Project title:	Brassicas: Evaluation of novel insecticides for control of cabbage root fly and aphids – continuation of FV 328a.
Project number:	FV 328b
Project Leader:	Rosemary Collier and Andrew Jukes Warwick HRI**,** Wellesbourne, Warwick CV35 9EF
Final report:	2009/2010
Previous reports:	N/A
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Location of project:	Warwick HRI**,** Wellesbourne, Warwick, CV35 9EF
Project co-ordinators:	Fred Tyler, Alphagrow Ltd, ACRS, Tarnside, Dimples Lane, Barnacre, Garstang, Lancashire, PR3 1UA
Date project commenced:	1 April 2009
Date project completed:	31 March 2010
Key words:	Cauliflower, Brussels sprout, cabbage root fly, aphids, caterpillars, flea beetles, foliar spray, seed treatment, pre-planting drench.

Signed on behalf of: **Warwick HRI**

Brian Thomas ***26 March 2010***

Signature:…………………………………………… ***Date***: ……………………………

Name Professor Brian Thomas

CONTENTS

GROWER SUMMARY

Headline

No evidence suggests a difference in efficacy between the two standard cabbage root fly control treatments (Tracer and Dursban). The novel insecticide Exp A shows excellent potential for controlling a wide range of pests to include cabbage root fly, aphids and caterpillars on brassicas by a variety of application methods.

Movento (spirotetramat) and Plenum (pymetrozine) applied as foliar sprays provide effective control of cabbage aphid on Brussels sprout. Control effects of Movento are the most persistent.

Background and expected deliverables

Cabbage root fly, *Delia radicum*, is one of the most serious pests of brassica crops in the United Kingdom. There are currently two approved chemicals, Chlorpyrifos (e.g. Dursban) and Spinosad (Tracer) (SOLA) for cabbage root fly control on leafy brassica crops in the UK. No product has been available to control cabbage root fly on swede and turnip since 2003. Cabbage root fly control on these crops relies increasingly on the use of physical barriers consisting of fine mesh netting. Only Chlorpyrifos is approved for control of cabbage root fly on radish. Alternative treatments using Spinosad, evaluated in 2006 (FV 242d), do not appear promising. In addition, there is no very effective insecticide treatment that controls 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 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. Greater reliance on neonicotinoid insecticides (e.g. Imidacloprid, Thiacloprid, Acetamiprid) increase 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 pest insects of brassica crops, principally cabbage root fly and aphids, but also taking account of efficacy against other brassica pests such as caterpillars, flea beetle and whitefly.

The expected deliverables from this work include:

- An evaluation of novel seed and drench treatments for the control of cabbage root fly and aphids.
- An evaluation of novel insecticide sprays and seed treatments for the control of aphids on Brussels sprout.

Summary of the project and main conclusions

The following experiments were done at Warwick HRI, Wellesbourne:

<u>Experiment 1 Novel insecticide treatments to control aphids, caterpillars, flea beetle and cabbage root fly on cauliflower</u>

Including an untreated control, there were 9 treatments (1 seed treatment, 1 Sanokote® treatment, 5 drench treatments and 1 Phytodrip treatment). Cauliflower seed (cv Skywalker) was sown on 28 May 2009. Plants were raised in a greenhouse and transplanted on 7 July 2009.

<u>Experiment 2 Novel insecticide treatments to control aphids caterpillars and whitefly on Brussels sprout</u>

Brussels sprout seed (cv Montgomery) was sown on 28 May 2009 into 308 Hassy trays and the trays were placed in a greenhouse. Plants were transplanted on 7 July 2009. There were 8 treatments (4 sprays, 2 Sanokote® treatments and 1 Phytodrip treatment) which included an untreated control. All sprays were applied using a knapsack sprayer fitted with 02F110 nozzles.

Experiment summaries and main conclusions

Experiment 1 - cauliflower

Destructive samples were taken from all plots on 7 August. Roots were washed and the roots and foliage weighed. Washed roots and stems were examined and scored for feeding damage by cabbage root fly larvae. Feeding damage to the roots from untreated control plots was too low to demonstrate statistically-significant effects, but the Chlorpyrifos (Dursban), Spinosad (Tracer) and Exp A drench treatments and the Fipronil seed treatment all reduced damage compared with the untreated control. None of the treatments reduced cabbage root fly feeding damage to the stem but the Phytodrip (Exp D) treatment increased damage compared to the untreated control. This is not surprising as this treatment has been shown previously to increase feeding damage when applied at the commercial rate. This is because the dose is too low to kill cabbage root fly larvae and merely delays their development and/or affects beneficial insects. Plants treated with Spinosad, Exp A, Exp C and Exp D had heavier roots than the untreated control and plants treated with Exp A, Exp C and Exp D also had heavier foliage.

Wet weather in summer 2009 suppressed populations of aphids and whitefly. There were few statistically significant differences in aphid numbers in the trial on cauliflower when assessed on 7 August. This probably reflects the overall low numbers of aphids present rather than an absence of treatment effects. By 4 September, however, aphid numbers had increased and Exp A (drench), Exp C (Sanokote® treatment) and Exp D (Phytodrip) had all reduced aphid numbers significantly compared to the untreated control. Similarly, caterpillar numbers were low in August but by September a significant reduction in numbers could be seen with Exp A compared with the untreated control. Exp B also appeared to reduce aphid and caterpillar numbers, but differences were not statistically significant. Flea beetle damage was low overall and again may be a reason for the lack of treatment effects, particularly with the seed treatments, some of which have provided flea beetle control in previous experiments.

At harvest, Exp A, Exp B and Fipronil increased curd weight and Exp A also increased curd diameter. Exp C and Exp D hastened maturity compared with the control treatment and Exp A reduced the spread of maturity. Table A summarises the observations from Experiment 1.

Table A: Summary of treatment effects in Experiment 1 (cauliflower). Comments refer to statistically significant treatment effects compared with the appropriate insecticide-free control treatment

Assessment	**Drench Dursban**	**Drench Tracer**	**Drench Exp A**	**Drench Exp B**	**Drench Nemolt**	**Seed treatment Fipronil**	**Sanokote® Exp C**	**Phytodrip Exp D**
Aphids			Decrease				Decrease	Decrease
Caterpillars			Decrease					
Foliage weight			Increase				Increase	Increase
Root weight		Increase	Increase				Increase	Increase
Root damage[1]	Decrease	Decrease	Decrease			Decrease		
Stem damage								Increase
Curd weight			Increase	Increase		Increase		
50% maturity							Decrease	Decrease
25-75% spread maturity			Decrease					

[1]Differences not statistically significant due to general lack of root damage, but almost certainly treatment effects

Experiment 2 – Brussels sprout

Evaluation of aphicide sprays was limited because of the low numbers of aphids early in the season due to the wet summer. However, aphid numbers increased considerably in September and 2 spray applications were made. At the time of the first assessment (11 September – pre-spraying), all of the sowing-time treatments (Exp C, Exp D and Sanokote® – Imidacloprid) had reduced aphid numbers compared with the untreated control. This control diminished over time but continued up to the last assessment on 2 November. There was no apparent control due to spray treatments (applied 16 September) when assessment were made 1 week after the first spray, but after the second spray (applied 30 September) all spray treatments except Exp B had reduced aphid numbers. Suppression of aphids continued with Exp A until 16 October (16 days after second spray) and Movento was continuing to give control on 2 November (33 days after second spray). Caterpillars, whitefly and flea beetle damage were also assessed but the only significant effect was a reduction in the incidence of whitefly on plants treated with Sanokote® – Imidacloprid on 11 September. Caterpillar numbers declined rapidly on all plots after 11 September and flea beetle damage was too low to see treatment effects. Table B summarises the observations from Experiment 2.

Table B: Summary of treatment effects in Experiment 2 (Brussels sprout). Comments refer to statistically significant treatment effects compared with the appropriate insecticide-free control treatment

Assessment	**Spray Exp A**	**Spray Exp B**	**Spray Movento**	**Spray Plenum**	**Sanokote® Exp C**	**Phytodrip Exp D**	**Sanokote®I midacloprid**
Aphids	Decrease		Decrease	Decrease	Decrease	Decrease	Decrease
Caterpillars							
Whitefly							Decrease
Flea beetle							

Conclusions

- All pre-planting insecticidal drench treatments had some positive effects on cabbage root fly feeding damage and/or plant weight, and an experimental treatment was more consistent in its effect than the approved treatments (Dursban and Tracer).
- Several sowing-time treatments showed effective control of aphids (Sanokote® – Imidacloprid, Sanokote® – Exp C, phytodrip – Exp D and drench – Exp A).
- Three sprays gave aphid control (Pymetrozine (Plenum), Exp A and Spirotetramat (Movento)). Treatment effects of Spirotetramat persisted the longest.

- One of the pre-planting insecticidal drench treatments appeared to reduce caterpillar numbers. Populations of whitefly and flea beetle were too low to assess the impact of seed or foliar spray treatments on these pests.
- Flea beetle and whitefly numbers were too low to establish accurate information on control of these pests.
- A number of treatments increased curd weight at harvest (Exp A - drench, Exp B - drench and Fipronil – seed-treatment) or root weight mid-season (Spinosad (Tracer) – drench, Exp A - drench, Exp C – Sanokote® and Exp D – Phytodrip)
- The most effective overall treatment appeared to be Exp A. When applied as either a pre-planting drench or as a foliar spray it gave control of aphids. The drench treatment also controlled caterpillars; increased root, foliage and cauliflower curd weight and decreased the spread in time to maturity.

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

- No evidence suggests a difference in efficacy between the two standard cabbage root fly control treatments (Tracer and Dursban).
- Movento and pymetrozine - Plenum provide effective control of cabbage aphid. The control effects of Movento are most persistent.
- Sanokote® (Exp C) treatment increases the amount of damage to cauliflower stems due to feeding by cabbage root fly larvae compared with untreated plants (as seen previously with Imidacloprid treatments).

SCIENCE SECTION

Introduction

The cabbage root fly (*Delia radicum*) is one of the most serious pests of brassica crops in the United Kingdom. There are currently two approved chemicals, Chlorpyrifos (e.g. Dursban)) and Spinosad (Tracer) (SOLA) 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 2003 and cabbage root fly control on these crops relies increasingly on the use of physical barriers consisting of fine mesh netting. 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 very 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 *Brevicoryne brassicae* and *Myzus 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, Acetamiprid) 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 potato 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 extension is to continue 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 whitefly and flea beetle.

There were 2 field experiments in 2009.

