FINAL REPORT

To:
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Brassicas: control of cabbage root fly on leafy and root brassicas

FV 242d

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Grower Summary

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Project title:	Brassicas: control of cabbage root fly on leafy and root brassicas
Project number:	FV 242d
Project Leader:	Rosemary Collier and Andrew Jukes Warwick HRI, Wellesbourne, Warwick CV35 9EF
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Signed on behalf of: **Warwick HRI**

Signature:..... ***Date***: .....
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Headline

Field experiment on radish

- The standard (approved) treatment of chlorpyrifos sprayed after drilling provided effective control of cabbage root fly larvae.
- When applied as a drench in-furrow at drilling, or as a spray to the seed bed after sowing, spinosad at 200l/ha did not control cabbage root fly.
- Spinosad would appear not to be a viable alternative to chlorpyrifos unless the dose can be increased.

Field experiment on calabrese

- Drench treatments of chlorpyrifos and spinosad reduced damage to the root area of calabrese but had less effect on the stem area above the roots.
- Deeper planting increased the level of damage to the stem area (irrespective of treatment).
- Calabrese spears can be successfully inoculated with cabbage root fly eggs and a good proportion develop into feeding larvae, providing a useful scientific tool for assessing new insecticides.
- Chlorpyrifos sprays (applied 1 and 10 days after inoculation) were the most effective at controlling the larvae.

Summary

- In the short term at least chlorpyrifos appears to offer the best solution for cabbage root fly control in both radish roots and calabrese spears.

Background and expected deliverables

Brassica crops are grown currently on approximately 30,000 ha in the UK and the marketed value of these crops is about £200M/annum [*Basic Horticultural Statistics for the United Kingdom 2005, Department for the Environment, Food and Rural Affairs, National Statistics*]. The cabbage root fly (*Delia radicum*) is the most serious pest of brassica crops in the United Kingdom. Since 1963, the larvae of this pest have been controlled by seed-treatments, drenches, sprays and granular formulations of mainly organophosphorus (OP) insecticides.

In 1999, the insecticides aldicarb, carbosulfan, chlorpyrifos, chlorfenvinphos, carbofuran, disulfoton, fonofos, phorate and trichlorfon were available to control the cabbage root fly. Now, growers of leafy brassicas are left with only two insecticides, chlorpyrifos and carbosulfan. The situation is even bleaker for swede and turnip growers since chlorfenvinphos, which is the only effective compound for control of second and third generation cabbage root fly on swedes and turnips, was withdrawn from use on 31 December 2003.

This project is for a continuation of previous work to find effective alternative (non-OP) treatments for control of cabbage root fly on leafy and root brassica crops. Previous trials have identified a number of active ingredients that might be effective for the control of cabbage root fly on the roots of leafy brassicas when applied either as seed treatments or pre-planting drenches. Of these, spinosad (Tracer) has been approved (SOLA) as a pre-planting drench treatment. Trials have shown that this treatment is generally as effective as a chlorpyrifos drench (Dursban). However, Tracer is effective only against cabbage root fly and does not give control of aphids or flea beetle.

So far we have been unable to identify a treatment that will provide complete control of two generations of cabbage root fly on swede. However, spinosad seed treatment does give good control of one generation and partial control of a further generation. This treatment will not be available to growers in the foreseeable future.

The proposed work for 2006 has been targeted at radish and calabrese. On radish, the aim is to evaluate spinosad and chlorpyrifos as post drilling sprays for control of cabbage root fly on radish. On calabrese, the aim is to evaluate a novel drench treatment for control of root damage and foliar spray treatments for the control of cabbage root fly larvae in the spear. The latter is a sporadic, but potentially devastating, problem for which there is no recommended insecticide treatment at present.

The purpose of this project is to find ways of controlling the cabbage root fly with non-OP insecticides and to find alternative methods of using those compounds which are still available.

The expected deliverables from this work include:

- An evaluation of the spinosad and chlorpyrifos as post drilling sprays for control of cabbage root fly in radish.
- An evaluation of in-furrow application of spinosad at drilling as an alternative to spraying.
- An evaluation of a technique for field inoculation of calabrese spears with cabbage root fly eggs.
- An evaluation of chlorpyrifos, spinosad, lambda-cyhalothrin and an experimental treatment (Exp A) as foliar sprays to control cabbage root fly larvae in calabrese spears
- An evaluation of the performance of chlorpyrifos and spinosad when drenched onto modules pre-planting with the modules then either planted deep or at the soil surface.

