafhoppers leaving the cages.

Evaluation date	Evaluation Timing (DA)*		Crop Growth Stage (BBCH)	Evaluation type (efficacy, phytotoxicity)	Assessment
	After first conventional insecticides	After first bio-pesticides			
10/9/20	-1	-1	2TL	Efficacy and phytotoxicity	Numbers of live leafhopper adults and nymphs, % leaf damage, phytotoxicity score.
14/9/20	4	4	2TL	Efficacy and phytotoxicity	Numbers of live leafhopper adults and nymphs, % leaf damage, phytotoxicity score.
18/9/20	8	8	2TL	Efficacy and phytotoxicity	Numbers of live leafhopper adults and nymphs, % leaf damage, phytotoxicity score.
25/9/20	15	15	2TL	Efficacy and phytotoxicity	Numbers of live leafhopper adults and nymphs, % leaf damage, phytotoxicity score.
2/10/20	22	22	3TL	Efficacy and phytotoxicity	Numbers of live leafhopper adults and nymphs, % leaf damage, phytotoxicity score.

\* DA – days after application

### Pilot sticky trap experiment

A pilot experiment was undertaken to compare the numbers of leafhopper adults trapped on red, yellow or blue sticky traps in a polytunnel. 'Sage' leafhopper adults (250) were released over 64 potted sage plants in an insect-proof mesh tent cage and allowed to settle for an hour before the traps were set up. Four replicate blocks of the three traps of each colour were placed around the sides of the tent (Figure 10, Appendix). The traps were mounted on canes pushed into a pot of compost for stability (Figure 11) with a 10cm gap between the traps and the block of sage plants in the centre. Numbers of leafhopper adults on the traps were recorded after two 6-day periods. The trap colours were re-randomised after the first 6-day period and additional leafhopper adults were released to the tent cage to replace those that had been caught on the traps in the first 6-day period.

### Statistical analysis

The data were analysed using Analysis of Variance (ANOVA). Angular transformation was used for data recorded as percentage leaf area damaged. Abbott's formula was used to calculate percentage reduction in numbers of leafhopper adults or percentage of leaf area damaged compared with the control where there was a significant treatment effect.

## Results

### Spray Coverage

Spray coverage was good on the upper sides of the top and lower leaves but very little spray reached the lower leaf side on the sage plants (Figure 13, Appendix).

### Phytotoxicity

No signs of phytotoxicity were observed in the trial in any of the treatments.

### Efficacy

#### Numbers of Leafhopper adults

One day before leafhopper adults were added to the plots, no damage or leafhoppers were seen on any of the trial plants.

On the first assessment, completed four days after the first application, there was a mean of 6.33 leafhopper adults per untreated plot (Table 1 and Figure 1), which was significantly higher than in plots treated with the industry standard Gazelle SG and the botanical bio-pesticides AHDB 9920 and AHDB 9919. Gazelle SG and AHDB 9919 were the most effective treatments on this date. Mean numbers of leafhopper adults on the plants treated with the other products were not significantly different to the untreated controls on this date.

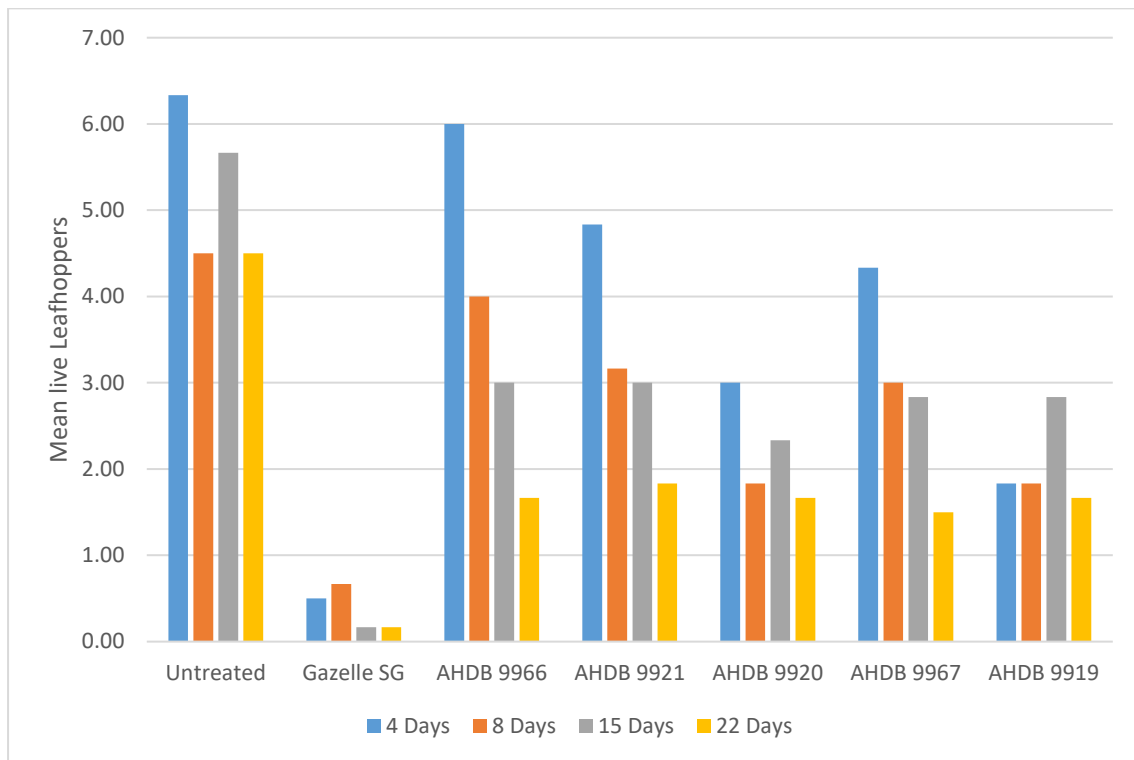
On the second assessment, completed eight days after the first application, there was a mean of 4.5 leafhopper adults per untreated plot (Table 1 and Figure 1), which was significantly higher than in plots treated with Gazelle SG and the botanical biopesticides AHDB 9920, AHDB 9967 and AHDB 9919. Mean numbers of leafhopper adults in plots treated with the conventional insecticides AHDB 9966 and AHDB 9921 were not significantly reduced compared with the untreated control.

