Project title:	Managing ornamental plants sustainably (MOPS)
Project number:	CP 124
Work package title:	Efficacy of plant protection products against sucking insects – western flower thrips / protected ornamentals
Work package leader:	Jude Bennison, ADAS
Report:	Annual report, January 2015
Previous report:	None
Key staff:	Jude Bennison, ADAS Gemma Hough, ADAS Kerry Maulden, ADAS
Location of work:	ADAS Boxworth, Cambs
Date work commenced:	May 2014
Date work completed (or expected completion date):	December 2014

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.

Jude Bennison
Senior Research Entomologist
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Signature Date 29 January 2015

Report authorised by:

John Atwood
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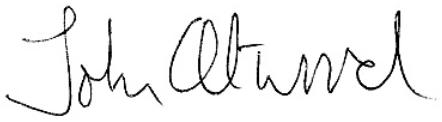

Signature Date 30 January 2015

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Growers Summary

Headline

- Actara, three new conventional pesticides and three new biopesticides currently in development showed efficacy against WFT on verbena but none gave a quick knockdown or prevented unacceptable thrips damage.

Background and expected deliverables

Western flower thrips (WFT), *Frankliniella occidentalis* is a common pest of many ornamental crops, mainly under protection. Feeding damage by adults and larvae on leaves and petals causes white flecks or patches, which later turn brown and necrotic. Feeding in leaf and flower buds can also cause distortion and stunting. In addition to causing direct damage which can make the plants unmarketable, WFT can also transmit tospoviruses including *Tomato spotted wilt virus (*TSWV) and *Impatiens necrotic spot virus* (INSV). These viruses also have a wide ornamental plant host range and can cause severe damage and plant losses. WFT is resistant to most or all currently approved chemical pesticides on many nurseries growing protected ornamentals.

The purpose of this experiment was to test the efficacy of products against WFT on a selected susceptible protected ornamental species.

Summary of the work and main conclusions

Materials and methods

Seven plant protection products (Table 1) were tested against western flower thrips (WFT), *Frankliniella occidentalis* on verbena (cv. Quartz) plants grown in two glasshouse compartments between July and August 2014 at ADAS Boxworth. The glasshouse compartments were fitted with insect-proof screens to minimise the risk of plants becoming infested with other insect pests. Each experimental plot was a cage (0.5 x 0.5 x 0.5 m) covered with thrips-proof mesh to avoid WFT adults flying between plots. There were six replicate plots (cages) per treatment. Temperature was regulated in the compartments by venting at 15°C and using insect-screened fans.

Plants were obtained as plugs and potted on into 9 cm pots on 21 May. The pots were kept in thrips-proof cages in a polytunnel at ADAS Boxworth until the plants were flowering. On 18 July,

plants for the experiment were selected, choosing plants uniform in size, vigour and number of flowers. Nine plants were arranged in three rows of three plants in each cage. Plants were selected so at the start of the experiment there was a mean of 20 open flowers per cage. The cages were stood on capillary matting and watered using sub-irrigation.

WFT adults were released to each cage on 18 July and 22 July. On each date, 20 adults were released (18 females and two males), equivalent to one adult per flower. WFT from a laboratory culture at ADAS Boxworth was used to infest plants. The WFT population was confirmed to be resistant to spinosad (Conserve) in a laboratory bioassay in May 2014 and is likely to be resistant to most other insecticides currently approved for use on protected ornamentals. This is typical of WFT populations on most commercial nurseries growing protected ornamentals.

Table 1. Products tested

MOPS code number	Biopesticide or conventional pesticide
Water control	-
Actara (thiamethoxam)	conventional
130	biopesticide
179	biopesticide
201	biopesticide
200	conventional
207	conventional
48	conventional

All treatments were applied to give good flower and leaf cover, just prior to run-off. Recommended application rates were used following consultation with the companies' technical experts. All treatments and the water control were applied using an Oxford Precision Sprayer fitted with an HC/1.74/3 nozzle, in 600 litres of water per hectare using 3 bar pressure. No adjuvants were used with any of the treatments. The water volume selected was consistent with the range of water volumes recommended by the suppliers and in consultation with an ADAS spray application expert. Each treatment was applied at weekly intervals for four weeks, on 29 July and 5, 12 and 19 August.

Numbers of live WFT adults and larvae per flower, top and middle leaf and percentage WFT damage to flowers and leaves were recorded one day before the first application, three and six days after the first application (days 3 and 6), six days after the second application (day 13) six days after the third application (day 20) and seven days after the fourth application (day 27). Any phytotoxicity was assessed on the same dates.

Results and Conclusions

- None of the treatments gave control of WFT adults in flowers or on leaves compared with water-treated controls. Where a significant reduction of thrips numbers was given compared with the water controls, only numbers of larvae were reduced. However, on the final assessment date Actara (positive control), biopesticide treatment 130 and conventional treatments 200 and 48 reduced numbers of WFT adults per top leaf compared with biopesticide treatment 179. On the same assessment date, all treatments except for biopesticide 179 reduced numbers of adults per middle leaf compared with biopesticide treatment 201. These results indicated that biopesticide treatments 179 and 201 may be less effective against WFT adults than the other treatments tested.
- None of the treatments gave a quick knock-down of WFT three days after the first treatment. Only one treatment (conventional treatment 48) reduced numbers of larvae per top leaf compared with water controls six days after the first treatment (Table 2, Figure 1).
- On the last three assessment dates (days 13, 20 and 27), numbers of available flowers per cage were too variable to draw any meaningful results from the data, with some cages having no live flowers due to senescence caused by WFT damage. Therefore only the efficacy data from top and middle leaves can be used on these assessment dates.
- Actara reduced numbers of WFT larvae on leaves compared with water-treated controls on the last three assessment dates (days 13, 20 and 27). Numbers of larvae were reduced on top leaves six days after the second treatment (day 13), on both top and middle leaves six days after the third treatment (day 20) and on middle leaves seven days after the fourth treatment (day 27), Table 2, Figures 1 and 2.
- The three conventional treatments (200, 207 and 48) were equally effective as Actara in reducing numbers of WFT larvae compared with water-treated controls on either top or middle leaves on the last three assessment dates (Table 2, Figures 1 and 2).

- The three biopesticide treatments (130, 179 and 201) reduced numbers of WFT larvae compared with water-treated controls on the last two assessment dates. Six days after the third treatment (day 20), all three biopesticides were as effective as Actara and the other three conventional treatments on both top and middle leaves. Seven days after the fourth treatment (day 27), biopesticides 130 and 179 were as effective as Actara and the other three conventional treatments on middle leaves but biopesticide 201 was ineffective.
- Where numbers of WFT larvae were reduced on top leaves on the last three assessment dates, there was a corresponding reduction in thrips leaf damage except for with conventional treatment 207 on day 13 and with biopesticide treatment 201 on day 20. Where numbers of WFT larvae were reduced on middle leaves on the last two assessment dates, there was only a corresponding reduction in thrips leaf damage on day 27.
- Although significant reductions in WFT numbers were given in this experiment, WFT damage to flowers and leaves would have made the plants unmarketable in all treatments. Therefore the treatments have most potential for contributing to WFT control as part of an IPM programme, together with the use of biological control agents such as the predatory mite *Neoseiulus cucumeris*. Safety to biological control agents would need to be confirmed.
- Biopesticide 179 caused white spotting to petals on a small number of flowers three and six days after the first treatment and white spotting to leaves on one plant only, six days after the first treatment. It is possible that if used at a lower concentration or as a finer spray, this damage may not occur.

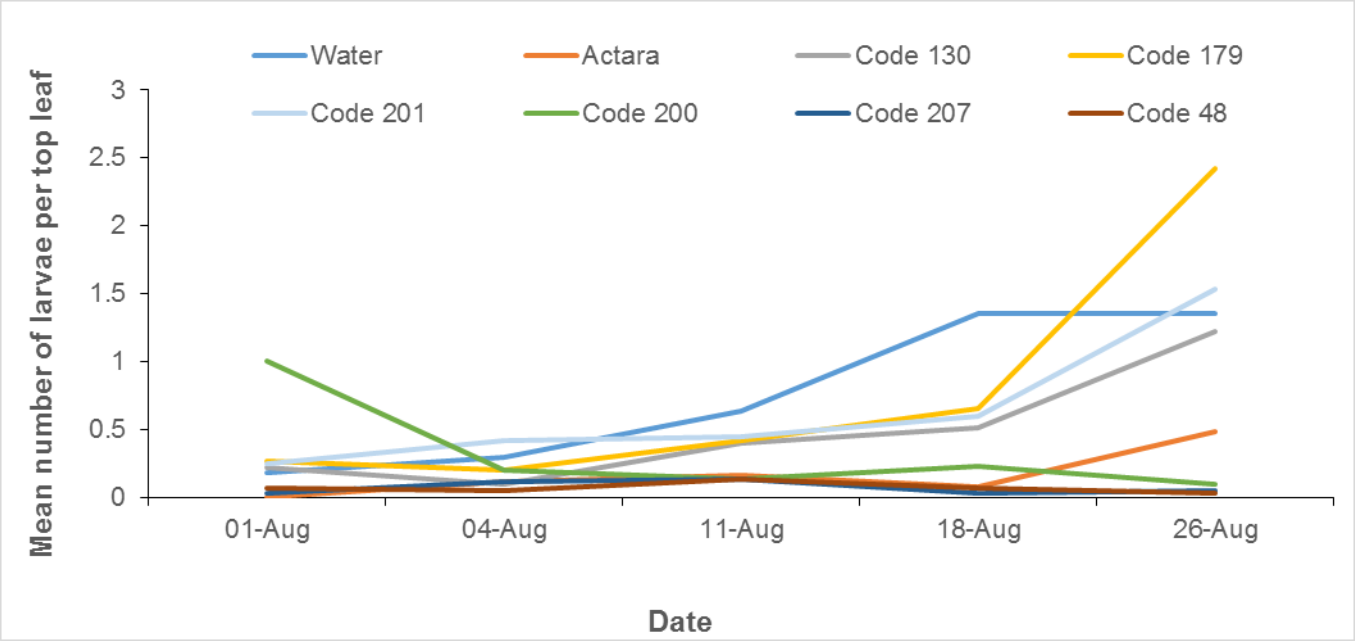


Figure 1 Mean numbers of WFT larvae per top leaf on each assessment date

Table 2. Mean numbers of WFT larvae per top (T) and middle (M) leaf 3, 6, 13, 20 and 27 days after the first treatment. *** significantly fewer than in water controls (P<0.05).** Where more than one treatment was effective on any one date, they were equally effective. LSD is least significant difference. NS is no significant reductions in numbers of larvae compared with water controls on that date.