Summary of the project and main conclusions

Two experiments were done in 2006 using four insecticides (Tracer (spinosad), Hallmark with Zeon Technology (lambda-cyhalothrin), Dursban (chlorpyrifos) and an experimental treatment (Exp A).

Experiments were done to answer the following questions:

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

2. Are there novel treatments to control cabbage root fly on the roots, stems and spears of calabrese? (Field Experiment 2)
3. How does depth of planting effect the efficacy of pre-planting drench treatments (spinosad and chlorpyrifos)? (Field Experiment 2)

Experiment summaries and main conclusions

1. Novel treatments to control cabbage root fly on radish

The experiment was done initially during July 2006 (to target the second generation of the cabbage root fly) but this coincided with some exceptionally hot dry weather. It appeared that, as a result of these conditions, the radish suffered badly from calluses and splitting. It was therefore difficult to determine which damage was due to cabbage root fly larvae. The experiment was repeated in August (to target the third generation of the cabbage root fly). Spinosad applied as a post-drilling spray and an in-furrow drench treatment at drilling were compared with a standard chlorpyrifos spray applied post-drilling.

Results

- The standard (approved) treatment of chlorpyrifos sprayed after drilling provided effective control of cabbage root fly larvae
- When applied as an in-furrow drench treatment at drilling, or as a spray to the seed bed after sowing, spinosad at 200 ml product/ha did not control cabbage root fly.
- Spinosad would appear not to be a viable alternative to chlorpyrifos unless the dose can be increased.

2. Novel treatments to control cabbage root fly on the roots, stems and spears of calabrese

The experiment was designed to assess the impact of depth of planting on control of cabbage root fly larvae in the soil and of foliar sprays on control of cabbage root fly larvae in the spears.

Two insecticides (spinosad and chlorpyrifos) were used to assess the effect of planting depth on pre-planting drench treatments and the depths investigated were 0 cm (surface) and 3-5 cm (deep) below the soil surface. Plant propagation modules containing the plants were treated with a laboratory pipette to ensure uniformity of dose. Root samples were assessed for cabbage root fly damage in August (after the second generation of the fly) and October (after the second and third generations of the fly).

Four insecticides (spinosad, chlorpyrifos, Exp A and lambda-cyhalothrin) were applied to control cabbage root fly larvae in the spears. Since natural infestation of this part of the plant is sporadic and unpredictable, spears were inoculated with laboratory-reared cabbage root fly eggs before spraying 1 and 7-10 days after inoculation. The inoculated spears were removed from the plants 3-4 weeks after

inoculation and cut open to find any larvae that had developed. Two sets of spears were inoculated, one in August and the second in September.

Results

- Deep-planted calabrese plants suffered more stem damage than surface-planted plants.
- Chlorpyrifos reduced stem damage to surface-planted plants compared with insecticide-free control plants.
- Spinosad and chlorpyrifos reduced root damage to calabrese plants at both planting depths
- Cabbage root fly eggs hatched and developed into larvae when inoculated onto calabrese spears.
- Chlorpyrifos sprays were the most effective at reducing the numbers of surviving cabbage root fly larvae on calabrese spears compared with insecticide-free control plants.
- Spinosad, lambda-cyhalothrin and Exp A reduced numbers of surviving cabbage root fly larvae on calabrese spears compared with insecticide-free control plants, but would not offer effective control.

Summary

Chlorpyrifos still remains the best option for control of cabbage root fly larvae on radish and calabrese roots, stems and spears. Spinosad is a possible alternative for control on the roots, stems and spears of calabrese but the permitted dose appears to be too low to offer any control in radish

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

The aim of this project was to evaluate novel insecticides for cabbage root fly control.

In-furrow treatments (field experiment - radish)

- **Spinosad** The dose tested was insufficient to control cabbage root fly larvae. Unless doses can be raised considerably it is unlikely that spinosad would be a viable control treatment.

Post- drilling spray treatment (field experiment -radish)

- **Chlorpyrifos** This is the standard treatment and is effective for control of cabbage root fly larvae in radish roots.

- **Spinosad** Ineffective at the dose tested.

Foliar spray treatment (field experiment - calabrese)

- **Chlorpyrifos** The most effective foliar spray for control of cabbage root fly larvae in calabrese spears.
- **Lambda-cyhalothrin** Limited effect, not suitable for cabbage root fly control.
- **Spinosad** Could be used as foliar spray for control of cabbage root fly larvae in calabrese spears, but dose may need to be increased.
- **Exp A** Could be used as foliar spray for control of cabbage root fly larvae in calabrese spears, but dose may need to be increased.