On the third and final assessments, completed 15 and 22 days after the first applications, mean numbers of leafhopper adults in all treatments were significantly lower than in the untreated control. Gazelle SG was the most effective treatment on these dates and all of the other treatments were equally effective.

**Table 1:** Mean numbers of live leafhopper adults per plot, 4, 8, 15 and 22 days after the first applications. Values sharing the same letters are not significantly different, those with different letters are significantly different.

	Mean Leafhopper adults per plot			
Date	14/9/20	18/9/20	25/9/20	2/10/20
DAT	4	8	15	22
Treatment				
Untreated	6.33 d	4.50 d	5.67 c	4.50 c
Gazelle SG	0.50 a	0.67 a	0.17 a	0.17 a
AHDB 9966	6.00 d	4.00 cd	3.00 b	1.67 b
AHDB 9921	4.83 cd	3.17 bcd	3.00 b	1.83 b
AHDB 9920	3.00 bc	1.83 ab	2.33 b	1.67 b
AHDB 9967	4.33 cd	3.00 bc	2.83 b	1.50 b
AHDB 9919	1.83 ab	1.83 ab	2.83 b	1.67 b
F value	11.40	8.42	11.61	9.77
P value	<.001	<.001	<.001	<.001
d.f.	6	6	6	6
s.e.d.	0.905	0.656	0.666	0.586
l.s.d.	1.848	1.340	1.360	1.198
	Not significantly different from untreated control (P>0.05)			

Significantly different from untreated control (P<0.05)



**Figure 1:** Mean numbers of live leafhopper adults per plot, 4, 8, 15 and 22 days after the first applications.

Abbott's formula was used to calculate percentage reduction in mean numbers of leafhopper adults per plot compared with the water controls and these are presented in Table 2.

**Table 2:** Percentage reduction in mean numbers of leafhopper adults per plot compared with Treatment 1 (untreated control), 4, 8, 15 and 22 days after the first treatments (Abbott's formula). **Significant reduction compared with the untreated control (P<0.05).**

	Percentage Reduction compared with untreated control (Abbott's Formula).			
Date	14/9/20	18/9/20	25/9/20	2/10/20
DAT	4	8	15	22
Treatment				
Untreated control				
Gazelle SG	<b>92.10%</b>	<b>85.18%</b>	<b>97.05%</b>	<b>96.29%</b>
AHDB 9966	5.26	11.11	<b>47.06%</b>	<b>62.96%</b>
AHDB 9921	23.69	29.62	<b>47.06%</b>	<b>59.27%</b>
AHDB 9920	<b>52.63%</b>	<b>59.27%</b>	<b>58.83%</b>	<b>62.96%</b>
AHDB 9967	31.58	<b>33.33%</b>	<b>50.01%</b>	<b>66.67%</b>
AHDB 9919	<b>71.06%</b>	<b>59.27%</b>	<b>50.01%</b>	<b>62.96%</b>

### Numbers of Leafhopper nymphs

No leafhopper nymphs were found during the trial in any of the assessments.

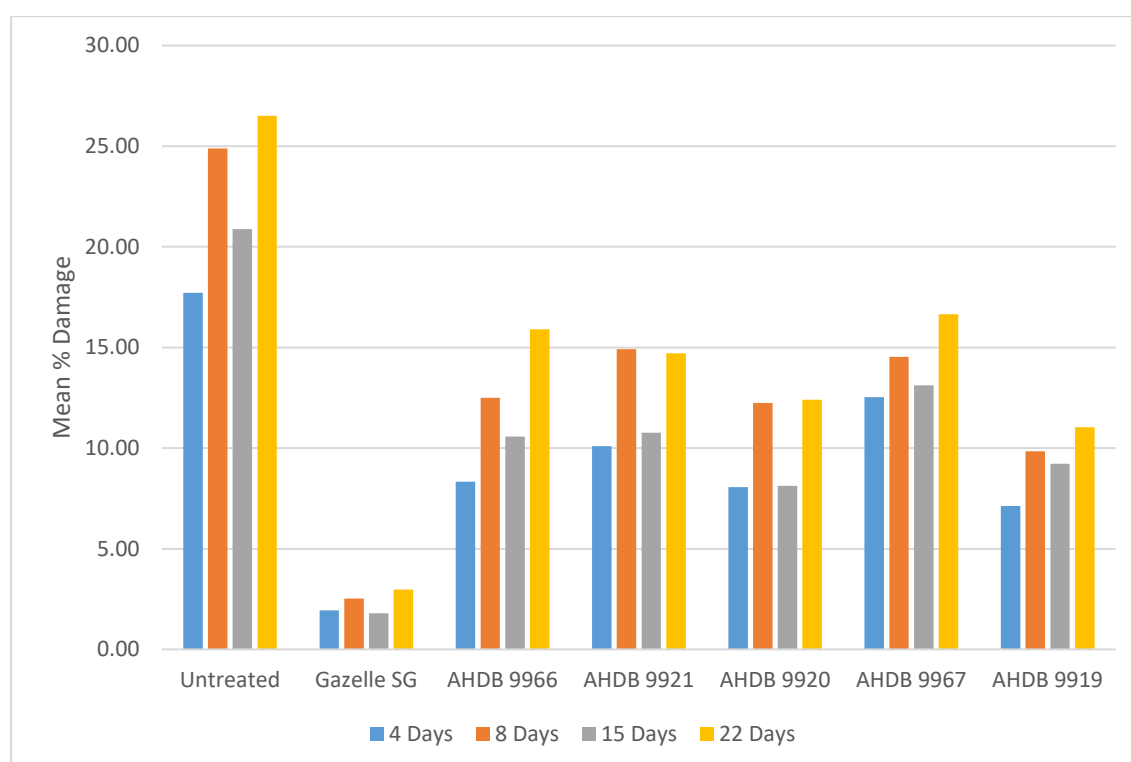
### Percentage of leaf area damaged



Assessments of the mean percentage leaf area damaged 4, 8, 15 and 22 days after the first applications are presented in Table 3, Table 4 and Figure 2. The data was not transformed to complete this analysis. At all assessment dates the mean percentage leaf area damaged was significantly reduced by all treatments compared with the untreated controls. The industry standard Gazelle SG was the most effective product, significantly reducing the damage more than all other treatments on all assessment dates (mean percentage damage reduced by 85-97%, Table 4) and maintaining mean percentage leaf area damaged below 3%.

