FINAL REPORT

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Brassicas: Evaluation of novel insecticides for control of cabbage root fly and aphids

FV 328

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Signed on behalf of: **Warwick HRI**

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GROWER SUMMARY

SCIENCE SECTION

FV 328

Brassicas: Evaluation of novel insecticides for control of cabbage root fly and aphids

Headline

- One novel insecticide seed treatment provided season-long control of aphids on cabbage and two novel insecticides applied as foliar sprays reduced an infestation of cabbage aphid on calabrese foliage.
- Three novel seed treatments provided some control of cabbage root fly larvae on cabbage.
- Chlorpyrifos sprays were more effective than Spinosad at controlling cabbage root fly larvae infesting calabrese spears. However, Chlorpyrifos used close to harvest on the edible part of the plant could result in unacceptably high residues.

Background and expected deliverables

The cabbage root fly (*Delia radicum*) and aphids (*Brevicoryne brassicae, Myzus persicae*) are the most serious pests of brassica crops in the United Kingdom. Although there are now three approved chemicals (Carbosulfan (Marshall), Spinosad (Tracer) and Chlorpyrifos (Dursban)) for cabbage root fly control on leafy brassica crops in the UK, no product has been available to control the cabbage root fly on swede and turnip since 31 December 2003. Only Chlorpyrifos is approved for control of cabbage root fly on radish and alternative treatments using Spinosad, evaluated in 2006 (FV 242d), do not appear promising. In addition, there is no effective insecticide treatment to control cabbage root fly larvae infesting Brussels sprout buttons and calabrese heads. Thus the need to find alternative treatments for cabbage root fly control is still pressing.

Aphids also continue to cause major problems for brassica growers and although several active ingredients are available, they do not provide a sufficient ‘armoury’ to control *B. brassicae* and *M. persicae* effectively when pest pressure is high and where insecticide resistant clones of *M. persicae* are present. A greater reliance on neonicotinoid insecticides (Imidacloprid, Thiacloprid) also increases the risk of selecting populations of *M. persicae* that are resistant to this group of insecticides.

This would have severe consequences for brassica and other vegetable growers and for the production of crops such as potatoes and sugar beet.

Fortunately, the agrochemicals industry is developing a number of novel insecticides, some of which have novel modes of action (which would relieve selection pressure for insecticide resistance) and some of which also appear to be quite mobile within the plant, which may improve their performance against one or more pests. Although the companies are developing these products for certain pests and crops, they are unlikely to evaluate some of the 'minor' uses in any detail.

The aim of this project was to evaluate novel insecticides for the control of the pest insects of brassica crops, principally the cabbage root fly and aphids, but also taking account of efficacy against other brassica pests such as flea beetle and whitefly.

The expected deliverables from this work include:

- An evaluation of novel seed treatments for the control of cabbage root fly and aphids in cabbage.
- An evaluation of a technique for field inoculation of calabrese spears with cabbage root fly eggs.
- An evaluation of Chlorpyrifos and Spinosad as foliar sprays to control cabbage root fly larvae in calabrese spears.
- An evaluation of novel insecticide sprays for the control of aphids on calabrese.

Summary of the project and main conclusions

Two experiments were done in 2007 using eleven insecticide products (Tracer (Spinosad), Dursban and Gigant (both Chlorpyrifos), Mundial (Fipronil), Aphox (Pirimicarb), Plenum (Pymetrozine), Biscaya (Thiacloprid) and 4 experimental treatments (Exp A, Exp B, Exp C and Exp D).

Experiments were done to answer the following questions:

1. Are there novel seed treatments to control cabbage root fly on cabbage? (Field Experiment 1).

2. Are there novel seed treatments to control aphids on cabbage? (Field Experiment 1).
3. Are there novel spray treatments to control cabbage root fly on the spears of calabrese? (Field Experiment 2).
4. Are there novel spray treatments to control aphids on the leaves of calabrese? (Field Experiment 2).

Experiment summaries and main conclusions

1. Novel seed treatments to control cabbage root fly and aphids on cabbage

Four insecticides (Chlorpyrifos, Fipronil and two new compounds, Exp A and Exp B) were assessed as seed treatments for the control of foliar pests and cabbage root fly. The experiment was transplanted during July 2007 (to target the second generation of the cabbage root fly). This coincided with some exceptionally wet weather. It appeared that, as a result of these conditions, aphid populations declined and did not begin to re-establish until September. Sensible evaluation of aphid control could not, therefore, be performed until this time. Damage due to cabbage root fly larvae was assessed 6 weeks after transplanting.

Results

Aphids

- An experimental seed treatment, Exp A (which was a mixture of two active ingredients), appeared to control *B. brassicae* up to 118 days after sowing.
- The other seed treatments tested (Chlorpyrifos, Fipronil and Exp B) appeared to be ineffective against aphids, but it should be noted that aphid control could not be assessed until 18 September (98 days after sowing) because aphid numbers were so low in July-August.

Cabbage root fly

- Both experimental treatments (Exp A and Exp B) and Fipronil reduced damage to the roots caused by cabbage root fly larvae.

- None of the treatments reduced cabbage root fly damage to the lower stem area and Fipronil actually increased damage.
- The standard Gigant (Chlorpyrifos) treatment appeared to be largely ineffective against cabbage root fly.

2. *Novel spray treatments to control cabbage root fly on calabrese spears and aphids on calabrese foliage*

The experiment was designed to assess novel insecticides applied as foliar sprays for the control of foliar pests (aphids and caterpillars) on calabrese foliage. Aphid numbers did not increase naturally, so the plots were infested with laboratory-reared aphids.

Five insecticides (Pirimicarb, Pymetrozine, Thiacloprid and two new compounds (Exp C, Exp D) were assessed as foliar sprays for the control of foliar pests. Sprays were applied in September after aphids had established on the plots. Counts of pest numbers were made before and after spraying.

Two insecticides (Spinosad and Chlorpyrifos) were applied to control cabbage root fly larvae in the calabrese spears. Since natural infestation of this part of the plant is sporadic and unpredictable, the spears were inoculated with laboratory-reared cabbage root fly eggs and then sprayed 1 and 9 days after inoculation. The inoculated spears were removed from the plants 42-44 days after inoculation and cut open to recover any larvae that had developed.

Results

- All of the test treatments (Pymetrozine, Pirimicarb, Thiacloprid and the two experimental treatments – Exp C and Exp D) controlled aphids
- Exp C with Phase II was the least effective treatment but all the other test treatments, including Exp C without adjuvant, were all equally good at controlling *B. brassicae.*
- Calabrese spears were successfully inoculated with cabbage root fly eggs and a good proportion of these eggs developed into feeding larvae.

- Chlorpyrifos sprays (applied 1 and 9 days after inoculation) were more effective than Spinosad at controlling the larvae.
- Chlorpyrifos used close to harvest on the edible part of the plant could result in unacceptably high residues.

Summary

- At least one novel seed treatment has the potential to provide season long control of *B. brassicae* on cabbage.
- Three novel seed treatments have the potential to provide some control of cabbage root fly larvae on cabbage.
- Two novel insecticides applied as foliar sprays reduced an infestation of *B. brassicae* on calabrese.
- Chlorpyrifos sprays were more effective than Spinosad at controlling cabbage root fly larvae infesting calabrese spears. However, Chlorpyrifos used close to harvest on the edible part of the plant could result in unacceptably high residues.

Financial benefits

- Without adequate insecticidal control, it is estimated that about 24% of the plants in field brassica crops would be rendered unmarketable by the cabbage root fly.
- In root crops, such as swede, turnip and radish, in which the pest attacks directly the part of the crop used for human consumption, the losses would be considerably higher. This sector of the industry may not be sustainable if the cabbage root fly cannot be controlled effectively.
- Even if cultural methods could be relied on to lower overall damage to 15-20%, the Industry could still be facing losses of about £30-40M per annum from the area of crop that needs protecting currently against attacks by the cabbage root fly.

Action points for growers

- Fipronil seed treatment (Mundial) reduced cabbage root fly damage to the roots of cabbage plants compared with the insecticide-free control treatment, although cabbage root fly damage to the lower stem area was greater.

Cabbage plants grown from seed treated with Fipronil had a greater amount of foliage than all other treatments when assessed 6 weeks after planting.

- Of the currently approved insecticides applied as foliar sprays to control aphids on calabrese in September 2007, Pirimicarb (Aphox), Pymetrozine (Plenum), Thiacloprid (Biscaya) all provided effective control of cabbage aphid.
- Both of the insecticide spray treatments applied to control cabbage root fly larvae on calabrese spears reduced cabbage root fly numbers and the proportion of spears damaged, but only Chlorpyrifos (Dursban WG) had a statistically significant effect. With greater replication it seems likely that Spinosad (Tracer) would also show a statistically significant effect and this treatment might be adequate for a light infestation. Spraying the edible part of the plant with Chlorpyrifos so close to harvest is likely to lead to unacceptably high residues.

SCIENCE SECTION

Introduction

The cabbage root fly (*Delia radicum*) and aphids (*Brevicoryne brassicae, Myzus persicae*) are the most serious pests of brassica crops in the United Kingdom. Although there are now three approved chemicals (Carbosulfan (Marshall), Spinosad (Tracer) and Chlorpyrifos (Dursban)) for cabbage root fly control on leafy brassica crops in the UK, no product has been available to control the cabbage root fly on swede and turnip since 31 December 2003. Only Chlorpyrifos is approved for control of cabbage root fly on radish and alternative treatments using Spinosad, evaluated in 2006 (FV 242d), do not appear promising. In addition, there is no effective insecticide treatment to control cabbage root fly larvae infesting Brussels sprout buttons and calabrese heads. Thus the need to find alternative treatments for cabbage root fly control is still pressing.

