Project title:	Brassicas: module drenches to control cabbage root fly
Project number:	FV 416
Project leader:	Dr Rosemary Collier Warwick Crop Centre School of Life Sciences The University of Warwick
Report:	Final report, November 2013
Previous report:	None
Key staff:	Rosemary Collier – project management Andrew Jukes – establishment of field trial and data collection Julie Jones – experimental design and analysis
Location of project:	Warwick Crop Centre, Wellesbourne, Warwick, CV35 9EF
Industry Representative:	Andy Richardson Allium and Brassica Centre Wash Road, Kirton, Boston Lincs, PE20 1QQ
Date project commenced:	1 May 2013
Date project completed (or expected completion date):	30 November 2013

[The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the trials 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.

Dr Rosemary Collier
Director
Warwick Crop Centre, School of Life Sciences, University of Warwick

Signature ..... Date .....

Report authorised by:

[Name]
[Position]
[Organisation]

Signature ..... Date .....

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GROWER SUMMARY

Headline

Tracer found to be an acceptable alternative to Dursban WG.

Background

For many years the cabbage root fly (*Delia radicum*) has been controlled on transplanted Brassica crops through the application of an organophosphorus insecticide (chlorpyrifos – Dursban WG) to the modules prior to transplanting. However, the future of this treatment is now uncertain. Within the last decade, an alternative treatment (spinosad – Tracer) has become available to growers, but whilst Dursban has been available, Tracer has not been used widely. One of the reasons for its limited use is the perception that Tracer is not such an effective treatment. Now that future use of Dursban is likely to be time-limited, it is important to establish whether there are limitations in the performance of Tracer.

Tracer drench treatments have been evaluated extensively in HDC projects on control of cabbage root fly and in general, when modules are transplanted immediately after treatment, there is little difference (on average) in the levels of control achieved with Tracer and Dursban. On all transplanted brassica crops, effective control is most critical during a period of several weeks after planting, whilst the plants are small and the root system is establishing. Larger, established plants can withstand a certain amount of cabbage root fly damage. One of the most recent comparisons of these two treatments was undertaken in a LINK project on companion planting for cabbage root fly control (FV 251), where both treatments were used as positive controls in field trials, mainly in commercial crops in Lincolnshire. In a total of 15 trials, and considering root damage:

Tracer performed better than Dursban on 8 occasions,
Dursban was better than Tracer on 2 occasions
There was no statistically significant difference on 5 occasions.

However, the performance of Tracer under sub-optimal conditions has not been evaluated and this is particularly in relation to delays in planting, where the modules have been treated but planting is delayed, often due to adverse weather conditions. There is concern that the effectiveness of the Tracer treatment may diminish while the plants are standing and that this will shorten the period when the treatment is effective once the plants are growing in the

soil. The key aim of this project was to undertake a field trial to establish whether this is likely to happen. A second aim was to evaluate the performance of some novel pre-planting treatments.

Summary

Two types of trial were conducted. The first was a field trial to assess the performance of aged treatments of Tracer and Dursban WG together with some novel treatments. The second was a glasshouse trial and concerned the persistence of Tracer and Dursban WG module drench treatments after heavy watering events.

Field trials

Two field trials were conducted using cauliflower as the test crop. Including an untreated control, there were 13 treatments. Tracer (spinosad) and Dursban WG (chlorpyrifos) were applied pre-planting 2 weeks, 1 week and 1 day before planting and further Tracer treatments applied at 1 week and 1 day before planting were heavily watered. Additional treatments included Mundial (fipronil) seed treatment and two biological treatments (one of which was a plant extract). One trial was timed to coincide with the peak of first generation cabbage root fly egg laying and the other with the peak of second generation egg laying. The cauliflower seed (cv Seoul) was sown on 17 April 2013 (Trial 1a) and 21 May 2013 (Trial 1b), transplanted on 25 May 2013 (Trial 1a) and 10 July 2013 (Trial 1b) and harvested on 28 June (Trial 1a – 5 weeks after planting) and 8 August (Trial 1b – 4 weeks after planting).

The harvested plants were weighed, and the roots and stems were scored for damage by cabbage root fly larvae. There was more damage to untreated plants in Trial 1b than in Trial 1a. Treatments performed similarly in both trials.

Most treatments increased plant weight in one or both trials compared with the untreated control, except HDCI055 which did not increase plant weight in either trial. There was some evidence of treatment timing affecting plant weight in Trial 1a, but there were no differences between Tracer and Dursban WG.

Most treatments decreased root damage in one or both trials compared with the untreated control, except HDCI056 which did not decrease root damage in either trial. In both trials, there were no differences between Dursban WG treatments or Tracer treatments at all treatment times. HDCI055 was more effective applied pre-planting than post-planting but

less effective than either Dursban WG or Tracer. The Mundial seed treatment was as effective as Dursban WG and Tracer.

Most of the treated plants had less stem damage than the untreated control, but this was only statistically significant with all of the Dursban WG treatments and in Trial 1a, with HDCI056 and Tracer treatments applied at Day 1 and Week 1 (plus heavy watering). There were no statistically significant differences between Dursban WG treatments but there was a clear reduction in efficacy with ageing residues. Although there were some significant differences between Tracer treatments and the control, there were no significant differences between any of the Tracer treatments and there was a less obvious effect of treatment time. At all treatment times Dursban WG treatments had less damage than Tracer treatments.

Glasshouse trial

In a glasshouse trial to determine the persistence of drench treatments, half the modules (containing calabrese plants) in six 345 Hassy trays were treated with Tracer and the other half were treated with Dursban WG (3 trays of each). Between sampling and watering events, the trays were maintained at maximum moisture-holding capacity on capillary matting. The modules were sampled (10 modules/treatment from each replicate tray) 1, 4, 7, 10, 13 and 16 days after treatment and watered once, heavily from above, between sampling occasions. Insecticide residue analysis was performed by ALS Food & Pharmaceutical.

The concentration of both insecticides declined gradually with time. After 16 days, 70% and 63% of the applied spinosad and chlorpyrifos respectively remained.

Main conclusions

- Module drench treatments of Tracer were as effective as Dursban WG at protecting the root zone of transplanted cauliflowers from attack by cabbage root fly larvae.
- The efficacy of Tracer was only marginally diminished when planting was delayed for 2 weeks following treatment or by heavy watering of the modules pre-planting.
- Residue studies suggested that Tracer was at least as persistent as Dursban WG when treated modules were exposed to a series of heavy watering events and stored at maximum moisture capacity.
- In most circumstances Tracer is likely to be an acceptable alternative to Dursban WG.

Financial Benefits

Without adequate insecticidal control, crop losses due to cabbage root fly damage would be considerable. It is estimated that about 24% of the plants in field brassica crops would be rendered unmarketable by the cabbage root fly without the application of effective control methods. Tracer appears to be as persistent in the module as Dursban WG and as effective in the field at controlling cabbage root fly in the root zone.