**Table 3:** Mean percentage leaf area damaged per plot, 4, 8, 15 and 22 days after the first applications. Values sharing the same letters are not significantly different, those with different letters are significantly different.

	Mean percentage leaf area damaged per plot			
Date	14/9/20	18/9/20	25/9/20	2/10/20
DAT	4	8	15	22
Treatment				
Untreated	17.72 d	24.88 d	20.88 d	26.51 d
Gazelle SG	1.94 a	2.52 a	1.79 a	2.97 a
AHDB 9966	8.33 b	12.50 bc	10.58 bc	15.90 c
AHDB 9921	10.10 bc	14.91 c	10.76 bc	14.72 bc
AHDB 9920	8.07 b	12.25 bc	8.12 b	12.41 bc
AHDB 9967	12.53 c	14.54 c	13.12 c	16.65 c
AHDB 9919	7.12 b	9.84 b	9.22 b	11.03 b
F value	15.71	21.66	22.93	21.29
P value	<.001	<.001	<.001	<.001
d.f.	30	30	30	30
s.e.d.	1.744	2.030	1.695	2.167
l.s.d.	3.561	4.146	3.462	4.426
	Not significantly different from untreated control (P>0.05)			
	Significantly different from untreated control (P<0.05)			



**Figure 2:** Mean percentage leaf area damaged per plot, 4, 8, 15 and 22 days after the first applications.

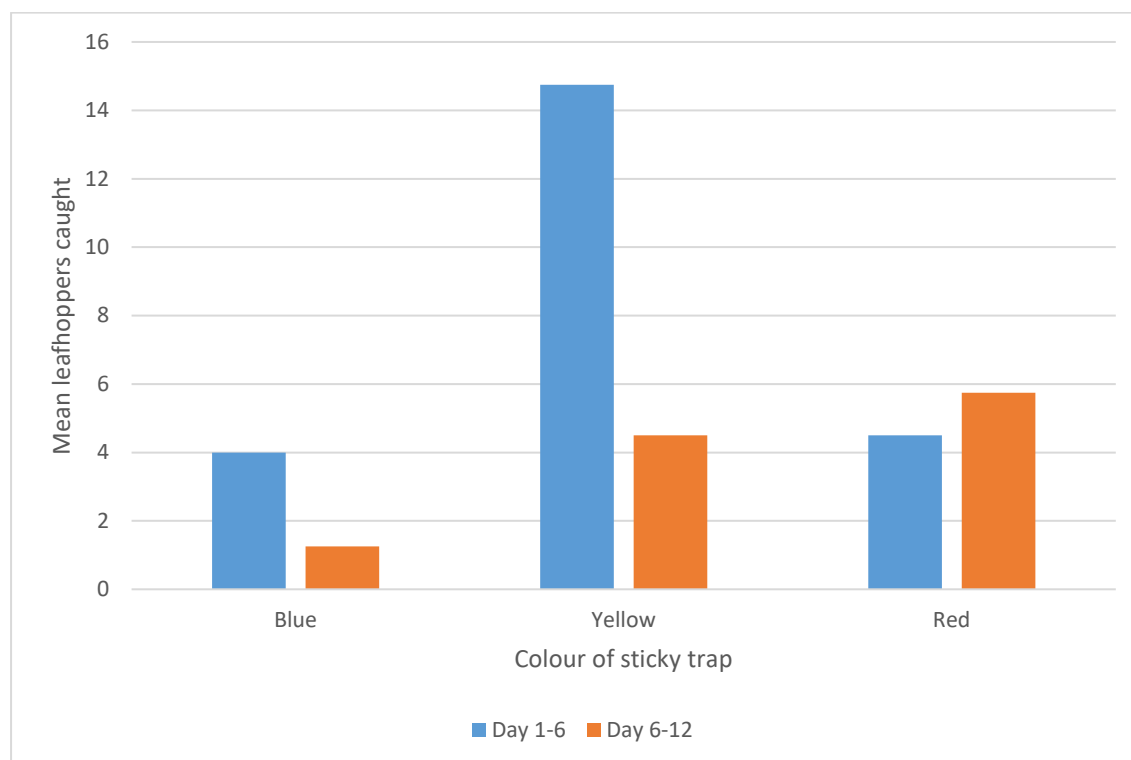
Abbott's formula was used to calculate percentage reduction in mean percentage leaf area damaged compared with the untreated controls and these values are presented in Table 4.

**Table 4:** Percentage reduction in leaf area damaged per plot compared with Treatment 1 (untreated control), 4, 8, 15 and 22 days after the first treatment (Abbott's formula). **Significant reduction compared with the untreated control (P<0.05).**

	Percentage Reduction compared to untreated control (Abbots Formula).			
Date	14/9/20	18/9/20	25/9/20	2/10/20
DAT	4	8	15	22
Treatment				
Untreated control				
Gazelle SG	89.05%	89.87%	91.43%	88.80%
AHDB 9966	52.99%	49.76%	49.33%	40.02%
AHDB 9921	43.00%	40.07%	48.47%	44.47%
AHDB 9920	54.46%	50.76%	61.11%	53.19%
AHDB 9967	29.29%	41.56%	37.16%	37.19%
AHDB 9919	59.82%	60.45%	55.84%	58.39%

### Pilot sticky trap experiment

Mean numbers of leafhopper adults caught on the different coloured sticky traps are presented in Figure 3 and Table 5. The data was not transformed to complete this analysis. In the first 6-day period significantly more leafhoppers were caught on the yellow traps than on the blue or red traps (P<0.05). However, lower numbers of leafhoppers were caught in the second 6-day period and there were no significant differences between the colours.



**Figure 3:** Mean numbers of leafhopper adults per sticky trap, after the first and second 6-day periods

**Table 5:** Mean numbers of leafhopper adults per sticky trap, after the first and second 6-day periods. Values sharing the same letters are not significantly different, those with different letters are significantly different.