Aphids also continue to cause major problems for brassica growers and although several active ingredients are available, they do not provide a sufficient 'armoury' to control *B. brassicae* and *M. persicae* effectively when pest pressure is high and where insecticide resistant clones of *M. persicae* are present. A greater reliance on neonicotinoid insecticides (Imidacloprid, Thiacloprid) also increases the risk of selecting populations of *M. persicae* that are resistant to this group of insecticides. This would have severe consequences for brassica and other vegetable growers and for the production of crops such as potatoes and sugar beet.

Fortunately, the agrochemicals industry is developing a number of novel insecticides, some of which have novel modes of action (which would relieve selection pressure for insecticide resistance) and some of which also appear to be quite mobile within the plant, which may improve their performance against one or more pests. Although the companies are developing these products for certain pests and crops, they are unlikely to evaluate some of the 'minor' uses in any detail.

The aim of this project was to evaluate novel insecticides for the control of the pest insects of brassica crops, principally the cabbage root fly and aphids, but also taking account of efficacy against other brassica pests such as flea beetle and whitefly.

Experiments were done to answer the following four questions:

1. Are there novel seed treatments that will control cabbage root fly on cabbage? (Experiment 1)
2. Are there novel seed treatments that will control aphids on cabbage? (Experiment 1)
3. Are there novel spray treatments that will control cabbage root fly on the spears of calabrese? (Experiment 2)
4. Are there novel spray treatments that will control aphids on the foliage of calabrese? (Experiment 2)

The test chemicals are shown as the active ingredients (with the product used in parenthesis) in the Materials and Methods sections, as certain chemicals are available under a range of different product names.

The actual active ingredients tested, together with the product used (shown in parenthesis), were: Spinosad (Tracer), Chlorpyrifos (Dursban WG and Gigant), Fipronil (Mundial), Pirimicarb (Aphox), Pymetrozine (Plenum), Thiacloprid (Biscaya), and 4 experimental treatments (Exp A, Exp B, Exp C and Exp D).

Experiment 1

Novel seed treatments to control infestations of cabbage root fly and aphids on cabbage

<u>Materials and methods</u>

The experiment was done within the field known as Sheep Pens at Warwick HRI, Wellesbourne. There were two aspects to the experiment (aphid control on the foliage and cabbage root fly control on the roots and lower stem area). The treatments are listed in Table 1.

Cabbage seeds (various cultivars, see Table 1) were sown in 308 Hassy trays (1 tray per treatment) on 8 June 2007 and kept in a glasshouse. The plants were transplanted into field plots when they reached the 4-leaf stage.

The planting date (9 July 2007) was chosen to target the second (peak in mid July) and third (late August) generations of cabbage root fly. The experiment was laid out as a balanced incomplete block design and there were 3 replicates of 7 treatments. Plots were 3.5 m x 1 bed (1.83 m) in size and there were 4 rows of 7 plants (28 plants). Plants were planted at 50 cm spacing within, and 38 cm between, rows.

<u>Assessments</u>

a) Phytotoxicity

Seedling counts were made once the seedlings had emerged in the glasshouse. The numbers of seedlings in each Hassy tray (maximum 308) were recorded. Two rows of 22 plants in each tray were also assessed for phytotoxicity (0-10 scale) and degree of stunting (1 = slight, 2 = moderate and 3 = heavy) on 21 June (13 days after sowing) before the plants were transplanted into the field plots.

Table 1 Treatments to control infestations of cabbage root fly larvae and aphids on cabbage

Code	Cabbage Variety	Active Ingredient	Dose and (seed lot)
1	Lennox	Untreated	
2	Lennox	Exp A	1.2 & 0.4 mg a.i. per seed
3	Ramco	Untreated	
4	Ramco	Exp B	0.6g product per 100,000 seeds
5	Duchy	Chlorpyrifos (Gigant)	9.6 g a.i./100,000 seeds
6	Duchy	Untreated	
7	Duchy	Fipronil (Mundial)	12.5 g a.i./100,000 seeds

b) Cabbage root fly monitoring

To provide background information, cabbage root fly egg laying activity was monitored in a small plot of cauliflower near to the main experimental plots. Soil samples were taken from around 20 plants twice a week from April until October 2007 and cabbage root fly eggs were extracted from the soil by flotation and counted.

c) Aphid assessment

Twelve plants were marked in the middle two rows of each plot and counts were made of winged, wingless and parasitized aphids on 6 August, 28 August, 18 September and 29 October 2007. The aphid species assessed were *Brevicoryne brassicae*, *Myzus persicae* and *Macrosiphum euphorbiae*. Caterpillars and moth/butterfly eggs were identified and counted. Finally, the leaves were scored for flea beetle feeding damage (0 = no damage, 1 = slight damage, 2 = moderate damage and 3 = heavy damage) on the first three sampling occasions.

d) Cabbage root fly damage assessment

On 21 August, 12 plants were dug from each plot. The roots were washed and the roots and lower stem of each plant were scored (0-5 scale, Table 2) for damage due to feeding by cabbage root fly larvae. The weight of the foliage and the roots was also recorded.

<u>Statistical analysis</u>

The data were subjected to Analysis of Variance.

Table 2. System used to score cabbage roots and stems for feeding damage by cabbage root fly larvae.

Damage score	% of surface area damaged
0	0
1	< 5
2	5 – 10
3	10 – 25
4	25 – 50
5	> 50

Results

a) Seedling emergence and phytotoxicity

The data are summarized in Table 3. There were insufficient data to allow sensible statistical analysis but it is clear that plants treated with Exp A were more damaged and stunted (Figure 2) than insecticide-free plants of the same and other varieties. However these effects were not apparent after transplanting into the field.

Table 3 Seedling emergence in a single 308 Hassy tray, mean leaf damage score (excluding missing plants) and mean stunting score (excluding missing plants) on 21 June (13 days after sowing).

Treatment	Cabbage Variety	Seedling Numbers (max 308)	Mean Damage Score	Seedling Stunting Score
1. Untreated	Lennox	266	0	1.10
2. Exp A	Lennox	275	0.684	2.13
3. Untreated	Ramco	299	0	1.05
4. Exp B	Ramco	295	0	1.02
5. Chlorpyrifos	Duchy	292	0	0.05
6. Untreated	Duchy	302	0.05	0.16
7. Fipronil	Duchy	295	0.05	0.10

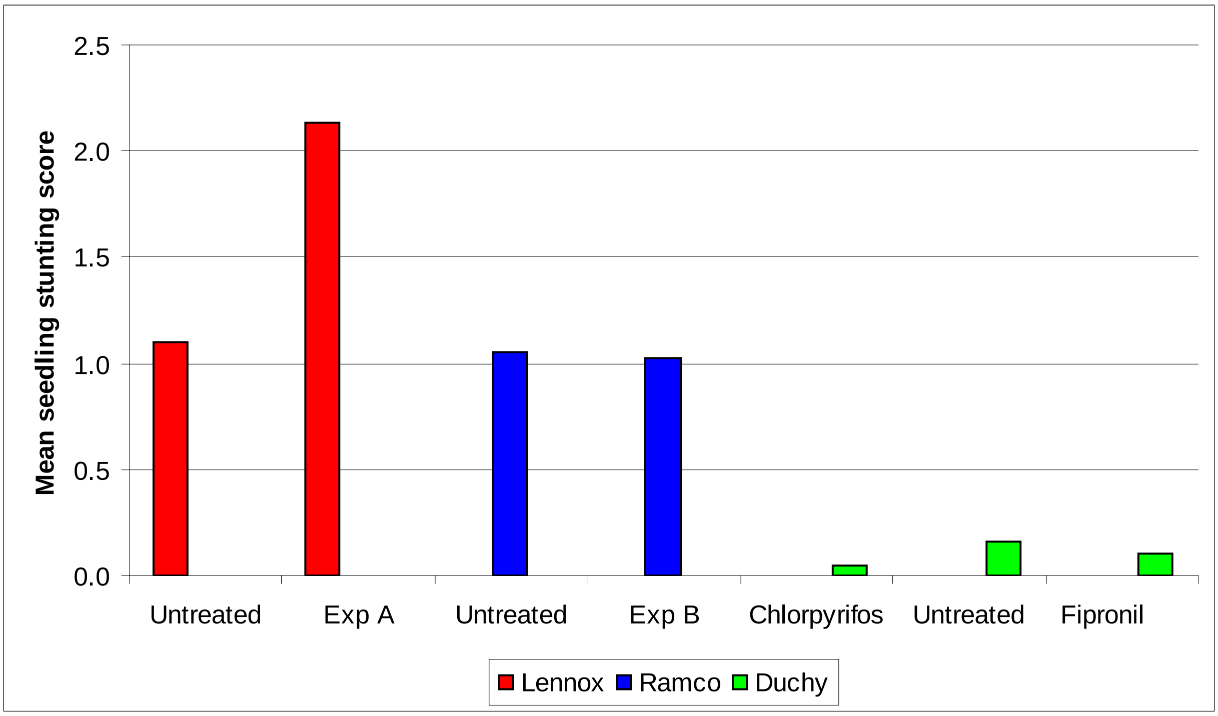

Figure 1 The mean stunting score of cabbage seedlings recorded 13 days after sowing

b) Cabbage root fly monitoring

The numbers of eggs laid on cauliflower plants in the nearby monitoring plot are shown in Figure 2. There was a distinct first generation of cabbage root fly but the second and third generations were separated less clearly.