The field experiments were as follows:

Experiment 1 - Novel insecticide treatments to control aphids, caterpillars, flea beetle and cabbage root fly on cauliflower

Experiment 2 - Novel insecticide treatments to control aphids, caterpillars and whitefly on Brussels sprout

Experiment 1 - Novel insecticide treatments to control aphids, flea beetle and cabbage root fly on cauliflower

Materials and methods

The experiment was done in the field known as Pump Ground at Warwick HRI, Wellesbourne.

There were 8 insecticide treatments (Table 1.1). A batch of cauliflower seeds (cv Skywalker) was treated with Fipronil (Mundial) on 21 May using the Experimental fluidised bed apparatus at WHRI, Wellesbourne using Sepiret 8153 polymer as sticker at 2% of product weight.

The cauliflower seed was sown in 308 Hassy trays on 28 May 2009. One tray was sown with the Fipronil treated seed, one with the addition of Sanokote® – Exp C and each seed in one tray was treated with 0.2 ml of a solution containing Exp D (using a 0.2 ml automatic pipette) to mimic a Phytodrip treatment. Five trays were sown with untreated seed and all of the trays were placed in a greenhouse. On 5 July 2009 (at the 4 leaf stage), the drench treatments were applied using a 1 ml automatic pipette. Treatments were washed on to the modules with an equivalent volume of water. Treatment details are shown in Table 1.1 and all plants were transplanted on 7 July 2009. The trial was laid out as an incomplete Trojan square design with 4 rows and 9 columns. Each plot was 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 44 plants.

Table 1.1 Treatments used in trial on cauliflower

	Application	**Product**	**a.i.**	**Rate**	
				mg a.i./plant	**product**
1		Untreated			
2	Drench	Dursban WG	Chlorpyrifos	4.5	6 g/1000 plants
3	Drench	Tracer	Spinosad	5.76	12 ml/1000 plants
4	Drench	Exp A		6	30ml/1000 plants
5	Drench	Exp B		1.4	7ml/1000 plants
6	Drench	Nemolt	Teflubenzuron	7.2	48ml/1000 plants
7	Seed		Fipronil	0.125	25ml/unit[1]
8	Sanokote® (Dead seed)	Exp C		1.2 + 0.4 (total)	
9	Phytodrip	Exp D		1.4	2 g /1000 seeds

[1] 1 unit = 100,000 seeds

Assessments

On 7 August, 12 cauliflower plants were sampled from each plot. The roots and stems of each plant were assessed for damage caused by cabbage root fly larvae and given a score from 0 – 5. The foliage and root weights were also recorded and foliar pest assessments were made. Data were also collected on 7 August (12 plants) on the numbers of the various species of aphids and caterpillars present, the presence of other insects and the amount of flea beetle damage (on a scale of 0 = none, 1 = slight, 2 = moderate and 3 = severe). The foliar pests were assessed again on 4 September (12 plants) and on this date the maximum plant width was also measured

Up to 32 (all remaining plants) cauliflower plants were harvested from each plot between 18 September and 23 October. Data were collected on the harvest date of each plant, the curd weight, the curd diameter and the class of each curd.

Results

Statistical analysis

All analyses were performed using analysis of variance (ANOVA). Interpretations were made using the treatment means along with standard errors of the difference (SED) and least significance difference (LSD) values. Where appropriate, transformations of the data were used to ensure homogeneity of variance between treatments. There were 4 replicates of each treatment arranged in an incomplete Trojan square design with 9 rows and 4 columns.

Foliar Pest Assessments

a) Aphids

A square root transformation was used for the analysis of the aphid counts to ensure homogeneity of variance between treatments. Tables present the means for each treatment together with F-Values and P-Vales. SEDs and 5% LSDs are presented for pair-wise comparisons.

Only *Brevicoryne brassicae* (cabbage aphid) was observed and no analyses were carried out on winged aphids as the counts were too small. For wingless aphids, the treatment factor for both dates was significant at the 5% level using an F-test. For the 7 August assessment a large number of zero values reduced the background variability and therefore inflated the significance of the treatment factor and the differences between treatments. For the 4 September assessment, Exp A – drench, Exp C – Sanokote® and Exp D – Phytodrip all had means significantly smaller than the untreated control. The mean numbers of aphids per plant are presented in Table 1.2 (winged), Table 1.3 (wingless) and Figure 1.1 (wingless)

Table 1.2 Cauliflower - Mean numbers of winged *Brevicoryne brassicae* on cauliflower plants

Treatment	7 August	4 September
Untreated	0.021	0.000
Chlorpyrifos	0.063	0.000
Spinosad	0.021	0.021
Exp A	0.021	0.000
Exp B	0.042	0.000
Teflubenzuron	0.000	0.021
Fipronil	0.031	0.000
Exp C	0.000	0.000
Exp D	0.000	0.000

Table 1.3 Cauliflower - Mean numbers of wingless *Brevicoryne brassicae*

Treatment	7 August		4 September	
	Back Trans.	Trans.	Back Trans.	Trans.
Untreated	0.157	0.396	23.59	3.161
Chlorpyrifos	0.998	0.999	10.87	2.387
Spinosad	0.169	0.411	21.85	3.084
Exp A	0.003	-0.050	0.58	-0.529
Exp B	0.038	0.194	6.27	1.838
Teflubenzuron	0.007	0.085	15.33	2.731
Fipronil	0.138	0.371	39.55	3.678
Exp C	0.007	0.081	0.86	-0.138
Exp D	0.028	-0.168	0.97	-0.025
F-val		3.020		4.180
P-val		0.029		0.007
SED		0.283		1.075
LSD		0.6		2.278
df		16		16

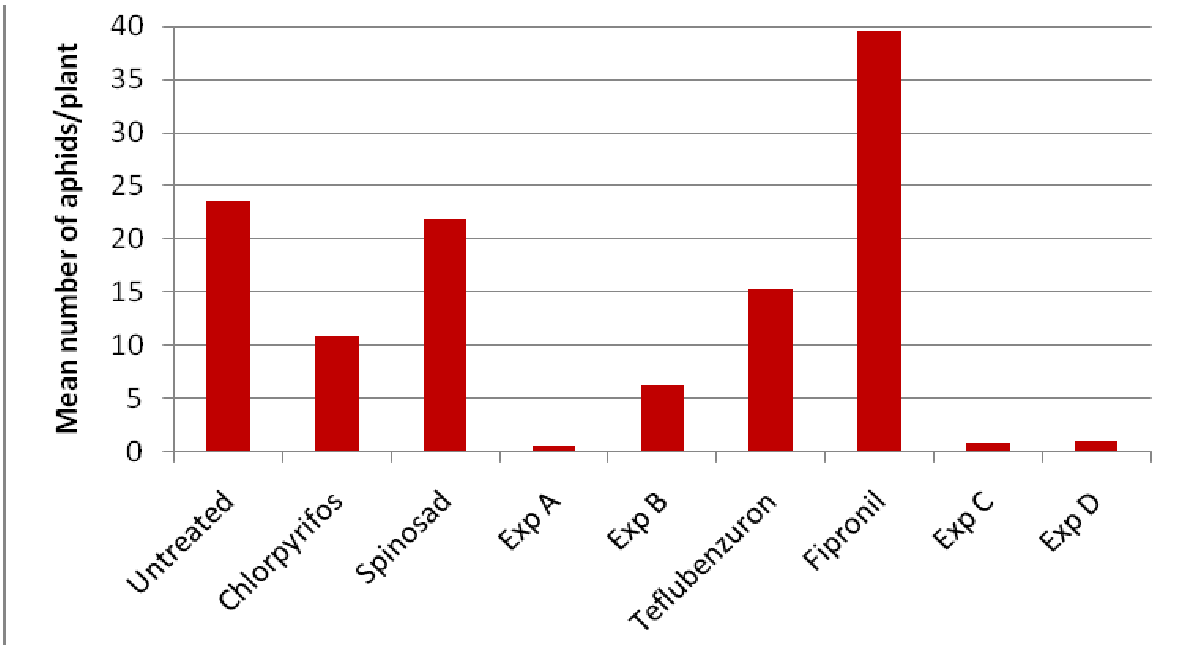

Figure 1.1 Cauliflower - Mean numbers of wingless *Brevicoryne brassicae* on 4 September 2009

b) Whitefly

Numbers were generally low and whitefly numbers were higher towards one side of the trial, making assessment of treatment effects difficult. The presence or absence of whitefly was recorded on individual cauliflower plants. An angular transformation was used for the analysis of the whitefly counts to ensure homogeneity of variance between treatments. The treatment factor was not significant at a 5% level using an F-test at either date. None of the treatments had a mean which was significantly smaller than that for the untreated control. The results are presented in Table 1.4.

Table 1.4 Cauliflower - Mean percentage of plants with whitefly

Treatment	7 August		4 September	
	Back Trans.	Trans.	Back Trans.	Trans.
Untreated	5.91	14.073	26.03	30.680
Chlorpyrifos	0.92	5.490	22.04	28.000
Spinosad	0.71	4.845	23.99	29.330
Exp A	4.88	12.765	30.49	33.520
Exp B	1.43	6.859	13.35	21.430
Teflubenzuron	1.31	6.563	22.81	28.530
Fipronil	0.00	-1.311	14.28	22.200
Exp C	8.22	16.658	14.58	22.440
Exp D	11.39	19.726	21.68	27.750
F-val		1.560		0.370
P-val		0.215		0.920
SED		7.120		9.700
LSD		15.100		20.570
df		16		16

c) Flea beetle

No transformations of the data were required. The treatment factor for both dates was not significant at a 5% level using an F-test. None of the treatment means were significantly different from the untreated control. This, to a large extent, is probably due to the low levels of damage observed and does not necessarily indicate an absence of control. The results are presented in Table 1.5.

Table 1.5 Cauliflower - Mean flea beetle damage score

Treatment	7 August	4 September
Untreated	0.994	1.036
Chlorpyrifos	1.045	1.091
Spinosad	0.985	1.083
Exp A	0.993	1.259
Exp B	1.072	1.141
Teflubenzuron	1.060	1.174
Fipronil	1.138	0.832
Exp C	0.980	1.192
Exp D	1.024	1.056
F-val	0.830	1.850
P-val	0.593	0.141
SED	0.077	0.125
LSD	0.162	0.266
df	16	16

d) Caterpillars

The presence or absence of caterpillars on individual plants was recorded. Caterpillars of small and large white butterflies and diamond-back, garden pebble and silver-Y moths were observed. The two butterflies were quite common and the moths were seen only on a few plants. Numbers had generally increased between the 2 assessment dates (7 August and 4 September). The percentage by number of plants with any type of caterpillar was analysed on both dates (Table 1.6 and Figure 1.2) and the percentage by number of plants with small white or large white caterpillars (Table 1.7) was analysed for the 4 September data only. An angular transformation was used to ensure homogeneity of the variance between the treatments. When presence or absence of any caterpillar was considered, the treatment factor was significant for the assessments on 4 September at the 10% level using an F-test. Exp A had a mean significantly smaller than the untreated control and Exp B also appeared to reduce caterpillar numbers (but not significantly). When small white and large white caterpillars were considered individually, a similar pattern was observed, but the treatment factor was not significant for either analysis.