	Mean Leafhopper Adults per trap	
	Day 1-6	Day 6-12
<b>Treatment</b>		
Blue	4 a	1.25 a
Yellow	14.75 b	4.5 a
Red	4.5 a	5.75 a
F value	8.76	1.98
P value	<0.05	>0.05
d.f.	9	9
s.e.d.	2.90	1.184
l.s.d.	7.09	2.679

## Discussion

One application of the industry standard conventional insecticide Gazelle SG gave significant reductions ( $P < 0.001$ ) in both leafhopper numbers and percentage leaf area damage compared with the untreated control on all assessment dates, confirming it to be a suitable positive control for use in the experiment. Gazelle SG was the most effective treatment, maintaining mean numbers of leafhopper adults at less than one per plot and mean percentage leaf area damaged below 3% throughout the experiment.

The botanical bio-pesticides AHDB 9920 & AHDB 9919 (both applied three times at five day intervals) gave significant reductions ( $P < 0.001$ ) in both leafhopper numbers and damage at all assessment dates. The botanical bio-pesticide AHDB 9967 (applied three times at seven day intervals) gave a significant reduction in leafhopper numbers ( $P < 0.001$ ) at all assessment dates from eight days after the first application but not on the day four assessment. However, it significantly reduced ( $P < 0.001$ ) leafhopper damage at all assessment dates. Thus, the three botanical biopesticides tested gave similar reductions in leafhopper numbers and damage. All three biopesticides are contact in action and thus require good spray coverage to kill the target pest. The spray deposition test with water sensitive paper prior to commencing treatments indicated that very little spray reached the undersides of the sage leaves. However, it was observed during the assessments that most of the adult leafhoppers were on the upper leaf surfaces, thus as the plants were not disturbed for treatment application, most of the adults are likely to have been hit by the foliar sprays.

The conventional insecticides AHDB 9966 (applied twice at 14-day intervals) and AHDB 9921 (applied twice at seven-day intervals) did not significantly reduce leafhopper numbers on the day four and eight assessments but significantly reduced ( $P < 0.001$ ) numbers on the day 15 and 22 assessments. Thus both these conventional products gave slower kill of leafhoppers than some of the biopesticide products. However, both treatments reduced the damage significantly ( $P < 0.001$ ) on all assessment dates.

None of the treatments prevented leafhopper damage, as leaf damage had already occurred by the day the first treatments were applied, one day after adding leafhopper adults. The leafhoppers started feeding immediately after release to the plots and high numbers were

added (20 per plot) in order to achieve significant differences between the treatments and the untreated control. It is likely that the treatments would have reduced leaf damage further if applied when leafhopper numbers were lower. Thus, although many of the plants in this trial would not have met the stringent retail standards for high quality culinary herbs with almost zero tolerance for pests or damage, if treatments had been applied against lower numbers of leafhoppers they might have maintained pest and damage levels below the commercial rejection threshold.

Most of the adults released to the plots on 10 September survived in the untreated plots until the final assessment 22 days later on 2 October. No leafhopper nymphs were recorded during the assessments. There are no published detailed reports of the life cycle of the chrysanthemum or 'sage' leafhopper, *E. melissae*, however, young nymphs were first observed on the undersides of sage leaves 25-29 days after adding *E. melissae* adults in a glasshouse during May and June 2020 (Bennison, unpublished data), suggesting that egg hatch is likely to occur 3-4 weeks after oviposition. Therefore in this efficacy trial, where the final assessment was done 22 days after adding leafhopper adults, there would have been insufficient time for nymphs to hatch from any eggs laid during the trial. Consequently, in short-term protected herb crops, most of the 'sage' leafhoppers are likely to be adults. However, in longer term and perennial outdoor crops, there would be time for nymphs to hatch from eggs and these tend to remain on leaf undersides and would thus be a more difficult target than adults for contact-acting plant protection products. Therefore the products tested in this efficacy trial might not be as effective against 'sage' leafhopper populations that include both adults and nymphs.

The novel products evaluated in this trial were selected as having a clear route to market and being IPM-compatible. However, if they gain approval or EAMUs for use on protected herbs, their safety and persistence with regard to specific biological control agents used within IPM programmes should be checked before commercial use. All treatments mixed and sprayed well. There were no phytotoxic effects.

It is difficult to draw a firm conclusion on the most effective trap colour for 'sage' leafhopper adults from the results of the pilot experiment completed in this project. Some growers of protected herbs have reported that red traps are more effective than yellow, but the results in this pilot test showed that, in one 6-day period, yellow traps caught significantly more than red or blue traps but in the second 6-day period when fewer leafhoppers were caught, there were no significant differences between the colours. Further work is needed to confirm the most effective trap colour for 'sage' leafhoppers.

## Conclusions

- Gazelle SG, used as the industry standard, was the most effective treatment in reducing numbers of leafhoppers on days 15 and 22 and the most effective in reducing damage on all dates.
- All treatments gave significant reductions in adult leafhopper numbers compared with the untreated control, although the two conventional insecticides were slower acting than most of the biopesticides.
- All treatments significantly reduced damage to the sage plants on all assessment dates.
- More work is needed to determine the most effective trap colour for 'sage' leafhoppers.
- No treatments caused phytotoxic effects

## Acknowledgements

With thanks to the AHDB for funding and supporting this project and for the financial and in kind contributions from the crop protection manufactures and distributors involved with the SCEPTREplus programme as listed below. In addition, thanks to Russell IPM for providing the traps for the pilot sticky trap experiment.

Agrii, Alpha Biocontrol Ltd, Andermatt, Arysta Lifescience, BASF, Bayer, Belchim, Bionema Limited, Certis Europe, Dow, DuPont, Eden Research, Fargro Limited, FMC, Gowan, Interfarm,

Lallemand Plant Care, Novozymes, Oro Agri, Russell IPM, Sumitomo Chemicals, Syngenta, UPL.