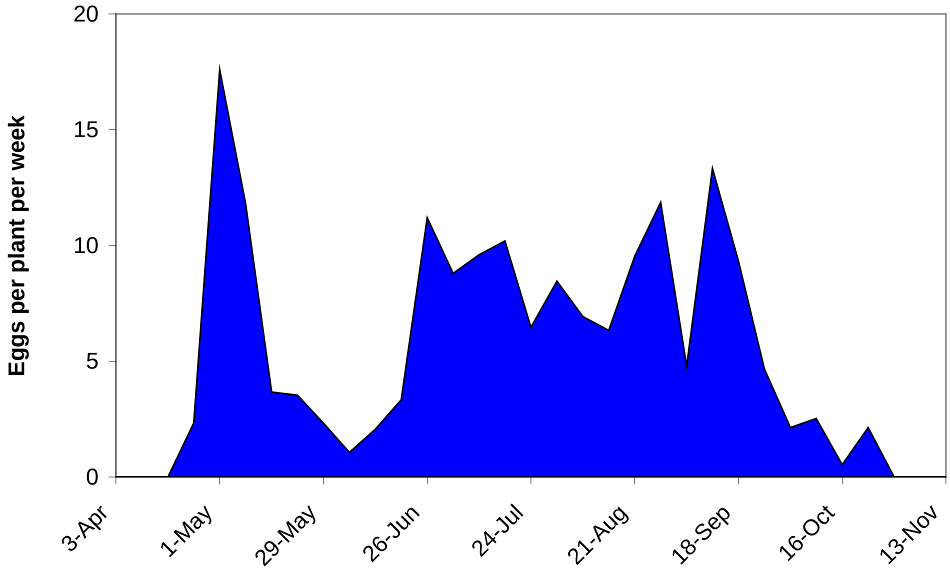

Figure 2 The numbers of cabbage root fly eggs laid on cauliflower plants in monitoring plots at Warwick HRI, Wellesbourne in 2007.

All variables were analysed using ANOVA and no data transformations were required. Pair-wise comparisons have been made using the 95% LSD where the main effect of treatment was found to be statistically significant.

b) Aphid and caterpillar numbers and flea beetle damage score

Data were collected on four occasions, 6 August (Tables 4-5), 28 August (Table 6), 18 September (Tables 7-8) and 4 October (Table 9). The total numbers of pest insects (on 12 plants) in each plot were analysed using ANOVA. For some individual species there were insufficient data for a sensible analysis, so some variables were not analysed at each sampling date. The total numbers of winged and wingless aphids, and the total numbers of moth/butterfly eggs and caterpillars were also analysed using ANOVA. The mean score for flea beetle feeding damage was also analysed using ANOVA.

In general, there were very few differences between the treatments. On 6 August, the numbers of aphids and caterpillars were very low (Tables 4-5) and by 28 August, the aphids had disappeared completely (Table 6). At this time, there was a statistically significant difference in the amount of flea beetle damage but it appeared to be due to cabbage variety and not treatment. By 18 September, aphid numbers had increased (predominantly *B. brassicae* – Figure 3) but there were still no statistically significant differences between treatments, despite the absence of wingless *B. brassicae* on Treatment 2 (Exp A) compared with a mean number of 160 on the comparable control treatment (Treatment 1) (Tables 7-8). Similarly, on 4 October, there were no wingless *B. brassicae* on Treatment 2 but a mean of 72 wingless *B. brassicae* on Treatment 1 (Table 9; Figure 4). There was little evidence of control by the other treatments.

Table 4. The mean numbers of aphids per plot (12 plants) recorded on 6 August 2007.

Treatment	Cabbage Variety	*Myzus persicae* winged	*Myzus persicae* wingless	Other	Total *Myzus persicae*	Total winged	Total wingless
1. Untreated	Lennox	0.67	0.00	0.43	0.0	0.76	0.00
2. Exp A	Lennox	0.95	0.43	0.00	1.4	0.90	0.43
3. Untreated	Ramco	0.24	0.00	0.57	0.0	0.33	0.00
4. Exp B	Ramco	4.24	0.57	0.71	4.8	4.19	0.57
5. Chlorpyrifos	Duchy	5.10	2.43	0.00	7.5	5.33	2.43
6. Untreated	Duchy	1.81	1.00	0.71	2.8	2.19	1.00
7. Fipronil	Duchy	6.67	1.86	0.86	8.5	6.62	1.86
F-prob		0.474	0.532	0.585	0.412	0.502	0.532
SED		3.452	1.702	0.639	4.56	3.523	1.702
LSD (95%)		8.447	4.165	1.563	11.15	8.619	4.165
df		6	6	6	6	6	6

Table 5. The mean numbers of caterpillars, moth/butterfly eggs per plot (12 plants) and the mean flea beetle damage score recorded on 6 August 2007.

Treatment	Cabbage Variety	*Plutella xylostella*	*Pieris rapae*	Total no. caterpillars	Total no. eggs	Flea beetle damage score
1. Untreated	Lennox	1.81	1.76	4.19	19.7	0.734
2. Exp A	Lennox	0.00	4.05	4.48	4.2	0.472
3. Untreated	Ramco	0.81	1.19	0.90	0.0	0.853
4. Exp B	Ramco	1.81	1.48	2.05	4.5	1.091
5. Chlorpyrifos	Duchy	0.10	1.33	2.33	0.0	0.937

6. Untreated	Duchy	0.00	2.33	5.90	0.1	0.925
7. Fipronil	Duchy	0.67	0.19	1.48	11.1	0.877
F-prob		0.285	0.463	0.774	0.502	0.069
SED		0.990	1.629	3.574	12.69	0.1438
LSD (95%)		2.422	3.986	8.746	31.05	0.3520
df		6	6	6	6	6

Table 6. The mean numbers of aphids and caterpillars per plot (12 plants) and the mean flea beetle damage score recorded on 28 August 2007. Statistically significant differences in the treatment means are shown by the letters next to each mean. Treatment means with a letter in common are said to be not significantly different.

		Aphids	Caterpillars						
Treatment	Cabbage Variety	Other	*Pieris rapae*		*Pieris brassicae*	*Autographa gamma*	Total	Flea beetle damage score	
1. Untreated	Lennox	0.24	0.48	ab	3.4	0.00	4.3	0.435	a
2. Exp A	Lennox	0.00	1.48	bc	0.0	0.43	0.0	0.558	ab
3. Untreated	Ramco	0.95	0.00	a	12.0	0.29	12.0	0.709	bc
4. Exp B	Ramco	0.00	1.76	c	2.8	0.00	4.0	0.629	abc
5. Chlorpyrifos	Duchy	1.10	0.62	ab	4.7	1.00	6.6	0.832	cd
6. Untreated	Duchy	0.67	1.33	bc	2.8	0.14	4.3	0.780	cd
7. Fipronil	Duchy	1.81	1.19	bc	0.0	0.57	0.0	0.935	d
F-prob		0.314	0.024		0.730	0.145	0.778	0.014	
SED		0.782	0.452		9.32	0.404	8.86	0.0889	
LSD (95%)		1.915	1.105		22.82	0.989	21.67	0.2174	
df		6	6		6	6	6	6	

Table 7. The mean numbers of aphids per plot (12 plants) recorded on 18 September 2007. Statistically significant differences in the treatment means are shown by the letters next to each mean. Treatment means with a letter in common are said to be not significantly different.

Treatment	Cabbage Variety	*Myzus persicae* winged	*Myzus persicae* wingless	*Brevicoryne brassicae* winged	*Brevicoryne brassicae* wingless	*Macrosiphumeuphorbiae* winged	Parasitised aphids
1. Untreated	Lennox	2.81	8.0	2.71	160	0.48	2.29
2. Exp A	Lennox	0.67	3.5	0.00	0	0.76	0.14
3. Untreated	Ramco	5.38	12.3	1.14	113	0.00	2.14
4. Exp B	Ramco	5.95	1.8	2.57	122	0.00	0.57
5. Chlorpyrifos	Duchy	4.24	10.3	0.57	170	0.19	0.29
6. Untreated	Duchy	6.52	15.6	4.57	227	0.48	0.29
7. Fipronil	Duchy	6.10	15.8	1.57	237	0.62	1.29
F-prob		0.109	0.431	0.287	0.293	0.342	0.361
SED		1.761	7.27	1.750	142.2	0.404	1.107
LSD (95%)		4.310	17.78	4.281	328.0	0.989	2.708
df		6	6	6	6	6	6

Treatment	Cabbage Variety	Total *Myzus persicae*	Total *Brevicoryne brassicae*	Total *Macrosiphum euphorbiae*	Total winged	Total wingless	Other	
1. Untreated	Lennox	10.9	163	0.76	6.00	169	1.05	c
2. Exp A	Lennox	4.1	0	2.76	1.29	0	0.76	bc
3. Untreated	Ramco	17.7	114	0.19	6.43	126	0.00	a

4. Exp B	Ramco	7.7	124	0.00	8.43	123	0.76	bc
5. Chlorpyrifos	Duchy	14.6	170	0.00	5.00	179	0.91	c
6. Untreated	Duchy	22.1	231	0.76	11.57	243	0.33	ab
7. Fipronil	Duchy	21.9	239	0.90	8.29	253	0.05	a
F-prob		0.265	0.295	0.471	0.159	0.263	0.002	
SED		7.49	143.7	1.539	2.955	140.2	0.202	
LSD (95%)		18.33	351.7	3.765	7.232	343.1	0.494	
df		6	6	6	6	6	6	

Table 8. The mean numbers of caterpillars per plot (12 plants) and the mean flea beetle damage score recorded on 18 September 2007.