Product name or MOPS code	Day 3		Day 6		Day 13		Day 20		Day 27	
	T	M	T	M	T	M	T	M	T	M
1. Water control	0.18	0.27	0.30	0.17	0.63	0.15	1.35	0.50	1.35	0.73
2. Actara	0	0.02	0.12	0.02	**0.17***	0.03	**0.08***	**0***	0.08	**0.08***
3. 130	0.22	0.08	0.10	0.15	0.40	0.27	**0.52***	**0.12***	0.52	**0.20***
4. 179	0.27	0.15	0.20	0.08	0.42	0.33	**0.65***	**0.13***	0.65	**0.32***
5. 201	0.25	0.13	0.42	0.27	0.45	0.20	**0.60***	**0.03***	0.60	**0.80***
6. 200	0.1	0.05	0.20	0.02	**0.13***	0.07	**0.23***	**0.03***	0.23	**0.02***
7. 207	0.03	0.08	0.12	0.02	**0.13***	0.03	**0.03***	**0***	0.03	**0***
8. 48	0.07	0.12	**0.05***	0.15	**0.13***	0.05	**0.07***	**0.02***	0.07	**0.02***
LSD	0.210 NS	0.220 NS	0.208	0.287 NS	0.328	0.09 NS	0.580	0.208	0.580 NS	0.394

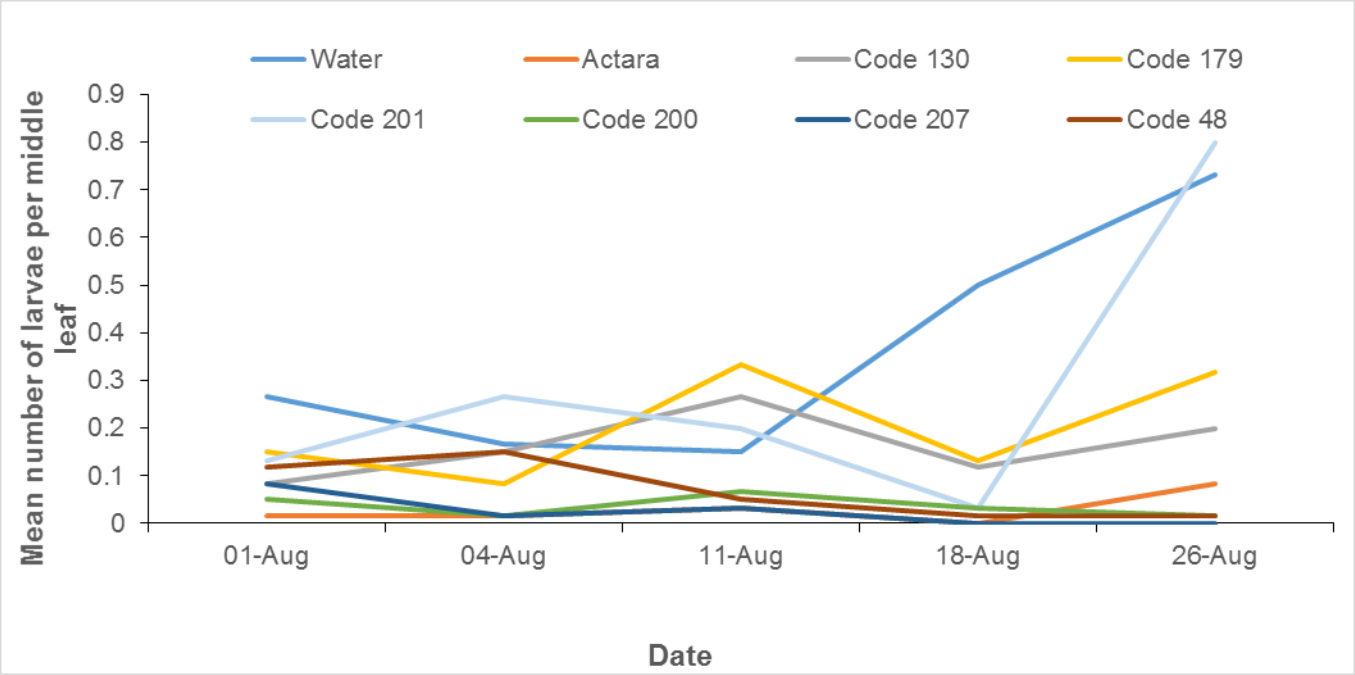


Figure 2 Mean numbers of WFT larvae per middle leaf on each assessment date

Action points

- Although Actara showed efficacy against WFT in this experiment, only use this product on ornamental plants in a glasshouse on plants that will not be sold or moved outside until after flowering. Actara has an EAMU for use on protected ornamentals but is subject to the current EU restrictions on the use of certain neonicotinoids (including thiamethoxam) on plants considered attractive to bees.
- If the three conventional pesticides (200, 207 and 48) gain approval in the future, consider their use against WFT as all were as effective at reducing numbers of WFT as Actara. Like Actara, treatment 207 is systemic and treatments 200 and 48 have translaminar action which helps to target the pest.
- If the three biopesticides (130, 179 and 201) gain approval in the future, consider their use against WFT as all were as effective as Actara and the other conventional pesticides against WFT larvae on two of the assessment dates except for 201 which was as effective on only one date. None of these biopesticides have systemic or translaminar action so require good spray coverage to reach the target. All have contact action but treatment 130 also has an antifeedant effect from the spray residue on plant surfaces and ingestion will interrupt larval moulting and adult reproduction. Target pests will also be affected by some secondary pick-up from spray residues with treatment 201.
- Do not rely on any of the treatments tested in this experiment for control of WFT. They would need to be used as part of an IPM programme and safety to biological control agents would need to be confirmed.

Science Section

Introduction

Various thrips species can damage ornamental plants (Bennison, 2009) but the most problematic species to control is western flower thrips (WFT), *Frankliniella occidentalis* as it is resistant to most or all currently available chemical pesticides (Bielza, 2008). WFT is a widespread and common pest of many ornamental crops, mainly under protection but it can also occur outdoors from spring to autumn. Common protected ornamental, HNS and cut flower host plants include alstroemeria, chrysanthemum, clematis, cyclamen, dahlia, fuchsia, lavatera, lisianthus, primula, and verbena. Feeding damage by adults and larvae on leaves and petals causes white flecks or patches, which later turn brown and necrotic. Feeding in leaf and flower buds can also cause distortion and stunting. In addition to causing direct damage which can make the plants unmarketable, WFT can also transmit tospoviruses including *Tomato spotted wilt virus (*TSWV) and *Impatiens necrotic spot virus* (INSV). These viruses also have a wide ornamental plant host range and can cause severe damage and plant losses. Symptoms include chlorotic or necrotic leaf spots, leaf rings, leaf yellowing and distortion, stem blackening and growing point death (Bennison, 2009; O'Neill & Bennison, 2010).

Due to problems with WFT pesticide resistance, leading growers of protected ornamentals, HNS and cut flowers use biological control methods within IPM programmes. Biological control agents used include predatory mites e.g. the plant-dwelling species *Neoseiulus (Amblyseius) cucumeris* and *Amblyseius swirskii* against thrips larvae on plants, and ground-dwelling species e.g. *Stratiolaelaps scimitus* (formerly known as *Hypoaspis miles*) against the larvae that drop to the ground to pupate. Foliar applications of entomopathogenic nematodes, *Steinernema feltiae* are also used for WFT control by a leading grower of pot chrysanthemums and some other growers of protected ornamentals. Growers using IPM sometimes need to use an IPM-compatible pesticide or biopesticide to supplement these biological control agents, e.g. during the summer months when the crop is flowering, when WFT breed rapidly. There is a need for an effective product to use in these situations and also for use on nurseries where IPM is not currently adopted. Although the entomopathogenic fungus, *Beauveria bassiana* (Naturalis-L) is available as a foliar spray for the reduction of thrips and other pests on protected ornamentals, growers have had disappointing results with thrips control, possibly due to the humidity requirements after application for optimum fungal efficacy.

Materials and methods

Site and crop details

Table 1. Test site and plot design information

Test location:	ADAS Boxworth
County	Cambridgeshire
Postcode	CB23 4NN
Soil type/growing medium	Levington M2 compost
Nutrition	-
Crop	Verbena
Cultivar	Quartz
Glasshouse* or Field	Glasshouse
Date of planting/potting	Plugs potted on 21 May 2014
Pot size	9 cm pots
Number of plants per plot	9
Trial design (layout in Appendix C)	Randomised block
Number of replicates	6
Plot size w (m), l (m), total area (m²)	0.5 x 0.5 x 0.5m (0.25m^2), total plot area 12m^2
Method of statistical analysis	Analysis of variance (ANOVA)

*Temperature and relative humidity settings are given in Appendix B

Treatment details

Table 2. Detail of products tested

MOPS code number	Active ingredient(s)	Manufacturer	Batch number	% a.i	Formulation type
1. Water (-ve control)	-	-	-	-	-
2. Actara (+ve control)	thiamethoxam	Syngenta	?	250g/kg (25%)	WG
3. 130	azadirachtin	Trifolio-M	140414A	1%	EC
4. 179	orange oil	Oro Agri	7579	60g/l	SL
5. 201	*Metarhizium anisopliae* var. *anisopliae* strain F52	Bayer CropScience	1408NFEC10	11%	OD
6. 200	cyantranilipole	Syngenta	SMU2FP016	120g/l	WG
7. 207	spirotetramat SC 100	Bayer CropScience	EDFL027182	?	SC
8. 48	emamectin (MK 244)	Syngenta	SMOOJ152	9.5 g/kg	SC

Table 3. Treatments

Product name or MOPS code number	Application timing	Product rate	Spray volume (L/ha)
1. Water (-ve control)	Weekly x 4	-	600
2. Actara (+ve control)	Weekly x 4	0.4 kg/ha (EAMU 0186/2014)	600
3. 130	Weekly x 4	0.3% (1.8 l/ha)	600
4. 179	Weekly x 4	0.4% (2.4 l/ha)	600
5. 201	Weekly x 4	1.25 l/ha	600
6. 200	Weekly x 4	0.313 kg/ha	600
7. 207	Weekly x 4	0.75 l/ha	600
8. 48	Weekly x 4	1.5 kg/ha	600

Application timing	
A1	29 July 2014
A2	5 August 2014
A3	12 August 2014
A4	19 August 2014

