SCEPTREPLUS

Final Trial Report

Trial code:	SP57 - W2021.014
Title:	Cabbage whitefly (*Aleyrodes proletella*) on kale
Crop	Group: Field vegetables - Brassica
Target	Cabbage whitefly - *Aleyrodes proletella* - ALEUPR
Lead researcher:	Rosemary Collier
Organisation:	University of Warwick, School of Life Sciences, Wellesbourne, Warwick CV35 9EF
Period:	May 2021 – September 2021
Report date:	31 December 2021
Report author:	Andrew Jukes and Rosemary Collier
ORETO Number: (certificate should be attached)	381

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.

31 December 2021

Rosemary Collier

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Date Authors signature

Trial Summary

Introduction

The cabbage whitefly (*Aleyrodes proletella*) has become an increasing problem for growers in recent years and particularly on kale and Brussels sprout crops. Between 2011 and 2016, AHDB invested in three research projects on cabbage whitefly (FV 399, 406, 406a) and a PhD studentship (Dr Spencer Collins) and these focused on control with insecticides, opportunities for physical and biological control, treatment timings/programmes and an improved understanding of basic biology. The projects also confirmed that Movento (spirotetramat) was the most effective insecticide treatment available and FV 406a indicated that treatments applied at the start of the second and third generations of cabbage whitefly were most effective. Since that work was undertaken some new products have become available and so this presents an opportunity to evaluate them.

Methods

Kale seed (cv Reflex) was sown into 308 Hassy trays containing M2 compost on 24 May 2021 and transplanted on 22 June. Transplanting into field plots was timed to coincide with the presence of whitefly. The trial was designed for four replicates of ten treatments. Treatments were applied at sowing ("Phytodrip") or as post-planting sprays. All insecticides were applied twice (29 July and 25 August) and were aimed at the second and third generations of the whitefly. An additional application of the bio-insecticides was made on 12 August. Numbers of whitefly eggs, larvae and adults were assessed pre-spray (28 July) and on 23 August, 2 days before the final spray. Further assessments were made on 8 September and 29 September (14 and 35 days respectively after the final spray).

Results

Levels of whitefly infestation were relatively low at the start of the trial but built up steadily over the assessment period to be quite severe on untreated plants at the end of the trial. The data was analysed by ANOVA and as the best indicator of control, results for larval infestation (as assessed by counting the number of leaves per plant with larvae) are presented in Table A. Though not statistically significant, and with low numbers on all plots, there is some evidence of a reduction in the numbers of larvae in plots treated with the Phytodrip treatment compared with the untreated control. After spraying, all of the conventional insecticide treatments (Movento, AHDB9821, AHDB9935 and AHDB9943) reduced larval infestation compared with the untreated control on all assessment dates. The standard Movento treatment was particularly effective and the level of control suggests that the timing of sprays was near optimum. AHDB9935 performed very similarly to Movento. AHDB9943 was effective but less persistent than Movento and AHDB9821 was the least effective of the conventional insecticides tested. There were few significant differences as a result of treatment with the bio-insecticides, with only plots treated with AHDB9946 and AHDB9820 having significantly lower levels of larval infestation than the untreated control at the final assessment.

Table A Mean number of leaves per plant with whitefly larvae pre-spray (28 July), after one conventional insecticide spray or two bio-insecticide sprays (23 August) and 14 days (8 September) and 35 days (29 September) after the application of two conventional insecticide sprays or three bio-insecticide sprays. Results significantly different ($p<0.05$) from the untreated control.

	Number of leaves with whitefly larvae			
Treatment	28 Jul	23 Aug	8 Sep	29 Sep
Control	0.88	2.97	8.59	14.96
Movento	0.88	0.28	0.13	0.00
AHDB9943 [1]	0.21	1.81	6.09	12.96
AHDB9821	0.67	1.66	5.69	10.29
AHDB9935	1.00	0.38	0.13	0.04
AHDB9943	0.58	0.72	1.34	3.96
AHDB9946 [2]	0.50	2.13	5.81	9.58
AHDB9928 [2]	0.38	2.16	8.47	13.50
AHDB9967 [2]	0.92	2.56	8.03	12.71
AHDB9820 [2]	0.83	2.41	8.56	10.21
F	1.596	4.379	8.927	18.281
P	0.161	0.001	<0.001	<0.001
SED	0.293	0.637	3.368	1.828
LSD	0.598	1.300	2.799	3.734
df	30	30	30	30

[1] "Phytodrip" at sowing. All other treatments were in-field sprays.
[2] Bio-insecticide.

Conclusion

The level of the control observed with the most effective treatments supports the findings of FV406a that insecticide treatments should be aimed at the start of the second and third generations of the whitefly. AHDB9935 was as effective as the standard Movento treatment. AHDB9943 performed well but was less persistent. AHDB9921 and all of the bio-insecticides, as tested, appeared not to provide adequate control.

Take home message:

AHDB9935 and AHDB9943 could provide an alternative to Movento for whitefly control. The bio-insecticides tested do not provide adequate control with the frequency of application employed. This may be improved by more regular application, but whitefly is best controlled by systemic compounds, as with spirotetramat in Movento.

Objectives

1. To evaluate the effectiveness of conventional and bio-insecticides applied against cabbage whitefly on kale as measured by the level of infestation.
2. To monitor the treated crop for phytotoxicity

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**
PP 1/152(3)	Design and analysis of efficacy evaluation trials	None
PP 1/135(3)	Phytotoxicity assessment	None
PP 1/181(3)	Conduct and reporting of efficacy evaluation trials including GEP	None

There were no deviations from EPPO guidance:

Test site

Item	**Details**
Location address	University of Warwick Wellesbourne Campus Wellesbourne Warwick CV35 9EF
Crop	Kale
Cultivar	Reflex
Soil or substrate type	Sandy loam
Agronomic practice	See Appendix A
Prior history of site	See Appendix A

Trial design

Item	**Details**
Trial design:	(4x5)/2 Trojan Square
Number of replicates:	4
Row spacing:	50 cm
Plot size: (w x l)	1.83 x 5 m
Plot size: (m^2)	9.2
Number of plants per plot:	22
Leaf Wall Area calculations	n/a

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	Control			
2	Movento	75g	0.5l	B D
3	AHDB9943 [1]	1g/1000 seeds	2g/1000 seeds	A
4	AHDB9821	120g	1l	B D
5	AHDB9935	30g	0.3l	B D
6	AHDB9943	80g	0.16kg	B D
7	AHDB9946 [2]	93g	1l	B C D
8	AHDB9928 [2]	132g	0.6kg	B C D
9	AHDB9967 [2]	192g	3.2l	B C D
10	AHDB9820 [2]	4080g	8l	B C D

[1] "Phytodrip" at sowing. All other treatments were in-field sprays.
[2] Bioinsecticide.