Table 1.6 Cauliflower - Mean percentage of plants with any caterpillars

Treatment	7 August		4 September	
	Back Trans.	Trans.	Back Trans.	Trans.
Untreated	2.55	9.195	43.69	41.380
Chlorpyrifos	2.64	9.341	34.22	35.800
Spinosad	0.46	3.891	32.10	34.510
Exp A	0.05	1.275	5.39	13.430
Exp B	1.24	6.388	7.57	15.970
Teflubenzuron	10.49	18.893	20.28	26.770
Fipronil	6.48	14.749	28.50	32.260
Exp C	3.98	11.500	74.77	59.850
Exp D	6.07	14.264	36.35	37.080
F-val		0.880		2.340
P-val		0.557		0.070
SED		8.200		12.900
LSD		17.370		27.350
df		16		16

Table 1.7 Cauliflower - Mean percentage of plants with small white and large white caterpillars on 4 September 2009

Treatment	Small white		Large white	
	Back Trans.	Trans.	Back Trans.	Trans.
Untreated	29.45	32.870	12.56	20.760
Chlorpyrifos	16.05	23.620	23.95	29.300
Spinosad	20.39	26.840	1.57	7.190
Exp A	3.53	10.830	1.12	6.060
Exp B	4.15	11.750	0.65	4.640
Teflubenzuron	16.70	24.120	3.26	10.400
Fipronil	9.99	18.430	2.25	8.630
Exp C	40.73	39.660	15.49	23.170
Exp D	29.33	32.790	7.43	15.820
F-val		1.550		1.800
P-val		0.217		0.151
SED		11.480		9.480
LSD		24.330		20.100
df		16		16

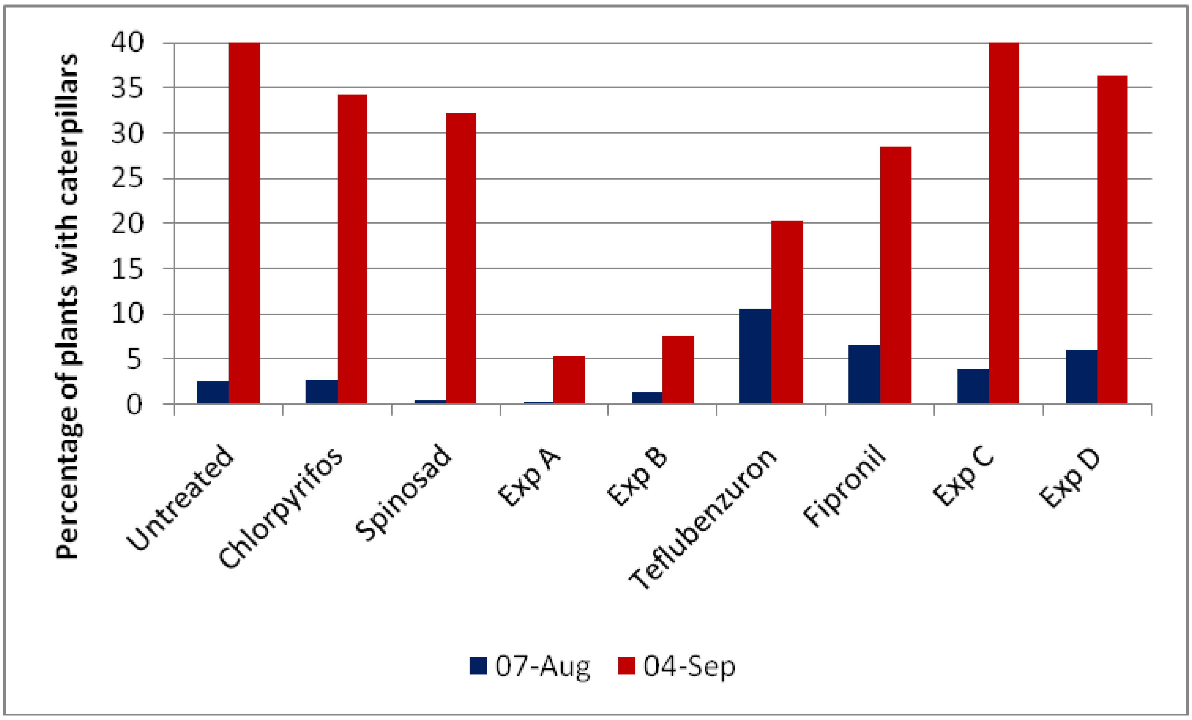

Figure 1.2 Cauliflower - mean percentage of plants with caterpillars on 4 September 2009

<u>Mid-season (7 August) root (cabbage root fly damage) and foliage assessments</u>

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%. Root and foliage weights were also recorded. The mean score or weight per plot was analysed and no transformations of the data were required. The results are presented in Table 1.8 and Figures 1.3 (root damage), 1.4 (stem damage), 1.5 (root weight) and 1.6 (foliage weight). The treatment factor was significant at the 5% level using an F-test for the analyses of the foliage weight, root weight and stem damage, but not for the analysis of root damage.

Exp A, Exp C and Exp D treatments all had mean foliage weights significantly larger than the untreated control plants. Spinosad, Exp A, Exp C and Exp D all had mean root weights significantly larger than the untreated plants. The only statistically significant difference in stem damage was an increase in damage on plants treated with Exp D compared with untreated plants.

The treatment factor for root damage was not considered to be significant at the 5% level. There were substantial numbers of zero values for the Chlorpyrifos, Spinosad and Exp A treatments. This had two effects; firstly it reduced the estimated background variability within the trial and hence inflated the significance of the differences between treatments. Secondly, it resulted in negative means being presented for these treatments. However, it appears likely that these 3 treatments and Fipronil all reduced cabbage root fly damage to the roots compared with the untreated control plants. This was not reflected in the stem damage because much of the stem area assessed would have been in the soil, above the zone that received the insecticide treatment (the plant propagation module).

Table 1.8 Cauliflower – Root and stem damage plus root and foliage weight mid-season (7 August 2009)

Treatment	Weight (g)		Cabbage root fly damage	
	Root	Foliage	Root	Stem
Untreated	6.29	142.7	0.369	2.55
Chlorpyrifos	7.33	183.3	-0.001	2.37
Spinosad	8.54	182.4	-0.011	2.41
Exp A	9.17	215.0	-0.022	2.58
Exp B	7.53	178.7	0.129	2.90
Teflubenzuron	6.76	157.6	0.104	2.55
Fipronil	8.12	160.0	0.054	2.15
Exp C	10.45	210.1	0.229	3.21
Exp D	8.60	220.3	0.249	3.29
F-val	3.190	3.250	1.760	2.600
P-val	0.023	0.021	0.160	0.049
SED	0.987	20.620	0.137	0.333
LSD	2.092	43.710	0.290	0.733
df	16	16	16	16

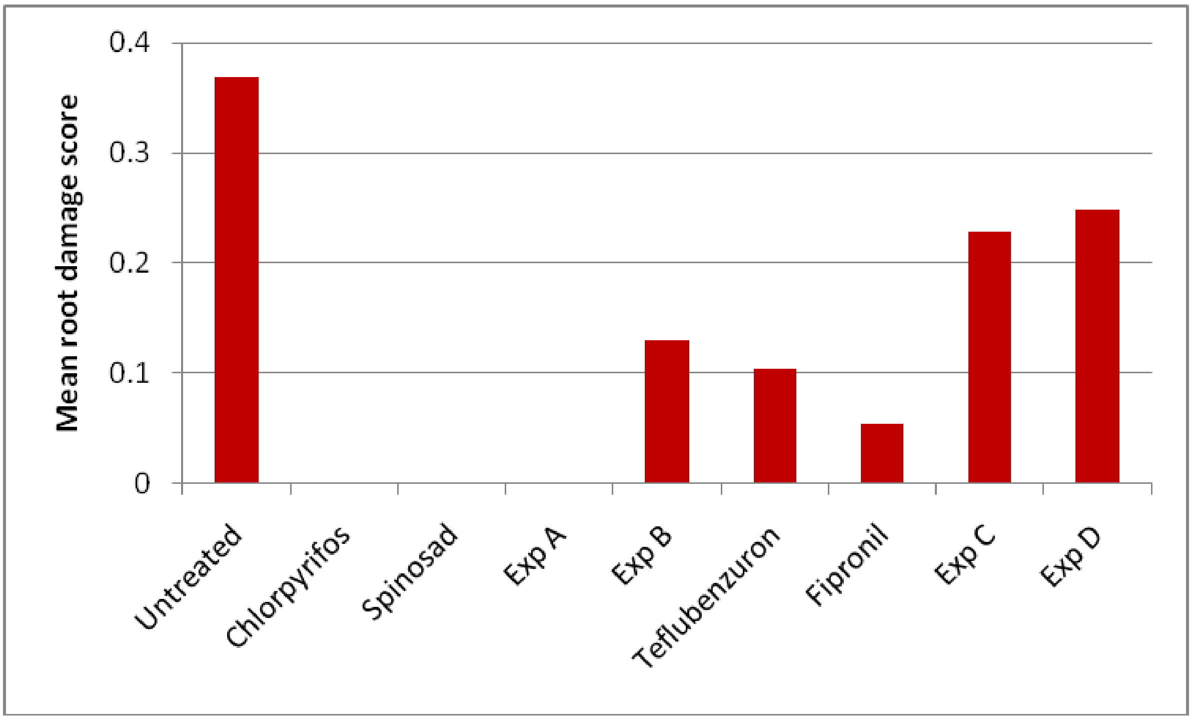

Figure 1.3 Cauliflower - mean root damage score due to cabbage root fly larvae on 7 August 2009