Table 4. Application details

Application No.	A1	A2	A3	A4
Application date	29/7/2014	5/8/2014	12/8/2014	19/8/2014
Time of day	3-4.20 pm	2.45-3.35 pm	11.40 am-2 pm	2.45-3.45 pm
Application method	Oxford Precision Sprayer fitted with a HC/1.74/3 nozzle, in 600 litres water/ha using 3 bar pressure	Oxford Precision Sprayer fitted with a HC/1.74/3 nozzle, in 600 litres water/ha using 3 bar pressure	Oxford Precision Sprayer fitted with a HC/1.74/3 nozzle, in 600 litres water/ha using 3 bar pressure	Oxford Precision Sprayer fitted with a HC/1.74/3 nozzle, in 600 litres water/ha using 3 bar pressure
Temperature of air – max/min (°C)	Start: 32.7 Finish: 32.4	Start: 29.5 Finish: 23.9	Start: 26.7 Finish: 27.1	Start: 19.1 Finish: 19.7
Relative humidity (%)	Start: 32.9 Finish: 29.3	Start: 39.7 Finish: 34.9	Start: 34.8 Finish: 30.9	Start: 45.2 Finish: 42.4
Cloud cover (%)	0	85	50	50
Crop growth stage	Flowering	Flowering	Flowering	Flowering
Crop comments				
Other*:				

*Includes soil temperature and moisture details where relevant

All treatments were applied to give good flower and leaf cover, just prior to run-off. Recommended application rates were used following consultation with the companies' technical experts. The

water volume selected (600 litres per ha) was consistent with the range of water volumes recommended by the suppliers and with advice from ADAS spray application expert, David Talbot. Spray deposition was assessed before the first treatment application by attaching water-sensitive paper to spare verbena plants in pots placed at the same spacing as in the experimental cages (plots). Papers were clipped to the upper and lower surfaces of top, middle and bottom leaves and placed on the floor between the pots.

Target pest(s)

Table 5. Target pest(s)

Common name	Scientific Name	Infestation level pre-application
western flower thrips (WFT)	*Frankliniella occidentalis*	40 adults per cage (plot), equivalent to 2 adults per flower

WFT adults were released to each cage (plot) on 18 July and 22 July. One each date, 20 adults were released (18 females and two males). One each date this was equivalent to one adult per flower as there were a mean of 20 flowers per cage at the time of release. WFT from a laboratory culture at ADAS Boxworth was used to infest plants. The WFT population was confirmed to be resistant to spinosad (Conserve) in a laboratory bioassay in May 2014 and is likely to be resistant to most other insecticides currently approved for use on protected ornamentals. This is typical of WFT populations on most commercial nurseries growing protected ornamentals.

Assessments

Numbers of WFT per flower head and leaf and thrips damage

At the pre-treatment assessment, numbers of live WFT adults and larvae were recorded from 10 flower heads and 10 upper leaves in each cage, sampling from the same position on each plant. Each flower head was tapped onto a small white plastic tray held under the flower head and any thrips dropping onto the tray were recorded, followed by tapping the thrips back onto the assessed flower. Leaf assessments were done by examining the upper and lower surface of each leaf. At the remaining assessments, numbers of live WFT adults and larvae were recorded and, in addition to 10 upper leaves, 10 middle leaves were also sampled. If less than 10 flower heads were available on any assessment date, as many as possible (up to ten) were assessed. The assessments were done in-situ using a head-band magnifier, to avoid removing flowers, leaves and thrips from the cages.

The following records were made:

- Numbers of live WFT adults and larvae per flower head or leaf
- Percentage flower head or leaf area with thrips damage scored as: 0, 1 (up to 5%), 2 (5-25%), 3 (25-50%) or 4 (over 50%).

Phytotoxicity

Phytotoxicity scores and photographs of any symptoms were taken at each application date. Records of any observed effects attributable to phytotoxicity were recorded by comparing them to the control plants. Symptoms were scored from 0-9 where 0 was no damage and 9 was where damage was very severe.

Table 6. Assessments

Assessment No.	Date	Growth stage	Timing of assessment relative to last application	Assessment of WFT numbers, WFT damage and phytotoxicity
1	28 July 2014	Flowering	1 day before first application	No. live WFT adults & larvae per flower & top leaf and crop safety
2	1 August 2014	Flowering	3 days after first application (day 3)	As for assessment 1 plus no. live WFT adults and larvae per middle leaf
3	4 August 2014	Flowering	6 days after first application (day 6)	As for assessment 2
4	11 August 2014	Flowering	13 days after first application (day 13), 6 days after second application	As for assessment 2 plus % flower and area damaged by WFT
5	18 August 2014	Flowering	20 days after first application (day 20), 6 days after third application	As for assessment 4

6	26 August 2014	Flowering	28 days after first application (day 28), 7 days after fourth application	As for assessment 4

Statistical analysis

The data from each assessment were analysed using analysis of variance (ANOVA) to calculate means, variance and LSDs ($P<0.05$).

Results

Spray coverage

The application method used achieved good spray coverage of the upper surface of top and middle leaves and the lower surface of top leaves, less good coverage of the lower surface of middle leaves and the upper surface of bottom leaves and poor coverage of the lower surface of bottom leaves. Similar coverage was given to the floor to that on top leaves (Figure 1).

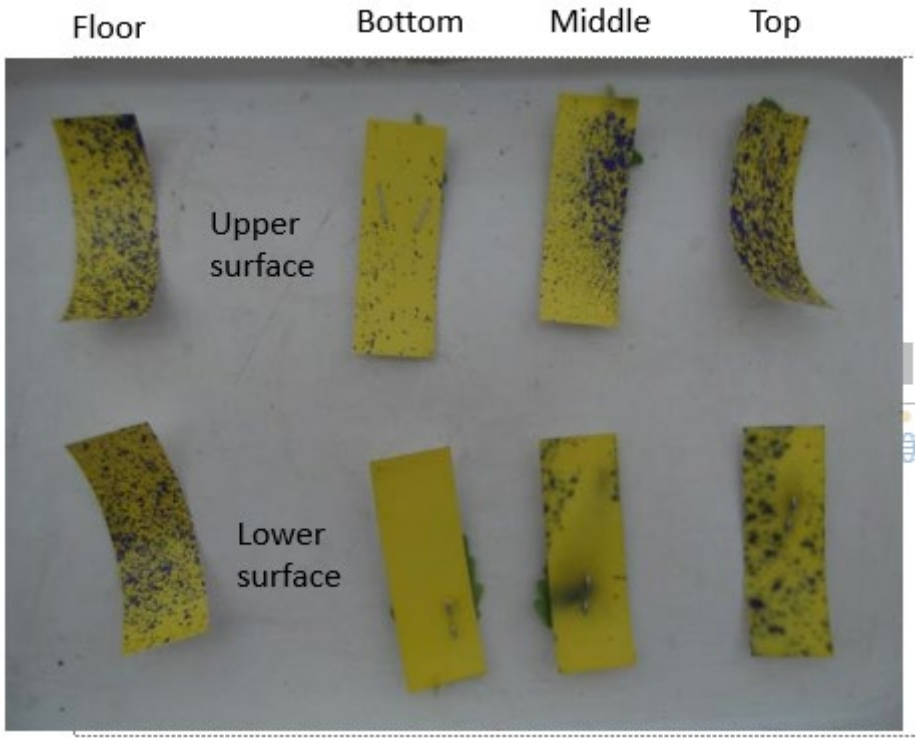


Figure 1. Spray coverage on water-sensitive paper clipped to the upper and lower leaf surfaces of top, middle and bottom leaves and placed on the floor.

Control of WFT

Numbers of flowers assessed per cage

It was intended to assess numbers of WFT adults and larvae on 10 flowers per replicate cage throughout the experiment. However, after the first three assessments (one day before treatment and three and six days after the first treatment), the numbers of available flowers per cage was very variable, with some cages having no live flowers due to thrips damage causing flower senescence. Therefore data on numbers of thrips per flower are only presented for the first three assessment dates. Data on numbers of flowers per cage were analysed for the last three assessment dates to determine whether any of the treatments increased numbers of flowers per cage. There were no effects of treatments six days after the second and third treatments but on the final assessment date, seven days after the fourth treatment, mean numbers of live flowers per cage were significantly increased from 0.3 in water controls, to 3.7 (Actara), 6.2 (code 200), 4.2 (code 207) and 4.7 (code 48), Table 7 and Figure 2. The four conventional treatments that increased flower number were equally effective ($P<0.05$).

Table 7. Mean numbers of flowers available per cage (up to 10). Data only analysed for last three assessments as 10 flowers per cage were available on the first three dates. Numbers in a column sharing the same letters are not significantly different at P<0.05 based on least significant differences (LSD). P = n.s. is not significant.

Product name or MOPS code	28/7/2014 (1 day before first treatment)	1/8/2014 (3 days after first treatment)	4/8/2014 (6 days after first treatment)	11/8/2014 (6 days after second treatment)	18/8/2014 (6 days after third treatment)	26/8/2014 (7 days after fourth treatment)
1. Water control	10	10	10	5.83	5.32	0.33 a
2. Actara (+ve control)	10	10	10	4.5	4.5	3.67 bc
3. 130	10	10	10	6.83	3.83	1.0 ab
4. 179	10	10	10	8.33	5	0.67 a
5. 201	10	10	10	5.67	4.09	0.5 a
6. 200	10	10	10	6.17	6.33	6.17 c
7. 207	10	10	10	4.33	5.5	4.17 c
8. 48	10	10	10	5.67	6.36	4.67 c
F value (7 df)	-	-	-	0.46 (P = n.s)	0.76 (P = n.s.)	P<0.001
LSD	-	-	-	3.699	3.579	2.782