Application details

	Application A	Application B	Application C	Application D
Application date	24/5/21	29/7/21	12/8/21	25/8/21
Time of day	14.00	19.30	18.00	17.00
Crop growth stage (Max, min average BBCH)	Seed	31-32	34-35	36-38
Crop height (cm)	N/A	20	50	75
Crop coverage (%)	N/A	50	75	100
Application Method	"Phytodrip"	Spray	Spray	Spray
Application Placement	Seed	Foliar	Foliar	Foliar
Application equipment	Pipette	Berthoud Vermorel 2000HP		
Nozzle pressure	N/A	2 bar		
Nozzle type	N/A	HC02		
Nozzle size	N/A	02		
Application water volume/ha	0.2 ml/block	300l conv 400l bio	300l conv 800l bio	300l conv 800l bio
Temperature of air - shade (°C)	N/A			
Relative humidity (%)	N/A			
Wind speed range (m/s)	N/A	Light	Light	Light
Dew presence (Y/N)	N/A	N	N	N
Temperature of soil - 2-5 cm (°C)	N/A	Not recorded	Not recorded	Not recorded
Wetness of soil - 2-5 cm	N/A	Dry	Dry	Dry
Cloud cover (%)	N/A	Not recorded	Not recorded	Not recorded

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

Common name	Scientific Name	EPPO Code	Infestation level pre-application [1]	Infestation level at start of assessment period [2]	Infestation level at end of assessment period [2]
Cabbage whitefly	*Aleyrodes proletella*	ALEUPR	0.7	3	15
Peach potato aphid	*Myzus persicae*	MYZUPE	Non target		
Cabbage aphid	*Brevicoryne brassicae*	BRVCBR	Non target		
Caterpillar	*Not identified to species*		Non target		

Infestation levels quoted as leaves per plant with larvae.
[1] Whole trial.
[2] Untreated plots only.

Method

Kale seed (cv Reflex) was sown into 308 Hassy trays containing M2 compost on 24 May 2021 and plants were raised in a glasshouse. The trial consisted of 10 treatments and each replicate consisted of 22 plants. Plants were transplanted into an area in Long Meadow Centre on 22 June at a spacing of 50 cm within rows and 50 cm between rows to give 2 x 5m rows in each plot. Transplanting into field plots was timed to coincide with the expected appearance of the second generation of whiteflies.

Treatments were applied at sowing ("Phytodrip") or as post-planting sprays. The "Phytodrip" treatments were applied directly to the seed after sowing in a small volume of water (0.2 ml). All insecticide spray treatments were applied to target the second and third generations of whitefly on 29 July and 25 August respectively. A further application of the bio-insecticides was made in between these two treatments on 12 August.

Assessment details

Germination and phytotoxicity were assessed on the sowing-time treatment on 7 June (14 days after sowing) and phytotoxicity on the transplants was assessed 7 days after the first sprays were applied.

The number of whitefly egg circles, the number of leaves with larvae (scales) and an adult whitefly score (Table 1) were assessed on 8 plants per plot (4 plants per row). Assessments were done pre-spray (28 July), 2 days before the final spray (23 August), 14 days after the final spray and 35 days after the final spray.

At the time of the two final assessments, plants were also assessed for the presence of aphids (*Myzus persicae* and *Brevicoryne brassicae*) and caterpillars (not identified to species).

Table 1 Adult whitefly scoring scheme.

Score	Number of whiteflies
0	0
1	1 - 10
2	11 - 100
3	101 - 500
4	>500

	Evaluation Timing (DA)*				
Evaluation date	**After sowing**	**After sprays**	**Crop Growth Stage (BBCH)**	**Evaluation type (efficacy, phytotox)**	**Assessment**
7/6/21	14	n/a	12	Phytotoxicity	Germination and leaf damage
28/7/21	55	Pre spray	32	Efficacy	Whitefly numbers
5/8/21	62	7 (First spray)	33	Phytotoxicity	Leaf damage
23/8/21	81	25 (First spray)	35	Efficacy	Whitefly numbers
8/9/21	97	14 (Third spray)	38	Efficacy	Whitefly numbers
29/9/21	118	35 (Third spray)	39	Efficacy	Whitefly numbers

* DA – days after application.

Statistical analysis

This trial was designed as a Trojan square for 10 treatments in a (4*5)/2 design. The data were analysed by ANOVA using the Excel data package. In all cases plot means were used. Data on aphid counts was angle-transformed prior to analysis.

Results

Phytotoxicity

The number of seedlings which had germinated 14 days after sowing is shown in Table 2. No analysis was possible but it is clear that there is little difference between treated and untreated plants

Table 2 The number of healthy, unhealthy and missing plants 14 days after sowing and treatment with a "Phytodrip" treatment.

	Number of seedlings (1st sowing)		
Treatment	Healthy	Unhealthy	Missing
Control 1	298	2	5
Control 2	299	4	10
AHDB9943	296	5	6

Post-spraying in the field there was no evidence of phytotoxic effects with any treatment.

Whitefly

The results for the number of whitefly egg circles per plant, the number of leaves with larvae per plant and the adult whitefly score are presented in Tables 3 – 6 and Figures 1 - 3.

Pre-spray there were no statistically significant differences between treatments with any of the measurements. There is some evidence that the Phytodrip treatment reduced larval infestation compared with the untreated control but the numbers were very low across the trial.

On 23 August (25 days after the first spray and 13 days after the second bio-insecticide spray) all of the analyses were statistically significant ($p<0.05$). The standard Movento treatment, AHDB9935 and AHDB9943 significantly reduced all measurements compared with the untreated control. AHDB9821 significantly reduced the number of leaves with larvae and AHDB9946 significantly reduced the numbers of egg circles and adult whitefly.

On 8 September (14 days after the second conventional insecticide or third bio-insecticide spray) all of the analyses were statistically significant ($p<0.05$). The standard Movento treatment, AHDB9935 and AHDB9943 significantly reduced all measurements compared with the untreated control. AHDB9821 significantly reduced the number of egg circles and leaves with larvae and AHDB9946 significantly reduced the number of egg circles.

On 29 September (35 days after the second conventional insecticide or third bio-insecticide spray) all of the analyses were statistically significant ($p<0.05$). The standard Movento treatment, AHDB9935, AHDB9943 and AHDB9946 significantly reduced all measurements compared with the untreated control. AHDB9821 significantly reduced the numbers of egg circles and leaves with larvae and AHDB9920 significantly reduced the number of leaves with larvae.

Table 3 Mean numbers per plant of cabbage whitefly egg circles, leaves with larvae and adult whitefly score pre-spray (28 July). Results significantly different ($p<0.05$) from the untreated control

	Cabbage whitefly		
Treatment	Egg circles	Leaves with larvae	Adult score
Control	4.21	0.88	0.75
Movento	4.25	0.88	0.54
AHDB9943 [1]	5.79	0.21	0.83
AHDB9821	3.42	0.67	0.46
AHDB9935	4.21	1.00	0.50
AHDB9943	3.92	0.58	0.58
AHDB9946 [2]	4.79	0.50	0.75
AHDB9928 [2]	4.58	0.38	0.75
AHDB9967 [2]	4.00	0.92	0.58
AHDB9820 [2]	4.79	0.83	0.88
F	0.428	1.596	2.137
P	0.909	0.161	0.058
SED	1.392	0.293	0.142
LSD	2.842	0.598	0.289
df	30	30	30

[1] "Phytodrip" at sowing. All other treatments were in-field sprays.
[2] Bioinsecticide.