		Caterpillars				
Treatment	Cabbage Variety	*Plutella xylostella*	*Pieris rapae*	*Evergestis forficalis*	Total	Flea beetle damage score
1. Untreated	Lennox	1.57	2.67	1.38	5.62	0.177
2. Exp A	Lennox	1.00	2.24	4.38	7.90	0.438
3. Untreated	Ramco	0.29	1.52	0.81	3.05	0.149
4. Exp B	Ramco	0.14	0.95	0.00	0.62	0.090
5. Chlorpyrifos	Duchy	0.57	0.67	0.00	1.33	0.245
6. Untreated	Duchy	1.71	1.24	0.10	3.33	0.448
7. Fipronil	Duchy	1.71	0.00	1.24	2.48	0.245
F-prob		0.546	0.114	0.208	0.137	0.631
SED		1.010	0.904	1.714	2.222	0.1908
LSD (95%)		2.472	2.211	4.195	5.438	0.4670
df		6	6	6	6	6

Table 9. The mean numbers of aphids and caterpillars per plot (12 plants) recorded on 4 October 2007.

		Aphids				Caterpillars		
Treatment	Cabbage	*Brevicoryne*	*Brevicoryne*	Total	Parasitised	*Pieris*	*Pieris*	Total

	Variety	*brassicae* winged	*brassicae* wingless	*Brevicoryne brassicae*	aphids	*rapae*	*brassicae*	
1. Untreated	Lennox	7.2	72	79	7.5	1.05	0.00	1.43
2. Exp A	Lennox	0.0	0	0	0.0	0.76	0.00	1.43
3. Untreated	Ramco	44.7	358	402	19.1	1.05	0.00	1.57
4. Exp B	Ramco	0.0	106	103	9.5	0.76	0.57	1.14
5. Chlorpyrifos	Duchy	7.2	181	188	10.0	0.19	0.86	1.14
6. Untreated	Duchy	0.0	89	89	0.5	0.00	0.71	0.14
7. Fipronil	Duchy	0.0	28	27	2.1	0.90	0.14	1.14
F-prob		0.128	0.124	0.113	0.260	0.672	0.111	0.913
SED		14.48	103.4	113.8	7.30	0.904	0.350	1.212
LSD (95%)		35.43	252.9	278.4	17.87	2.211	0.856	2.966
df		6	6	6	6	6	6	6

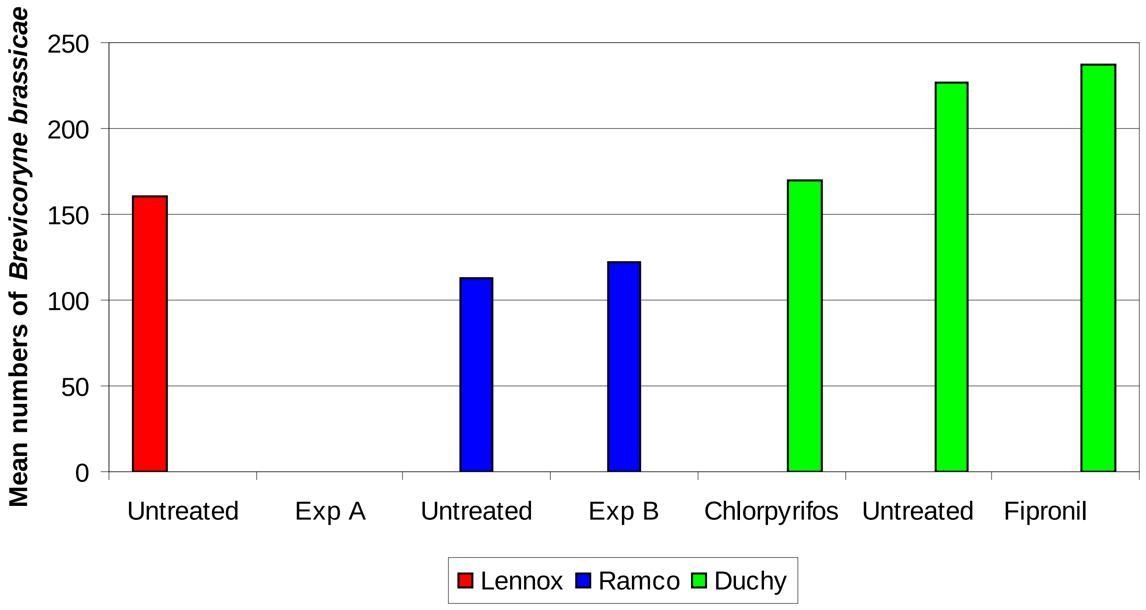

Figure 3. The numbers of wingless *Brevicoryne brassicae* recorded per plot (12 plants) on 18 September 2007.

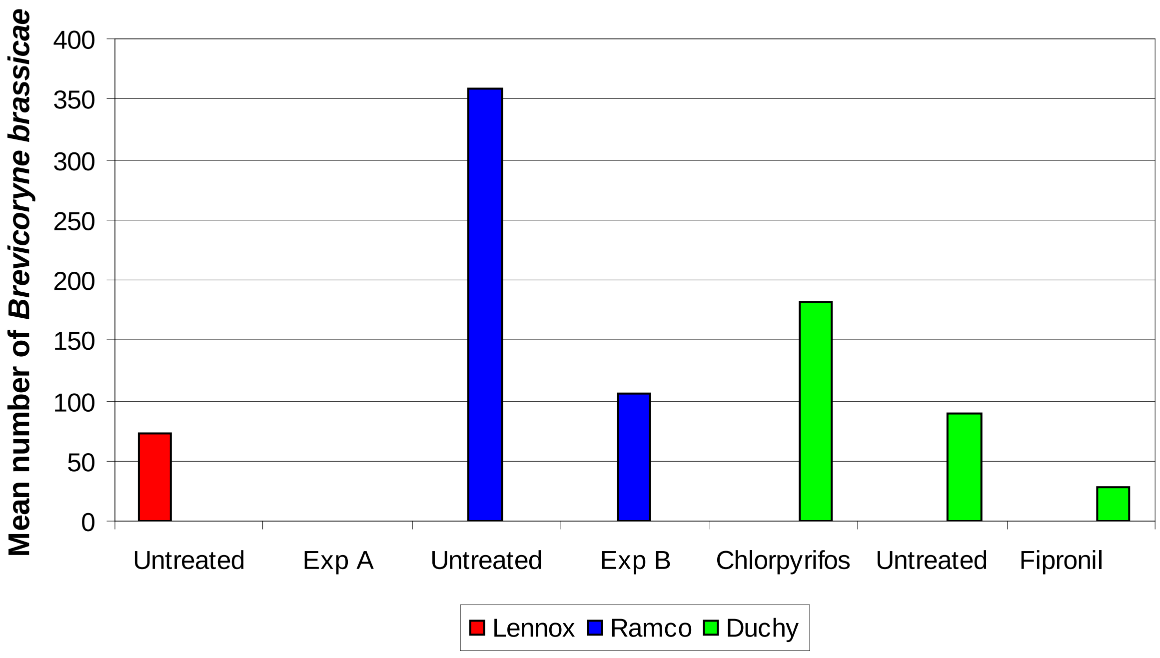

Figure 4. The numbers of wingless *Brevicoryne brassicae* recorded per plot (12 plants) on 4 October 2007.

d) Cabbage root fly damage

Plants were classified according to the amount of damage on the lower stem and roots (see Table 2). The variables analysed were the proportion in each damage category and a mean damage score for both stem and root, the total weight of plants (foliage and roots) per plot and the individual plant weight (foliage and roots). The mean damage score for each plot was calculated by giving each damage category a numeric value, which was: 0 = 0%, 1 = <5%, 2= 5-10%, 3= 10-25%, 4= 25-50% and 5= >50% damage.

No plants showed signs of heavy root damage (scores 4 and 5). The results are summarised in Table 10. The Fipronil treatment (Treatment 7) had more stem damage and less root damage than the comparable control treatment (Treatment 6). Treatments Exp A (Treatment 2) and Exp B (Treatment 4) also reduced root damage compared to their respective control treatments (Treatment 1 and Treatment 3).

Stem damage scores are shown in Table 11 and Figure 5. No statistically significant treatment effects were evident for the proportion of plants in the lower stem damage categories. In the most severe damage class, treatment Exp B (Treatment 4) had a higher proportion affected than the comparable insecticide-free control treatment (Treatment 3).

Treatment Exp B (Treatment 4) had a significantly higher proportion of roots with no damage than several other treatments (Treatments 1, 5 and 6) but not compared with the comparable insecticide-free control treatment (Treatment 3) (Table 12; Figure 6). However, treatment Exp A (Treatment 2) did have a higher of proportion of roots with no damage than the comparable insecticide-free control treatment (Treatment 1). There were no statistically significant differences in the proportions affected in the other root damage categories.

Table 10. The mean root and stem damage scores assessed on 21 August 2007 (6 weeks after planting). Statistically significant differences in the treatment means are shown by the letters next to each mean. Treatment means with a letter in common are said to be not significantly different.