Action Points

- The work has shown that Tracer is as effective as Dursban WG so growers should consider Tracer as an alternative treatment

SCIENCE SECTION

Introduction

For many years the cabbage root fly (*Delia radicum*) has been controlled on transplanted brassica crops through the application of an organophosphorus insecticide (chlorpyrifos – Dursban) to the modules prior to transplanting. However, the future of this treatment is now uncertain. Within the last decade, an alternative treatment (spinosad – Tracer) has become available to growers, but whilst Dursban has been available, Tracer has not been used widely. One of the reasons for its limited use is the perception that Tracer is not such an effective treatment. Now that future use of Dursban is likely to be time-limited, it is important to establish whether there are limitations in the performance of Tracer.

Tracer drench treatments have been evaluated extensively in HDC projects on control of cabbage root fly and in general, when modules are transplanted immediately after treatment, there is little difference (on average) in the levels of control achieved with Tracer and Dursban. On all transplanted brassica crops, effective control is most critical during a period of several weeks after planting, whilst the plants are small and the root system is establishing. Larger, established plants can withstand a certain amount of cabbage root fly damage. One of the most recent, comparisons of these two treatments was undertaken in a LINK project on companion planting for cabbage root fly control (FV 251), where both treatments were used as positive controls in field trials, mainly in commercial crops in Lincolnshire. In a total of 15 trials, and considering root damage:

- Tracer performed better than Dursban on 8 occasions,
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However, the performance of Tracer under sub-optimal conditions has not been evaluated and this is particularly in relation to delays in planting, where the modules have been treated but planting is delayed, often due to adverse weather conditions. There is concern that the effectiveness of the Tracer treatment may diminish while the plants are standing and that this will shorten the period when the treatment is effective once the plants are growing in the soil. The key aim of this project was to undertake a field trial to establish whether this is likely to happen. A second aim was to evaluate the performance of some novel pre-planting treatments.

Two types of trial were conducted. The first was a field trial to assess the performance of aged treatments of Dursban WG and Tracer together with some novel treatments. The second was a glasshouse trial and concerned the persistence of Dursban WG and Tracer module drench treatments after heavy watering events.

Materials and methods

Field trials

Cabbage root fly numbers and egg laying were monitored in cauliflower and swede crops at Warwick Crop Centre, Wellesbourne. Two trials were conducted near to the monitoring plots. One was timed to coincide with the peak of first generation cabbage root fly egg laying and the other with the peak of second generation egg laying. For both trials the crop investigated was cauliflower and there were 13 insecticide treatments (Table 1), three of which were biological. The cauliflower seed (cv Seoul, Moles Seeds) was sown in 308 Hassy trays on 17 April 2013 (Trial 1a) and 21 May 2013 (Trial 1b). One tray was sown with seed treated with fipronil (Mundial) and six trays were sown with insecticide-free seed. All of the trays were placed in a greenhouse. Drench treatments were applied using a 1 ml automatic pipette (except HDCI056 – applied in 3.5 ml) at various times (Table 2) according to the treatment schedule. Treatments were washed onto the modules with an equivalent volume of water. One Tracer treatment (treated 1 day before planting) also received one additional heavy watering 4 hours after treatment and another Tracer treatment (treated 1 week before planting) received an additional four heavy waterings 4 hours, 2, 4 and 6 days after treatment. Samples were taken from treatments 1 – 6 (10 modules/treatment) immediately after treatment and immediately before planting. In all cases the plant was removed at the module surface with scissors and the modules were sealed in plastic bags and frozen (-20^{0}C) before dispatch for analysis. Residue analysis was performed by ALS Food & Pharmaceutical, Chatteris, PE16 6QZ. All plants were transplanted on 25 May 2013 (Trial 1a) and 10 July 2013 (Trial 1b). The post-planting treatments (9 and 11) were applied in 70 ml water, around the base of the plant, using a beaker. The trial was laid out as a balanced row and column design with 4 rows and 14 columns. Treatments were replicated 4 times with 8 replicates of the untreated control. Each plot was 3.5 m x 1 bed (1.83 m wide) and there were 4 rows per bed. The plants were spaced at 50 cm along rows and 35 cm between rows. In total, each plot contained 32 plants.

Table 1. Treatments used in trials on cauliflower

Code	Product	a.i.	Application timing	Rate (product/1,000 plants)	Watering
1	Dursban WG	Chlorpyrifos	2 weeks pre-transplanting	6 g	Maintain at moisture capacity with capillary matting
2	Tracer	Spinosad	2 weeks pre-transplanting	12 ml	Maintain at moisture capacity with capillary matting
3	Dursban WG	Chlorpyrifos	1 week pre-transplanting	6 g	Maintain at moisture capacity with capillary matting
4	Tracer	Spinosad	1 week pre-transplanting	12 ml	Maintain at moisture capacity with capillary matting
5	Dursban WG	Chlorpyrifos	1 day pre-transplanting	6 g	Maintain at moisture capacity with capillary matting
6	Tracer	Spinosad	1 day pre-transplanting	12 ml	Maintain at moisture capacity with capillary matting
7	Untreated				
8	HDCI055		1 day pre-transplanting	120 ml	Maintain at moisture capacity with capillary matting
9	HDCI056		1 hour pre-transplanting + post planting		Maintain at moisture capacity with capillary matting
10	Mundial	Fipronil	Seed treatment		Maintain at moisture capacity with capillary matting
11	HDCI055		Post-transplanting	120 ml	Maintain at moisture capacity with capillary matting
12	Tracer	Spinosad	1 day pre-transplanting	12 ml	Maintain at moisture capacity with capillary matting 3 l water/tray overhead 4 hours after treatment
13	Tracer	Spinosad	1 week pre-transplanting + 4 x heavy watering after application	12 ml	Maintain at moisture capacity with capillary matting 4 x 3 l water/tray overhead 4 hours, 2 days, 4 days and 6 days after treatment

Table 2. Treatment dates in trials on cauliflower

Code	Product	a.i.	Application timing	Treatment Date	
				Trial 1a	Trial 1b
1	Dursban WG	Chlorpyrifos	2 weeks pre-transplanting	7 May	26 June
2	Tracer	Spinosad	2 weeks pre-transplanting	7 May	26 June
3	Dursban WG	Chlorpyrifos	1 week pre-transplanting	14 May	3 July
4	Tracer	Spinosad	1 week pre-transplanting	14 May	3 July
5	Dursban WG	Chlorpyrifos	1 day pre-transplanting	20 May	9 July
6	Tracer	Spinosad	1 day pre-transplanting	20 May	9 July
7	Untreated				
8	HDCI055[1]		1 day pre-transplanting	20 May	9 July
9	HDCI056[1]		1 hour pre-transplanting + 2 weeks post planting	21 May	10 July
10	Mundial	Fipronil	Seed treatment	17 April	
11	HDCI055[1]		Post-transplanting	30 May	17 July
12	Tracer	Spinosad	1 day pre-transplanting	20 May	9 July
13	Tracer	Spinosad	1 week pre-transplanting + 4 x heavy watering after application	14 May	3 July

[1] Biological treatment

Assessments

On 28 June (Trial 1a) and 8 August (Trial 1b), 12 cauliflower plants were sampled from the centre of each plot. After washing, the roots and stems of each plant were assessed for damage caused by cabbage root fly larvae. The stem covers the area of the plant above the module but below the soil surface. Root and stem damage were assigned a score based on the estimated surface area which had been visibly damaged due to feeding by larvae of the cabbage root fly. The scale used was 0 = no damage, 1 = 0 - 5%, 2 = 5 - 10%, 3 = 10 - 25%, 4 = 25 - 50% and 5 = >50%. The weights of the roots and foliage were also recorded.