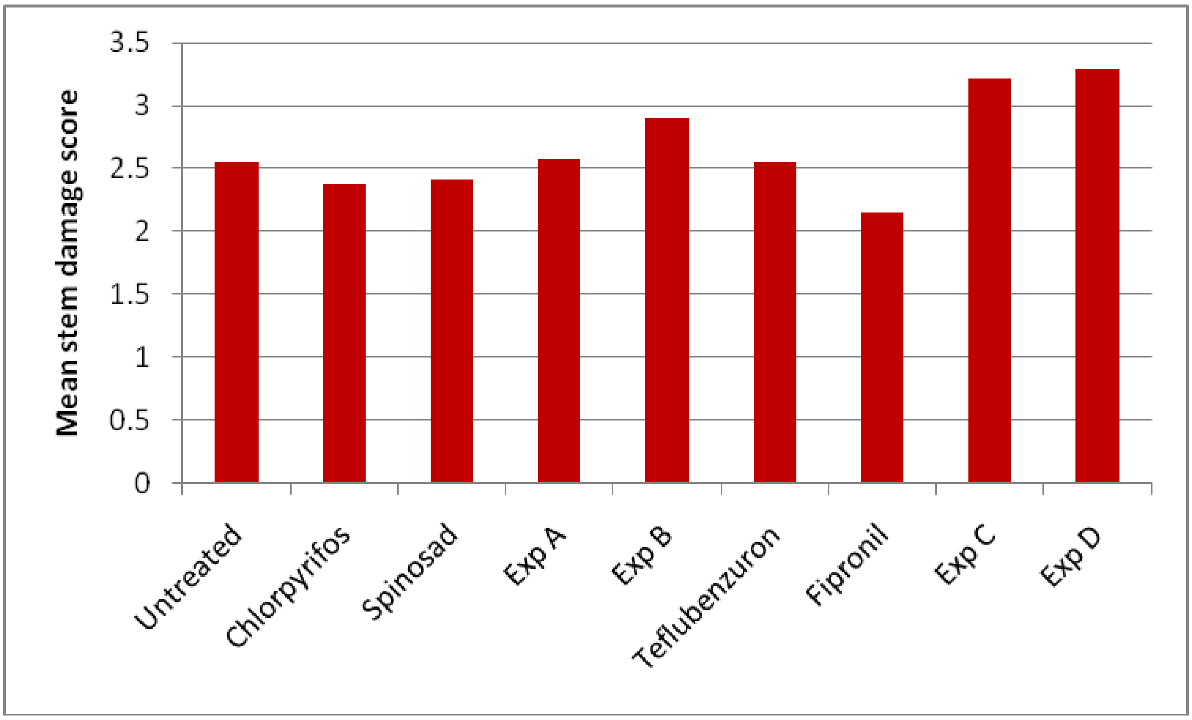

Figure 1.4 Cauliflower - mean stem damage score due to cabbage root fly larvae on 7 August 2009

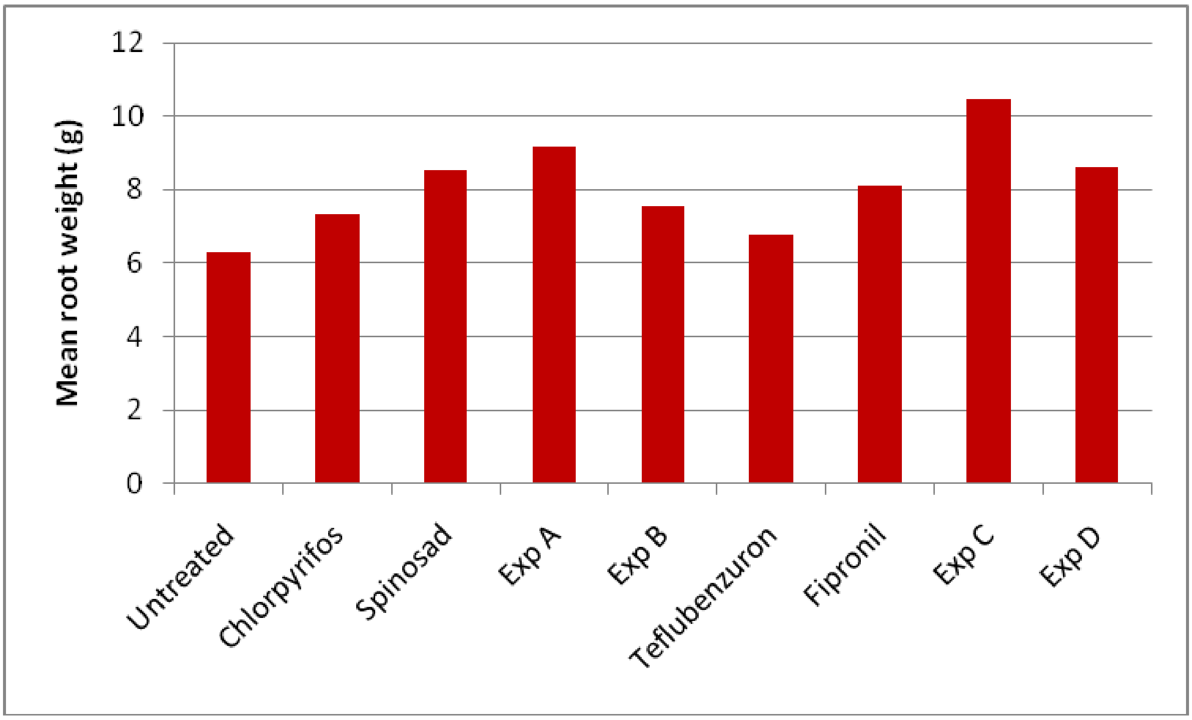

Figure 1.5 Cauliflower - mean root weight on 7 August 2009

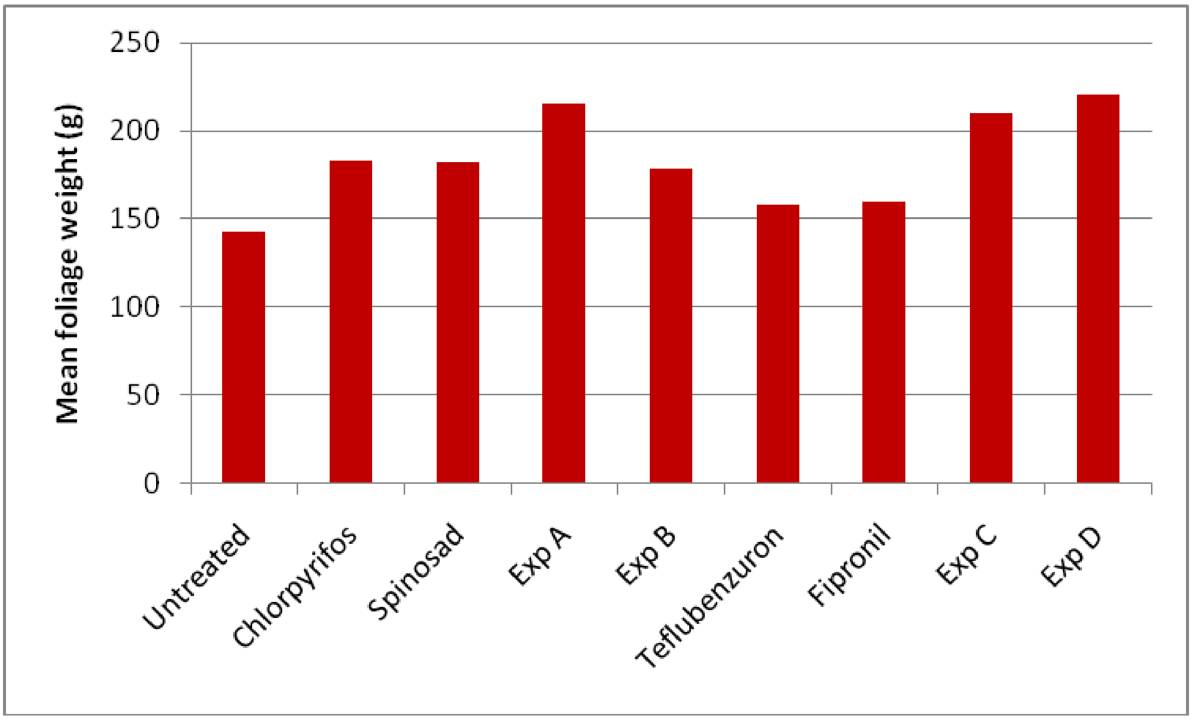

Figure 1.6 Cauliflower - mean foliage weight on 7 August

<u>Plant width</u>

The maximum plant width was measured on 4 September and no transformation of the data was required. The treatment factor was not significant at a 5% level using an F-test and there were no significant differences between the means of different treatments (Table 1.9).

Table 1.9 Cauliflower - Mean maximum plant width (4 September 2009)

Treatment	Maximum width (cm)
Untreated	53.9
Chlorpyrifos	54.1
Spinosad	54.0
Exp A	56.5
Exp B	54.5
Teflubenzuron	55.0
Fipronil	58.1
Exp C	58.2
Exp D	57.2
F-val	1.140
P-val	0.391
SED	2.427
LSD	5.174
df	16

Harvest

Assessments were made of cauliflower curd weights, curd diameters and curd quality. Analyses were done on the curd weight, curd diameter and percentage of class 1 curds. Also, a linear interpolation was used to determine the time taken to achieve 10, 25, 50 75 and 90% curd harvest assuming a start date of 3 days before the harvest commenced. For the analysis of the percentage of class 1 curds, an angular transformation was used to ensure homogeneity of the variance between treatments. No other data transformations were required. Curd weight (Figure 1.7), curd diameter and percentage class 1 curds are presented in Table 1.10. Time to 50% harvest (Figure 1.8), time between 25 and 75% harvest (Figure 1.9) and time between 10 and 90% harvest are presented in Table 1.11. The treatment effect was significant at the 5% level using an F-test for all analyses except the ‘class 1’ and ‘time between 10 and 90% harvest’ analyses. For the curd weight, Exp A, Exp B and Fipronil treatments all had mean weights which were significantly larger than the untreated control, but only Exp A had a diameter significantly larger than the untreated control.

Exp A, Exp C and Exp D all reached 50% harvest more quickly than the untreated control. The time elapsed between 25 and 75% of harvest gives some measure of the spread of harvest times. Only Exp A had a mean significantly smaller than the untreated control treatment. There were no statistically significant differences when considering the elapsed time between 10 and 90% of harvest and this is probably due to there being a much larger estimate of background variability.