Treatment	Cabbage Variety	Mean stem damage score	Mean root damage score

1. Untreated	Lennox	2.075	bc	0.750	c
2. Exp A	Lennox	2.187	c	0.167	ab
3. Untreated	Ramco	2.062	bc	0.444	bc
4. Exp B	Ramco	2.231	c	0.028	a
5. Chlorpyrifos	Duchy	1.148	ab	0.389	abc
6. Untreated	Duchy	1.091	a	0.593	c
7. Fipronil	Duchy	2.574	c	0.111	ab
F-prob		0.049		0.017	
SED		0.3846		0.1843	
LSD (95%)		0.9411		0.4016	
df		6		6	

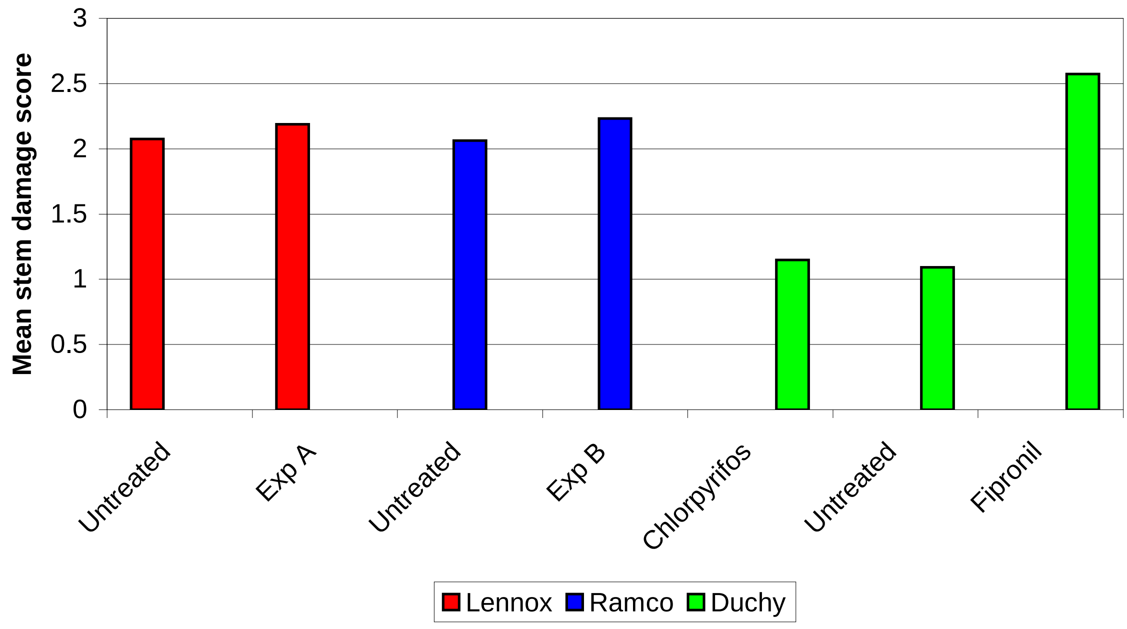

Figure 5. The mean stem damage score per plot (12 plants) on 21 August 2007.

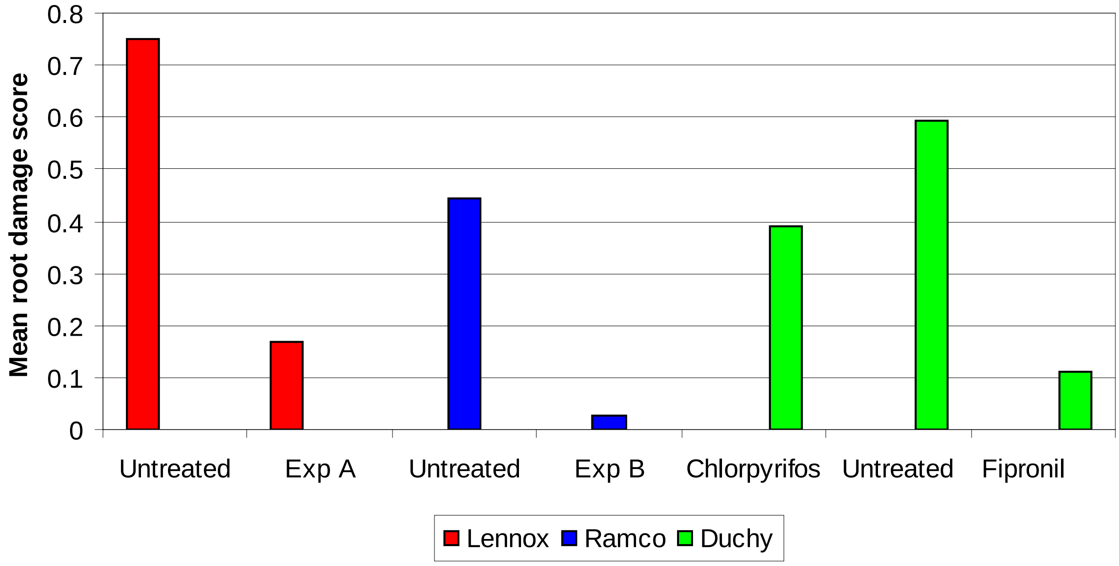

Figure 6. The mean root damage score per plot (12 plants) on 21 August 2007.

Table 11. The mean numbers of plants in each stem damage category assessed on 21 August 2007 (6 weeks after planting). Statistically significant differences in the treatment means are shown by the letters next to each mean. Treatment means with a letter in common are said to be not significantly different.

		Stem Damage							
Treatment	Cabbage Variety	No Damage	<5%	5-10%	10-25%	25-50%		>50%	
1. Untreated	Lennox	0.126	0.209	0.377	0.095	0.142	ab	0.052	ab
2. Exp A	Lennox	0.218	0.155	0.181	0.179	0.204	b	0.064	ab
3. Untreated	Ramco	0.137	0.317	0.137	0.179	0.214	b	0.016	a
4. Exp B	Ramco	0.237	0.141	0.212	0.083	0.215	b	0.111	b
5. Chlorpyrifos	Duchy	0.332	0.332	0.248	0.071	0.000	a	0.040	ab
6. Untreated	Duchy	0.222	0.460	0.264	0.083	0.003	a	0.000	a
7. Fipronil	Duchy	0.000	0.293	0.233	0.226	0.250	b	0.028	a
F-prob		0.246	0.183	0.602	0.802	0.033		0.044	

SED		0.1202	0.1077	0.1190	0.1260	0.0685	0.0292
LSD (95%)		0.2942	0.2636	0.2911	0.3083	0.1677	0.0714
df		6	6	6	6	6	6

Table 12. The mean numbers of roots in each root damage category assessed on 21 August 2007 (6 weeks after planting). Statistically significant differences in the treatment means are shown by the letters next to each mean. Treatment means with a letter in common are said to be not significantly different.

		Root Damage				
Treatment	Cabbage Variety	No Damage		<5%	5-10%	10-25%
1. Untreated	Lennox	0.528	a	0.239	0.234	0.008
2. Exp A	Lennox	0.889	bc	0.025	0.008	0.020
3. Untreated	Ramco	0.722	abc	0.148	0.067	0.067
4. Exp B	Ramco	0.972	c	0.005	0.008	0.008
5. Chlorpyrifos	Duchy	0.694	ab	0.291	0.000	0.020
6. Untreated	Duchy	0.490	a	0.455	0.079	0.000
7. Fipronil	Duchy	0.889	bc	0.124	0.000	0.020
F-prob		0.011		0.209	0.089	0.818
SED		0.1209		0.1578	0.0673	0.0476
LSD (95%)		0.2634		0.3861	0.1648	0.1165
df		6		6	6	6

The cumulative proportion of plants with less than 5%, less than 10%, less than 25% and less than 50% stem damage were also analysed (Table 13). Chlorpyrifos (Treatment 5) and the comparable insecticide-free control treatment (Treatment 6) had a higher proportion with stem damage <10% than Fipronil (Treament 7). No statistically significant differences were found in the analyses of cumulative root damage (Table 14).

Table 13. The cumulative numbers of roots in each stem damage category assessed on 21 August 2007 (6 weeks after planting). Statistically significant differences in the treatment means are shown by the letters next to each mean. Treatment means with a letter in common are said to be not significantly different.

		Stem Damage			
Treatment	Cabbage	<5%	<10%	<25%	<50%

	Variety				
1. Untreated	Lennox	0.334	0.711 ab	0.806 ab	0.948 ab
2. Exp A	Lennox	0.373	0.554 a	0.732 a	0.937 ab
3. Untreated	Ramco	0.454	0.592 a	0.770 a	0.984 b
4. Exp B	Ramco	0.378	0.591 a	0.674 a	0.889 a
5. Chlorpyrifos	Duchy	0.664	0.912 b	0.983 bc	0.960 ab
6. Untreated	Duchy	0.681	0.946 b	1.000 c	1.000 b
7. Fipronil	Duchy	0.264	0.496 a	0.723 a	0.972 b
F-prob		0.171	0.056	0.020	0.044
SED		0.1526	0.1250	0.0760	0.292
LSD (95%)		0.3733	0.3058	0.1860	0.0714
df		6	6	6	6

Table 14. The cumulative numbers of roots in each root damage category assessed on 21 August 2007 (6 weeks after planting).

		Root Damage	
Treatment	Cabbage Variety	<5%	<10%
1. Untreated	Lennox	0.758	0.992
2. Exp A	Lennox	0.972	0.980
3. Untreated	Ramco	0.865	0.933
4. Exp B	Ramco	0.984	0.992
5. Chlorpyrifos	Duchy	0.984	0.980
6. Untreated	Duchy	0.925	1.000
7. Fipronil	Duchy	0.984	0.980
F-prob		0.285	0.818
SED		0.0952	0.0476
LSD (95%)		0.2330	0.1165
df		6	6

At the time of the 6-week assessment, foliage and root weights were recorded for 12 plants in each plot. The total weight and the mean weight were analysed and the key results given in Table 15 and Figure 7. Fipronil (Treatment 7) had a higher total foliage weight than all other treatments.