Table 4 Mean numbers per plant of cabbage whitefly egg circles, leaves with larvae and adult whitefly score after one conventional insecticide spray or two bio-insecticide sprays (23 August). Results significantly different ($p<0.05$) from the untreated control

	Whitefly		
Treatment	Egg circles	Leaves with larvae	Adult score
Control	78.19	2.97	2.00
Movento	7.72	0.28	0.97
AHDB9943 [1]	42.44	1.81	1.69
AHDB9821	41.16	1.66	1.84
AHDB9935	8.91	0.38	1.06
AHDB9943	6.69	0.72	0.94
AHDB9946 [2]	34.81	2.13	1.53
AHDB9928 [2]	55.69	2.16	1.69
AHDB9967 [2]	61.63	2.56	1.88
AHDB9820 [2]	58.69	2.41	1.81
F	3.655	4.379	8.188

P	0.003	0.001	<0.001
SED	18.571	0.637	0.198
LSD	37.926	1.300	0.405
df	30	30	30

[1] "Phytodrip" at sowing. All other treatments were in-field sprays.
[2] Bio-insecticide.

Table 5 Mean numbers per plant of cabbage whitefly egg circles, leaves with larvae and adult whitefly score after two conventional insecticide sprays or three bio-insecticide sprays (8 September). Results significantly different ($p<0.05$) from the untreated control

	Cabbage whitefly		
Treatment	Egg circles	Leaves with larvae	Adult score
Control	135.72	8.59	2.00
Movento	6.16	0.13	1.03
AHDB9943 [1]	96.59	6.09	1.97
AHDB9821	34.19	5.69	1.88
AHDB9935	7.41	0.13	0.91
AHDB9943	9.41	1.34	1.03
AHDB9946 [2]	71.97	5.81	2.00
AHDB9928 [2]	74.03	8.47	2.00
AHDB9967 [2]	90.09	8.03	2.00
AHDB9820 [2]	76.38	8.56	1.97
F	2.964	8.927	111.328
P	0.012	<0.001	<0.001
SED	73.922	3.368	0.131
LSD	61.434	2.799	0.109
df	30	30	30

[1] "Phytodrip" at sowing. All other treatments were in-field sprays.
[2] Bio-insecticide.

Table 6 Mean numbers per plant of cabbage whitefly egg circles, leaves with larvae and adult whitefly score after two conventional insecticide sprays or three bio-insecticide sprays (29 September). Results significantly different ($p<0.05$) from the untreated control

	Cabbage whitefly		
Treatment	Egg circles	Leaves with larvae	Adult score
Control	116.25	14.96	2.38
Movento	4.92	0.00	0.96
AHDB9943 [1]	71.13	12.96	2.13
AHDB9821	50.54	10.29	2.04
AHDB9935	7.83	0.04	1.00
AHDB9943	10.83	3.96	1.63
AHDB9946 [2]	30.04	9.58	1.79
AHDB9928 [2]	78.38	13.50	2.21
AHDB9967 [2]	77.92	12.71	2.08
AHDB9820 [2]	77.92	10.21	2.13
F	4.535	18.281	17.432
P	<0.001	<0.001	<0.001
SED	25.120	1.828	0.1680
LSD	51.302	3.734	0.3432
df	30	30	30

[1] "Phytodrip" at sowing. All other treatments were in-field sprays.
[2] Bio-insecticide.

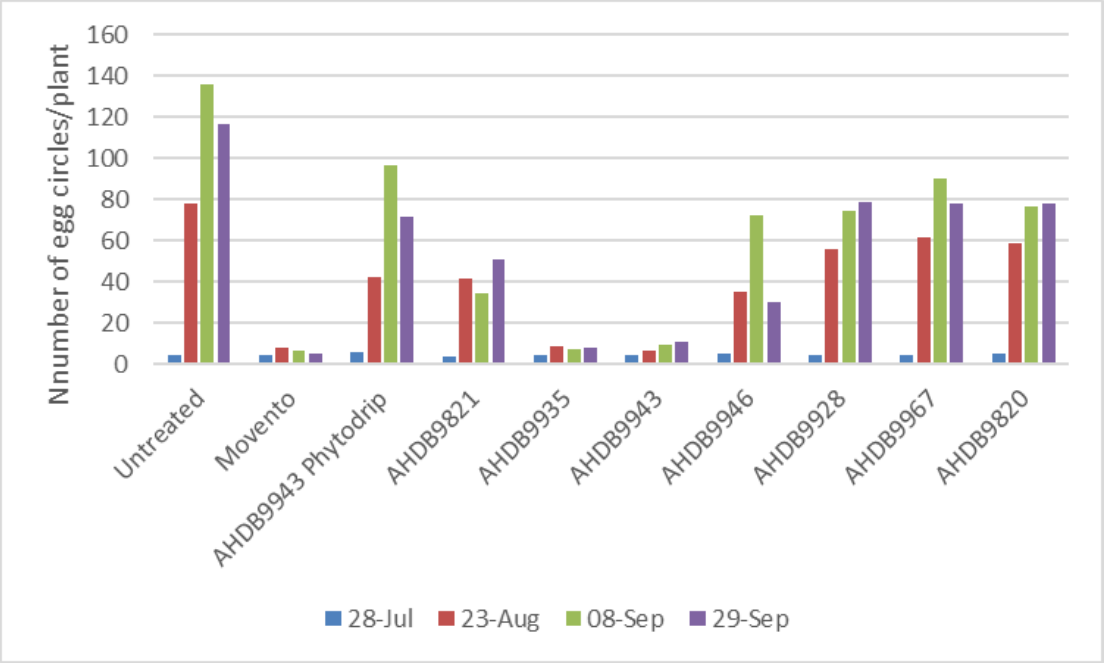

Figure 1 Mean number of cabbage whitefly egg circles per plant on four assessment dates.