Table 1.10 Cauliflower - Curd harvest data

Treatment	Weight (g)	Diameter (cm)	Percent class 1	
			Back Trans.	Trans.
Untreated	483.9	9.90	36.3	3.453
Chlorpyrifos	564.9	10.11	45.4	3.864
Spinosad	537.1	10.13	41.9	3.712
Exp A	710.7	11.49	49.7	4.043
Exp B	580.1	10.67	49.2	4.021
Teflubenzuron	548.6	10.57	39.9	3.623
Fipronil	587.2	10.29	53.7	4.203
Exp C	477.5	9.63	32.9	3.286
Exp D	534.3	10.14	32.5	3.270
F-val	4.600	4.200		0.800
P-val	0.005	0.007		0.610
SED	44.770	0.378		0.522
LSD	94.290	0.802		1.107
df	16	16		16

Table 1.11 Cauliflower – Spread of curd harvest (days)

Treatment	Time to 50% harvest (days)	Spread of harvest (days)	
		25 - 75%	10 - 90%
Untreated	10.19	8.66	16.39
Chlorpyrifos	8.89	8.01	16.09
Spinosad	7.48	7.00	12.65
Exp A	6.82	4.76	9.80
Exp B	12.54	8.98	16.90
Teflubenzuron	12.30	7.58	15.19
Fipronil	8.97	11.48	20.02
Exp C	5.64	7.23	13.24
Exp D	4.91	5.82	10.44
F-val	4.900	3.140	1.710
P-val	0.003	0.025	0.171
SED	1.699	1.470	3.382
LSD	3.601	3.117	7.170
df	16	16	16

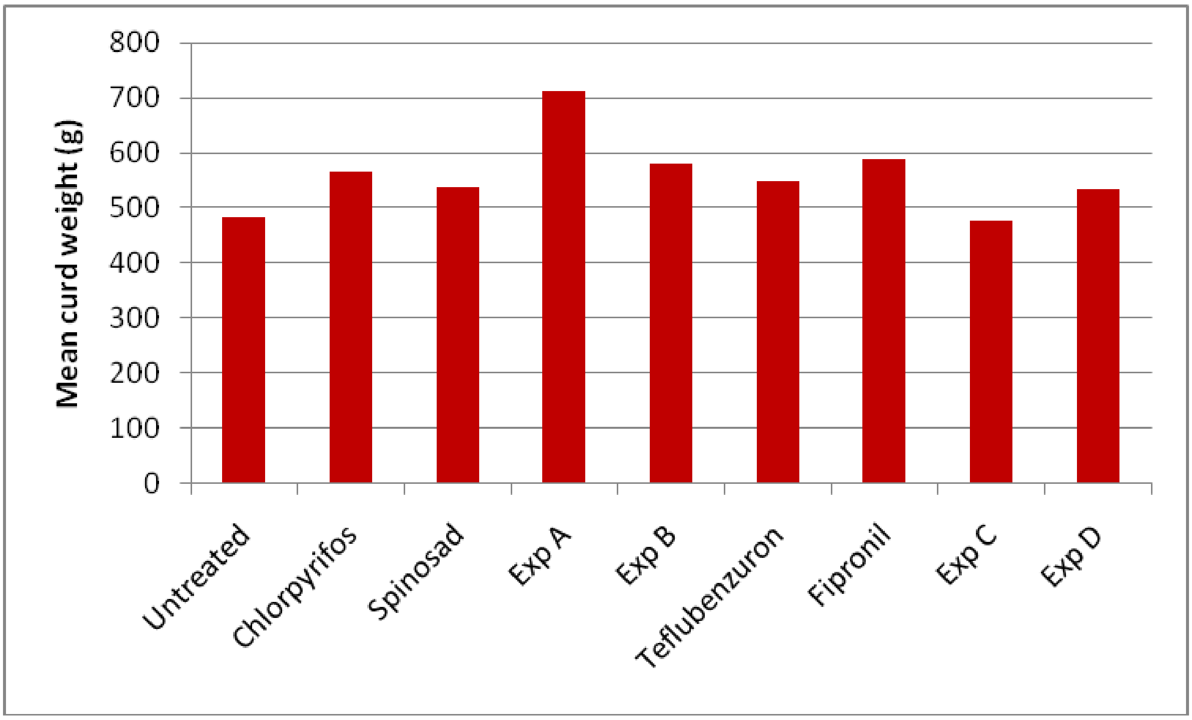

Figure 1.7 Cauliflower – mean curd weight at harvest

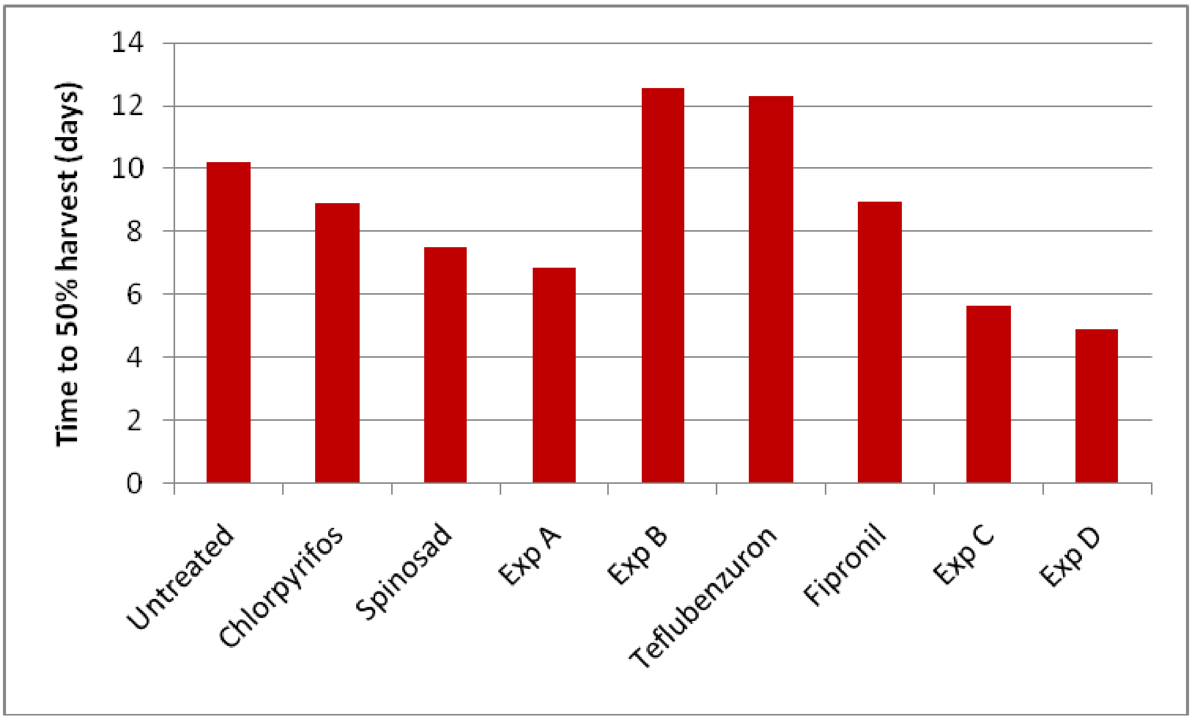

Figure 1.8 Cauliflower – time to 50% maturity

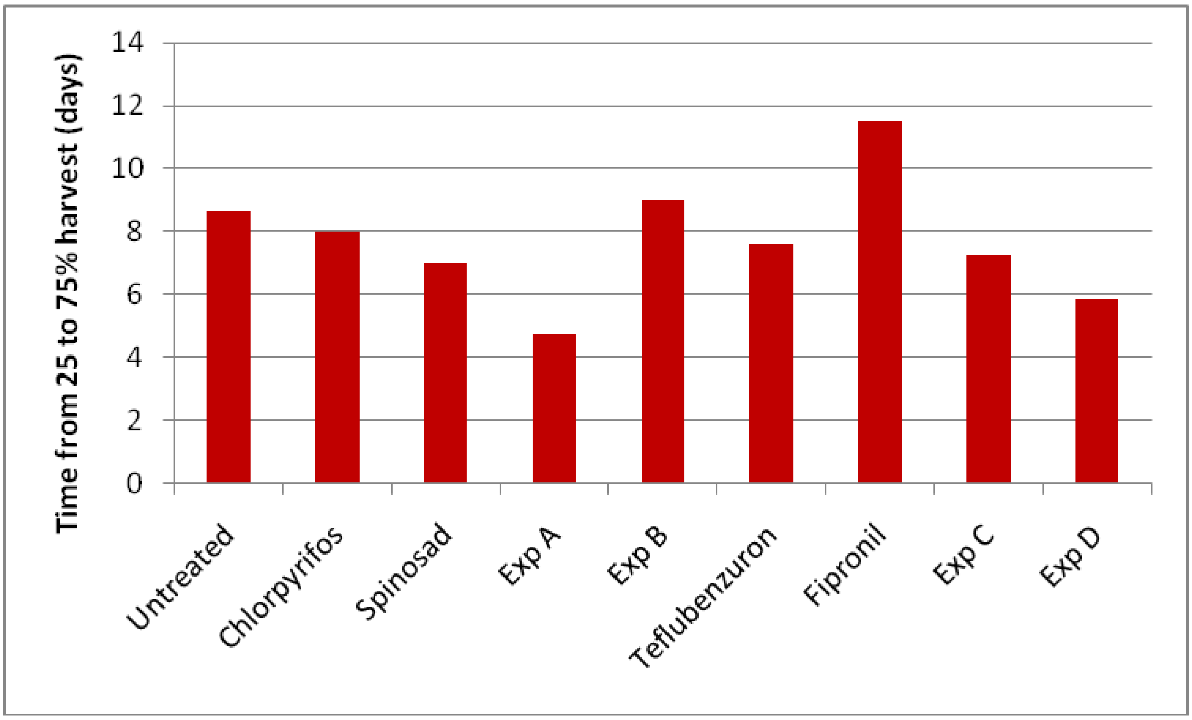

Figure 1.9 Cauliflower – 25 to 75% spread of maturity

Experiment 2 - Novel insecticide treatments to control aphids, caterpillars and whitefly on Brussels sprout

Materials and methods

The experiment was planted in the field known as Pump Ground. Brussels sprout seed (cv Doric) was sown on 28 May 2009 into 308 Hassy trays. One tray was sown with the addition of Exp C - Sanokote®, one with the addition of Imidacloprid - Sanokote® and each seed in one tray was treated with 0.2 ml of a solution containing Exp D (using a 0.2 ml automatic pipette) to mimic a Phytodrip treatment. Five trays were sown with untreated seed and all of the trays were placed in a greenhouse.

The plants were transplanted on 7 July 2009. The plots were 5 m x 1 bed (1.83 m wide) and there were 4 rows per bed. The plants were spaced at 50 cm within and 35 cm between rows. The trial was designed as a Trojan square with 4 rows and 8 columns. Including an untreated control, there were 8 treatments (Table 2.1). All sprays were applied using a knapsack sprayer fitted with 02F110 nozzles. The first series of sprays (applied 16 September) were applied in 300 l water/ha and the second series of sprays (applied 30 September) were applied in 600 l water/ha.