Table 15. The mean weights (individual and per plot) (12 plants) for foliage and roots at the time of the 6-week harvest (21 August 2007). Statistically significant differences in the treatment means are shown by the letters next to each mean. Treatment means with a letter in common are said to be not significantly different.

		Mean weight of foliage (g)				Mean weight of roots (g)	
Treatment	Cabbage Variety	Individual plant		Total per plot		Individual plant	Total per plot
1. Untreated	Lennox	145.0	abc	1732	ab	8.44	101.5
2. Exp A	Lennox	189.1	cd	2214	b	10.32	121.3
3. Untreated	Ramco	100.9	a	1226	a	6.43	77.8
4. Exp B	Ramco	127.5	ab	1522	a	8.40	100.0
5. Chlorpyrifos	Duchy	187.7	c	2244	b	10.74	128.0
6. Untreated	Duchy	154.5	bc	1846	ab	7.88	91.8
7. Fipronil	Duchy	241.2	d	2910	c	13.28	159.9
F-prob		0.007		0.010		0.093	0.128
SED		21.30		271.4		1.795	23.60
LSD		52.13		664.2		4.391	57.76
df		6		6		6	6

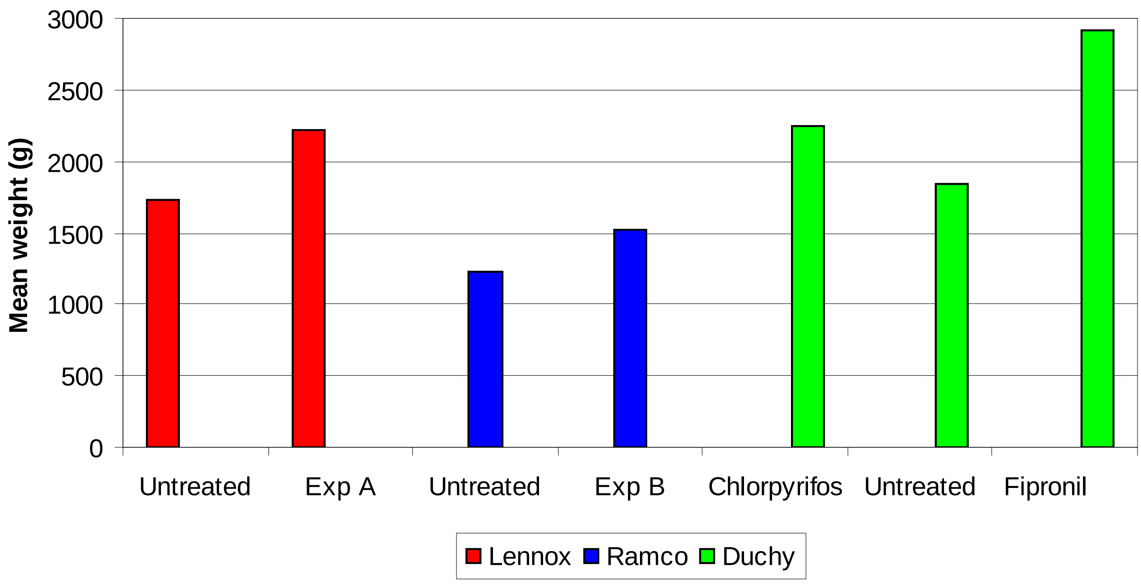

Figure 7. The mean weight of cabbage foliage per plot (12 plants) on 21 August 2007.

Discussion

Treatment 2 (Exp A) caused a small amount of damage to the leaves of the seedlings and seedling vigour was also reduced. However, this effect was not apparent once the plants were transplanted into the field. Despite this seedling damage, Exp A was the only treatment that appeared to provide aphid control later in the season (no aphids were found on these plants - although the results were not statistically significant) together with some control of cabbage root fly larvae. Treatment 4 (Exp B) and Treatment 7 (Fipronil) also reduced cabbage root fly feeding damage to the roots. Fipronil was the only treatment which affected stem damage and this treatment increased stem damage compared with the comparable insecticide-free control treatment. It is possible that amounts of Fipronil which are sub-lethal to cabbage root fly larvae were present at, and just below, the soil surface. These amounts may have been enough to reduce the effectiveness of beneficial insects, resulting in the higher levels of stem damage observed. There was no evidence of flea beetle control, but flea beetle damage was light.

Experiment 2

Novel spray treatments to control cabbage root fly infestations on calabrese spears and aphid infestations on calabrese foliage

Materials and methods

The experiment was done within the field known as Sheep Pens at Warwick HRI, Wellesbourne. There were two aspects to the experiment (the effect of foliar sprays on aphid infestations on the foliage and the effect of foliar sprays on infestations of cabbage root fly in the spears) and different plots (including the insecticide-free control plots) were used to investigate each aspect. The treatments are listed in Table 16.

Calabrese seeds (cv Beaumont) were sown in 308 Hassy trays on 1 June 2007 and kept in a glasshouse. When the plants reached the 4-leaf stage they were transplanted into field plots.

The experiment was laid out as a partially balanced incomplete block design and there were 3 replicates of 10 treatments. Plots were 4.5 m x 1 bed (1.83 m) in size and there were 4 rows of 9 plants (36 plants). Plants were planted at 50 cm spacing within, and 38 cm between, rows.

Table 16. Foliar treatments applied to calabrese to control aphids on the foliage and cabbage root fly in the spears.

Code	Target Pest	Active ingredient and (product)	Adjuvant	Dose (ml or g product/ha)
1	Aphid	Untreated		
2	Aphid	Pymetrozine (Plenum)	Phase II	400 g
3	Aphid	Exp C		480 ml
4	Aphid	Pirimicarb (Aphox)	Agral	420 g
5	Aphid	Exp C	Phase II	480 ml
6	Aphid	Thiacloprid (Biscaya)	Phase II	400 ml
7	Aphid	Exp D	Phase II	500
8	CRF - spear	Untreated		
9	CRF - spear	Chlorpyrifos (Dursban WG)	Agral	1200 g
10	CRF - spear	Spinosad (Tracer)	Agral	200 ml

a) Control of aphids on the foliage

Aphid numbers were monitored in the insecticide-free control plots. As aphid numbers did not increase naturally, the plants were infested with *B. brassicae* and *M. persicae* (an insecticide-susceptible clone (green in colour) and an insecticide-resistant clone (esterase-R2, MACE, kdr-SR resistances - red in colour)). The 6 central plants in each plot were inoculated with *B. brassicae* (10 aphids per plant) on 29 August and 3 each of the central 6 plants were inoculated with susceptible and resistant *M. persicae* (10 aphids per plant) on 4 September. The plants were sprayed on 20 September (Treatments 1- 7, Table 16). A spray rate of 300 l water/ha was used for all treatments.

b) Control of cabbage root fly in spears

When the primary (central) spears had reached a diameter of 3-5 cm (3 October 2007), 20 plants per plot were inoculated with 20 laboratory-reared cabbage root fly eggs. The twenty freshly-laid eggs were placed onto a small (about 1 x 2 cm) piece of moistened black filter paper. An incision (1-2 cm long) was opened across the selected spears and one egg batch was inserted, ensuring that all of the eggs were inside the spear. The incision was closed around the filter paper. On the same day (3 October 2007) and 9 days after inoculation (12 October 2007), the treated plots were sprayed using a knapsack sprayer. A spray rate of 600 l water/ha was used. Agral was added to all spray solutions at a rate of 300 ml/1000 l.

Assessments

a) Aphid, caterpillar and flea beetle assessments

When aphid infestations had established, 10 plants in the middle two rows of each plot (the 6 inoculated plants and 2 plants either end of them) were marked and counts were made of winged, wingless and parasitized aphids on 17 September (pre-spraying). The numbers of caterpillars and moth/butterfly eggs were also recorded and the foliage was scored for flea beetle damage (0 = no damage, 1 = slight damage, 2 = moderate damage and 3 = heavy damage). On 27 September (post-spraying), the pests on the same 10 plants in each plot were assessed as before.

b) Spear assessments

The inoculated spears were cut from the plants on 14 (replicate 1), 15 (replicate 2) and 16 (replicate 3) November (42, 43 and 44 days after inoculation respectively) and stored in a cold room until they were assessed. The spears were then cut at the point of initial incision and examined for damage due to feeding by cabbage root fly larvae. These damaged areas were cut further to remove the larvae. The numbers of larvae in each spear were recorded.

Results

a) Aphid, caterpillar and flea beetle assessments

Pre-spray and post-spray aphid counts were recorded on ten plants within each plot and the total post-spray count within each plot was analysed using REML. No moth/butterfly eggs were recorded on the second assessment date and several other categories had insufficient non-zero data to provide a sensible analysis. The pre-spray count for each post-spray assessment was included in the model as a covariate.