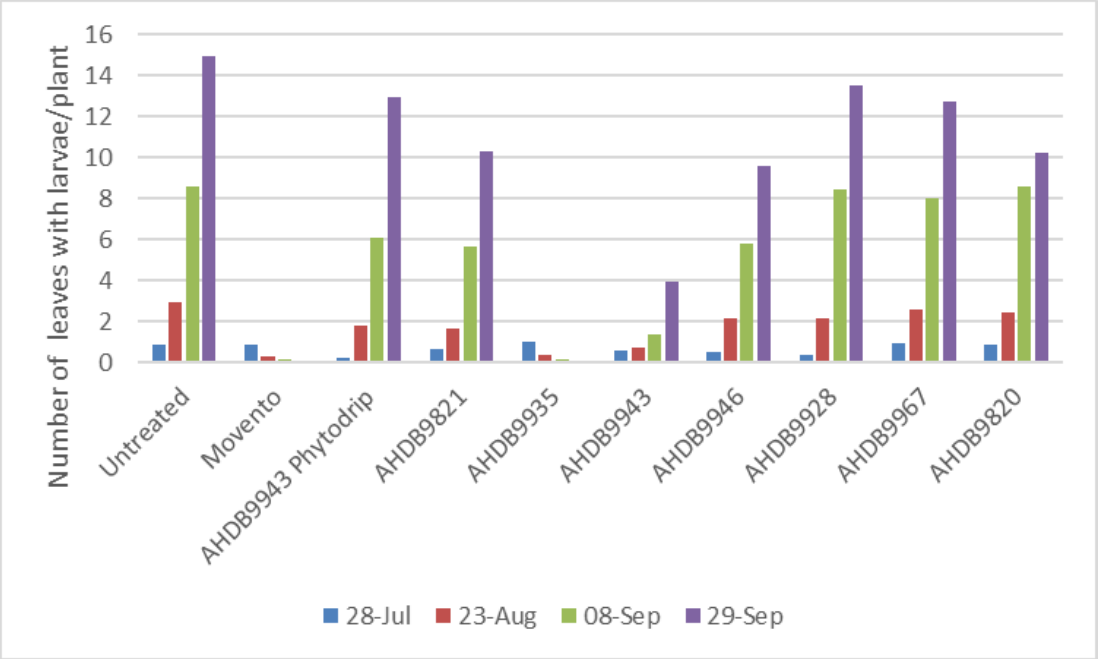

Figure 2 Mean number of leaves per plant with cabbage whitefly larvae on four assessment dates.

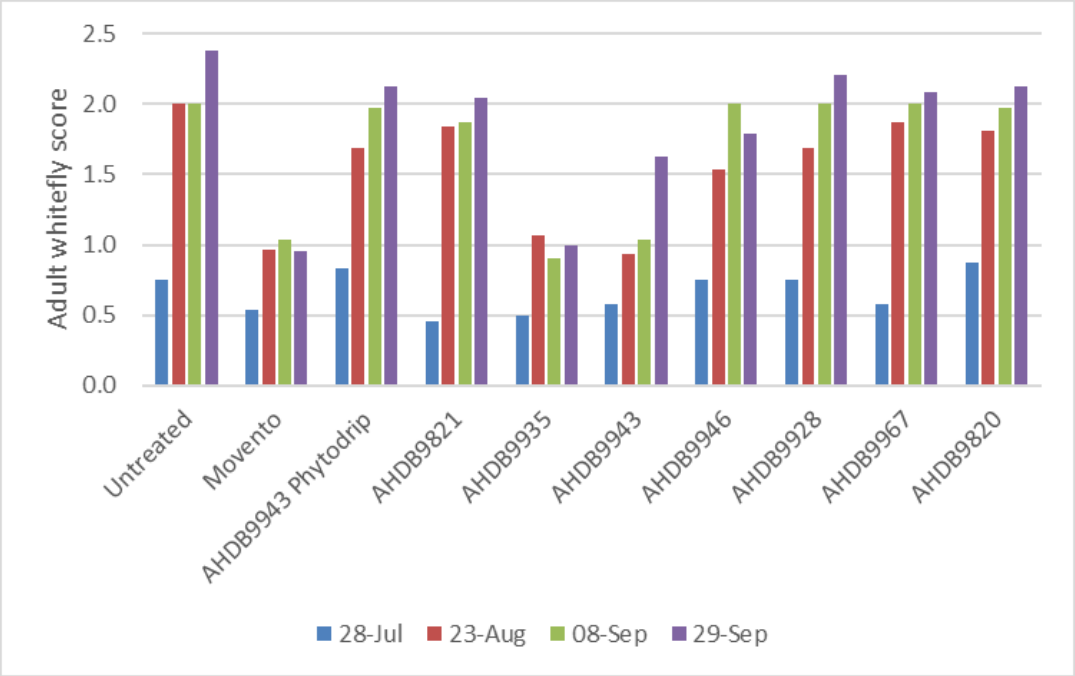

Figure 3 Mean adult cabbage whitefly score on four assessment dates.

Aphids and caterpillars

The results for the percentage plants with aphids (*Myzus persicae* or *Brevicoryne brassicae*) and caterpillars are presented in Tables 7 - 9 and Figures 4 - 5.
On 8 September both aphid analyses were statistically significant ($p<0.05$). The standard Movento treatment, AHDB9821, AHDB9935 and AHDB9943 all significantly reduced the percentage of plants with *Brevicoryne brassicae* compared with the untreated control. There were lower numbers of *Myzus persicae* and no treatment significantly reduced infestation compared with the untreated control, but the standard Movento treatment, AHDB9821, AHDB9935, the Phytodrip treatment and AHDB9943 all significantly reduced the percentage of plants infested compared with AHDB9946, AHDB9928 and AHDB9820.

On 29 September only the *Brevicoryne brassicae* analysis was statistically significant ($p<0.05$). The standard Movento treatment, AHDB9821 and AHDB9935 all significantly reduced the percentage of plants which were infested, compared with the untreated control.

Very few caterpillars were observed and analyses on both dates were not statistically significant.

Table 7 Mean percentage plants with aphids after two conventional insecticide sprays or three bio-insecticide sprays (8 September). Results significantly different ($p<0.05$) from the untreated control

	Brevicoryne brassicae		*Myzus persicae*	
Treatment	Angle-transformed	Back-transformed	Angle-transformed	Back-transformed
Control	37.5	37.1	14.6	6.4
Movento	0.0	0.0	0.0	0.0
AHDB9943 [1]	40.7	42.6	0.0	0.0
AHDB9821	0.0	0.0	5.2	0.8
AHDB9935	0.0	0.0	0.0	0.0
AHDB9943	10.4	3.2	5.2	0.8
AHDB9946 [2]	43.2	46.8	31.4	27.2
AHDB9928 [2]	39.1	39.7	30.0	25.0
AHDB9967 [2]	27.3	21.0	17.9	9.4
AHDB9820 [2]	48.8	56.5	29.6	24.4
F	12.94		5.16	
P	<0.001		<0.001	
SED	7.85		8.20	
LSD	16.04		16.74	
df	30		30	

[1] "Phytodrip" at sowing. All other treatments were in-field sprays.
[2] Bio-insecticide.

Table 8 Mean percentage plants with aphids after two conventional insecticide sprays or three bio-insecticide sprays (29 September). Results significantly different ($p<0.05$) from the untreated control

	Brevicoryne brassicae		*Myzus persicae*	
Treatment	Angle-transformed	Back-transformed	Angle-transformed	Back-transformed
Control	58.7	73.0	14.8	6.6
Movento	0.0	0.0	0.0	0.0
AHDB9943 [1]	66.3	83.9	23.3	15.6
AHDB9821	31.8	27.7	6.0	1.1
AHDB9935	6.0	1.1	0.0	0.0
AHDB9943	63.6	80.2	12.0	4.4
AHDB9946 [2]	66.3	83.9	14.8	6.6
AHDB9928 [2]	67.5	85.4	22.5	14.6
AHDB9967 [2]	84.0	98.9	26.1	19.3
AHDB9820 [2]	84.0	98.9	27.7	21.6
F	12.17		1.20	
P	<0.001		0.33	
SED	12.16		13.26	
LSD	24.83		27.08	
df	30		30	

[1] "Phytodrip" at sowing. All other treatments were in-field sprays.
[2] Bio-insecticide.