Glasshouse trial

Calabrese transplants were supplied by the Allium & Brassica Centre. Six 345 Hassy trays were received. The centre row of 15 plants was removed and half of each tray (11 rows x 15 plants) was treated with Tracer and the other half was treated with Dursban WG (Table 3). Both treatments were applied in 1 ml of treatment solution using a laboratory pipette. The treatments were washed-in with a similar volume of water. Between sampling and watering events the trays were maintained at approximately 100% moisture holding capacity on capillary matting. Sampling and watering dates are displayed in Table 4. Water (4 litres/tray) was applied with a watering can and all of the water which ran through the tray was collected and the volume recorded (Table 4). Samples (10 modules/treatment from each replicate tray) were taken 1, 4, 7, 10, 13 and 16 days after treatment. In all cases the plant was removed at the module surface with scissors and the modules were sealed in plastic bags and frozen (-20^{0}C) before dispatch for analysis. Residue analysis was performed by ALS Food & Pharmaceutical, Chatteris, PE16 6QZ.

Table 3. Treatments applied in glasshouse watering trial

Code	Product	a.i.	Rate (product/1000 plants)	Rate (mg a.i./module)
1	Dursban WG	Chlorpyrifos	6 g	4.5
2	Tracer	Spinosad	12 ml	5.76

Table 4.Treatment, watering and sampling dates and water run-through collected in the glasshouse watering trial.

			Volume water collected (l)					
		Replicate	A	B	C	D	E	F
Action	Days after treatment	Date						
Water		21 Apr						
Treatment	0	22 Apr						
Sample	1	23 Apr						
Water	2	24 Apr	2.70	2.75	3.00	2.80	2.90	2.85
Sample	4	26 Apr						
Water	5	27 Apr	2.95	3.15	3.00	3.00	3.20	2.70
Sample	7	29 Apr						
Water	8	30 Apr	3.25	3.10	3.20	2.80	3.10	2.75
Sample	10	2 May						
Water	11	3 May	3.20	3.25	3.20	2.85	3.10	3.15
Sample	13	5 May						
Water	14	6 May	3.00	3.20	2.85	2.75	3.05	2.80
Sample	16	8 May						

Results

Field trials

Statistical analysis

All analyses were performed using analysis of variance (ANOVA). Interpretations were made using the treatment means together with standard errors of the difference (SED) and least significance difference (LSD) values. There were 4 replicates of each treatment and 8 replicates of the untreated control arranged in a balanced row and column design with 14 rows and 4 columns.

Cabbage root fly activity

The numbers of eggs laid on cauliflower plants in the monitoring plot are shown in Figure 1. First and second fly generation egg laying peaked in late May and late July respectively.

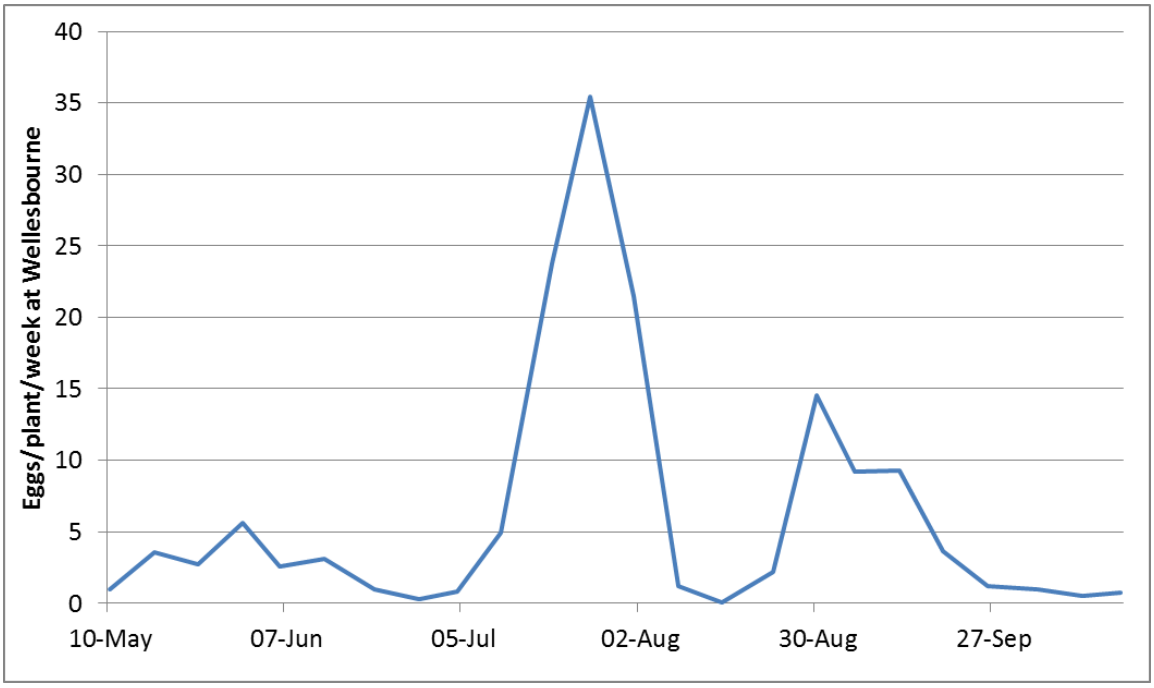

Figure 1 The numbers of cabbage root fly eggs laid per plant per week on cauliflower plants at Warwick Crop Centre, Wellesbourne in 2013

Phytotoxicity

None of the insecticide treatments had phytotoxic effects.

Mid-season assessments

No data transformations were required for any of the analyses (root damage, stem damage, plant weight). The treatment factor was significant at the 5% level using an F-test for all of the analyses and the results are presented in Table 5, Figure 2 and Figure 3 (plant weight), Table 6, Figure 4 and Figure 5 (root damage) and Table 7, Figure 6 and Figure 7 (stem damage).