## Appendix

### a. Trial diary

Date	Note
07/08/2020	6 seeds sown in 9cm square pots filled with Levington M2 compost. Pots placed in main glasshouse under insect netting
14/08/2020	Sage germinating well, covered by netting.
11/08/2020	Sage pots moved into tents and cages as netting was touching the plants causing them to bend.
26/08/2020	Sage checked and is looking healthy, appropriate time to thin.
10/9/20	Each cage of four plants infested with 20 adult leafhoppers.
11/09/2020	First spray applied with no issues. T5 applied in the morning with rain water. Noticed that there was already leafhopper damage to many of the sage plants. Logger placed in plot 404 and another logger in a logger house in the poly tunnel.
15/09/2020	Assessment (4 DAT) completed.
16/09/2020	Day 6 spray applied with no issues
18/09/2020	Assessment completed (8 DAT). Spray completed with no issues. No phytotoxicity seen but some leaves are turning purple but as this was also seen in untreated did not note as phytotoxicity.
21/09/2020	Day 11 spray completed with no issues
25/09/2020	Day 15 spray of T3 & T6 applied with no problems, very windy day so put the sides of the polytunnel down to avoid drift and still used board. Assessment (15 DAT) completed.
02/10/2020	Final harvest (22 DAT) assessment of the plots,

### b. Trial Photographs



**Figure 4:** Microscope view of leafhopper damage to untreated sage leaf with black dot (red arrow) from felt tip pen (22 days post first application). Leaf with 25% area damaged and with small black leafhopper faecal specks.



**Figure 5:** Examples of leafhopper damage in the untreated control (left) and the industry standard Gazelle SG (right) on final assessment (22 days post first application).



**Figure 6:** Leafhopper trial at rear of polytunnel outlined in red (SP 56 aphid trial in the foreground)



**Figure 7:** Pete Seymour marking leaves with felt tip before adding leafhoppers.





**Figure 8:** Jude Bennison assessing live leafhoppers and damage. Cage lid only opened slightly to minimize leafhopper escape.



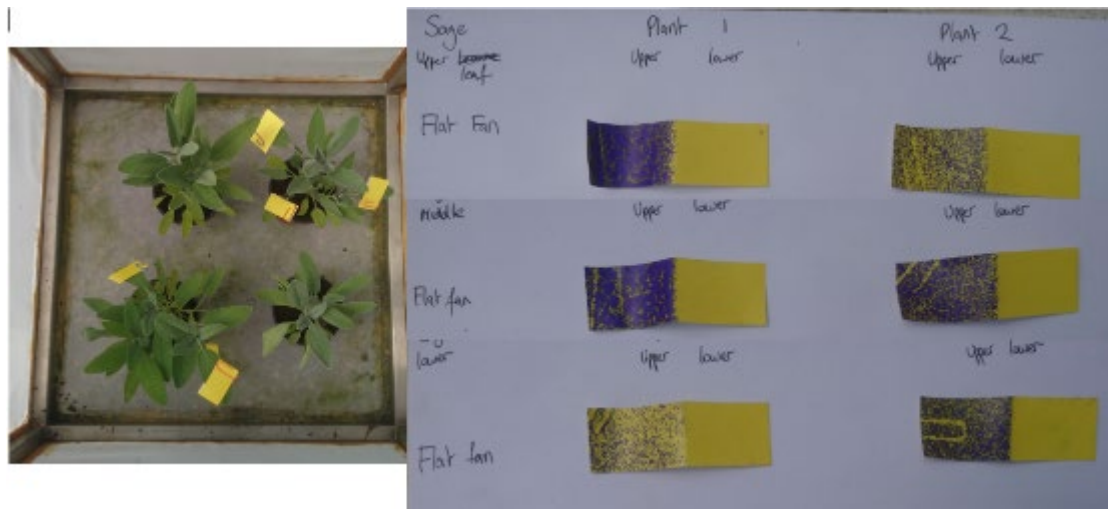
**Figure 9:** Pilot sticky trap experiment in mesh tent cage.



**Figure 10:** Sticky traps mounted on canes close to sage plants.

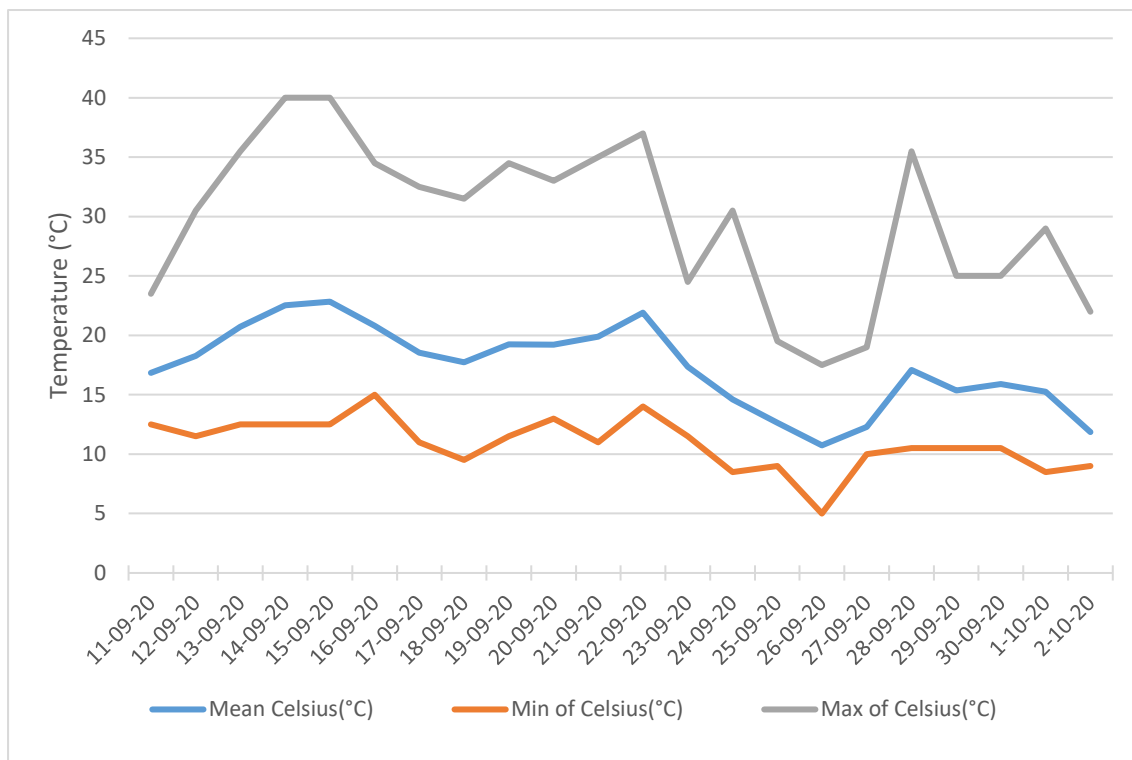


**Figure 11:** Close-up of *E. melissae* stuck on a yellow sticky trap.



**Figure 12:** Plants used for spray deposition test (left) and spray deposition on water sensitive papers from the three leaf heights (right). The left hand side of each paper is the upper side of the leaf, the right hand side is the underside.