Table 9 Mean percentage plants with caterpillars on 8 and 29 September after two conventional insecticide sprays or three bio-insecticide sprays.

	08-Sep		29-Sep	
Treatment	Angle-transformed	Back-transformed	Angle-transformed	Back-transformed
Control	5.2	0.8	6.0	1.1
Movento	7.5	1.7	0.0	0.0
AHDB9943 [1]	5.2	0.8	0.0	0.0
AHDB9821	5.2	0.8	12.0	4.4
AHDB9935	23.0	15.3	0.0	0.0
AHDB9943	0.0	0.0	0.0	0.0
AHDB9946 [2]	5.2	0.8	6.0	1.1
AHDB9928 [2]	10.4	3.2	0.0	0.0
AHDB9967 [2]	0.0	0.0	0.0	0.0
AHDB9820 [2]	5.2	0.8	0.0	0.0
F	1.83		1.47	
P	0.10		0.21	
SED	6.80		4.92	
LSD	13.89		10.04	
df	30		30	

[1] "Phytodrip" at sowing. All other treatments were in-field sprays.
[2] Bio-insecticide

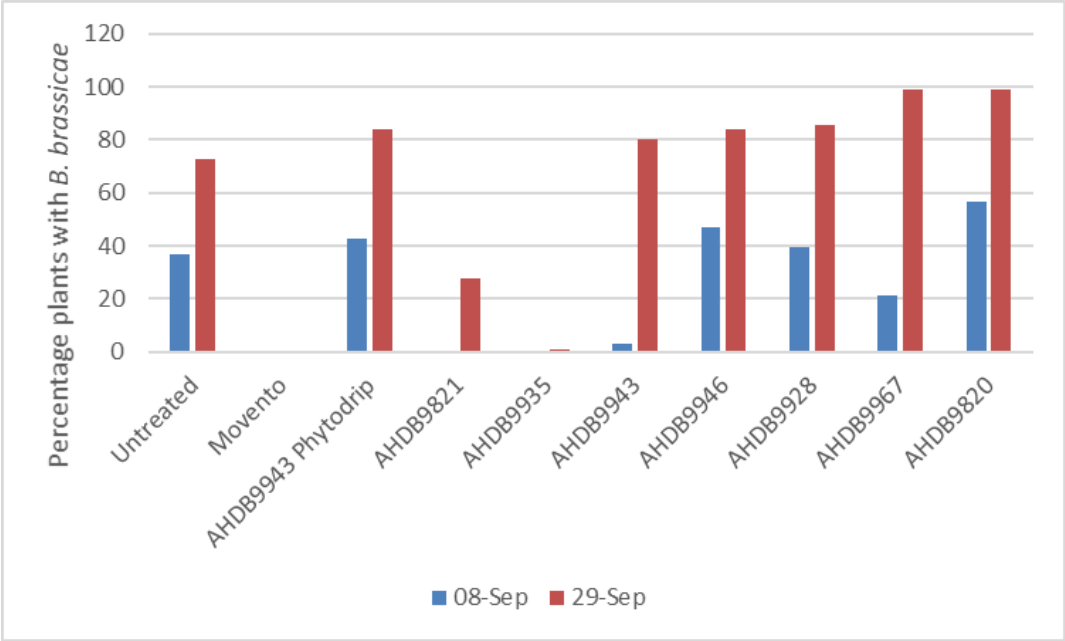

Figure 4 Mean percentage plants with *Brevicoryne brassicae* on 8 and 29 September after two conventional insecticide sprays or three bio-insecticide sprays.

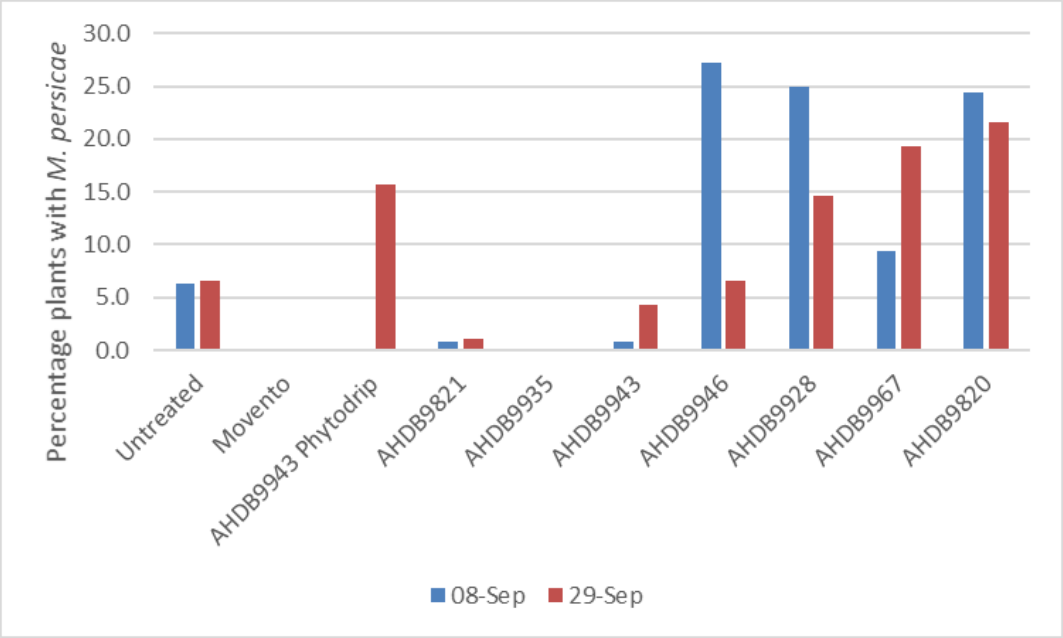

Figure 5 Mean percentage plants with *Myzus persicae* on 8 and 29 September after two conventional insecticide sprays or three bio-insecticide sprays.

Discussion

There were no statistically significant differences between treatments for the pre-spray assessment of whitefly but there is some evidence that the Phytodrip treatment (AHDB9943) reduced larval infestation compared with the untreated control. However, the numbers were very low across the trial.

Percentage reductions in numbers of whitefly egg circles and numbers of leaves with larvae, compared with the untreated control, were calculated using the formula below and are displayed in Table 10:

% reduction = (number on control – number on treated)/number on control x 100

The level of the control observed with the most effective treatments supports the findings of FV406a that insecticide treatments should be aimed at the start of the second and third generations of the whitefly. This is particularly important with products such as Movento where only two applications per crop are approved. Movento reduced the numbers of egg circles and the numbers of leaves with larvae by more than 90% on all three post application assessments, the final assessment being 35 days after the final application and the first assessment being 25 days after the first spray. AHDB9935 was as effective as the standard Movento treatment. AHDB9943 performed well but was less persistent. AHDB9921 was less effective but significantly reduced the number of leaves with larvae for all assessments and the number of egg circles for assessments on 8 and 29 September.