Plant weight

In Trial 1a, all of the treatments except the two treatments with HDCI055 increased plant weight compared to the untreated control. Comparing Dursban WG treatments; the 1-day treatment gave larger plants than the 2-week treatment. Similarly the 1-week Tracer treatment gave larger plants than the 2-week treatment but not the other Tracer treatments. At all treatment time points there was no difference between Dursban WG and Tracer.

In Trial 1b, only the week 1, week 2 and week 1 (watering) Tracer treatments and week 1 and Day 1 Dursban WG treatments increased plant weight compared with the untreated

control. There were no differences between Dursban WG treatments or Tracer treatments and at all treatment times there was no difference between Dursban WG and Tracer.

Table 5. Plant weight in two cauliflower trials

			Plant weight (g)	
Code	**Product**	**Application timing**	**Trial 1a**	**Trial 1b**
1	Dursban WG	2 weeks pre-transplanting	243.4	295.2
2	Tracer	2 weeks pre-transplanting	229.2	322.0
3	Dursban WG	1 week pre-transplanting	268.1	313.7
4	Tracer	1 week pre-transplanting	278.3	340.8
5	Dursban WG	1 day pre-transplanting	281.8	312.8
6	Tracer	1 day pre-transplanting	243.4	300.4
7	Untreated		204.6	279.5
8	HDCI055	1 day pre-transplanting	224.3	290.1
9	HDCI056	1 hour pre-transplanting + 2 weeks post planting	278.3	239.1
10	Mundial	Seed treatment	241.4	301.3
11	HDCI055	Post-transplanting	235.1	295.7
12	Tracer	1 day pre-transplanting	266.4	305.1
13	Tracer	1 week pre-transplanting + 4 x heavy watering after application	250.2	342.1
F-val			4.16	5.32
P-val			<0.001	<0.001
SED Treatment vs Treatment			18.56	16.76
SED Treatment vs Untreated			16.08	14.52
LSD Treatment vs Treatment			37.52	33.88
LSD Treatment vs Untreated			32.49	29.34
df			40	40