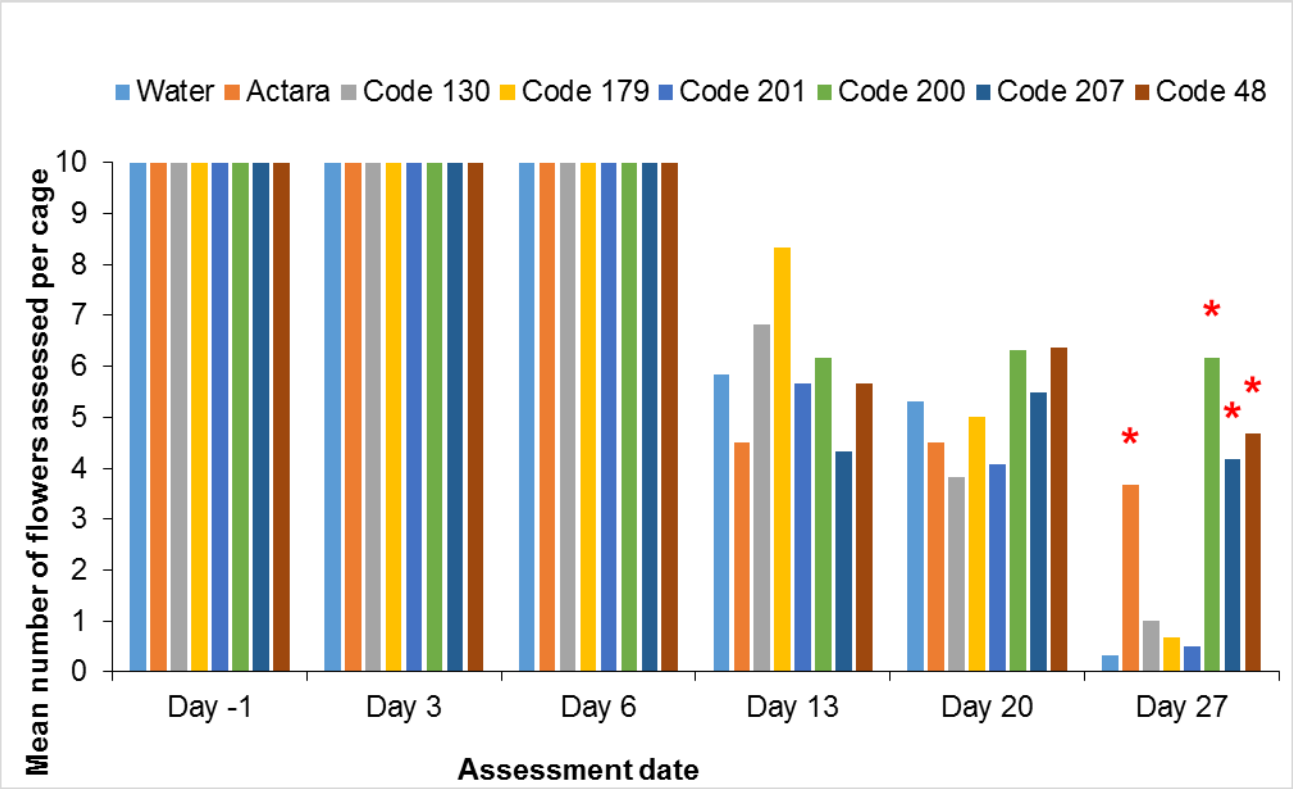


Figure 2. Mean numbers of flowers assessed per cage on each assessment date, according to flower availability (up to 10 per cage). * significantly more flowers per cage than in water controls (P<0.05)

Mean numbers of WFT adults per flower

Data is only presented for the first three assessment dates, due to the large variability in mean numbers of flowers per cage on the remaining assessment dates. Mean numbers of live WFT adults per flower in the water controls were 0.4, 0.5 and 1.4 one day before and three and six days after the first treatment respectively (Table 8). None of the treatments significantly reduced mean numbers of WFT adults per flower either three or six days after the first treatment (P<0.05).

Table 8. Mean numbers of live WFT adults per flower (data only presented for the first three dates as on the last three dates numbers of flowers per cage were very variable with some cages having no flowers, thus drawing conclusions from the analysis was not valid). P = n.s. is not significant.

Product name or MOPS code	28/7/2014 (1 day before first treatment)	1/8/2014 (3 days after first treatment)	4/8/2014 (6 days after first treatment)
1. Water control	0.43	0.53	1.37
2. Actara (+ve control)	0.52	0.25	0.72
3. 130	0.37	0.62	1.02
4. 179	0.30	0.45	0.68
5. 201	0.22	0.63	0.97
6. 200	0.18	0.33	0.50
7. 207	0.20	0.65	0.95
8. 48	0.68	0.90	1.45
F value (7 df)	0.66 (P = n.s.)	0.36 (P = n.s.)	0.52 (P = n.s.)
LSD	0.596	0.548	0.996

Mean numbers of WFT larvae per flower

Data is only presented for the first three assessment dates, due to the large variability in mean numbers of flowers per cage on the remaining assessment dates. Mean numbers of live WFT larvae per flower in the water controls were 0.1, 0.4 and 0.9 one day before and three and six days after the first treatment respectively (Table 9). None of the treatments significantly reduced mean numbers of WFT larvae per flower either three or six days after the first treatment ($P<0.05$).

Table 9. Mean numbers of live WFT larvae per flower (data only presented for the first three dates as on the last three dates numbers of flowers per cage were very variable with some cages having no flowers, thus drawing conclusions from the analysis was not valid). P = n.s. is not significant.

Product name or MOPS code	28/7/2014 (1 day before first treatment)	1/8/2014 (3 days after first treatment)	4/8/2014 (6 days after first treatment)
1. Water control	0.12	0.42	0.92
2. Actara (+ve control)	0.20	0.20	0.5
3. 130	0.32	0.52	0.58
4. 179	0.08	0.25	0.62
5. 201	0.17	0.35	0.98
6. 200	0.15	0.08	0.68
7. 207	0.28	0.58	0.70
8. 48	0.07	0.22	0.83
F value (7 df)	0.48 (P = n.s.)	0.07 (P = n.s.)	0.66 (P = n.s.)
LSD	0.264	0.34	0.57

Mean numbers of WFT adults per top leaf

There was no significant effect of treatment on mean numbers of live WFT adults per top leaf on the first five assessment dates. On the final assessment date, seven days after the fourth treatment, none of the treatments reduced numbers of WFT adults compared with the water controls. However, Actara and coded products 130, 200 and 48 significantly reduced mean numbers of WFT adults to 0.1 adult per leaf or below, compared with coded product 179 which led to a mean of 0.5 adults per leaf (Table 10).

Table 10. Mean numbers of live WFT adults per top leaf. Numbers in a column sharing the same letters are not significantly different at P<0.05 based on least significant differences (LSD). P = n.s. is not significant. P = n.s. is not significant.

Product name or MOPS code	28/7/2014 (1 day before first treatment)	1/8/2014 (3 days after first treatment)	4/8/2014 (6 days after first treatment)	11/8/2014 (6 days after second treatment)	18/8/2014 (6 days after third treatment)	26/8/2014 (7 days after fourth treatment)
1. Water control	0.03	0.03	0.10	0.33	0.30	0.25 ab
2. Actara (+ve control)	0.10	0	0.07	0.13	0.23	0.03 a
3. 130	0.02	0.02	0.12	0.15	0.30	0.13 a
4. 179	0.02	0.03	0.12	0.13	0.37	0.45 b
5. 201	0.07	0.02	0.10	0.13	0.23	0.28 ab
6. 200	0.03	0	0.02	0.13	0.13	0.10 a
7. 207	0.07	0	0	0.33	0.28	0.27 ab
8. 48	0.1	0.03	0.02	0.12	0.18	0.08 a
F value (7 df)	0.71 (P = n.s.)	0.45 (P = n.s.)	0.23 (P = n.s.)	0.19 (P = n.s.)	0.36 (P = n.s.)	0.04 (P<0.05)
LSD	0.121	0.044	0.099	0.328	0.198	0.253

Mean numbers of WFT adults per middle leaf

None of the treatments reduced mean numbers of live WFT adults per middle leaf on any assessment date. However, on the final assessment date, seven days after the fourth treatment, all treatments except for coded product 179 significantly reduced mean numbers of live WFT adults to less than 0.2 per middle leaf compared with coded product 201 which led to a mean of 0.4 adults per leaf (Table 11).

Table 11. Mean numbers of live WFT adults per middle leaf. Numbers in a column sharing the same letters are not significantly different at P<0.05 based on least significant differences (LSD). Numbers in a column sharing the same letters are not significantly different at P<0.05 based on least significant differences (LSD). P = n.s. is not significant. – not assessed.

Product name or MOPS code	28/7/2014 (1 day before first treatment)	1/8/2014 (3 days after first treatment)	4/8/2014 (6 days after first treatment)	11/8/2014 (6 days after second treatment)	18/8/2014 (6 days after third treatment)	26/8/2014 (7 days after fourth treatment)
1. Water control	-	0.08	0.05	0.07	0.33	0.17 a
2. Actara (+ve control)	-	0	0.02	0.08	0.13	0.07 a
3. 130	-	0.02	0.03	0.07	0.13	0.12 a
4. 179	-	0.02	0.02	0.03	0.18	0.23 ab
5. 201	-	0.02	0.07	0.07	0.28	0.42 b
6. 200	-	0.15	0.17	0.03	0.05	0.12 a
7. 207	-	0.08	0.05	0.08	0.12	0.07 a
8. 48	-	0.05	0.07	0.12	0.07	0.02 a
F value (7 df)	-	0.70 (P = n.s.)	0.75 (P = n.s.)	0.73 (P = n.s.)	0.07 (P = n.s.)	0.005 (P<0.01)
LSD	-	0.178	0.178	0.10	0.196	0.191

Mean numbers of live WFT larvae per top leaf

There were no significant effects of treatment on mean numbers of live WFT larvae per top leaf three days after the first treatment. Six days after the first treatment, coded product 48 significantly reduced mean numbers of live larvae from 0.3 in the water controls to 0.05 per leaf (P<0.05), Table 12 and Figure 3. Six days after the second treatment, mean numbers of WFT larvae in the water controls (0.6 per leaf) were significantly reduced by Actara (0.2 per leaf) and by coded products 200, 207 and 48 (all 0.1 per leaf), P<0.05. Six days after the third treatment, mean numbers of

WFT larvae in the water controls (1.4 per leaf) were significantly reduced by all treatments to less than 0.7 per leaf. At the final assessment, none of the treatments significantly reduced mean numbers of larvae from 1.4 per leaf in the water controls, however Actara and coded products 200, 207 and 48 all significantly reduced numbers of larvae compared to coded product 179.

Table 12. Mean numbers of live WFT larvae per top leaf. Numbers in a column sharing the same letters are not significantly different at P<0.05 based on least significant differences (LSD). Numbers in a column sharing the same letters are not significantly different at P<0.05 based on least significant differences (LSD). P = n.s. is not significant.