Of the bio-insecticides, after three sprays AHDB9946 was comparable with two sprays of the conventional insecticide AHDB9921, with a significant reduction in egg circles on all assessments, adult whitefly on 23 August and 29 September and the

number of leaves with larvae on 29 September. AHDB9920 had a single significant reduction in the number of leaves with larvae on 29 September.

Table 10 Mean percentage reduction in numbers of egg circles and leaves with larvae compared with the untreated control on three assessment dates.

Date	23 Aug	8 Sept	29 Sept	23 Aug	8 Sept	29 Sept
Treatment	Egg circles			Leaves with larvae		
Movento	90.1	95.5	95.8	90.5	98.5	100.0
AHDB9943 [1]	45.7	28.8	38.8	38.9	29.1	13.4
AHDB9821	47.4	74.8	56.5	44.2	33.8	31.2
AHDB9935	88.6	94.5	93.3	87.4	98.5	99.7
AHDB9943	91.4	93.1	90.7	75.8	84.4	73.5
AHDB9946 [2]	55.5	47.0	74.2	28.4	32.4	35.9
AHDB9928 [2]	28.8	45.5	32.6	27.4	1.5	9.7
AHDB9967 [2]	21.2	33.6	33.0	13.7	6.5	15.0
AHDB9820 [2]	24.9	43.7	33.0	18.9	0.4	31.8

[1] "Phytodrip" at sowing. All other treatments were in-field sprays.
[2] Bio-insecticide

AHDB9935 and AHDB9943 could provide an alternative to Movento for whitefly control. The bio-insecticides tested do not provide adequate control with the frequency of application employed. This may be improved by more regular application, but whitefly is best controlled by systemic compounds, as with spirotetramat in Movento.

The presence of aphids and caterpillars was recorded on the two assessments after the final sprays. Very few caterpillars were observed and there were no statistically significant differences between treatments. A large proportion of plants were infested with *Brevicoryne brassicae* and a lower proportion with *Myzus persicae.* No plants treated with Movento were infested with either aphid and AHDB9935 performed similarly. AHDB9921 (0% plants infested) and AHDB9943 (3% plants infested) both performed well 14 days after the final treatment (8 September) but effects were reduced 35 days after treatment (29 September) with 28% and 80% of plants infested with *Brevicoryne brassicae* after treatment with AHDB9921 and AHDB9943 respectively. None of the bio-insecticides provided effective aphid control.

All treatments mixed and sprayed well. There were no phytotoxic effects.

Conclusions

- Two sprays of the standard Movento treatment timed to coincide with the 2nd and 3rd generations of whitefly provided excellent control for at least 35 days after the final treatment was applied.
- Two sprays of AHDB9935 were as effective as the standard treatment.
- Two sprays of AHDB9943 were effective but not as persistent as Movento or AHDB9935.
- AHDB9943 applied at sowing as a Phytodrip may offer some early season protection but did not reduce whitefly infestation at the 2nd/3rd generation stage.
- AHDB9946 applied three times was the most effective bio-insecticide but it did not offer the same level of control as the conventional insecticides Movento, AHDB9935 or AHDB9943.
- All of the conventional insecticides (Movento, AHDB9935, AHDB9943 and AHDB9921) also provided effective aphid control, with Movento and AHDB9935 being the most persistent.
- There were insufficient numbers of caterpillars to see treatment differences.
- No treatments caused phytotoxic effects.

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Agrii, Alpha Biocontrol Ltd, Andermatt, Arysta Lifescience, BASF, Bayer, Belchim, Bionema Limited, Certis Europe, Corteva, Eden Research, Fargro Limited, FMC, Gowan, Interfarm, Lallemand Plant Care, Novozymes, Oro Agri, Russell IPM, Sumitomo Chemicals, Syngenta, UPL.

Appendix

a. Crop diary – events related to growing crop

Crop	Cultivar	Planting/sowing date	Row width (m)
Kale	Reflex	24/5/21 (sowing)	0.5
		22/6/21 (planting)	

Previous cropping

Year	Crop
2019	Fallow
2020	Fallow

Cultivations

Date	Description	Depth
19/3/21	Ploughing	25cm
16/6/21	Bed forming	15cm

Active ingredient(s) / fertiliser(s) applied to the trial area

Date	Product	Rate	Unit
29/9/20	0:20:20 NPK	333	Kg/ha
16/6/21	Nitram	100	Kg N/ha
19/7/21	Nitram	232	Kg N/ha

Pesticides applied to the trial area

Date	Product	Rate	Unit
22/6/21	Sultan Metazachlor	1.5	l/ha

Details of irrigation regime

Date	Type, rate and duration	Amount applied (mm)
23/6/21	Wright Rain, 30 mins	2.5
1/9/21	Wright Rain, 30 mins	2.5
6/9/21	Wright Rain, 30 mins	2.5
8/9/21	Wright Rain, 30 mins	2.5

Other actions

Date	Action
22/6/21	Trial area netted to exclude rabbits and birds
15/9/21	Hand weeded

b. Trial diary

	Experimental Diary
Date	Event
24-May	Seed sown
24-May	Phytodrip treatment applied
24-May	Plants raised in E8
14-Jun	Plants moved to GL5
22-Jun	Trial transplanted
28-Jul	Pre-spray whitefly assessment
29-Jul	Spray treatments applied (all)
12-Aug	Spray treatments applied (bio only)
23-Aug	Whitefly assessment
25-Aug	Spray treatments applied (all)
08-Sep	Whitefly assessment
29-Sep	Whitefly assessment

c. Climatological data during study period

	Temperature		Rainfall (mm)
Date	Max 09-09	Min 09-09	Total 09-09
01/06/2021	24.6	8.6	0
02/06/2021	26.7	9.6	0
03/06/2021	20	16.2	0
04/06/2021	19	9.2	0
05/06/2021	21.8	7.4	1.2
06/06/2021	22	13.6	0
07/06/2021	22.3	14.1	0
08/06/2021	22.6	8.3	0
09/06/2021	23.7	8.8	0
10/06/2021	23.2	14.8	0
11/06/2021	20.7	16.3	0
12/06/2021	23.1	11.5	0
13/06/2021	26.6	9.2	0
14/06/2021	24.9	13.7	0
15/06/2021	24.1	7.6	0
16/06/2021	26.4	11.8	0.8
17/06/2021	22.4	14.8	3.2
18/06/2021	15.5	12.2	16
19/06/2021	17.3	11.7	7
20/06/2021	14.2	11.6	0
21/06/2021	16.6	9	0.8
22/06/2021	17	10	0
23/06/2021	21.9	4.5	0.6
24/06/2021	20.9	13.7	2
25/06/2021	17.7	13.3	0
26/06/2021	19.9	12.4	0
27/06/2021	18.3	13.4	4.6
28/06/2021	15.5	12.5	0
29/06/2021	17.9	13.2	0
30/06/2021	18.4	9.2	0
01/07/2021	19.8	10.8	0
02/07/2021	23	10.9	1.6
03/07/2021	22.5	15	3.6
04/07/2021	21.4	14.5	8.4
05/07/2021	19.9	13.1	4.8
06/07/2021	19.1	12.1	0
07/07/2021	21.9	14	1.8
08/07/2021	23.7	13.5	0
09/07/2021	22.4	12	0
10/07/2021	20.5	12.9	0
11/07/2021	21	11.8	0.8