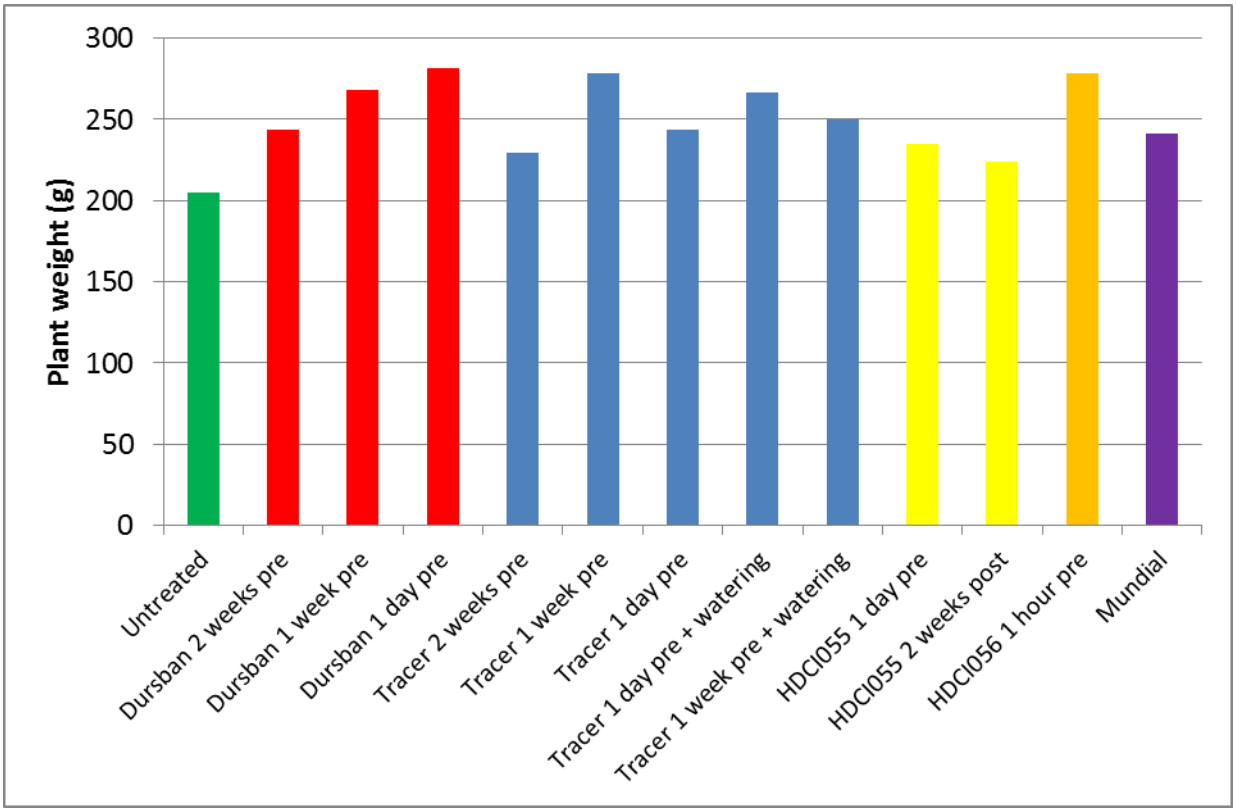

Figure 2. Plant weight 4 weeks after planting in Trial 1a

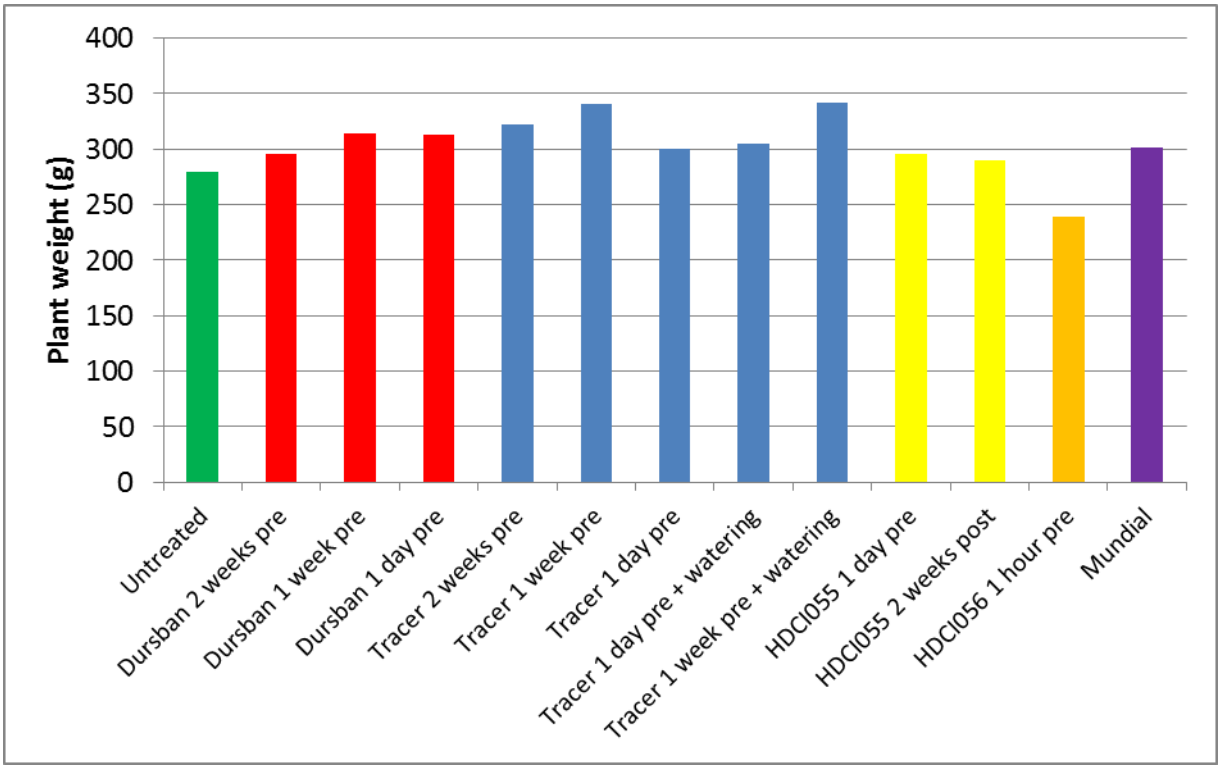

Figure 3. Plant weight 5 weeks after planting in Trial 1b

Root damage

In Trial 1a all of the treatments except HDCI055 post-planting and HDCI056 decreased root damage compared to the untreated control. There were no differences between Dursban WG treatments or Tracer treatments at all treatment times. HDCI055 applied pre-planting decreased damage compared with HDCI055 applied post-planting. Mundial and HDCI055 were as effective as the Dursban WG and Tracer treatments.

In Trial 1b all of the treatments except HDCI056 decreased root damage compared to the untreated control. There were no differences between Dursban WG treatments or Tracer treatments and at all treatment times there was no difference between Dursban WG and Tracer. HDCI055, while significantly reducing damage compared to the untreated control, was significantly less effective than the Dursban WG, Tracer and Mundial treatments.

Table 6. Root damage score in two cauliflower trials

			Root damage score	
Code	**Product**	**Application timing**	**Trial 1a**	**Trial 1b**
1	Dursban WG	2 weeks pre-transplanting	0.375	0.000
2	Tracer	2 weeks pre-transplanting	0.214	0.021
3	Dursban WG	1 week pre-transplanting	0.333	0.021
4	Tracer	1 week pre-transplanting	0.208	0.021
5	Dursban WG	1 day pre-transplanting	0.187	0.042
6	Tracer	1 day pre-transplanting	0.187	0.063
7	Untreated		1.199	2.042
8	HDCI055	1 day pre-transplanting	1.525	1.424
9	HDCI056	1 hour pre-transplanting + 2 weeks post planting	1.333	2.146
10	Mundial	Seed treatment	0.292	0.625
11	HDCI055	Post-transplanting	0.472	1.146
12	Tracer	1 day pre-transplanting	0.104	0.146
13	Tracer	1 week pre-transplanting + 4 x heavy watering after application	0.089	0.146
F-val			18.72	30.56
P-val			<0.001	<0.001
SED Treatment vs Treatment			0.176	0.231
SED Treatment vs Untreated			0.152	0.200
LSD Treatment vs Treatment			0.355	0.466
LSD Treatment vs Untreated			0.307	0.404
df			40	40

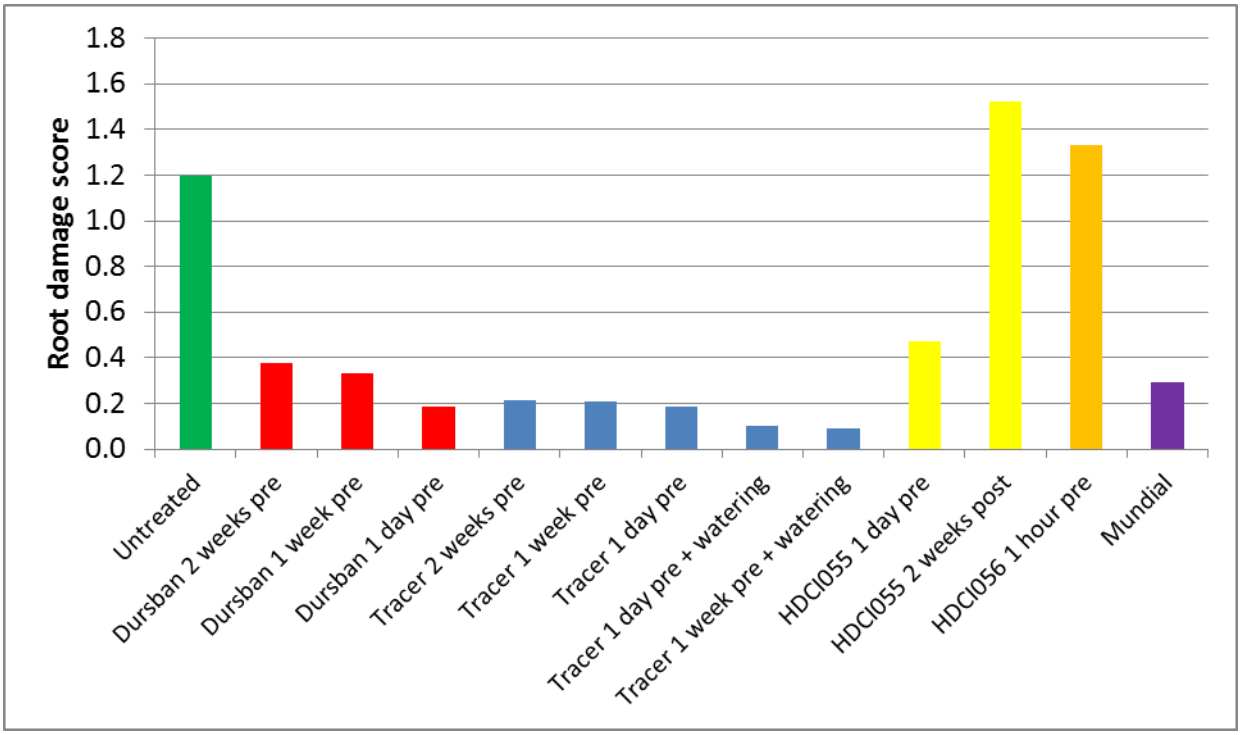

Figure 4. Root damage score 4 weeks after planting in Trial 1a.