*c. Climatological data during study period.*



**Figure 13:** Mean temperature (°C) with maximum and minimum per day in the trial area.



301	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
302	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
303	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
304	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
305	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
306	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
307	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
401	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
402	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
403	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
404	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
405	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
406	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
407	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
501	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
502	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
503	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
504	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
505	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
506	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
507	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
601	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
602	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
603	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
604	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
605	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
606	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
607	0	0	N/a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

4	101	6	0	0	12.50	0.25	6.50	5.00	2.75	1.00	4.67
	102	0	0	0	1.25	8.75	0.00	3.75	1.25	2.50	2.92
	103	3	0	0	2.75	6.25	4.00	5.00	1.50	2.50	3.67
	104	3	0	0	10.25	0.75	1.25	1.25	0.50	2.50	2.75
	105	3	0	0	0.50	7.50	3.25	1.50	7.75	5.50	4.33
	106	5	0	0	30.00	12.75	24.00	1.25	32.50	7.50	18.00
	107	4	0	0	16.25	0.50	16.25	19.25	8.75	3.75	10.79
	201	4	0	0	14.00	17.50	11.25	12.50	22.50	35.00	18.79
	202	1	0	0	11.25	12.50	7.50	0.00	0.50	8.75	6.75
	203	2	0	0	17.50	11.50	4.00	11.25	25.00	20.25	14.92
	204	6	0	0	18.75	2.75	31.25	10.00	22.50	2.75	14.67
	205	2	0	0	21.25	8.75	4.00	1.50	9.25	1.25	7.67
	206	6	0	0	8.75	2.75	7.75	8.75	10.25	6.25	7.42
	207	0	0	0	2.75	2.75	4.25	0.25	2.50	0.50	2.17
	301	0	0	0	13.75	2.50	7.75	7.75	1.50	8.25	6.92
	302	4	0	0	4.00	5.25	10.00	15.00	11.25	10.00	9.25
	303	0	0	0	1.25	0.00	2.50	0.00	1.25	1.50	1.08
	304	8	0	0	10.00	5.00	17.50	3.75	10.00	3.25	8.25
	305	8	0	0	26.25	13.75	22.50	12.50	18.75	3.00	16.13
	306	9	0	0	10.00	10.50	15.00	4.25	12.50	36.25	14.75
	307	5	0	0	10.00	3.75	27.50	6.25	9.50	10.00	11.17
	401	4	0	0	12.50	15.25	11.25	15.00	11.25	6.50	11.96
	402	2	0	0	10.00	6.50	8.75	8.75	9.00	4.00	7.83
	403	6	0	0	26.50	0.50	27.75	15.25	5.25	2.75	13.00
	404	0	0	0	2.00	0.50	1.75	0.00	0.50	1.00	0.96

405	7	0	0	5.00	4.25	4.00	12.50	7.50	18.75	8.67
406	5	0	0	28.75	8.00	18.75	5.25	20.00	2.50	13.88
407	1	0	0	21.25	7.75	3.00	1.00	15.50	8.00	9.42
501	4	0	0	4.25	11.25	8.75	1.25	6.50	8.75	6.79
502	1	0	0	4.00	8.75	10.00	4.00	17.50	1.50	7.63
503	5	0	0	45.00	15.00	13.75	38.75	31.25	7.50	25.21
504	2	0	0	38.75	12.50	11.50	1.50	4.00	8.00	12.71
505	0	0	0	1.25	0.25	4.00	0.50	5.00	0.00	1.83
506	4	0	0	15.00	5.00	12.50	6.75	5.00	2.50	7.79
507	2	0	0	10.00	3.00	18.75	13.75	5.00	6.50	9.50
601	6	0	0	8.75	3.75	6.25	21.25	3.00	13.75	9.46
602	9	0	0	31.25	3.00	28.75	3.75	31.25	12.75	18.46
603	3	0	0	4.00	14.25	3.75	16.50	4.00	11.25	8.96
604	3	0	0	2.50	0.25	1.50	3.75	3.00	5.00	2.67
605	7	0	0	18.75	13.75	10.00	2.50	21.50	9.00	12.58
606	8	0	0	5.25	10.00	7.50	13.75	3.00	5.25	7.46
607	3	0	0	4.50	2.50	26.25	17.75	8.75	6.50	11.04