12/07/2021	20.5	13.9	0
13/07/2021	23.2	13.3	0
14/07/2021	24	11.2	0
15/07/2021	23.7	11.5	0
16/07/2021	28	10.1	0
17/07/2021	29.3	12.2	0
18/07/2021	30.9	13.8	0
19/07/2021	30.8	16.8	0
20/07/2021	30.9	16.1	0
21/07/2021	29.5	14.5	0
22/07/2021	30.1	14.5	0
23/07/2021	25	15.6	0
24/07/2021	21.7	15.2	0
25/07/2021	22.9	15.5	0
26/07/2021	27.3	12.7	0
27/07/2021	23.4	16.4	1.4
28/07/2021	20.5	14.6	2.8
29/07/2021	22.9	11.5	4.6
30/07/2021	17.4	13.1	26.8
31/07/2021	19.8	13.1	1.6
01/08/2021	20	12.9	0
02/08/2021	20	10.7	0
03/08/2021	20.5	11.3	0
04/08/2021	24	10.1	0
05/08/2021	20.6	11.9	3.2
06/08/2021	22.6	14.8	0
07/08/2021	20.9	11.8	0
08/08/2021	20.2	14.9	0
09/08/2021	22.5	12.1	0
10/08/2021	25.3	11.6	0
11/08/2021	23.1	11.6	0
12/08/2021	24.4	9.6	0
13/08/2021	23	12.8	0
14/08/2021	25	13.3	0
15/08/2021	22.6	13.1	0.2
16/08/2021	18.4	11.2	0
17/08/2021	19.3	12.4	0
18/08/2021	21.2	14.7	0
19/08/2021	23.6	13.7	0
20/08/2021	22	15.6	0.2
21/08/2021	19.1	16.2	8
22/08/2021	22.2	13.6	0
23/08/2021	21.8	14.6	0
24/08/2021	20.6	8.2	0

25/08/2021	18.4	14.7	0
26/08/2021	20.1	13	0
27/08/2021	17.2	9.9	0
28/08/2021	22	7.6	0
29/08/2021	18.6	7.8	0
30/08/2021	16.9	13.3	0.2
31/08/2021	17	12.5	0
01/09/2021	17.6	13	0
02/09/2021	19.6	13.2	0
03/09/2021	21.1	14.2	0
04/09/2021	21.2	11.4	0
05/09/2021	26	11.4	0
06/09/2021	28.7	12.3	0
07/09/2021	30.1	12.9	0
08/09/2021	29.7	13.1	0.8
09/09/2021	21.8	15.6	4.4
10/09/2021	22.5	16.7	1.2
11/09/2021	22.6	15.7	0
12/09/2021	19.9	10.6	0.2
13/09/2021	20.9	13.6	1.4
14/09/2021	16.4	13.4	4
15/09/2021	20.5	13	0
16/09/2021	22.4	9.9	0
17/09/2021	21.5	10.1	0
18/09/2021	23.8	9.8	1.8
19/09/2021	20.6	11.7	0.4
20/09/2021	21.1	7.2	0
21/09/2021	20.9	6.4	0
22/09/2021	20.9	7.2	0
23/09/2021	23.5	10.9	0
24/09/2021	24.3	9.1	0
25/09/2021	22.3	14.7	0
26/09/2021	22.5	13.1	10
27/09/2021	18.1	11.2	0.6
28/09/2021	17.4	9.7	17
29/09/2021	15.2	6.2	6.4
30/09/2021	16.3	6.9	5.2

d. Raw data from assessments

Numbers of whitefly egg circles, number of leaves with larvae, adult whitefly score, percentage plants with *Myzus persicae*, percentage plants with *Brevicoryne brassicae* and percentage plants with caterpillars (plot means) on for occasions

		Whitefly			Aphid (%)		Caterpillar (%)
Treatment	Plot	Egg circles	Larvae	Adults	*B. brassicae*	*M. persicae*	
28-Jul							
1	9	5.33	0.50	0.83			
1	14	1.33	0.50	0.50			
1	28	4.00	0.50	0.67			
1	31	6.17	2.00	1.00			
2	3	7.33	0.83	0.83			
2	16	2.50	0.67	0.67			
2	21	6.17	1.17	0.67			
2	39	1.00	0.83	0.00			
3	5	4.83	0.17	0.67			
3	18	5.67	0.17	0.83			
3	30	4.50	0.33	0.83			
3	33	8.17	0.17	1.00			
4	8	4.50	0.50	0.50			
4	12	3.50	0.50	0.50			
4	23	3.33	1.00	0.50			
4	35	2.33	0.67	0.33			
5	2	3.17	1.00	0.50			
5	19	3.00	1.00	0.33			
5	25	6.17	0.67	0.67			
5	37	4.50	1.33	0.50			
6	7	4.50	0.50	0.67			
6	20	3.67	0.00	0.67			
6	22	2.67	0.50	0.33			
6	34	4.83	1.33	0.67			
7	1	6.50	1.17	0.83			
7	13	7.17	0.33	0.83			
7	29	3.33	0.17	0.67			
7	36	2.17	0.33	0.67			
8	10	5.67	0.00	0.50			
8	15	3.50	0.33	0.83			
8	24	7.17	0.83	0.83			
8	38	2.00	0.33	0.83			
9	4	5.50	1.67	0.50			
9	17	3.50	0.67	0.50			
9	26	2.17	0.67	0.33			
9	32	4.83	0.67	1.00			
10	6	8.00	1.17	0.83			
10	11	5.00	1.00	1.00			
10	27	2.83	0.50	1.00			
10	40	3.33	0.67	0.67			

23-Aug							
1	9	75.13	4.38	2.13			
1	14	42.75	0.88	2.00			
1	28	43.63	2.13	1.63			
1	31	151.25	4.50	2.25			
2	3	9.13	0.25	1.00			
2	16	4.50	0.25	1.00			
2	21	10.00	0.25	1.13			
2	39	7.25	0.38	0.75			
3	5	43.38	2.13	1.88			
3	18	23.38	2.13	1.63			
3	30	12.75	0.88	1.25			
3	33	90.25	2.13	2.00			
4	8	31.00	1.63	1.75			
4	12	28.75	1.13	2.00			
4	23	54.13	1.50	2.00			
4	35	50.75	2.38	1.63			
5	2	12.75	0.88	1.25			
5	19	6.38	0.13	1.00			
5	25	4.75	0.00	1.00			
5	37	11.75	0.50	1.00			
6	7	6.50	1.38	1.00			
6	20	4.50	0.13	0.88			
6	22	5.13	0.50	0.88			
6	34	10.63	0.88	1.00			
7	1	65.13	3.63	2.00			
7	13	38.13	2.00	2.00			
7	29	12.50	1.25	1.00			
7	36	23.50	1.63	1.13			
8	10	9.38	0.38	1.13			
8	15	47.00	3.13	1.88			
8	24	76.63	1.75	2.00			
8	38	89.75	3.38	1.75			
9	4	69.13	2.63	2.00			
9	17	64.38	2.63	2.00			
9	26	31.25	2.00	1.50			
9	32	81.75	3.00	2.00			
10	6	43.13	2.38	1.75			
10	11	91.00	3.38	2.00			
10	27	33.50	1.38	1.75			
10	40	67.13	2.50	1.75			
08-Sep							
1	9	136.88	8.88	2.00	25.00	12.50	0.00
1	14	53.50	6.13	1.88	25.00	37.50	0.00
1	28	67.50	6.75	2.00	62.50	0.00	0.00
1	31	285.00	12.63	2.13	37.50	0.00	12.50
2	3	7.13	0.00	1.13	0.00	0.00	25.00
2	16	5.25	0.00	1.00	0.00	0.00	0.00
2	21	8.13	0.13	1.00	0.00	0.00	0.00