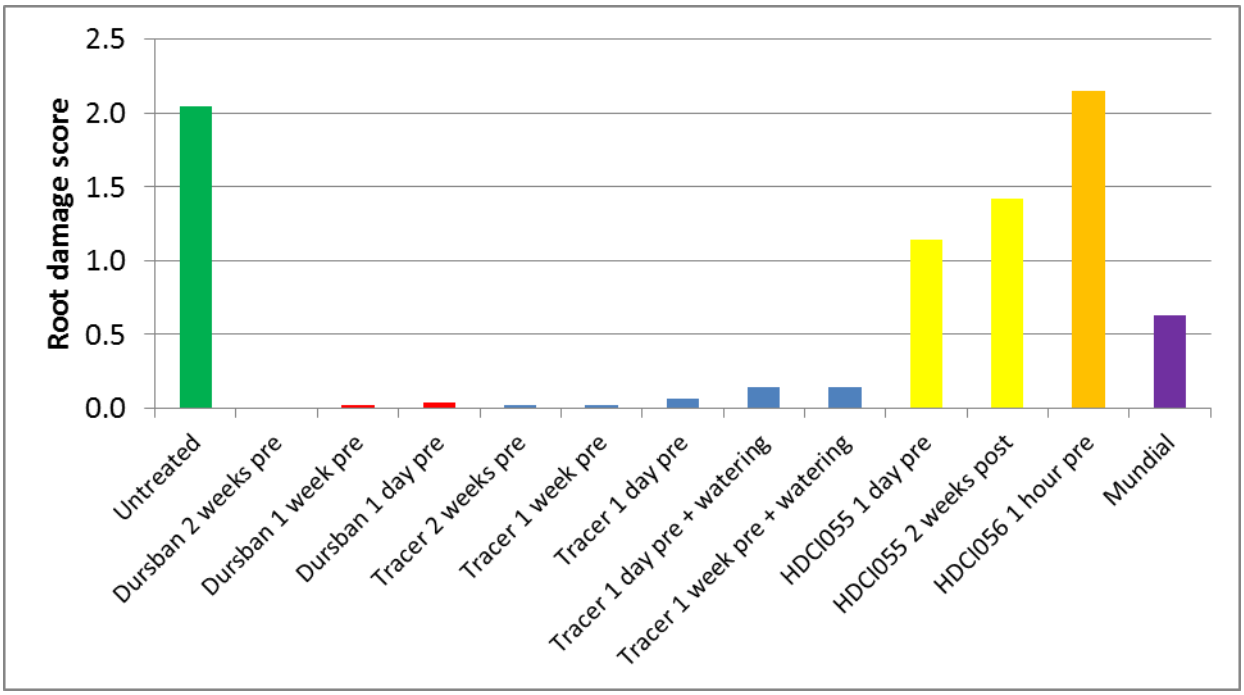

Figure 5. Root damage score 4 weeks after planting in Trial 1b.

Stem damage

In Trial 1a all of the treatments had less stem damage than the untreated control but this was only significant with all of the Dursban WG treatments, Tracer treatments applied at Day 1 and Week 1 (plus heavy watering) and HDCI056. There were no significant differences between Dursban WG treatments but there was a clear reduction in efficacy with ageing residues. Tracer was less effective and although there were some statistically significant differences between treatments and the control, there were no statistically significant differences between treatments and there was a less obvious effect of treatment time. At all treatment times plants from Dursban WG treatments had less damage than Tracer treatments.

In Trial 1b, all of the treatments had less stem damage than the untreated control but this was only statistically significant with all of the Dursban WG treatments (and nearly significant with the HDCI056 treatment). There were no statistically significant differences between Dursban WG treatments and no apparent reduction in efficacy with ageing residues. Similarly there were no differences between Tracer treatments. At all treatment times, plants treated with Dursban WG had less damage than those treated with Tracer.

Table 7. Stem damage score in two cauliflower trials

			Stem damage score	
Code	**Product**	**Application timing**	**Trial 1a**	**Trial 1b**
1	Dursban WG	2 weeks pre-transplanting	0.625	1.30
2	Tracer	2 weeks pre-transplanting	1.231	3.02
3	Dursban WG	1 week pre-transplanting	0.375	0.96
4	Tracer	1 week pre-transplanting	1.292	3.08
5	Dursban WG	1 day pre-transplanting	0.104	1.33
6	Tracer	1 day pre-transplanting	1.125	3.04
7	Untreated		1.755	3.66
8	HDCI055	1 day pre-transplanting	1.250	3.38
9	HDCI056	1 hour pre-transplanting + 2 weeks post planting	1.139	2.71
10	Mundial	Seed treatment	1.667	3.12
11	HDCI055	Post-transplanting	1.438	3.65
12	Tracer	1 day pre-transplanting	1.417	3.35
13	Tracer	1 week pre-transplanting + 4 x heavy watering after application	0.983	3.02
F-val			4.80	4.93
P-val			<0.001	<0.001
SED Treatment vs Treatment			0.333	0.609
SED Treatment vs Untreated			0.288	0.527
LSD Treatment vs Treatment			0.673	1.230
LSD Treatment vs Untreated			0.583	1.065
df			40	40