8	101	5	0	0	15.00	14.00	2.75	1.50	6.75	10.00	8.33
	102	1	0	0	0.75	0.00	0.50	1.25	2.50	6.25	1.88
	103	1	0	0	5.75	5.25	6.50	10.75	7.50	11.25	7.83
	104	1	0	0	0.38	5.00	6.00	13.00	4.00	6.25	5.77
	105	2	0	0	2.25	6.00	7.75	2.50	4.00	10.00	5.42
	106	3	0	0	54.00	22.50	26.75	17.50	18.75	5.00	24.08
	107	3	0	0	6.75	1.50	18.75	17.50	21.25	4.00	11.63
	201	3	0	0	30.00	9.25	13.25	12.75	29.25	4.25	16.46
	202	1	0	0	7.50	2.50	2.50	22.50	12.50	6.25	8.96
	203	3	0	0	4.25	23.75	26.25	17.75	23.00	9.25	17.38
	204	5	0	0	46.25	8.00	26.25	10.00	35.00	13.50	23.17
	205	1	0	0	18.00	3.75	15.00	5.25	17.75	5.00	10.79
	206	2	0	0	8.75	11.25	20.00	11.25	18.75	5.50	12.58
	207	0	0	0	1.75	1.25	6.75	3.00	2.50	2.25	2.92
	301	1	0	0	8.75	5.75	13.75	20.00	7.50	17.50	12.21
	302	2	0	0	6.25	25.00	10.00	20.00	13.75	26.25	16.88
	303	1	0	0	3.50	0.00	4.25	0.00	1.25	0.75	1.63
	304	2	0	0	20.00	5.75	23.75	18.75	15.00	8.75	15.33
	305	4	0	0	27.50	8.75	31.25	32.50	28.75	5.00	22.29
	306	5	0	0	21.25	13.00	35.00	14.00	18.75	17.75	19.96
	307	4	0	0	15.00	1.25	12.50	6.75	13.75	3.75	8.83
	401	5	0	0	12.50	21.25	28.75	16.25	21.25	15.00	19.17
	402	5	0	0	8.75	2.00	8.75	5.75	13.00	14.00	8.71
	403	2	0	0	25.25	10.00	28.25	7.50	22.50	6.50	16.67
	404	0	0	0	3.00	0.00	4.00	0.00	1.50	0.00	1.42
	405	4	0	0	7.50	16.25	16.25	20.00	12.50	11.25	13.96
	406	6	0	0	40.00	13.75	26.25	11.25	32.50	17.50	23.54
	407	2	0	0	15.00	10.00	15.00	10.00	13.75	10.00	12.29
	501	3	0	0	8.00	11.25	13.75	8.75	15.00	13.75	11.75
	502	2	0	0	6.25	6.25	19.25	8.75	13.75	10.00	10.71
	503	3	0	0	48.75	12.50	25.00	21.00	45.00	22.50	29.13
	504	3	0	0	27.50	0.00	32.50	7.50	28.75	13.75	18.33
	505	1	0	0	4.25	0.00	3.75	0.00	7.50	1.25	2.79
	506	3	0	0	17.50	5.00	13.75	2.50	8.75	6.25	8.96
	507	0	0	0	11.75	12.50	23.75	8.75	8.00	12.50	12.88
	601	4	0	0	13.50	35.00	30.00	21.25	21.25	23.75	24.13

	602	6	0	0	45.00	10.00	58.75	12.50	27.50	8.75	27.08
	603	3	0	0	8.00	11.25	10.25	21.25	3.50	8.75	10.50
	604	1	0	0	3.75	6.75	8.00	2.00	4.00	2.50	4.50
	605	3	0	0	13.75	7.50	38.75	2.50	14.00	10.00	14.42
	606	6	0	0	8.75	12.50	6.25	11.25	12.50	10.00	10.21
	607	2	0	0	5.00	6.25	16.25	18.75	20.50	12.50	13.21
15	101	3	0	0	37.50	0.75	31.75	9.25	21.25	7.50	18.00
	102	0	0	0	1.25	2.50	0.00	0.25	0.00	3.50	1.25
	103	2	0	0	4.25	5.00	6.25	12.50	7.50	8.75	7.38
	104	4	0	0	21.25	3.75	25.00	8.75	10.00	1.50	11.71
	105	4	0	0	7.50	3.75	4.00	14.25	10.25	4.50	7.38
	106	7	0	0	35.00	1.75	36.75	3.75	52.50	2.50	22.04
	107	2	0	0	17.00	15.00	16.25	1.50	27.50	1.25	13.08
	201	2	0	0	16.25	8.00	11.25	35.25	28.75	13.75	18.88
	202	3	0	0	2.75	0.00	12.50	21.25	8.75	6.00	8.54
	203	3	0	0	13.75	20.00	12.00	40.00	20.50	5.50	18.63
	204	6	0	0	33.75	7.50	31.25	7.50	45.00	12.50	22.92
	205	3	0	0	13.25	1.25	30.00	0.50	1.75	2.50	8.21
	206	2	0	0	18.75	5.00	11.75	7.25	10.00	1.25	9.00
	207	0	0	0	3.25	0.50	3.75	1.25	0.00	0.00	1.46
	301	3	0	0	7.25	7.00	4.50	4.50	4.75	5.75	5.63
	302	2	0	0	5.75	6.25	4.25	15.00	13.25	17.00	10.25
	303	0	0	0	4.50	0.50	2.25	0.00	0.00	0.00	1.21
	304	3	0	0	13.75	5.50	13.25	2.25	9.25	5.50	8.25
	305	5	0	0	40.75	6.50	27.00	20.50	6.25	3.75	17.46
	306	4	0	0	18.25	5.00	17.50	5.50	27.50	5.50	13.21
	307	2	0	0	23.75	3.25	7.50	1.00	12.50	2.25	8.38
	401	4	0	0	10.50	6.50	15.50	5.50	6.25	13.75	9.67
	402	3	0	0	10.75	7.75	5.50	8.25	8.50	6.00	7.79
	403	4	0	0	26.75	8.75	23.25	7.00	17.25	2.50	14.25
	404	0	0	0	2.75	0.00	1.25	0.00	1.25	0.00	0.88
	405	1	0	0	18.75	2.50	6.25	12.75	3.50	12.00	9.29
	406	4	0	0	45.00	8.75	27.50	11.50	22.50	7.50	20.46
	407	3	0	0	13.75	2.75	5.50	6.50	10.75	2.50	6.96
	501	5	0	0	14.50	4.25	9.75	2.50	3.75	1.75	6.08
	502	2	0	0	2.50	2.50	7.00	5.00	12.50	6.00	5.92
	503	4	0	0	25.00	25.00	11.25	20.00	30.00	2.50	18.96
	504	2	0	0	26.25	2.50	26.25	3.75	14.25	3.75	12.79
	505	0	0	0	1.75	0.25	3.00	0.50	6.50	0.00	2.00
	506	4	0	0	16.25	2.25	12.50	3.00	6.00	1.25	6.88
	507	2	0	0	5.50	2.25	24.50	9.50	14.50	8.75	10.83
	601	1	0	0	9.00	10.25	37.00	5.00	11.25	8.75	13.54
	602	8	0	0	45.00	6.25	33.75	2.00	38.75	15.00	23.46
	603	2	0	0	12.00	20.50	5.00	12.50	6.25	8.75	10.83
	604	1	0	0	7.75	0.50	3.75	1.25	0.50	10.00	3.96
	605	4	0	0	15.75	5.00	22.00	3.00	19.50	4.25	11.58
	606	2	0	0	11.00	9.25	6.00	6.50	16.50	2.75	8.67
	607	3	0	0	9.25	7.00	11.25	8.00	7.00	13.00	9.25
22	101	3	0	0	40.00	2.50	30.00	4.00	19.75	3.75	16.67
	102	0	0	0	2.00	10.00	2.00	1.75	0.00	4.00	3.29
	103	2	0	0	5.75	13.25	11.75	16.75	8.25	19.25	12.50
	104	2	0	0	26.75	4.00	22.25	2.75	6.25	4.00	11.00