2	39	4.13	0.38	1.00	0.00	0.00	0.00
3	5	106.25	8.25	2.00	62.50	0.00	12.50
3	18	63.38	4.25	2.00	12.50	0.00	0.00
3	30	28.00	2.00	1.88	12.50	0.00	0.00
3	33	188.75	9.88	2.00	87.50	0.00	0.00
4	8	25.75	4.75	1.88	0.00	0.00	0.00
4	12	25.63	5.25	1.88	0.00	12.50	0.00
4	23	48.13	6.75	2.00	0.00	0.00	12.50
4	35	37.25	6.00	1.75	0.00	0.00	0.00
5	2	11.63	0.13	1.13	0.00	0.00	25.00
5	19	2.38	0.13	0.75	0.00	0.00	12.50
5	25	6.38	0.13	0.75	0.00	0.00	12.50
5	37	9.25	0.13	1.00	0.00	0.00	12.50
6	7	8.88	1.13	1.00	0.00	12.50	0.00
6	20	6.25	0.50	1.00	0.00	0.00	0.00
6	22	8.75	1.38	1.00	12.50	0.00	0.00
6	34	13.75	2.38	1.13	12.50	0.00	0.00
7	1	140.00	8.88	2.13	50.00	25.00	0.00
7	13	60.63	5.75	2.00	50.00	25.00	0.00
7	29	24.75	2.13	1.88	37.50	12.50	0.00
7	36	62.50	6.50	2.00	50.00	50.00	12.50
8	10	36.13	2.75	2.00	37.50	25.00	0.00
8	15	60.00	9.00	2.00	75.00	0.00	12.50
8	24	72.50	10.38	2.00	37.50	37.50	0.00
8	38	127.50	11.75	2.00	12.50	62.50	12.50
9	4	71.50	8.13	2.00	12.50	0.00	0.00
9	17	62.50	7.50	2.00	25.00	12.50	0.00
9	26	45.13	6.88	2.00	37.50	12.50	0.00
9	32	181.25	9.63	2.00	12.50	25.00	0.00
10	6	69.38	8.88	2.00	50.00	25.00	0.00
10	11	143.13	11.38	2.00	75.00	12.50	0.00
10	27	26.75	5.25	1.88	50.00	37.50	0.00
10	40	66.25	8.75	2.00	50.00	25.00	12.50
29-Sep							
1	9	85.83	13.83	2.33	50.00	0.00	0.00
1	14	74.17	14.67	2.00	50.00	16.67	16.67
1	28	85.00	14.50	2.33	100.00	33.33	0.00
1	31	220.00	16.83	2.83	66.67	0.00	0.00
2	3	2.83	0.00	0.83	0.00	0.00	0.00
2	16	6.17	0.00	1.00	0.00	0.00	0.00
2	21	6.17	0.00	1.00	0.00	0.00	0.00
2	39	4.50	0.00	1.00	0.00	0.00	0.00
3	5	64.17	13.67	2.00	83.33	0.00	0.00
3	18	44.50	12.00	2.00	66.67	16.67	0.00
3	30	35.83	9.83	2.00	66.67	16.67	0.00
3	33	140.00	16.33	2.50	100.00	50.00	0.00
4	8	33.50	10.33	2.00	16.67	0.00	0.00
4	12	46.67	9.33	2.00	66.67	16.67	16.67
4	23	62.50	11.67	2.17	16.67	0.00	16.67
4	35	59.50	9.83	2.00	16.67	0.00	0.00

5	2	11.17	0.00	1.17	0.00	0.00	0.00
5	19	3.50	0.17	1.00	16.67	0.00	0.00
5	25	6.83	0.00	0.67	0.00	0.00	0.00
5	37	9.83	0.00	1.17	0.00	0.00	0.00
6	7	14.67	4.67	1.83	66.67	16.67	0.00
6	20	4.33	2.33	1.33	100.00	0.00	0.00
6	22	10.83	4.67	1.67	66.67	0.00	0.00
6	34	13.50	4.17	1.67	66.67	16.67	0.00
7	1	53.33	14.33	2.00	66.67	0.00	0.00
7	13	26.17	10.17	2.00	83.33	0.00	0.00
7	29	8.67	4.17	1.17	66.67	33.33	0.00
7	36	32.00	9.67	2.00	100.00	16.67	16.67
8	10	24.33	6.83	2.00	100.00	0.00	0.00
8	15	90.00	15.33	2.33	83.33	33.33	0.00
8	24	77.50	15.83	2.17	100.00	0.00	0.00
8	38	121.67	16.00	2.33	16.67	66.67	0.00
9	4	54.17	14.17	2.17	83.33	0.00	0.00
9	17	86.67	11.67	2.17	100.00	16.67	0.00
9	26	52.50	11.00	2.00	100.00	33.33	0.00
9	32	118.33	14.00	2.00	100.00	50.00	0.00
10	6	68.33	10.50	2.00	100.00	0.00	0.00
10	11	148.33	15.67	2.50	100.00	0.00	0.00
10	27	35.83	7.67	2.00	83.33	50.00	0.00
10	40	59.17	7.00	2.00	100.00	83.33	0.00

e. Photographs of the trial

Trial on 12 August

Whitefly egg circles with adult whitefly on underside of kale leaf

f. Field plan

7	5	2	9	3	10	6	4	1	8
1	2	3	4	5	6	7	8	9	10
10	4	7	1	8	2	9	3	5	6
11	12	13	14	15	16	17	18	19	20
2	6	4	8	5	9	10	1	7	3
21	22	23	24	25	26	27	28	29	30
1	9	3	6	4	7	5	8	2	10
31	32	33	34	35	36	37	38	39	40

1	Untreated control
2	Movento
	AHDB9943
3	Phytodrip
4	AHDB9821
5	AHDB9935
6	AHDB9943
7	AHDB9946
8	AHDB9928
9	AHDB9967
10	AHDB9820

Certificate of

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

This certifies that

Warwick Crop Centre, School of Life Sciences

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
Biologicals and Semiochemicals

Date of issue: **6 October 2017**
Effective date: **20 March 2017**
Expiry date: **19 March 2022**

Signature Alison Richardson
Authorised signatory

Certification Number
ORETO 381

HSE
Chemicals Regulation Division

Department of Agriculture and Rural Development