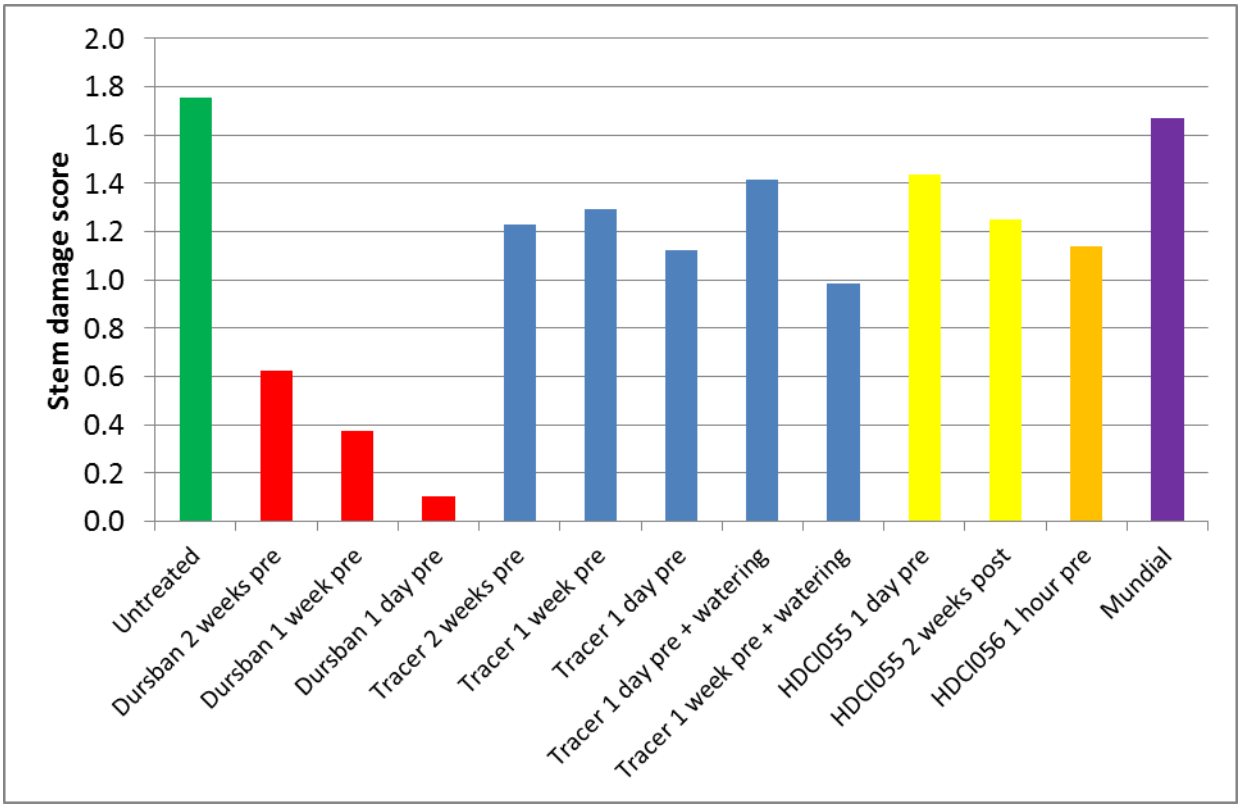

Figure 6. Stem damage score 4 weeks after planting in Trial 1a.

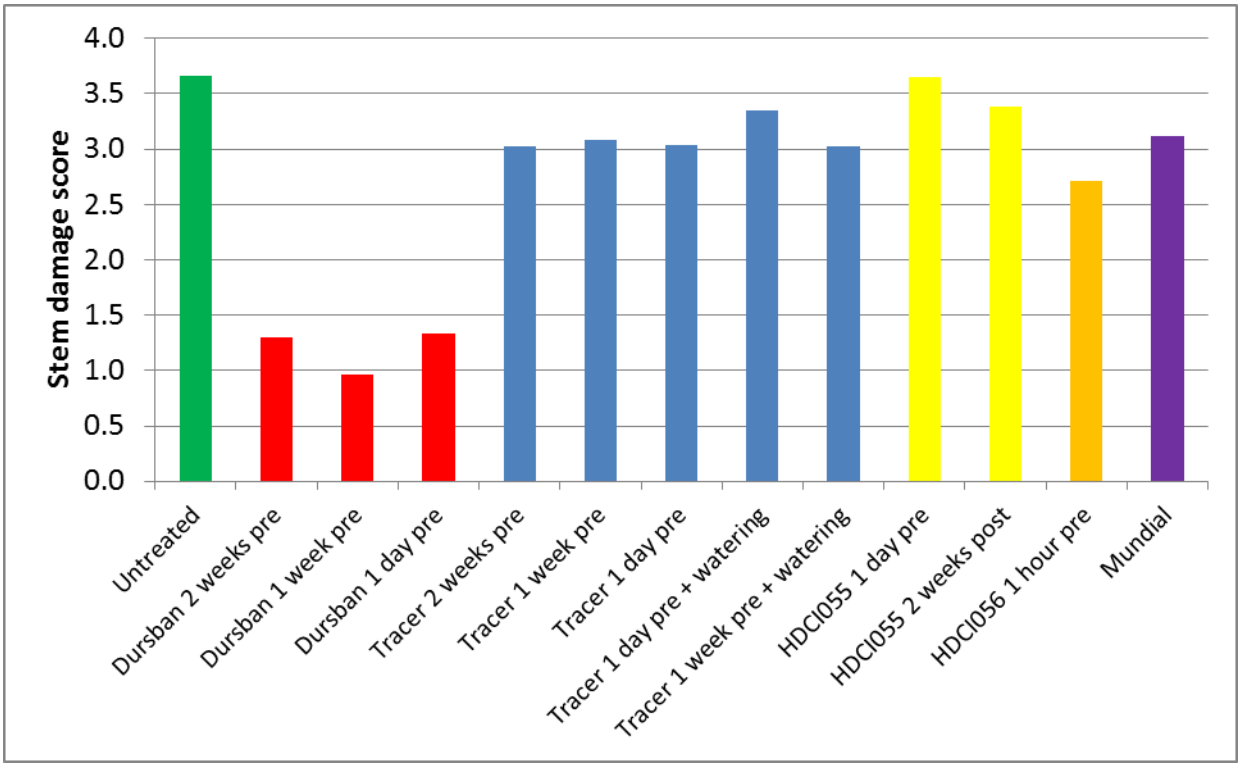

Figure 7. Stem damage score 5 weeks after planting in Trial 1b.

Residues in modules

The results of residue measurements from peat modules in the field trials are presented in Table 8. Only one composite sample of 10 modules was taken for each treatment occasion at treatment and at planting. As such there is no measure of error. Results suggest almost no breakdown of spinosad in either trial, but around 40% loss of chlorpyrifos from the Week 1 treatment in Trial 1a and the Week 2 treatment in Trial 1b. However, with no replication the results should be treated as a guide only.

Table 8. Spinosad and chlorpyrifos concentrations in peat modules at treatment and at planting in two field

			Spinosad		Chlorpyrifos	
Trial	Treatment time	Sample	mg/ module	% remaining	mg/ module	% remaining
1a	Day 1	At treatment	4.42		4.51	
1a	Day 1	At planting	4.10	92.6	4.87	108.1
1a	Week 1	At treatment	3.58		5.20	
1a	Week 1	At planting	3.69	103.0	3.00	57.6
1a	Week 2	At treatment	3.92		3.83	
1a	Week 2	At planting	5.05	129.0	3.88	101.2
1b	Day 1	At treatment	3.65		4.86	
1b	Day 1	At planting	4.66	127.9	4.46	91.8
1b	Week 1	At treatment	5.06		3.42	
1b	Week 1	At planting	5.26	104.0	3.90	114.0
1b	Week 2	At treatment	4.05		6.32	
1b	Week 2	At planting	3.73	92.1	3.89	61.5

Glasshouse trial

The results of residue measurements from peat modules in the glasshouse watering trial are presented in Table 9 (together with the standard deviation and coefficient of variation) and Figure 8 and represent the means of six replicate samples. Initial doses (chlorpyrifos= 3.47 and spinosad = 3.71 mg/module) are somewhat short of the target (chlorpyrifos = 4.5 and spinosad = 5.76 mg/module) doses. Considering the accuracy of the treatment application it seems likely this is down analytical underestimation. Also, in some sample sets the coefficient of variation is relatively high (52% for Day 10 chlorpyrifos) which is equally surprising considering the application method and the fact that all of the trays were treated and stored in the same way.