105	2	0	0	7.00	2.50	7.50	12.75	15.50	7.75	8.83
106	5	0	0	43.25	6.00	40.75	1.75	56.25	13.75	26.96
107	3	0	0	8.25	1.50	22.75	25.75	20.00	4.50	13.79
201	0	0	0	12.00	8.75	21.50	29.75	31.00	14.00	19.50
202	2	0	0	2.00	12.25	4.75	2.25	9.00	27.00	9.54
203	0	0	0	23.25	13.50	35.25	1.75	36.25	25.75	22.63
204	6	0	0	27.75	13.25	38.75	24.25	45.00	13.25	27.04
205	2	0	0	12.25	2.25	10.50	5.75	30.00	2.00	10.46
206	3	0	0	24.00	14.50	17.25	12.75	9.75	11.75	15.00
207	0	0	0	2.00	3.00	2.00	0.00	1.25	0.00	1.38
301	1	0	0	10.75	3.00	9.50	17.00	12.00	7.00	9.88
302	1	0	0	6.00	20.50	7.00	14.00	9.00	19.00	12.58
303	0	0	0	0.00	0.00	3.50	0.00	3.00	0.00	1.08
304	1	0	0	13.50	3.75	24.25	11.25	16.25	6.25	12.54
305	4	0	0	43.75	6.25	38.75	4.75	13.75	10.00	19.54
306	2	0	0	37.50	7.50	32.50	14.75	38.75	14.25	24.21
307	2	0	0	7.75	4.25	20.25	5.00	19.75	5.75	10.46
401	2	0	0	12.75	13.25	28.25	6.75	5.50	11.75	13.04
402	0	0	0	8.25	1.75	7.00	18.75	9.75	5.50	8.50
403	2	0	0	24.25	12.50	29.25	2.25	21.00	11.00	16.71
404	0	0	0	3.00	0.00	3.50	0.00	1.50	1.00	1.50
405	0	0	0	20.00	18.75	20.00	15.00	6.75	20.00	16.75
406	4	0	0	46.25	10.25	51.75	10.00	35.00	6.75	26.67
407	1	0	0	11.00	5.00	17.75	11.00	16.25	13.25	12.38
501	3	0	0	24.00	13.50	25.75	12.25	12.00	5.75	15.54
502	1	0	0	9.75	19.75	20.75	12.50	12.25	3.25	13.04
503	3	0	0	45.00	10.00	47.00	13.75	30.00	22.50	28.04
504	1	0	0	34.00	5.00	21.25	1.25	26.75	6.25	15.75
505	1	0	0	6.25	0.00	9.00	0.50	4.50	0.00	3.38
506	3	0	0	27.50	5.00	20.00	3.75	16.25	3.75	12.71
507	3	0	0	15.75	11.25	31.50	7.75	13.00	11.50	15.13
601	3	0	0	12.75	10.00	43.25	21.25	29.00	13.75	21.67
602	5	0	0	53.75	17.50	53.75	8.75	37.50	13.75	30.83
603	2	0	0	14.25	13.50	14.25	12.75	3.75	14.50	12.17
604	0	0	0	10.00	5.00	8.25	1.25	1.25	17.50	7.21
605	1	0	0	33.75	6.50	27.00	13.75	35.00	7.50	20.58
606	0	0	0	14.50	8.75	9.50	11.25	18.75	7.75	11.75
607	2	0	0	16.25	0.00	10.50	6.00	6.00	15.00	8.96



TREATMENT	6	2	6	5	7	5
BLOCK	1	2	3	4	5	6
PLOT	107	207	307	407	507	607
TREATMENT	1	5	3	1	4	3
BLOCK	1	2	3	4	5	6
PLOT	106	206	306	406	506	606
TREATMENT	4	3	1	3	2	6
BLOCK	1	2	3	4	5	6
PLOT	105	205	305	405	505	605
TREATMENT	7	1	4	2	6	2
BLOCK	1	2	3	4	5	6
PLOT	104	204	304	404	504	604
TREATMENT	5	6	2	6	1	7
BLOCK	1	2	3	4	5	6
PLOT	103	203	303	403	503	603
TREATMENT	2	7	5	7	5	1
BLOCK	1	2	3	4	5	6
PLOT	102	202	302	402	502	602
TREATMENT	3	4	7	4	3	4
BLOCK	1	2	3	4	5	6
PLOT	101	201	301	401	501	601

Trt	Product	Timing
1	Untreated	N/A
2	Gazelle SG	Day 1
3	AHDB 9966	Day 1 & 15
4	AHDB 9921	Day 1 & 8
5	AHDB 9920	Day 1, 6 & 11
6	AHDB 9967	Day 1, 8 & 15
7	AHDB 9919	Day 1, 6 & 11



**Figure 15:** Trial layout showing treatment, block, plot position and timing.

ORETO certificate



# Certificate of

**Official Recognition of Efficacy Testing Facilities  
or Organisations in the United Kingdom**

*This certifies that*

**RSK ADAS Ltd**

complies with the minimum standards laid down in  
Regulation (EC) 1107/2009 for efficacy testing.

The above Facility/Organisation has been officially  
recognised as being competent to carry out efficacy trials/tests  
in the United Kingdom in the following categories:

**Agriculture/Horticulture  
Stored Crops  
Biologicals and Semiochemicals**

**Date of issue:** 1 June 2018  
**Effective date:** 18 March 2018  
**Expiry date:** 17 March 2023

**Signature**   
*Authorised signatory*

Certification Number

ORETO 409

  
Chemicals Regulation Division

 Department of  
Agriculture and  
Rural Development