A square root transformation was required to improve the underlying model assumptions and the back-transformed means are given in italics. The results are displayed in Table 17 (*M. persicae*), Table 18 and Figure 8 (*B. brassicae*), Table 19 (total aphids) and Table 20 (caterpillars). All of the treatments, except Treatment 5 (Exp C + phase II), reduced the numbers of wingless *B. brassicae* compared with the insecticide-free control treatment but there were no differences between the other treatments (which all worked well). All treatments except Treatment 2 (Pymetrozine) also reduced the numbers of winged *M. persicae* compared with the insecticide-free control treatment and although all of the treatments reduced the numbers of wingless green (susceptible) *M. persicae*, the differences were not statistically significant. There were insufficient numbers of red (resistant) *M. persicae* to make any comparisons and there were insufficient numbers of caterpillars to draw any sensible conclusions about caterpillar control.

Table 17. The numbers of *Myzus persicae* per plot (10 plants) on calabrese foliage after spraying with insecticides - 27 September 2007. Statistically significant differences in the treatment means are shown by the letters next to each mean. Treatment means with a letter in common are said to be not significantly different. Back-transformed means are shown in italics.

Treatment	*Myzus persicae* winged			*Myzus persicae* wingless		Total *Myzus persicae*	
1. Untreated	1.036	b	*1.074*	2.841	*8.072*	3.364	*11.318*
2. Pymetrozine + Phase II	0.318	ab	*0.101*	0.344	*0.118*	0.414	*0.171*
3. Exp C (no adjuvant)	0.109	a	*0.012*	0.000	*0.000*	0.000	*0.000*
4. Pirimicarb	0.000	a	*0.000*	0.464	*0.215*	0.503	*0.253*
5. Exp C + Phase II	0.000	a	*0.000*	1.522	*2.318*	1.835	*3.368*
6. Thiacloprid + Phase II	0.030	a	*0.001*	0.000	*0.000*	0.000	*0.000*
7. Exp D	0.000	a	*0.000*	0.834	*0.696*	0.429	*0.184*
Covariate	*Myzus persicae* winged			*Myzus persicae* wingless		Total *Myzus persicae*	
χ- prob	0.556			0.544		0.899	
χ- prob	0.037			0.160		0.073	
SED	0.3687			1.369		1.319	
LSD (95%)	0.8115			3.013		2.903	
df	6			6		6	

Table 18. The numbers of *Brevicoryne brassicae* per plot (10 plants) on calabrese foliage after spraying with insecticides - 27 September 2007. Statistically significant differences in the treatment means are shown by the letters next to each mean. Treatment means with a letter in common are said

to be not significantly different. Back-transformed means are shown in italics.

Treatment	*Brevicoryne brassicae* winged		*Brevicoryne brassicae* wingless			Total *Brevicoryne brassicae*		
1. Untreated	0.333	*0.111*	10.614	c	*112.56*	10.649	c	*113.41*
2. Pymetrozine + Phase II	0.000	*0.000*	2.027	ab	*3.690*	2.039	ab	*3.157*
3. Exp C (no adjuvant)	0.000	*0.000*	4.689	ab	*21.610*	4.647	ab	*21.598*
4. Pirimicarb	0.089	*0.008*	0.335	a	*0.030*	0.353	a	*0.125*
5. Exp C + Phase II	0.000	*0.000*	6.241	bc	*39.621*	6.252	bc	*39.091*
6. Thiacloprid + Phase II	0.545	*0.297*	1.914	ab	*3.753*	1.974	ab	*3.898*
7. Exp D	0.141	*0.020*	2.423	ab	*5.874*	2.422	ab	*5.865*
Covariate	*Brevicoryne brassicae* winged		*Brevicoryne brassicae* wingless			Total *Brevicoryne brassicae*		
χ- prob	0.066		0.280			0.262		
χ- prob	0.397		<0.001			<0.001		
SED	0.3166		2.211			2.216		
LSD (95%)	0.6968		4.866			4.877		
df	6		6			6		

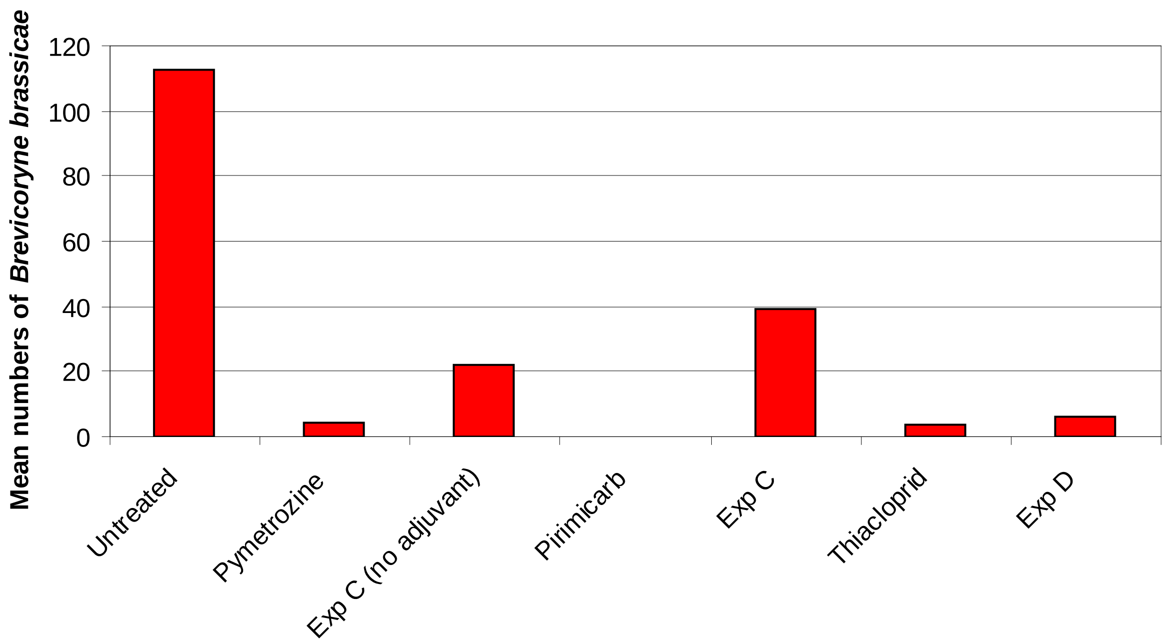

Figure 8. The mean numbers of wingless *Brevicoryne brassicae* per plot (10 plants) on 27 September.

Table 19. The total numbers of winged, wingless and parasitized aphids per plot (10 plants) on calabrese foliage after spraying with insecticides - 27 September 2007. Statistically significant differences in the treatment means are shown by the letters next to each mean. Treatment means with a letter in common are said to be not significantly different. Back-transformed means are shown in italics.

Treatment	Total wingless			Parasitised aphids		Total winged	
1. Untreated	11.275	c	*126.387*	1.634	*2.671*	1.102	*1.215*
2. Pymetrozine + Phase II	1.778	a	*2.758*	1.067	*1.139*	0.299	*0.090*
3. Exp C (no adjuvant)	4.681	ab	*21.656*	1.007	*1.013*	0.072	*0.005*
4. Pirimicarb	0.844	a	*0.324*	0.000	*0.000*	0.000	*0.000*
5. Exp C + Phase II	6.945	b	*49.106*	1.549	*2.401*	0.022	*0.000*
6. Thiacloprid + Phase II	1.821	a	*3.494*	1.728	*2.987*	0.554	*0.307*
7. Exp D	2.413	ab	*5.808*	2.063	*4.255*	0.167	*0.028*
Covariate	Total wingless			Parasitised aphids		Total winged	
χ- prob	0.325			0.007		0.594	
χ- prob	<0.001			0.260		0.250	
SED	2.210			0.8650		0.5094	
LSD (95%)	4.8642			1.9039		1.1212	
df	6			6		6	

Table 20. The numbers of caterpillars per plot (10 plants on calabrese foliage after spraying with insecticides - 27 September 2007. Back-transformed means are shown in italics.

Treatment	*Evergestis forficalis*		*Autographa gamma*		Total caterpillars	
1. Untreated	0.011	*0.000*	0.000	*0.000*	0.019	*0.000*
2. Pymetrozine + Phase II	0.001	*0.000*	0.016	*0.000*	0.698	*0.487*
3. Exp C (no adjuvant)	0.014	*0.000*	0.000	*0.000*	0.451	*0.203*
4. Pirimicarb	0.000	*0.000*	0.328	*0.121*	0.676	*0.457*
5. Exp C + Phase II	0.327	*0.107*	0.628	*0.394*	1.504	*2.263*
6. Thiacloprid + Phase II	0.472	*0.223*	0.065	*0.004*	2.771	*7.680*
7. Exp D	0.458	*0.209*	0.114	*0.013*	0.900	*0.811*
Covariate	*Evergestis forficalis*		*Autographa gamma*	Total caterpillars	*Evergestis forficalis*	
χ- prob	0.946		0.707		0.993	
χ- prob	0.709		0.016		0.148	
SED	0.4243		0.2353		1.039	
LSD (95%)	0.9339		0.5179		2.287	
df	6		6		6	

b) Spear assessments

The proportion of damaged plants in each plot was analysed using REML. No data transformations were required and the results are summarised in Table 21 and Figure 9. Fewer plants showed signs of damage in the Chlorpyrifos treatment.

Table 21. The mean proportion of calabrese spears damaged by cabbage root fly larvae after insecticide spray treatment - 14-16 November 2007. Statistically significant differences in the treatment means are shown by the letters next to each mean. Treatment means with a letter in common are said to be not significantly different.