Table 2.1 Treatments applied to Brussels sprout plots to control aphids

	Product	Active ingredient	Application method	Rate (product/ha)	Wetter
1	Exp A		Spray	1000 ml	Phase II @ 0.5%
2	Exp B		Spray	175 ml	Phase II @ 0.5%
3	Movento	Spirotetramat	Spray	480 ml	
4	Plenum	Pymetrozine	Spray	400 g	Phase II @ 0.5%
5	Exp C		Dead seed	1.2 + 0.4 mg a.i./seed	
6	Exp D		Phytodrip	1.4 mg a.i./seed	
7	Sanokote® Smart - Gaucho	Imidacloprid	Dead seed	1.4 mg a.i./seed	
8	Untreated				

<u>Assessments</u>

Pest assessments were made on five occasions, 11 September (pre-spray), 23 September (post first spray), 8 October (post second spray), 16 October and 2 November. For each assessment, counts of winged aphids, wingless aphids and caterpillars were made. On the first 4 assessments, each plant was also assessed for whitefly presence or absence and on the final assessment whitefly infestation was scored on a scale of 0 (no whitefly) – 3 (established colonies) scale. Flea beetle damage was scored at the first assessment (11 September) but as the damage was low it was not re-assessed. "Spray" plots (including the untreated control) were assessed on all occasions but the sowing-time treatments were only assessed on 11 September, 8 October and 2 November.

Results

Statistical analysis

All analyses were carried out using Analysis of Variance (ANOVA) and interpretations have been made using treatment means along with standard errors of the difference (SED) and least significance difference (LSD) values.

For the occasions where all treatments were assessed, a Trojan Square Design was assumed and on the occasions when only the spray treatments were assessed a randomised complete block design was assumed.

Foliar pests

a) Aphids

The vast majority of aphids were wingless *Brevicoryne brassicae,* but winged aphids were also observed. A few wingless *Myzus persicae* were also recorded but in insufficient numbers to attempt any analysis.

The formal analysis using ANOVA was performed on winged and wingless *Brevicoryne brassicae*.   A square root transformation of both data sets was used to ensure homogeneity between treatments.

Table 4.2 shows the back-transformed means together with the transformed means for the analysis of the winged aphid data. The treatment factor was significant on 8 October and 2 November (where all treatments have been assessed) at the 5% level using an F-test. On 8 October the untreated control had a mean that was significantly larger than all treatments except Exp B - spray and on 2 November, the untreated control had a mean significantly larger than the sowing-time treatments only.

Table 4.2 Brussels sprout - Mean number of winged *Brevicoryne brassicae* per plot

Treatment	11 Sept		23 Sept		8 Oct		16 Oct		2 Nov	
	Back-Trans.	Trans.	Back Trans.	Trans.	Back Trans.	Trans.	Back Trans.	Trans.	Back Trans.	Trans.
Exp A	0.04	0.197	2.44	1.563	0.43	0.657	0.62	0.786	0.50	0.704
Exp B	0.08	0.276	1.13	1.065	2.44	1.563	1.69	1.299	2.13	1.461
Spirotetramat	0.00	0.000	1.97	1.402	0.36	0.603	0.38	0.615	0.29	0.534
Pymetrozine	0.01	0.102	0.05	0.217	0.22	0.467	0.22	0.467	0.50	0.708
Exp C	0.00	0.000	*	*	0.48	0.691	*	*	0.04	0.203
Exp D	0.00	0.000	*	*	0.37	0.605	*	*	0.06	0.234
Imidacloprid	0.00	0.000	*	*	0.22	0.473	*	*	0.09	0.302
Untreated	0.01	0.072	3.00	1.731	1.65	1.284	1.20	1.095	0.99	0.996
F-val		2.250		1.180		4.900		1.700		7.430
P-val		0.078		0.367		0.003		0.214		<0.001
SED		0.100		0.780		0.258		0.371		0.223
LSD		0.210		1.700		0.542		0.808		0.468
df		18		12		18		12		18

Table 4.3 shows the back transformed means together with the transformed means for the analysis of the wingless aphid data set. The treatment factor was significant on all occasions except 23 September at the 5% level using an F-test. The differences due to treatments at the first assessment (11 September – pre spray) were due to the sowing – time treatments (Exp C - Sanokote®, Exp D – Phytodrip and Imidacloprid - Sanokote®) which all had significantly less wingless aphids than the untreated control. On 8 October, the untreated control had a mean significantly larger than all other treatments except Exp B - spray. On 16 October, the mean for the untreated control was significantly larger than the means for Exp A - spray and Spirotetramat – spray, and on 2 November, the untreated control had a mean significantly larger than Spirotetramat - spray and the three sowing-time treatments (Exp C - Sanokote®, Exp D - Phytodrip and Imidacloprid - Sanokote®). The results are expressed graphically in Figures 2.1 (spray treatments) and 2.2 (sowing-time treatments)

Table 4.2 Brussels sprout - Mean number of wingless *Brevicoryne brassicae* per plot

Treatment	11 Sep		23 Sep		8 Oct		16 Oct		2 Nov	
	Back Trans.	Trans.	Back Trans.	Trans.	Back Trans.	Trans.	Back Trans.	Trans.	Back Trans.	Trans.
Exp A	103.0	10.149	461.0	21.470	42.5	6.518	50.1	7.080	107.8	10.381
Exp B	84.5	9.193	186.4	13.650	521.6	22.838	404.2	20.100	313.7	17.712
Spirotetramat	91.5	9.564	240.9	15.5200	2.7	1.629	1.4	1.200	0.9	0.970
Pymetrozine	49.9	7.060	64.9	8.060	56.5	7.519	108.7	10.420	109.0	10.443
Exp C	0.0	0.000	*	*	5.4	2.319	*	*	9.7	3.122
Exp D	0.0	0.000	*	*	4.6	2.137	*	*	13.8	3.714
Imidacloprid	0.1	0.228	*	*	3.8	1.942	*	*	12.7	3.565
Untreated	50.8	7.130	331.6	18.210	434.0	20.832	398.0	19.950	262.7	16.208
F-val		9.700		1.370		8.970		6.910		5.510
P-val		<0.001		0.301		<0.001		0.004		0.002
SED		2.067		6.090		4.110		4.430		3.836
LSD		4.343		13.270		8.640		9.660		8.060
df		18		12		18		12		18

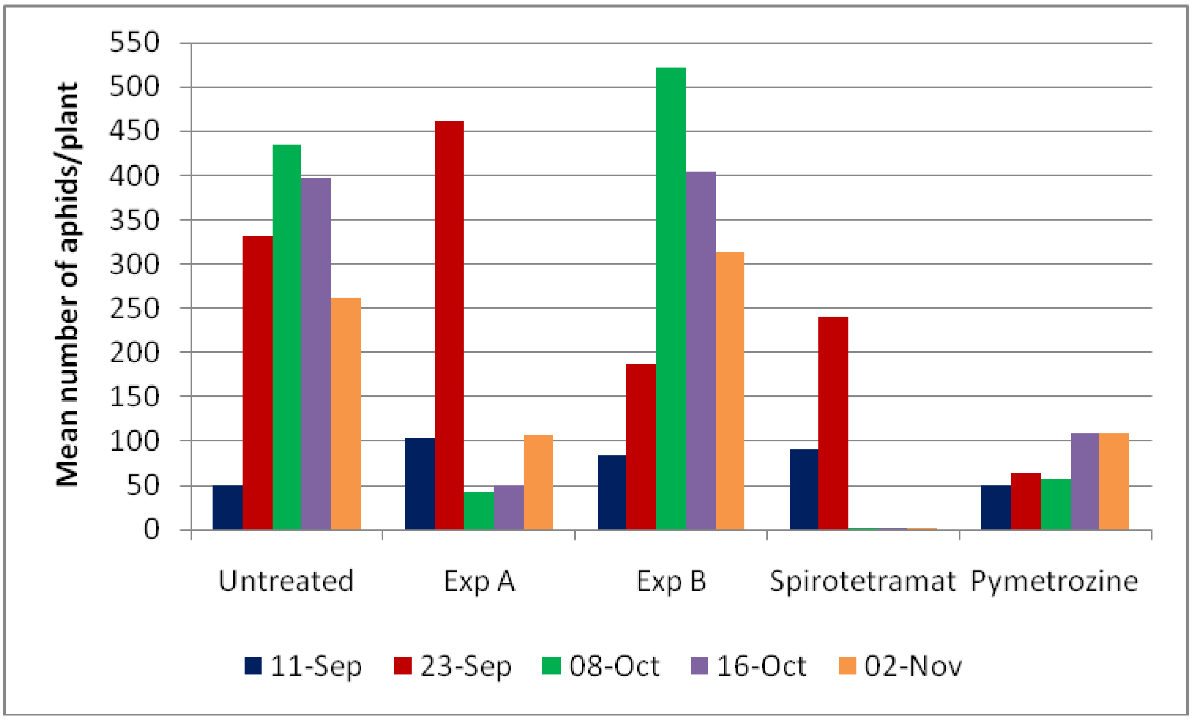

Figure 2.1 Brussels sprout - Mean number of wingless *Brevicoryne brassicae* on sprayed plots (sprays were applied on 16 and 30 September)

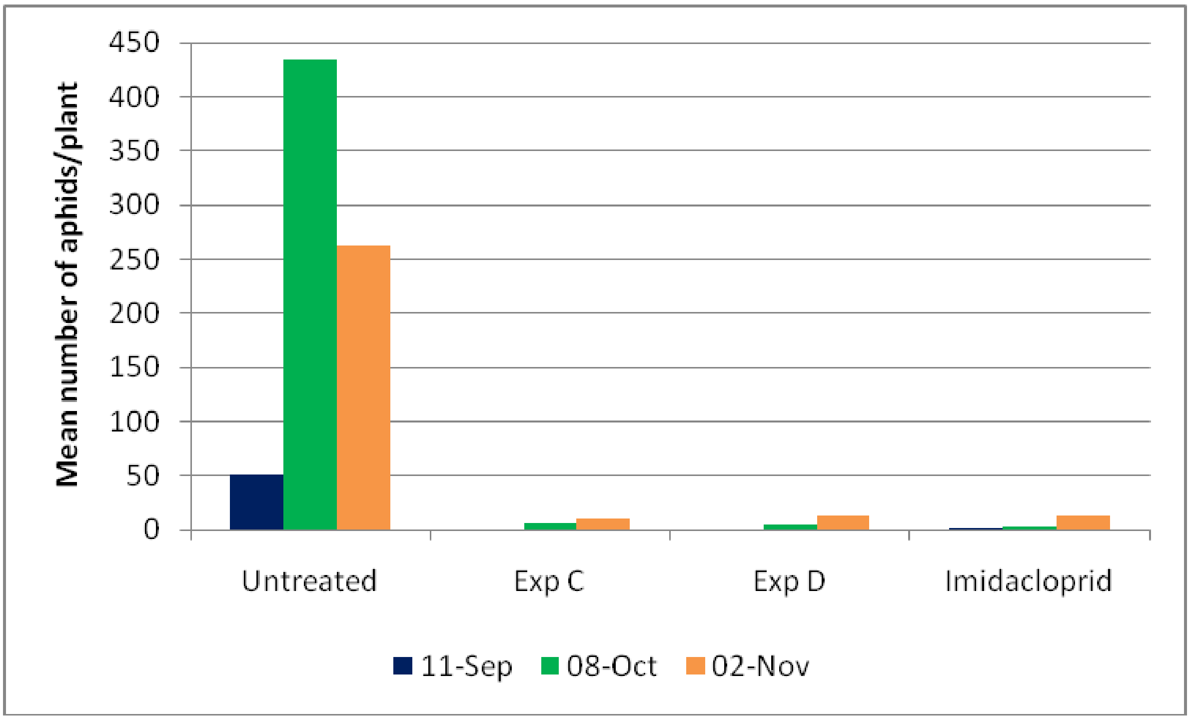

Figure 2.2 Brussels sprout - Mean number of wingless *Brevicoryne brassicae* on sowing-time treatment plots (sprays were applied on 16 and 30 September)

b) Whitefly

All analyses on the whitefly infestation were carried out using a square root transformation to ensure homogeneity of variance between treatments. For the first four assessments presence or absence was recorded and the results are expressed as the percentage of plants infested (Table 4.3). On the last assessment occasion a 0 – 3 score was used, so the results are expressed as a mean score per plot (Table 4.3).