Product name or MOPS code	28/7/2014 (1 day before first treatment)	1/8/2014 (3 days after first treatment)	4/8/2014 (6 days after first treatment)	11/8/2014 (6 days after second treatment)	18/8/2014 (6 days after third treatment)	26/8/2014 (7 days after fourth treatment)
1. Water control	0.07	0.18	0.30 bc	0.63 b	1.35 b	1.35 abc
2. Actara (+ve control)	0.38	0	0.12 ab	0.17 a	0.08 a	0.48 ab
3. 130	0.28	0.22	0.10 ab	0.40 ab	0.52 a	1.22 abc
4. 179	0.23	0.27	0.20 abc	0.42 ab	0.65 a	2.42 c
5. 201	0.18	0.25	0.42 c	0.45 ab	0.60 a	1.53 bc
6. 200	0.13	0.1	0.20 abc	0.13 a	0.23 a	0.10 a
7. 207	0.10	0.03	0.12 ab	0.13 a	0.03 a	0.05 a
8. 48	0.32	0.07	0.05 a	0.13 a	0.07 a	0.03 a
F value (7 df)	0.74 (P = n.s.)	0.09 (P = n.s.)	0.021 (P<0.05)	0.02 (P<0.05)	P<0.001	0.003 (P<0.01)
LSD	0.406	0.210	0.208	0.328	0.580	1.249

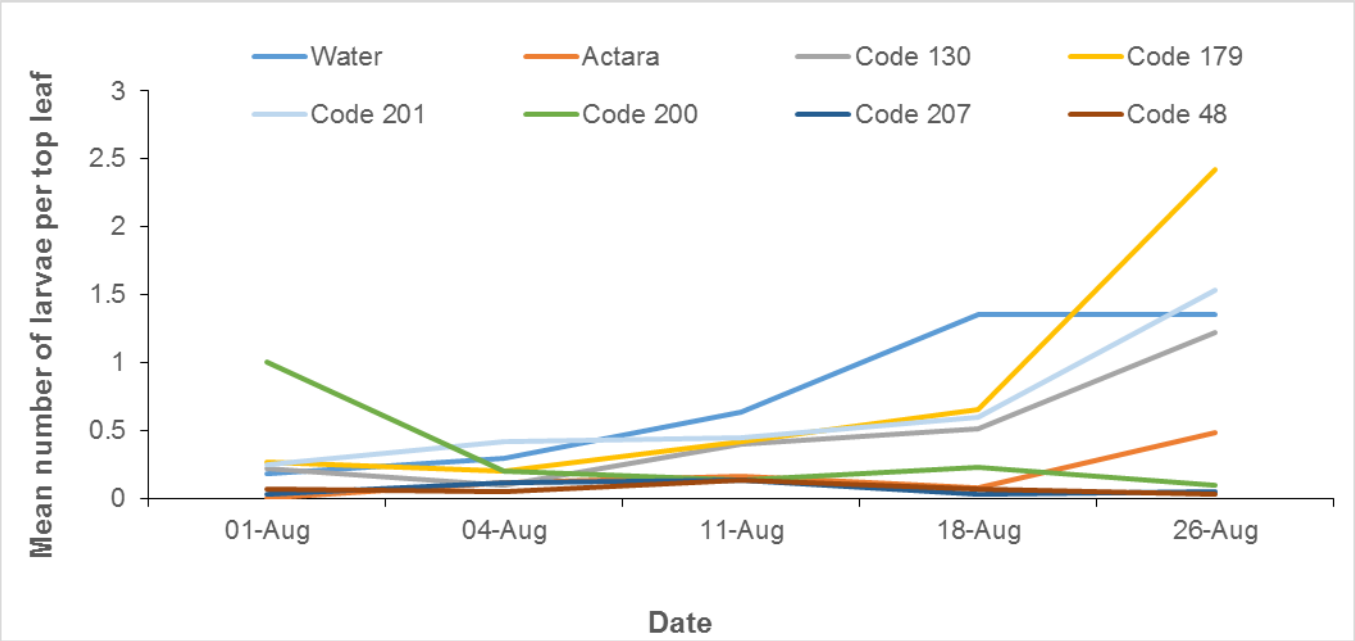


Figure 3. Mean numbers of WFT larvae per top leaf on each assessment date

Mean numbers of live WFT larvae per middle leaf

There were no treatment effects on mean numbers of live WFT larvae per middle leaf three or six days after the first treatment or six days after the second treatment. Six days after the third treatment, all treatments significantly reduced mean numbers of live larvae from 0.5 per leaf in the water controls to between 0 and 0.1 per leaf ($P<0.05$), Table 13 and Figure 4. At the final assessment, seven days after the fourth treatment, all treatments except for coded product 201 significantly reduced numbers of live WFT larvae per leaf from 0.7 per leaf in the water controls to between 0 and 0.3 per leaf.

Table 13. Mean numbers of live WFT larvae per middle leaf. Numbers in a column sharing the same letters are not significantly different at $P<0.05$ based on least significant differences (LSD).

Numbers in a column sharing the same letters are not significantly different at P<0.05 based on least significant differences (LSD). P = n.s. is not significant. – is not assessed.

Product name or MOPS code	28/7/2014 (1 day before first treatment)	1/8/2014 (3 days after first treatment)	4/8/2014 (6 days after first treatment)	11/8/2014 (6 days after second treatment)	18/8/2014 (6 days after third treatment)	26/8/2014 (7 days after fourth treatment)
1. Water control	-	0.27	0.17	0.15	0.50 b	0.73 b
2. Actara (+ve control)	-	0.02	0.02	0.03	0 a	0.08 a
3. 130	-	0.08	0.15	0.27	0.12 a	0.20 a
4. 179	-	0.15	0.08	0.33	0.13 a	0.32 a
5. 201	-	0.13	0.27	0.20	0.03 a	0.80 b
6. 200	-	0.05	0.02	0.07	0.03 a	0.02 a
7. 207	-	0.08	0.02	0.03	0 a	0 a
8. 48	-	0.12	0.15	0.05	0.02 a	0.02 a
F value (7 df)	-	0.46 (P = n.s.)	0.33 (P = n.s.)	0.09 (P = n.s.)	P<0.001	P<0.001
LSD	-	0.220	0.287	0.237	0.208	0.394

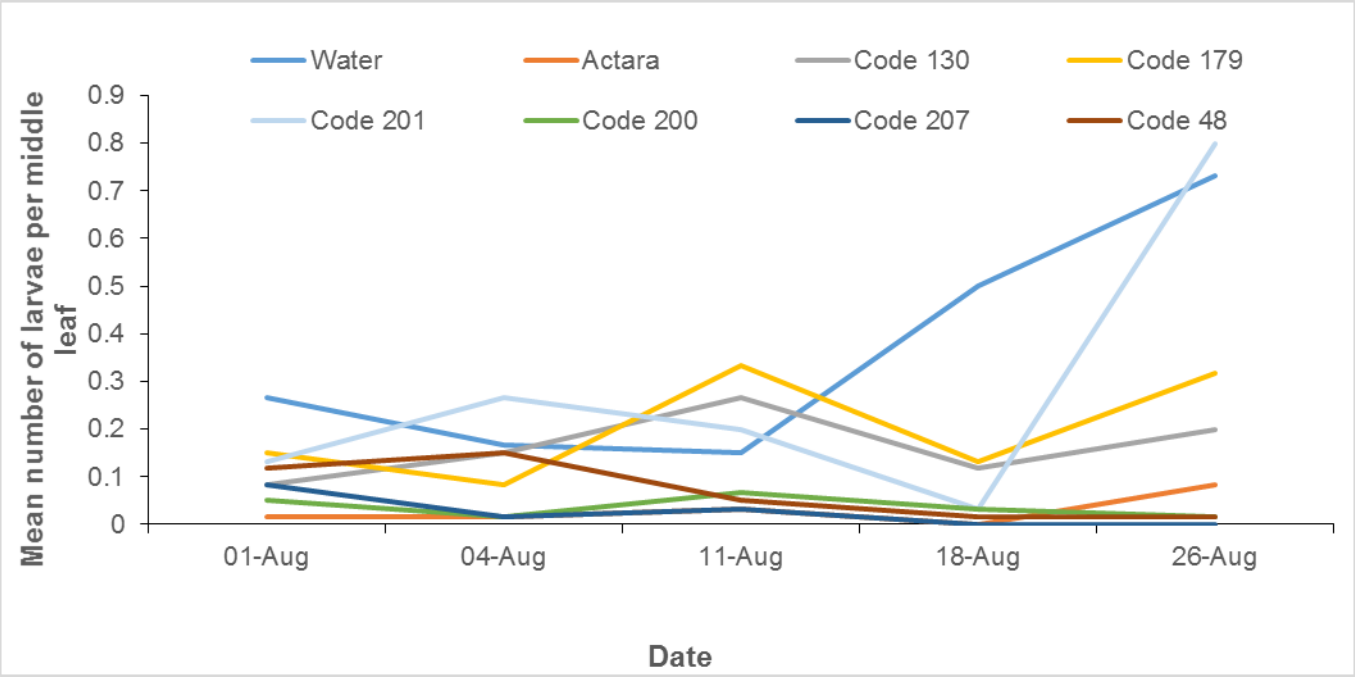


Figure 4. Mean numbers of WFT larvae per middle leaf on each assessment date

WFT damage to top leaves

WFT damage to leaves was only assessed on the final three assessment dates. Six days after the second treatment, Actara and coded products 200 and 48 significantly reduced the mean leaf damage score from 1.1 in the controls (just over 5% leaf area damaged) to 0.5, 0.4 and 0.3 respectively (just under 5% leaf area damaged), $P<0.05$, Table 14 and Figure 5. Six days after the third treatment, all treatments except for coded product 201 reduced the mean leaf damage score from 1.9 in the water controls (5-25% leaf area damaged) to between 0.4 and 1.3 (also within the range of 5-25% leaf area damaged). Coded products 48 and 200 were the most effective. At the final assessment, seven days after the fourth treatment, Actara and coded products 200, 207 and 48 all significantly reduced the leaf damage score from 2.2 in the water controls (5-25% leaf area damaged) to between 0.1 and 0.5 (up to 5% leaf area damaged).

Please note that analysis of a score should be used with caution as data is not normally distributed.

Table 14. Mean WFT damage score per top leaf. Percentage leaf area with thrips damage scored as: 0, 1 (up to 5%), 2 (5-25%), 3 (25-50%) or 4 (over 50%). Numbers in a column sharing the same letters are not significantly different at P<0.05 based on least significant differences (LSD). Numbers in a column sharing the same letters are not significantly different at P<0.05 based on least significant differences (LSD). P = n.s. is not significant. – is not assessed.