Treatment	Proportion damaged	
8. Untreated	0.972	b
9. Chlorpyrifos	0.565	a
10. Spinosad	0.919	b
	<0.001	
SED	0.0648	
LSD (95%)	0.1800	
df	2	

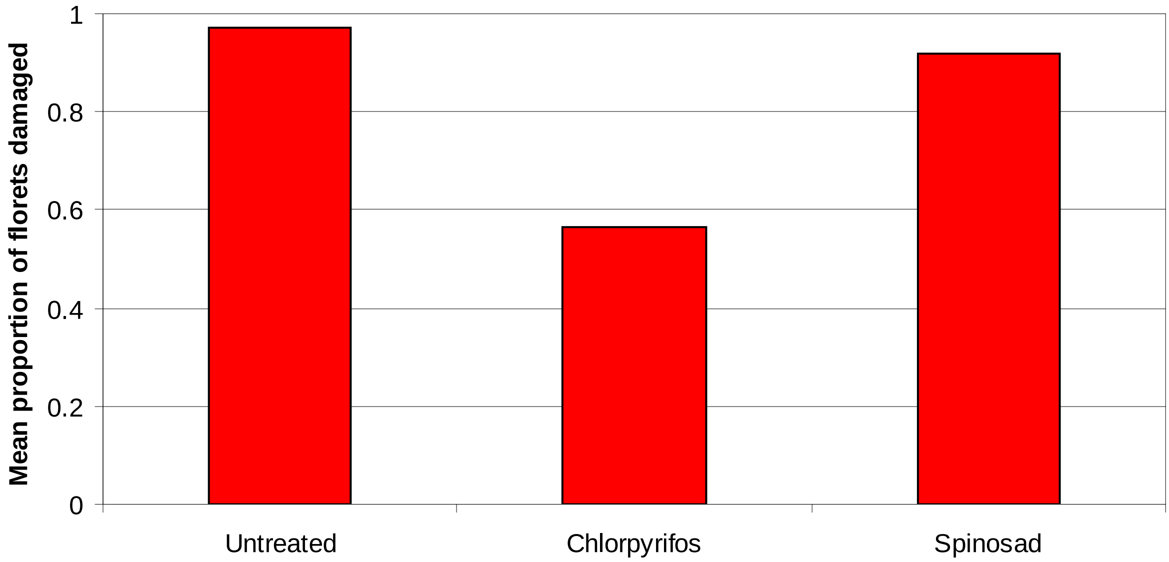

Figure 9. The mean proportion of calabrese spears damaged by cabbage root fly larvae after insecticide spray treatment - 14-16 November 2007.

The numbers of second and third instar larvae were also recorded and were analysed using REML. The χ- probability value in the tables is associated with the Wald Statistic. The results (Table 22) show that Chlorpyrifos treatment had fewer third instar larvae and total numbers of larvae than the other two treatments, but there was no statistically significant difference between the untreated plants and those treated with Spinosad. A significant treatment effect was suggested for the total number of second instar larvae, however, the pair-wise comparisons do not indicate any differences between the treatments. The untreated plants had a higher number of second instar larvae than those treated with Spinosad, which in turn had a higher count than the Chlorpyrifos treatment. The total numbers of larvae are also displayed in Figure 10.

Table 22. The numbers of second instar larvae, third instar larvae and the total numbers of cabbage root fly larvae per plot (20 plants) recovered from calabrese spears after spray treatment - 14-16 November 2007. Statistically significant differences in the treatment means are shown by the letters next to each mean. Treatment means with a letter in common are said to be not significantly different

Treatment	Second instar larvae		Third instar larvae		Total number of Larvae	
8. Untreated	11.40	a	85.65	b	99.57	b
9. Chlorpyrifos	2.18	a	12.50	a	13.99	a
10. Spinosad	6.67	a	60.00	b	66.63	b
χ- prob	0.026		<0.001		<0.001	
SED	3.410		10.577		12.13	
LSD (95%)	9.466		29.361		33.67	
df	2		2		2	

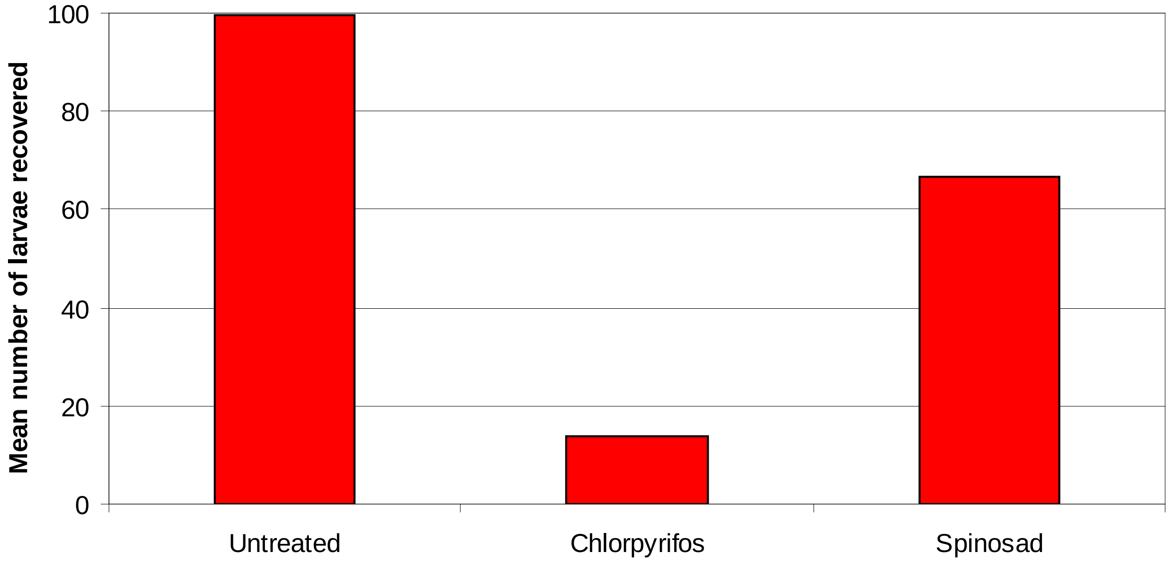

Figure 10. The mean number of cabbage root fly larvae per plot (20 plants) recovered from calabrese spears after spray treatment - 14-16 November 2007.

<u>Discussion</u>

Aphid populations did not build up naturally, probably as a result of the very wet weather in July 2007, so laboratory-reared aphids were introduced. *Brevicoryne brassicae* numbers increased following inoculation and the efficacy of the insecticide sprays against this species could be assessed. Numbers of insecticide resistant and susceptible *M. persicae* did not reach sufficient levels to allow good assessments of insecticide efficacy.

This trial has confirmed that calabrese spears (and probably cauliflower curds and possibly Brussels sprout buttons) can be infested artificially with cabbage root fly with a fair degree of success. This means that treatments can be tested in the absence of a natural infestation. Natural infestations are sporadic, weather dependent and hard to predict. Chlorpyrifos sprays were very effective against cabbage root fly larvae in calabrese spears. However, although Spinosad was less effective, had there been more replication, it is likely that the difference between Spinosad and the insecticide-free control treatment would have been statistically significant. Spraying the edible part of the plant with Chlorpyrifos so close to harvest is likely to lead to unacceptably high residues.

CONCLUSIONS

Cabbage seed treatments

a) Phytotoxicity

The novel insecticide Exp A caused a small amount of damage to the leaves of the cabbage seedlings. Seedling vigour was also reduced. However, this effect was not apparent once the plants were transplanted into the field.

b) Control of foliar pests

There was no evidence of flea beetle control, but damage was light. Aphid numbers were very low until September, when numbers of *B. brasicae* increased (but not to the levels usually observed). Despite the fact that no *B. brassicae* were found on plants treated with Exp A on either 18 September (13 weeks after sowing) or 29 October (19 weeks after sowing), there was no statistically significant treatment effect compared with the comparable insecticide-free control treatment. However, it was clear that Exp A provided long-term control of aphids. There was no obvious control by any of the other treatments at that time.

c) Control of cabbage root fly larvae

Exp A, Exp B and Fipronil all reduced root damage due to feeding by cabbage root fly larvae compared with the insecticide-free control treatments. However, Exp A did not reduce stem damage and Fipronil increased stem damage compared with the insecticide-free control. Surprisingly, the standard Chlorpyrifos treatment appeared to have been ineffective

Sprays on calabrese

a) Control of aphids

It was a difficult year for experiments on aphid control with less than usual numbers of aphids present throughout the season. Artificial infestation of plants with *Brevicoryne brassicae* was more successful than with *Myzus persicae.* Consequently, the results for *B. brassicae* are more reliable. All of the insecticides tested as foliar sprays reduced the numbers of wingless *B. brassicae.* Exp C (with Phase II) appeared to be the least effective treatment. The other insecticides had similar efficacy to one another.

b) Control of cabbage root fly on spears

This trial has confirmed that calabrese spears (and probably cauliflower curds and possibly Brussels sprout buttons) can be infested artificially with cabbage root fly with a fair degree of success. This means that treatments can be tested in the absence of a natural infestation. Natural infestations are sporadic, weather dependent and hard to predict.

Both of the insecticide spray treatments appeared to have some effect on cabbage root fly numbers and the proportion of spears damaged, but only Chlorpyrifos had a statistically significant effect. With greater replication it seems likely that Spinosad would also show a statistically significant effect and this treatment might be adequate for a light infestation. Spraying the edible part of the plant with Chlorpyrifos so close to harvest is likely to lead to unacceptably high residues.

TECHNOLOGY TRANSFER

Date	Description
April 2007	Timing is of the essence in aphid control. HDC News April 2007, 20-21.
July/August 2007	Choices for cabbage root fly control. HDC News July/August 2007, 22-23.

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