The only significant treatment effect at the 5% level using an F-test was on 11 September. The Imidacloprid - Sanokote treatment had a mean significantly smaller than the untreated control.

Table 4.3 Brussels sprout - Mean percentage of plants with whitefly (11 September to 16 October) or mean whitefly score (2 November)

Treatment	11 Sept		23 Sept		8 Oct		16 Oct		2 Nov	
	Back Trans.	Trans.	Back Trans.	Trans.	Back Trans.	Trans.	Back Trans.	Trans.	Back Trans.	Trans.
Exp A	13.8	0.371	79.8	0.893	87.3	0.934	51.4	0.717	0.448	0.670
Exp B	17.7	0.421	75.9	0.871	82.5	0.909	73.5	0.857	0.746	0.863
Spirotetramat	13.8	0.371	54.0	0.735	53.1	0.729	53.8	0.734	0.605	0.778
Pymetrozine	27.9	0.528	72.0	0.849	68.6	0.828	79.1	0.890	0.689	0.830
Exp C	14.1	0.375	*	*	53.2	0.730	*	*	0.952	0.976
Exp D	15.1	0.388	*	*	83.9	0.916	*	*	1.171	1.082
Imidacloprid	0.5	0.072	*	*	58.8	0.767	*	*	1.007	1.003
Untreated	18.6	0.431	73.9	0.860	73.8	0.859	76.1	0.873	0.818	0.905
F-val		4.210		1.130		1.470		0.960		2.400
P-val		0.007		0.387		0.238		0.466		0.064
SED		0.090		0.082		0.098		0.119		0.121
LSD		0.190		0.179		0.206		0.258		0.254
df		18		12		18		12		18

c) Caterpillars

The numbers of caterpillars on individual plants were recorded. Caterpillars of small and large white butterflies and diamond-back, garden pebble and silver-Y moths were observed. Small white, large white and diamond-back moth caterpillars occurred in sufficient numbers to be analysed separately and the total numbers of caterpillars were also analysed. Square root transformations were used for all analyses to ensure homogeneity of variance between treatments. The results for 11 September counts are shown in Table 4.4.

For all caterpillar counts, there were virtually no caterpillars after 11 September, so it was impossible to assess the efficacy of the sprays, but the sowing-time treatments could be assessed. For all analyses the treatment term was not significant at the 5% level using an F-test. There were no statistically significant differences between treatments.

Table 4.4 Brussels sprout - Mean numbers of caterpillars on 11 September (pre spray)

Treatment	Small white		Large white		Diamond-back moth		Total	
	Back Trans.	Trans.	Back Trans.	Trans.	Back Trans.	Trans.	Back Trans.	Trans.
Exp A[1]	0.061	0.246	0.083	0.289	0.061	0.246	0.463	0.681
Exp B[1]	0.021	0.144	0.104	0.322	0.042	0.204	0.331	0.575
Spirotetramat[1]	0.063	0.251	0.037	0.191	0.011	0.107	0.192	0.438
Pymetrozine[1]	0.121	0.349	0.063	0.250	0.086	0.293	0.476	0.690
Exp C	0.095	0.309	0.184	0.429	0.011	0.107	0.525	0.724
Exp D	0.030	0.174	0.547	0.740	0.047	0.217	0.893	0.945
Imidacloprid	0.052	0.227	0.555	0.745	0.104	0.322	1.078	1.038
Untreated	0.005	0.072	0.000	0.000	0.039	0.197	0.279	0.528
F-val		1.200		1.960		0.560		2.270
P-val		0.353		0.118		0.780		0.076
SED		0.115		0.263		0.147		0.191
LSD		0.242		0.552		0.310		0.401
df		18		18		18		18

[1]Assessment made before spraying so all plots were 'untreated'.

d) Flea beetle

Flea beetle damage scores were recorded on 11 September (pre spray) but, as the damage was light and there was no discernable flea beetle activity, no further assessments were made. As such, only the sowing-time treatments could be assessed for flea beetle control. Damage was recorded on a 0 – 3 scale and the mean scores for each plot were analysed. Square root transformations were used to ensure homogeneity of variance between treatments and the results are presented in Table 4.5. The treatment factor was not significant at the 5% level using an F-test and there were no significant differences between the means. As flea beetle tends to be a damaging pest early in the season, particularly to seedlings and young plants, it is probably not too surprising that treatment effects could not be seen on plants which would have largely grown through any damage.

Table 4.5 Brussels sprout - Mean flea beetle damage score on 11 September

Treatment	Back transformed	Transformed
Exp A	0.840	0.917
Exp B	0.879	0.938
Spirotetramat	0.865	0.930
Pymetrozine	1.000	1.000
Exp C	0.669	0.818
Exp D	0.918	0.958
Imidacloprid	0.879	0.938
Untreated	0.918	0.958
F-val		0.920
P-val		0.512
SED		0.077
LSD		0.162
df		18

Discussion

Cauliflower

Wet weather in the early part of summer 2009 (see Appendix) suppressed populations of aphids until early September when large infestations of *Brevicoryne brassicae* began to develop. There were few statistically significant differences in aphid numbers in the trial on cauliflower when it was assessed in early August but, in early September Exp A – drench (10 weeks after treatment), Exp C – Sanokote® (14 weeks after treatment) and Exp D – Phytodrip (14 weeks after treatment) were all still providing good control of aphids.

Flea beetle damage was low, as were the numbers of whitefly and this may be a reason for the lack of treatment effects, particularly with the Sanokote® and Phytodrip treatments, some of which have provided flea beetle control in previous experiments.

Caterpillar numbers were relatively high on 4 September and although treatment effects could not be seen for individual species, when the data for all species together were analysed, Exp A – drench (and possibly Exp B – drench) was providing excellent control of caterpillars 10 weeks after treatment. As these treatments were applied to the modules before planting, control of foliar pests is clearly due to systemic activity, with pest mortality occurring after feeding.

Cauliflowers treated with Exp A - drench, Spinosad - drench, Exp C – Sanokote® and Exp D - Phytodrip had increased root weight when they were assessed on 7 August and all of these treatments, apart from Spinosad also increased foliage weight. Direct evidence of a reduction in cabbage root fly feeding damage to the plant roots was not clear, due to low levels of root damage, but it is likely that Chlorpyrifos, Spinosad and Exp A drenches together with the Fipronil seed treatment all reduced damage to the cauliflower roots. No reduction in cabbage root fly damage to the lower stem area was observed. Indeed, Exp D – Phytodrip (and possibly Exp C – Sanokote®) appeared to increase stem damage compared with the untreated control treatments and this is not surprising, since both treatments have been shown, in the past, to cause this effect. It may be because these insecticides delay cabbage root fly development (thereby increasing feeding damage) when they are applied at commercial rates, which are sub-lethal doses for cabbage root fly larvae (an effect previously seen with Imidacloprid treatments).

Finally, Exp A – drench, Exp B – drench and Fipronil - seed treatment all increased curd weight at harvest compared with the control treatments, and both Exp C - Sanokote® and Exp D – Phytodrip hastened maturity compared with the control treatments. Exp D in particular has been seen to reduce the time to cauliflower maturity in previous trials and this appears to be a physiological response as much as being due to pest control. The spread of maturity was also reduced by Exp A - drench.

<u>Brussels sprout</u>

As with the cauliflower, wet weather in the early part of summer 2009 suppressed populations of aphids until early September when large infestations of *Brevicoryne brassicae* began to develop. Pre-spray assessments indicated that all 3 sowing-time treatments (Exp C – Sanokote®, Imidacloprid – Sanokote® and Exp D – Phytodrip) were providing excellent control of aphids and although slightly diminished, this control continued until the last assessment on 2 November (23 weeks after treatment). Spray treatments were applied on 16 and 30 September. Initially (1 week after spraying) none of the treatments appeared to be effective. This is not surprising, since at least some of the insecticides (e.g. Pymetrozine, Spirotetramat) do not have knock-down activity and take some time to be effective. The second spray was applied, with the spray volume increased from 300 to 600 l/ha to ensure that the treatments penetrated the dense foliage. Subsequent assessments indicated that Exp A, Spirotetramat and Pymetrozine had all reduced aphid numbers and this effect persisted until 16 October for Exp A and until the last assessment date (2 November) for Spirotetramat. Whether control was due to the first and second sprays together or predominantly due to the higher volume second spray is unclear, but with high aphid pressure it would be reasonable to assume that a second application would be necessary over this time period.

Flea beetle damage was difficult to assess due to its low level and the size of the plants. Flea beetle damage is more important with seedlings and young plants and the absence of positive results here does not indicate that these treatments are necessarily unsuitable for flea beetle control. Similarly, whitefly numbers were relatively low and with the exception of the Imidacloprid – Sanokote® treatment at the first assessment there was little evidence of control. With greater pest pressure treatment differences would become clear. Caterpillar control was not apparent with any of the sowing-time treatments and unfortunately the caterpillars had disappeared before the spray treatments could be assessed. So a comparison could not be made between Exp A – drench, which controlled caterpillars on cauliflower and the Exp A - spray used on the Brussels sprout plots.