Product name or MOPS code	28/7/2014 (1 day before first treatment)	1/8/2014 (3 days after first treatment)	4/8/2014 (6 days after first treatment)	11/8/2014 (6 days after second treatment)	18/8/2014 (6 days after third treatment)	26/8/2014 (7 days after fourth treatment)
1. Water control	-	-	-	1.12 c	1.92 e	2.17 b
2. Actara (+ve control)	-	-	-	0.50 ab	0.72 ab	0.53 a
3. 130	-	-	-	0.80 bc	1.27 cd	1.65 b
4. 179	-	-	-	0.95 bc	1.2 bcd	2.02 b
5. 201	-	-	-	0.97 bc	1.5 de	1.98 b
6. 200	-	-	-	0.43 ab	0.57 a	0.40 a
7. 207	-	-	-	0.67 abc	0.85 abc	0.70 a
8. 48	-	-	-	0.25 a	0.38 a	0.05 a
F value (7 df)	-	-	-	0.01 (P<0.05)	P<0.001	P<0.001
LSD	-	-	-	0.489	0.461	0.640

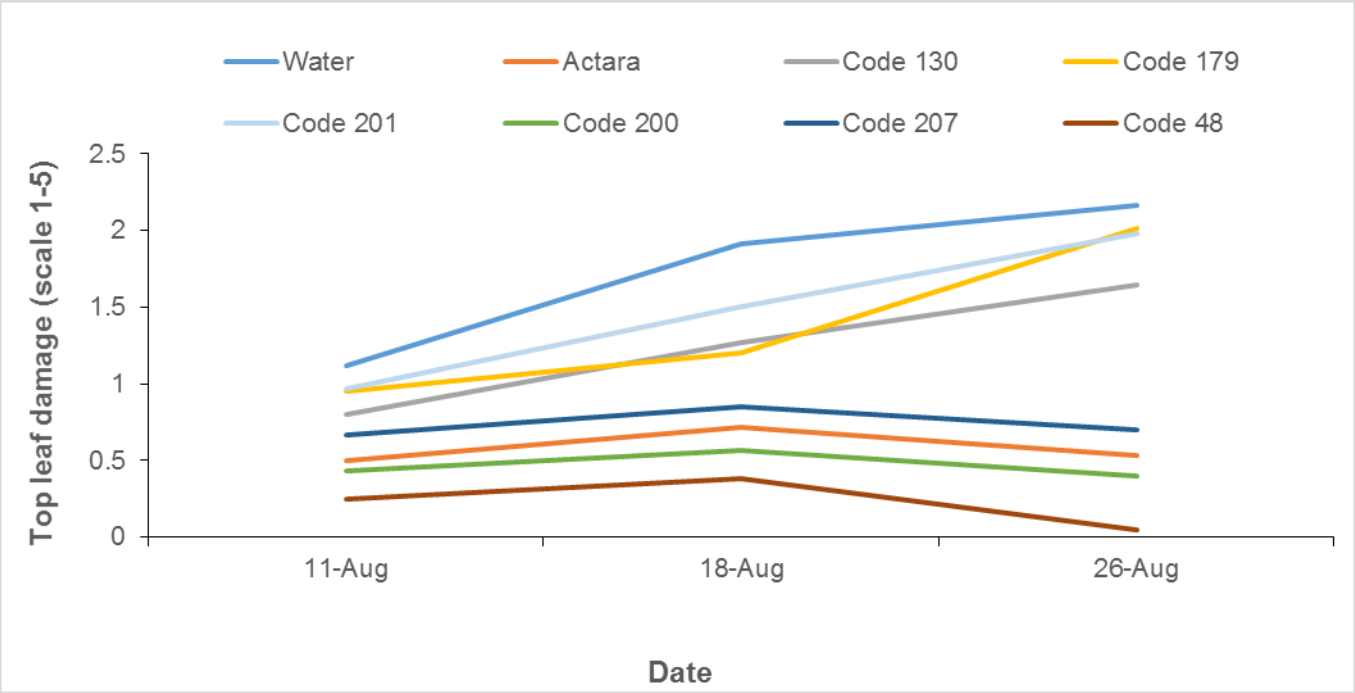


Figure 5. WFT damage score per top leaf on each assessment date

WFT damage to middle leaves

None of the treatments reduced the mean leaf damage score compared with that in the water controls six days after the second or third treatments (Table 15 and Figure 6). However, at the final assessment, seven days after the fourth treatment, coded products 130, 200, 207 and 48 all significantly reduced the mean leaf damage score from 1.4 in the water controls (up to 5% leaf area damaged to 0.5-0.7 (also within the range of up to 5% leaf area damaged), $P<0.05$.

Please note that analysis of a score should be used with caution as data is not normally distributed.

Table 15. Mean WFT damage score per middle leaf. Percentage leaf area with thrips damage scored as: 0, 1 (up to 5%), 2 (5-25%), 3 (25-50%) or 4 (over 50%). Numbers in a column sharing the same letters are not significantly different at P<0.05 based on least significant differences (LSD). Numbers in a column sharing the same letters are not significantly different at P<0.05 based on least significant differences (LSD). P = n.s. is not significant. – is not assessed.

Product name or MOPS code	28/7/2014 (1 day before first treatment)	1/8/2014 (3 days after first treatment)	4/8/2014 (6 days after first treatment)	11/8/2014 (6 days after second treatment)	18/8/2014 (6 days after third treatment)	26/8/2014 (7 days after fourth treatment)
1. Water control	-	-	-	0.57	1.1	1.43 b
2. Actara (+ve control)	-	-	-	0.45	0.68	0.80 ab
3. 130	-	-	-	0.68	0.92	0.72 a
4. 179	-	-	-	0.70	1.32	1.42 b
5. 201	-	-	-	0.70	0.83	1.13 ab
6. 200	-	-	-	0.40	0.43	0.45 a
7. 207	-	-	-	0.42	0.50	0.50 a
8. 48	-	-	-	0.45	0.90	0.52 a
F value (7 df)	-	-	-	0.749 (P = n.s.)	0.052 (P = n.s.)	0.006 (P<0.01)
LSD	-	-	-	0.490	0.563	0.625

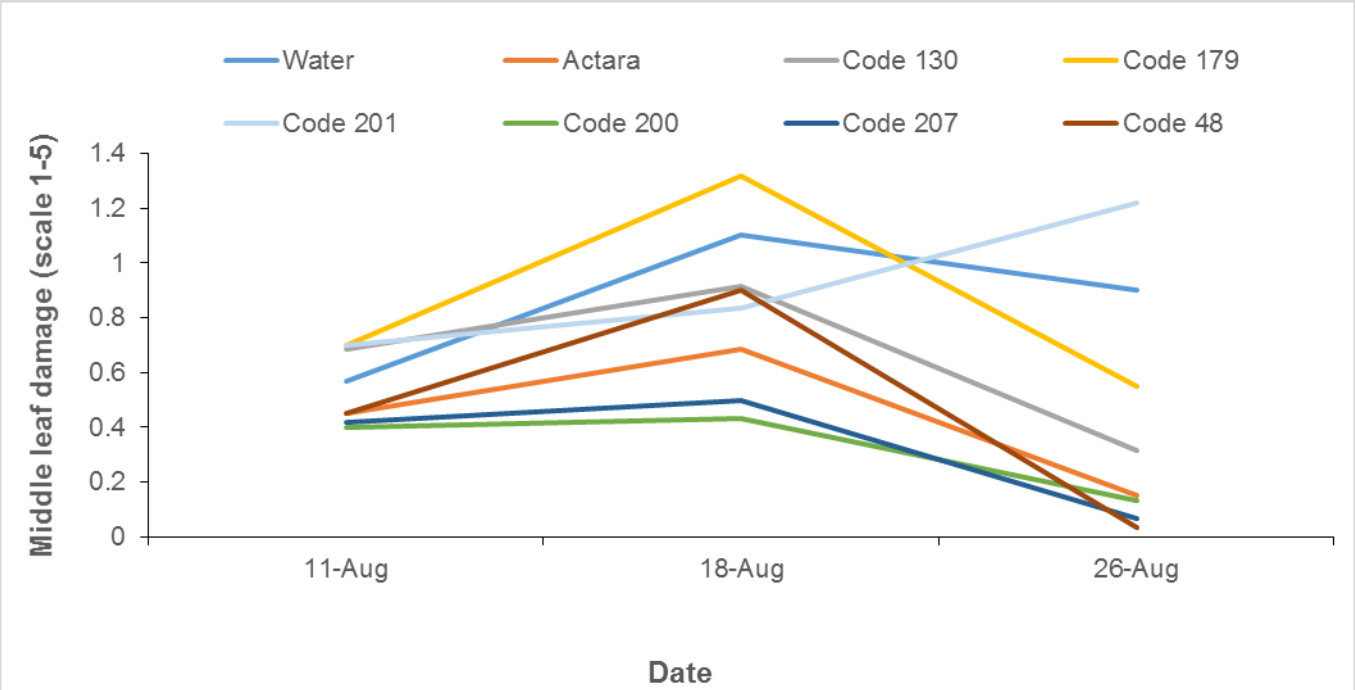


Figure 6. WFT damage score per middle leaf on each assessment date

Crop damage (phytotoxicity)

Symptoms of phytotoxicity were recorded with only one treatment, coded product 179, which caused white spotting to the petals three and six days after the first spray. On day three, the mean damage score was 2.2 (using a score of 1-9 where 1 is slight and 9 is very severe) and spotting was recorded on one flower in each of the six replicate cages. On day six, the mean damage score was 1.3 and spotting was recorded on one flower in three of the six cages. On day six, white spotting was also recorded on the leaves on one plant in one of the six cages.

Formulations

No problems were encountered during mixing or application of any of the product formulations under test.

Effect on non-targets

No effects on other pests were noted during completion of this experiment. A slight infestation of glasshouse and potato aphid (*Aulacorthum solani*) was recorded but this was effectively controlled by releasing the aphid parasitoid *Aphidius ervi* in every cage.

Discussion

None of the treatments reduced numbers of WFT adults or larvae per flower or per middle leaf three or six days after the first treatment. The only significant effect of treatment within the first week of treatment was that six days after the first treatment, coded conventional product 48 reduced numbers of WFT larvae per top leaf compared with those in the water controls. These results indicated that overall, none of the products are likely to provide a quick 'knockdown' effect on WFT.

On the last three assessment dates, numbers of flowers per cage were too variable to draw any meaningful results from the data, with some cages having no flowers at all due to senescence caused by WFT damage. Therefore only the efficacy data from top and middle leaves can be used on these assessment dates. When the data on the effect of treatment on number of live flowers per cage were analysed, on the final assessment date, mean numbers of flowers were increased compared with in water controls by Actara and the other three conventional treatments.

None of the treatments significantly reduced numbers of WFT adults per top or middle leaf compared with the water controls on any assessment date. Where a significant reduction in thrips numbers was given compared with water controls, only numbers of larvae were reduced. This could have been due to the treatments killing the larvae, and/or due to sub-lethal effects such as reducing egg laying by the adult females. The only treatment effects on numbers of WFT adults were that on the final assessment date, Actara and coded treatments 130, 200 and 48 significantly reduced numbers of adults per top leaf compared with coded treatment 179 and all treatments except for treatment 179 significantly reduced numbers of adults per middle leaf compared with coded product 201.