Table 9. Spinosad and chlorpyrifos concentrations in peat modules 1, 4, 7, 10, 13 and 16 days after treatment in a glasshouse trial (sd = standard deviation and CV = coefficient of variation)

	Spinosad				Chlorpyrifos			
Days after treatment	mg/ module	sd	CV (%)	% remaining	mg/ module	sd	CV (%)	% remaining
1	3.71	0.380	10.2	100	3.47	0.793	22.8	100
4	3.21	0.492	15.3	86.4	3.23	1.018	31.5	93.1
7	3.36	0.320	9.5	90.5	2.64	0.619	23.4	76.1
10	3.24	0.383	11.8	87.4	2.69	1.399	52.1	77.4
13	3.12	0.699	22.4	83.9	2.39	0.383	16.0	68.9
16	2.61	0.376	14.4	70.4	2.18	0.521	23.9	62.8

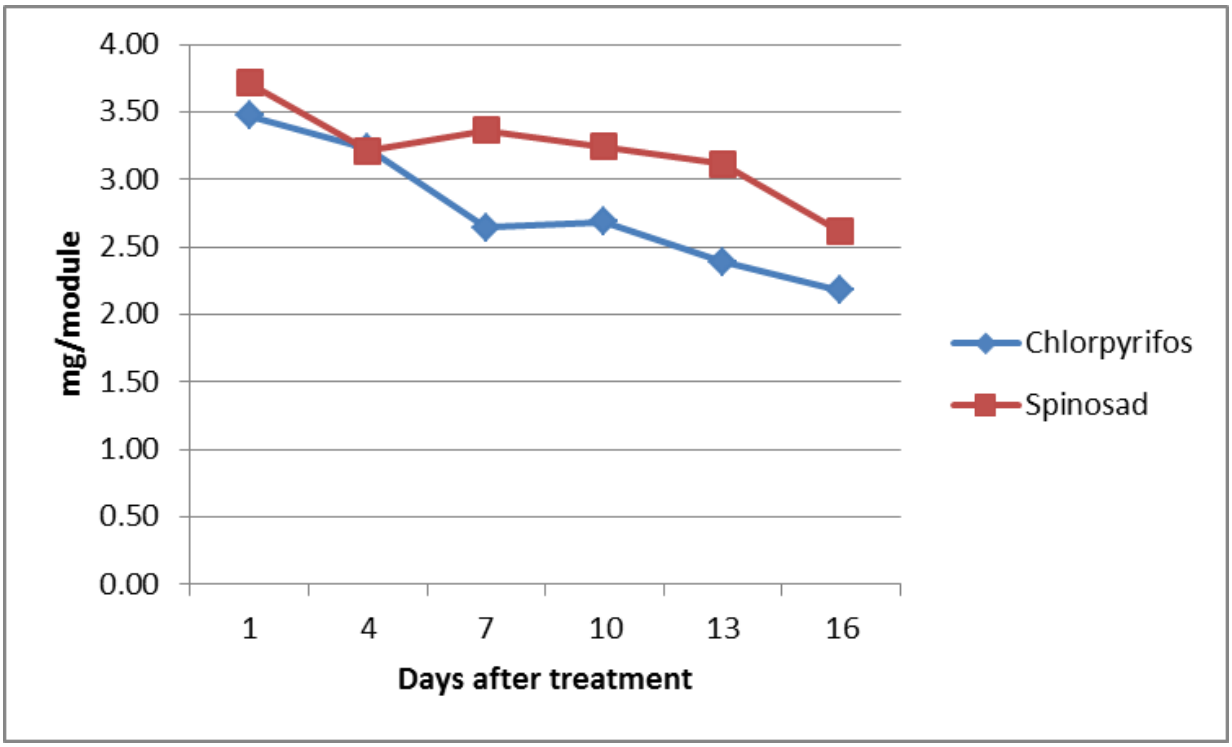

Figure 8 The decline of chlorpyrifos and spinosad residues in peat modules 1 to 16 days after treatment.

Discussion

Field trials

Efficacy of the test insecticides was assessed 4 to 5 weeks after planting, which is the critical period for plant establishment, and was tested, in separate trials, against the first and second generations of the cabbage root fly. Results suggest that if root damage alone is considered then there is little difference between Dursban WG and Tracer treatments irrespective of when the plants were treated or how much water they received. Mundial appears to be almost as good when applied as a seed treatment and the biological treatment HDCI055 applied pre-planting also provided good control, if not being as effective as the conventional insecticides. When considering stem damage, which covers the area of the plant above the module but below the soil surface, a different pattern emerges. Dursban WG was the most effective treatment and efficacy appeared to decline with aged residues. As this has not been a consistent finding in other trials (Jukes et al., 2011, Collier et al., 2010), it could be weather-dependent. Tracer provided some control but this was not always statistically significant and Mundial and HDCI055 were ineffective. However, the biological insecticide HDCI056 gave some reduction of damage in the stem though it was ineffective in the root. Presumably this control was due to the post-planting drench rather than the pre-planting module drench. Differences in plant weight were less obvious but in general effective treatments increased plant weight compared to the untreated control, though there was little difference between effective treatments.

Glasshouse trial

Residues studies in the glasshouse trial would indicate that there is a gradual decline in the concentration of both chlorpyrifos and spinosad. It is impossible, from these results, to determine how much of each insecticide was broken down and how much was washed out. Never-the-less it is clear that the persistence of the two insecticides is very similar and it is likely that Tracer-treated plants should have in excess of 70% of the initial dose remaining if held on the nursery for 2 weeks before planting, even if heavily watered.

Conclusions

- Tracer appears to be as persistent as Dursban WG in plant propagation modules
- Tracer- treated plants can be held on nurseries and with exposure to heavy watering for at least 2 weeks without significant reduction in performance
- Tracer is as effective as Dursban WG in control of damage in the root zone

- Tracer was less effective than Dursban WG at controlling damage in the stem zone (between the module and the soil surface)
- Mundial performed similarly to Tracer
- The bio-insecticide HDCI055 was reasonably effective in the root zone as a pre-planting treatment but ineffective in the stem zone
- The biological insecticide HDCI056 was ineffective in the root zone but partially effective in the stem zone

Knowledge and Technology Transfer

October 2013	Article for HDC/BGA Newsletter
November 2013	Presentation at HDC Brassica Technical Seminar

References

Jukes, A.A., Collier, R.C. & Elliott, M.S. (2011) Novel strategies for pest control in field vegetable crops. Horticultural Development Company, Final Report Project FV 375.

Collier, R., Effingham, P. Miles, M., Constable, J. Watson, K. & Fountain, N. (2010). Brassica: companion planting for pest control. Final Report. HortLINK project HL0174; HDC Project FV 251.