Conclusions

- Cabbage root fly control was difficult to assess due to relatively low levels of damage observed in the root area but there was direct evidence of control with Spinosad, Chlorpyrifos and Exp A drenches and with Fipronil seed treatment. Also increases in root weight mid-season (Spinosad – drench, Exp A - drench, Exp C – Sanokote® and Exp D – Phytodrip) could be attributed to cabbage root fly control.
- Several sowing-time treatments (Imidacloprid - Sanokote®, Exp C – Sanokote®, Exp D - Phytodrip and Exp A - drench) showed effective control of aphids up to 23 weeks after application.
- Three sprays gave aphid control (Plenum, Exp A and Spirotetramat). Treatment effects of Spirotetramat persisted the longest.
- Flea beetle and whitefly numbers were too low to establish accurate information on control of these pests.
- A number of treatments increased curd weight at harvest (Exp A - drench, Exp B - drench and Fipronil – seed-treatment).

- The most effective overall treatment appeared to be Exp A. When applied as either a pre-planting drench or as a foliar spray, it controlled aphids. The drench treatment also controlled caterpillars; increased root, foliage and cauliflower curd weight and decreased the spread in time to maturity.

TECHNOLOGY TRANSFER

February 2010 Article for HDC News

ACKNOWLEDGEMENTS

We thank the HDC for funding this work, Elsoms Limited for providing much of the seed, Andrew Mead for providing the experimental design, Matthew Mitchell for assistance with the field experiments, Richard Jackson for the statistical analysis and Fred Tyler for his advice.

APPENDIX

Weather records Warwick HRI, Wellesbourne

DATE	TEMP_MAX	TEMP_MIN	RAINFALL
01/05/2009	18.4	10.9	0
02/05/2009	17.8	5.4	0
03/05/2009	14.2	6	0.1
04/05/2009	13.2	1.9	0.1
05/05/2009	19.6	8.6	0
06/05/2009	18.3	10.6	0
07/05/2009	17.7	10.6	0
08/05/2009	16.1	8.7	0
09/05/2009	16.1	6.4	0
10/05/2009	17.4	2.3	0
11/05/2009	15	5.5	0
12/05/2009	16.4	5.6	0.7
13/05/2009	14.2	7.2	0.8
14/05/2009	14.1	9.6	16.5
15/05/2009	16.8	10.2	5.3
16/05/2009	14.6	6.5	2.8
17/05/2009	13.9	5.5	5.1
18/05/2009	15.2	9.2	1.7
19/05/2009	15.1	9.8	5
20/05/2009	16.9	7.7	0.5
21/05/2009	17.4	7	1.2
22/05/2009	17	6.5	0
23/05/2009	20.8	9.7	0
24/05/2009	21.8	4.5	0
25/05/2009	19.8	7.1	0.1
26/05/2009	16.9	11	1
27/05/2009	19.4	7.1	0
28/05/2009	21.5	10.8	0
29/05/2009	24.5	7.7	0
30/05/2009	22.6	7.1	0
31/05/2009	23.4	8.6	0
01/06/2009	24.3	9.3	0
02/06/2009	25	6.3	0
03/06/2009	16.7	10.3	0
04/06/2009	18.2	3.4	0
05/06/2009	15.8	7.6	25.2
06/06/2009	12	9	30.9
07/06/2009	14.1	7.3	1.4
08/06/2009	16	6.6	1.5
09/06/2009	15.2	9.4	1.7
10/06/2009	16.5	10.1	3.4

11/06/2009	17.7	9.2	3.5
12/06/2009	19	3.3	0
13/06/2009	23.2	14.2	0
14/06/2009	22.2	10.7	0
15/06/2009	22.1	11.4	0.3
16/06/2009	22.3	9.1	0
17/06/2009	18.9	11.6	1.2
18/06/2009	18.6	8.1	0
19/06/2009	18.9	8.4	2
20/06/2009	18.4	10.7	0.5
21/06/2009	17.1	11.3	0.1
22/06/2009	21.4	9.8	0
23/06/2009	23.9	13.4	0
24/06/2009	23.3	8.2	0
25/06/2009	24.9	10.9	0
26/06/2009	20.1	12.6	5.3
27/06/2009	23.7	13.4	0
28/06/2009	24.5	12.3	0
29/06/2009	29.2	14.9	0
30/06/2009	29	15.1	0
01/07/2009	29.7	18.5	0
02/07/2009	28.6	16	4
03/07/2009	25.2	17	0
04/07/2009	24.2	14	0
05/07/2009	24.2	11.3	0
06/07/2009	21.8	13.2	3.9
07/07/2009	19.9	11.1	8
08/07/2009	19.4	12.2	0
09/07/2009	19.2	7.7	0
10/07/2009	20.3	7.4	1
11/07/2009	23.1	13.8	13
12/07/2009	21.7	14.2	0
13/07/2009	22.6	12.3	0.1
14/07/2009	21.2	11.9	5.4
15/07/2009	22.4	13.8	0.4
16/07/2009	21.2	11	7.1
17/07/2009	17.7	13.3	3.2
18/07/2009	20.6	12.2	0.3
19/07/2009	18.8	12.5	9.2
20/07/2009	20	9.5	7.7
21/07/2009	18.6	13	3.7
22/07/2009	21.1	13.2	0
23/07/2009	21.8	11.8	0
24/07/2009	20.9	11.9	1.2
25/07/2009	23.2	10.5	0

26/07/2009	19.2	13.1	6.6
27/07/2009	20.1	12.3	0.2
28/07/2009	22.2	10.8	3.9
29/07/2009	16.4	14.5	27.8
30/07/2009	18.9	10.6	0
31/07/2009	20.4	9.6	3.3
01/08/2009	17.9	12.5	8.2
02/08/2009	19.8	9.1	0
03/08/2009	21.3	12.3	2.3
04/08/2009	19.9	15.9	19.7
05/08/2009	21.9	16.6	0.4
06/08/2009	21.2	13.2	13.3
07/08/2009	23	14.1	0
08/08/2009	22.2	9.6	0
09/08/2009	24	9	0
10/08/2009	21	13.1	0.1
11/08/2009	25.4	15.4	0.1
12/08/2009	22.2	16	2.9
13/08/2009	20.1	14.9	0
14/08/2009	22.4	10.9	0.2
15/08/2009	24	16.5	0
16/08/2009	22.6	12.6	0
17/08/2009	22.6	12.6	0
18/08/2009	21.7	11.3	0
19/08/2009	27.5	14.1	0
20/08/2009	22.6	16.8	0
21/08/2009	19.6	11.5	0.4
22/08/2009	23.2	6.2	0
23/08/2009	25.9	14	0
24/08/2009	21.8	15.2	0
25/08/2009	21.4	8.4	2.6
26/08/2009	19.1	12.5	1.7
27/08/2009	22.6	13.2	0
28/08/2009	18.9	11.1	0.7
29/08/2009	19.3	8.3	0
30/08/2009	19.8	7.5	0
31/08/2009	22.9	15.4	0
01/09/2009	20.3	12.6	3.5
02/09/2009	18.2	11.5	6.4
03/09/2009	17.5	12.3	0.4
04/09/2009	18.2	8.3	0
05/09/2009	17.5	8	0
06/09/2009	18.8	12.2	0
07/09/2009	22.2	14.5	0
08/09/2009	24.3	17	0

09/09/2009	20.4	12	0
10/09/2009	19.7	4.3	0
11/09/2009	19.9	4.3	0
12/09/2009	21.4	6.6	0
13/09/2009	18.1	5.3	0
14/09/2009	17.6	12.1	0
15/09/2009	18.7	11.7	0
16/09/2009	18.3	12.7	0
17/09/2009	15.8	11.7	0
18/09/2009	20.1	11.6	0
19/09/2009	22.5	10.8	0
20/09/2009	19.6	11.1	0
21/09/2009	18.9	6.8	0
22/09/2009	20.3	11.4	0.2
23/09/2009	17.8	10.3	0
24/09/2009	18.6	5.6	0
25/09/2009	16.9	5.8	0
26/09/2009	19.5	6	0
27/09/2009	18.8	6	0
28/09/2009	19.5	12.8	0
29/09/2009	20.7	9.8	0
30/09/2009	18.9	14.1	0
01/10/2009	18.9	12.3	0
02/10/2009	15.2	6.1	0
03/10/2009	18.2	12.7	0
04/10/2009	16.8	5.3	0
05/10/2009	16.7	5.3	1.5
06/10/2009	19.2	11.3	10.1
07/10/2009	11.2	9.3	0
08/10/2009	14.3	1.5	0
09/10/2009	14.2	3.2	3.5
10/10/2009	17.9	9	0.3
11/10/2009	15.7	10.7	0.5
12/10/2009	15.4	4.4	0
13/10/2009	15.5	-3.7	0
14/10/2009	17.3	5.8	0.3
15/10/2009	15.8	9.7	2
16/10/2009	13.7	9	0
17/10/2009	12.9	6.1	0
18/10/2009	11.8	3.9	0
19/10/2009	13.3	5.5	0
20/10/2009	12.6	5.9	1.7
21/10/2009	14.9	8	0
22/10/2009	15.6	8.8	0.1
23/10/2009	16.6	9.3	0.9

24/10/2009	17.3	11.4	0.7
25/10/2009	16.2	10.9	1.1
26/10/2009	16	9.5	1.7
27/10/2009	17.1	9.2	0
28/10/2009	18.5	10.6	0
29/10/2009	16.8	5.8	0
30/10/2009	15.1	10.6	1.4
31/10/2009	17.2	12.5	4.4
01/11/2009	15.7	11.1	3
02/11/2009	11.9	5	4
03/11/2009	13.2	7.7	2.7
04/11/2009	12.4	5	2.5
05/11/2009	12.2	6.4	3.6
06/11/2009	10.5	7.2	1.6
07/11/2009	10.7		0.3
08/11/2009	10.6	4.6	1.8
09/11/2009	8.6	0.7	0.8
10/11/2009	7.8	4.4	0.7
11/11/2009	9.1	5.2	5.8
12/11/2009	13.6	5.9	13.1
13/11/2009	14.3	8.5	10.5
14/11/2009	11.8	9.5	1.5
15/11/2009	13	5.3	2.1
16/11/2009	13.1	8	0
17/11/2009	12.6	7.5	0
18/11/2009	13.9	9.3	0.2
19/11/2009	13.7	12.1	5.4
20/11/2009	8.8	12.1	0.4
21/11/2009	14.4	6.8	6.8
22/11/2009	10.2	7.6	2.8
23/11/2009	13.3	7.5	2.1
24/11/2009	13.3	7	6.2
25/11/2009	10.1	7.2	5.2
26/11/2009	9.7	5.4	0.1
27/11/2009	9.1	4.3	2.1
28/11/2009	6.2	4	6.3
29/11/2009	7.7	4	4
30/11/2009	5.4	3.7	0