Actara (thiamethoxam) was used as the positive control in this experiment as it was considered to be the only currently approved conventional insecticide that might give control of the spinosad-resistant population of WFT used, which is typical of those found on many protected ornamental nurseries. However, Actara, although having an EAMU for use on protected ornamentals for control of WFT, is unlikely to be used by growers of flowering ornamentals as it is subject to the current EU restrictions on the use of neonicotinoids on flowering plants considered to be attractive to bees. Actara may only be used in a glasshouse and treated plants must not be moved outside (or sold) until after they have finished flowering. In addition, Actara and all the other treatments were applied four times at weekly intervals and the EAMU restricts the use of Actara to a maximum number of two applications per structure per year, as a resistance management strategy. Actara did not significantly reduce numbers of WFT larvae until six days after the second treatment, when it was equally effective on top leaves as the three conventional coded products. Actara also gave a significant reduction of WFT larvae on both top and middle leaves six days after the third treatment,

when it was equally effective as all other treatments. On the final assessment date, seven days after the fourth treatment, Actara significantly reduced numbers of WFT larvae per middle leaf, when it was equally effective as all treatments except the biopesticide code 201 which was ineffective.

Conventional treatment 48 was the only treatment that significantly reduced numbers of larvae per top leaf compared with the water controls six days after the first treatment. On the three subsequent assessment dates, six days after the second and third treatments and seven days after the fourth treatment, all three conventional treatments (200, 207 and 48) was equally effective as Actara at reducing numbers of larvae on either top or middle leaves.

The three biopesticide treatments (130, 179 and 201) were only effective in reducing numbers of larvae compared with the water controls on the last two assessment dates, six and seven days after the third and fourth treatments respectively. Six days after the third treatment, all three biopesticides were as effective as Actara and the other three conventional treatments on both top and middle leaves. Seven days after the fourth treatment, biopesticides 130 and 179 were as effective as Actara and the other three conventional treatments on middle leaves but biopesticide 201 was ineffective.

Significant reductions in numbers of larvae were given on top leaves on three of the assessment dates and on middle leaves on two of the dates. This indicates that although the results with the water sensitive paper indicated that coverage of the lower surface of middle leaves was less good than that of top leaves, sufficient spray coverage reached middle leaves to have an effect on WFT larvae (which were found on both upper and lower leaf surfaces). Actara is both systemic and translaminar in action, conventional treatment 207 is systemic and conventional treatments 48 and 200 have translaminar action, so the four conventional treatments should have had some effect even if spray coverage was less effective on the undersides of leaves than on upper surfaces. None of the biopesticide treatments are either systemic or translaminar and therefore would require good coverage to achieve best effect.

Where numbers of WFT larvae were reduced on top leaves on the last three assessment dates, there was a corresponding reduction in thrips damage except for with conventional treatment 207 six days after the second treatment and with biopesticide treatment 201 six days after the third treatment. Where numbers of WFT larvae were reduced on middle leaves on the last two assessment dates, there was only a corresponding reduction in leaf damage on the final assessment date, seven days after the fourth treatment. This was probably due to numbers of WFT larvae being lower on middle leaves than on top leaves and thus less leaf damage occurred.

The only phytotoxicity symptoms observed were with biopesticide treatment 179, which caused white spotting to petals on a small number of flowers three and six days after the first treatment,

and white spotting to leaves on one plant only, six days after the first treatment. This treatment had been recommended to be used in this experiment as a fine mist (e.g. 150 litres per ha) by the suppliers but was used as a high volume spray to be consistent with the application method for all other treatments, and with spray methods commonly used by commercial growers. It is possible that had the treatment been applied as a fine mist, this phytotoxicity symptom may not have occurred. However, the supplier's own phytotoxicity data suggested that when applied at water volumes of 1,500 litres per ha (600 l/ha was used in this experiment), the product was safe to some ornamental species flowers and leaves when applied at 0.5-2% dose rates and only damaged the leaves of another species when applied at the 2% dose rate (0.4% dose rate used in this experiment).

Conclusions

- Verbena plants were successfully infested with WFT and numbers increased in flowers and on leaves on assessment dates during the experiment in the water-treated controls.
- None of the treatments gave control of WFT adults in flowers or on leaves compared with water-treated controls. However, on the final assessment date Actara (positive control), biopesticide treatment 130 and conventional treatments 200 and 48 reduced numbers of WFT adults per top leaf compared with biopesticide treatment 179 and all treatments reduced numbers of adults per middle leaf compared with biopesticide treatment 201.
- None of the treatments gave a quick knock-down of WFT three days after the first treatment. Only one treatment (conventional treatment 48) reduced numbers of larvae per top leaf compared with water controls six days after the first treatment.
- Actara reduced numbers of WFT larvae on leaves compared with water-treated controls on the last three assessment dates. Numbers of larvae were reduced on top leaves six days after the second treatment, on both top and middle leaves six days after the third treatment and on middle leaves seven days after the fourth treatment.
- The three conventional treatments (50, 207 and 48) were equally effective as Actara in reducing numbers of WFT larvae compared with water-treated controls on either top or middle leaves on the last three assessment dates.
- The three biopesticide treatments (130, 179 and 201) reduced numbers of WFT larvae compared with water-treated controls on the last two assessment dates. Six days after the third treatment, all three biopesticides were as effective as Actara and the other three conventional treatments on both top and middle leaves. Seven days after the fourth

treatment, biopesticides 130 and 179 were as effective as Actara and the other three conventional treatments on middle leaves but biopesticide 201 was ineffective.

- Although significant reductions in WFT numbers were given in this experiment, WFT damage to flowers and leaves would have made the plants unmarketable in all treatments. Therefore the treatments have most potential for contributing to WFT control as part of an IPM programme, together with the use of biological control agents such as the predatory mite *Neoseiulus cucumeris*. Safety of the treatments to biological control agents would need confirming.
- Biopesticide 179 caused white spotting to petals on a small number of flowers three and six days after the first treatment and white spotting to leaves on one plant only, six days after the first treatment.

References

Bielza P (2008) Insecticide resistance management strategies against the western flower thrips, *Frankliniella occidentalis*. Pest Manag. Sci. **64**, 1131-1138.

Bennison, J. (2009). Thrips control on protected ornamental crops. *HDC Factsheet 14/09.*

O'Neill, T. & Bennison, J. (2010). *Tomato spotted wilt virus* in protected edible crops. *HDC Factsheet 23/10.*

Appendix A – Study conduct

ADAS is officially recognised by United Kingdom Chemical Regulations Directorate as competent to carry out efficacy testing. The experiments reported were carried out according the internal ADAS operating procedures

GLP compliance will not be claimed in respect of this study.

Relevant EPPO/CEB 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
PP 1/160(2)	Thrips on glasshouse crops	Size of cages and plants limited the number of plants per plot to nine rather than a minimum of 15. Six replicates of each treatment rather than the minimum of four.

There were no significant deviations from the EPPO and national guidelines other than those indicated above

Appendix B – Meteorological data

Location of the weather station	On site (ADAS Boxworth)
Distance to the trial site	0 m
Origin of the weather data	Weather station for long term average Data logger for average conditions during the trial

Long-term averages from *location* Boxworth 30 year mean

Month/period	Av temp (ºC)	Min temp (ºC)	Max temp (ºC)	Rainfall (mm)
May	11.8	6.9	16.8	43.5
June	14.8	9.6	19.9	50.8
July	17.3	11.8	22.8	45.8
August	17.5	12.2	22.6	51.9

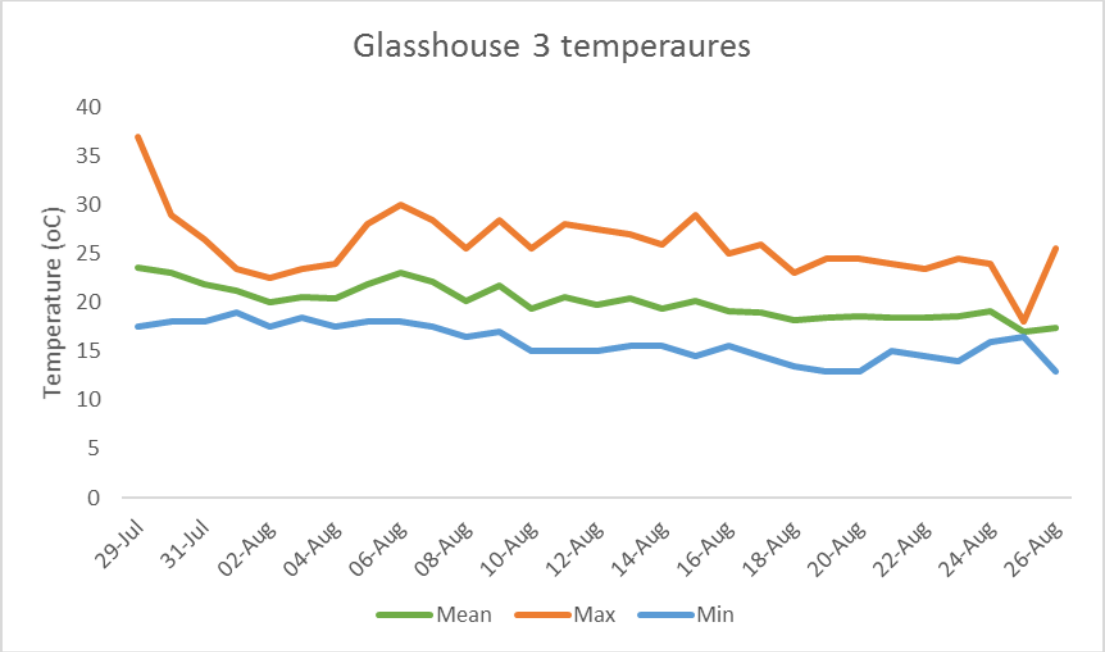
Average conditions during the trial:

Month/period	Av temp (ºC)	Min temp (ºC)	Max temp (ºC)	Av RH (%)*	Rainfall (mm)
Glasshouse 3	20.1	15.9	25.9	87.7	n/a
Glasshouse 4	19.5	15.3	25.1	89.7	n/a

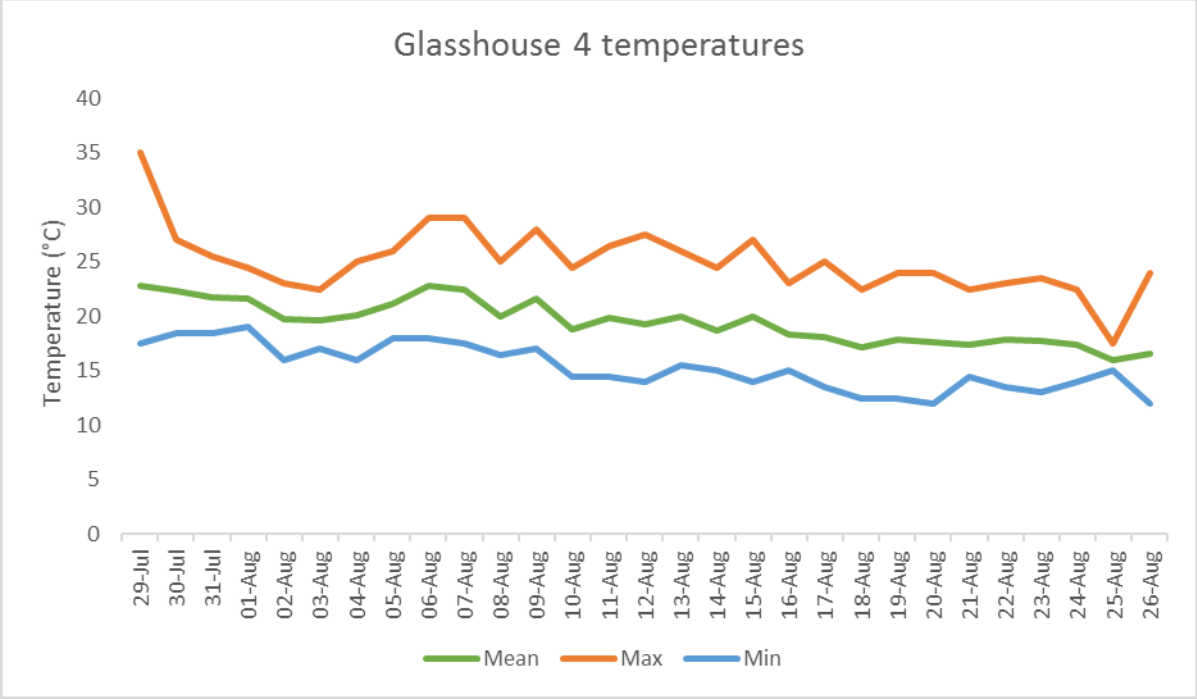
***protected crops only**

Weather at treatment application period (in vestibules of glasshouses 3 and 4):

Month/period	Min temp (ºC)	Max temp (ºC)	Rainfall (mm)
29/7/2014	32.4	32.7	-
5/8/2014	23.9	29.5	-
12/8/2014	26.7	27.1	-
19/9/2014	19.1	19.7	-



Mean, maximum and minimum temperatures in cages in glasshouse 3



Mean, maximum and minimum temperatures in cages in glasshouse 4

Appendix C – Agronomic details

Growing system

Crop	Cultivar	Planting/sowing date	Row width (m) or pot spacing
Verbena	Quartz	Plug plants potted up on 21 May 2014	9 cm pots arranged in three rows of three, spaced 5 cm apart

Other pesticides - active ingredient(s) / fertiliser(s) applied to the trial area

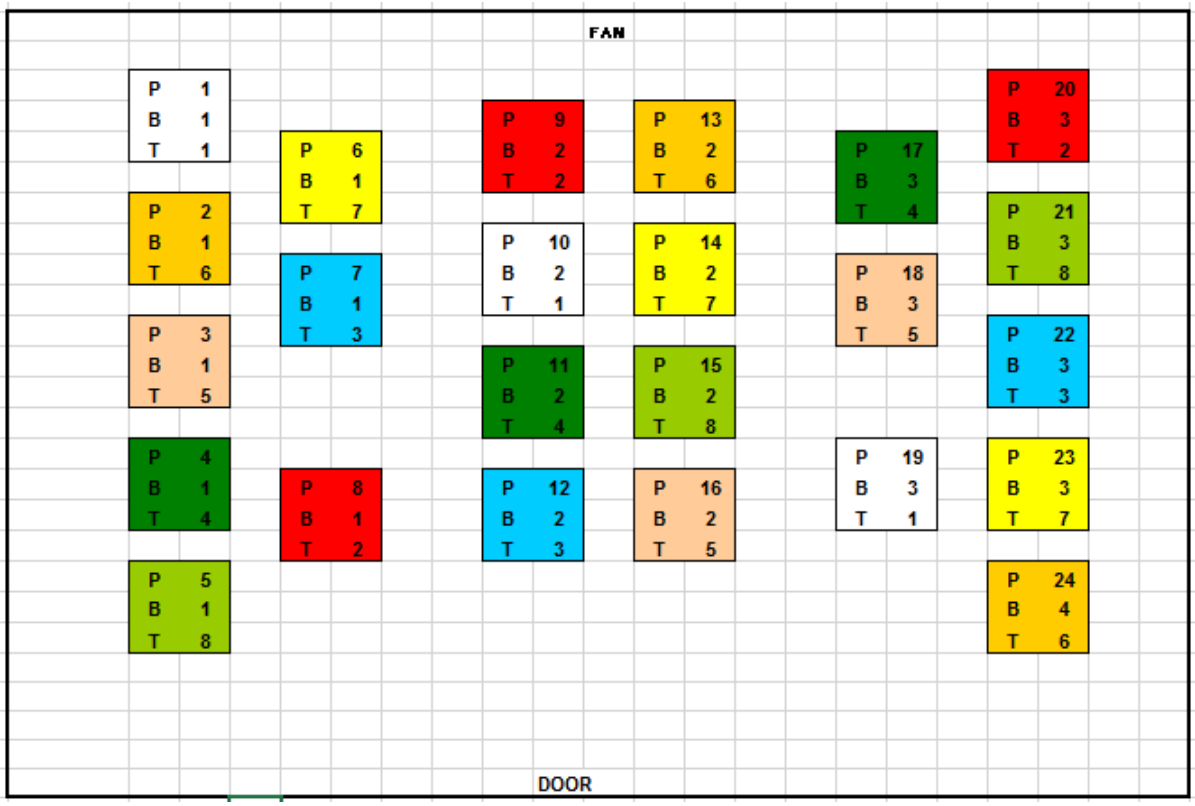
Date	Product	Rate	Unit
24 July and 7 August	The aphid parasitoid *Aphidius ervi* applied for control of glasshouse and potato aphid, *Aulacorthum solani*	5 per cage	

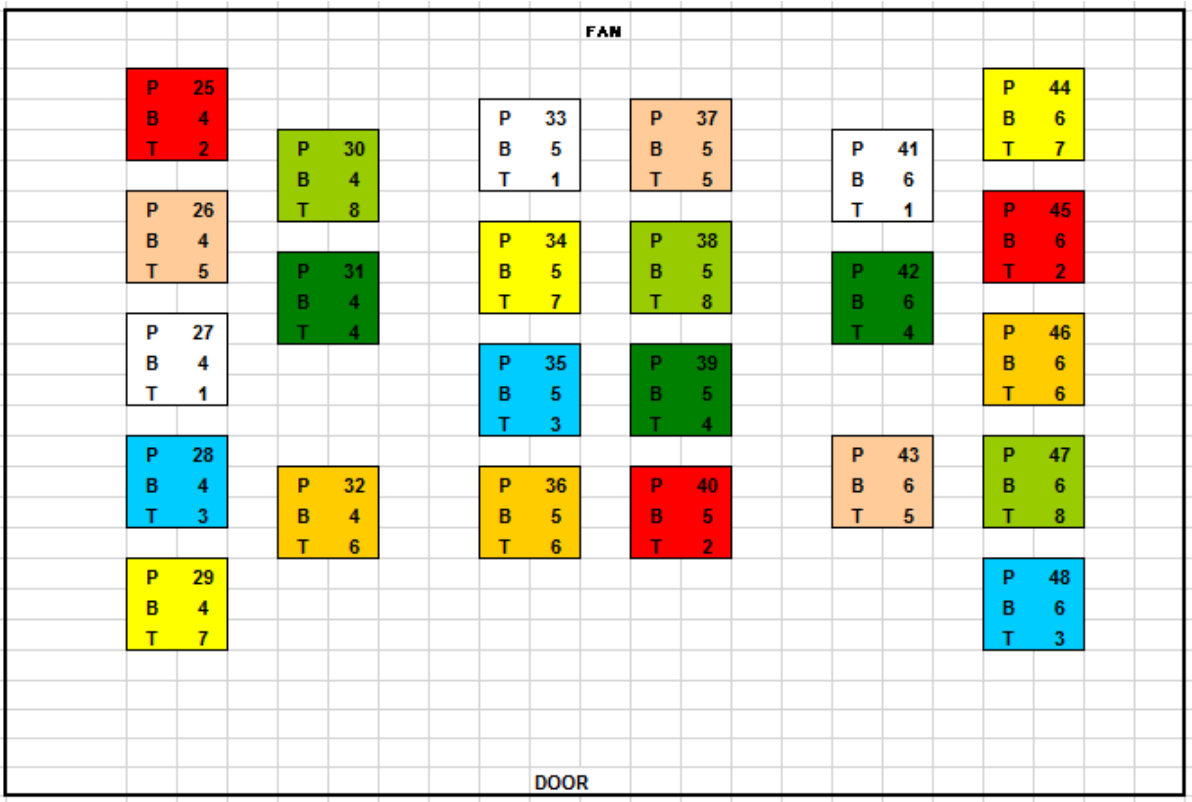
Details of irrigation regime (pot-grown crops)

Type of irrigation system employed (e.g. overhead sprinkler, hand watering, drip, ebb and flow, capillary sandbed or capillary matting)
Drip-irrigation onto capillary matting underneath cages

Appendix D – Trial layout in glasshouse 3 (top) and 4 (bottom)

(P = plot, B = block, number 1-8 = treatment number)





Appendix E – Copy of the Certificate of Official Recognition of Efficacy Testing Facility or Organisation

Certificate of

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

This certifies that

ADAS UK Limited

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: 10 May 2013
Effective date: 18 March 2013
Expiry date: 17 March 2018

Signature

Authorised signatory

Certification Number
ORETO 339

HSE
Chemicals Regulation Directorate

Department of Agriculture and Rural Development

Appendix F – Photographs

Figure 1. Plots (cages) in glasshouse compartment

Figure 2. Arrangement of 9 verbena plants per cage

Figure 3. WFT damage to verbena petals

Figure 4. WFT damage to verbena leaves

	
Figure 5. Phytotoxicity (white spotting to petals) caused by biopesticide treatment 179	Figure 6. WFT larva