Module drench treatments (field experiment – calabrese)

- **Chlorpyrifos** Provided good protection for roots when surface- or deep-planted and some protection for stems when surface-planted.
- **Spinosad** Provided good protection for roots when surface- or deep-planted but no protection for stems at either depth.

SCIENCE SECTION

Introduction

The work during this one-year project was "short-term", and was concerned with finding possible replacements for the OP-based treatments applied currently and with quantifying the efficacy of different methods of application.

Experiments were done to answer the following three questions:

1. Are there novel treatments to control cabbage root fly on radish? (Field Experiment 1)
2. Are there novel treatments to control cabbage root fly on the roots, stems and spears of calabrese? (Field Experiment 2)
3. How does depth of planting effect the efficacy of pre-planting drench treatments (spinosad and chlorpyrifos)? (Field Experiment 2)

For scientific reasons, 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), lambda-cyhalothrin (Hallmark with Zeon Technology) and an experimental treaetment (Exp A).

Experiment 1

Novel treatments to control cabbage root fly on radish

Materials and methods

The experiment was drilled on 10 July 2006 to coincide with egg laying by the second generation of the cabbage root fly. The experiment was laid out as a Latin Square design. Plots were 10 m x 1 bed (1.83 m) in size and there were 4 replicates of 4 treatments (Table 1). Seeds were drilled at 40 seeds per metre using a Stanhay drill unit and there were 4 rows/bed. The in-furrow drench treatment was applied using a drill mounted peristaltic pump unit. After drilling the spray treatments were applied using a knapsack sprayer with coarse nozzles at 1000 l water/ha. The treatments were watered-in by irrigating the plots for about 30 minutes. Then one half of each plot was covered with insect proof netting on a frame formed from polypropylene water pipe to make a cage (approximately 0.5 m tall). Laboratory-reared flies (50 females + additional males) were released into the cages on 17 and 28 July. The radish plants were harvested on 7 August.

There was some exceptionally hot dry weather during this trial. This may well have resulted in poor survival of the released flies and, in addition, it appeared that, as a result of the hot weather conditions, the radish suffered badly from scab and splitting. It was therefore difficult to determine which damage was due to feeding by the cabbage root fly larvae.

Because of these problems, the experiment was re-drilled on 25 August to coincide with egg laying by the third generation of cabbage root fly. The experiment was laid out as a Latin Square design. Plots were 5 m x 1 bed (1.83 m) in size and there were 4 replicates of 4 treatments (Table 1). Seeds were drilled at 40 seeds per metre using a Stanhay drill unit and there were 4 rows/bed. The in-furrow drench treatment was applied using a drill mounted peristaltic pump unit. After drilling, the spray treatments were applied using a knapsack sprayer with coarse nozzles at 1000 l water/ha. The treatments were watered-in with approximately 30 minutes of irrigation. On this occasion, all the plots were exposed to the natural population of cabbage root fly.

Table 1 Treatments to control cabbage root fly larvae in radish.

			Dose	
Treatment	Active ingredient	Product	g a.i./ha	Product/ha
1	Chlorpyrifos	Dursban WG	900	1200 g
2	Spinosad	Tracer	96	200 ml
3	Spinosad	Tracer	48 [1]	100 ml
4	Untreated	No insecticide		

[1] Standard rate halved as only 4 rows/bed were drilled compared to the commercial 8 rows/bed

Assessments

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 2006 and cabbage root fly eggs were extracted from the soil by flotation and counted.

First drilling

Seedling emergence in a 1 m length of each of the two middle uncovered rows was assessed on 21 and 28 July 2006. Two x 1 m portions of row were harvested from the caged and uncaged areas of each plot on 7 August 2006. The roots were washed, counted and scored (0-3 scale, Table 2) for damage due to cabbage root fly larvae. The data were subjected to Analysis of Variance

Second drilling

Seedling emergence in a 1 m length of each of the two middle rows was assessed on 6 September and the radish from the same 1 m portions of row were harvested on 28 September. The roots were washed, counted and scored (0-5 scale, Table 2) for damage due to cabbage root fly larvae. The data were subjected to Analysis of Variance.

Table 2 Cabbage root fly damage scoring system for first and second drillings of radish.

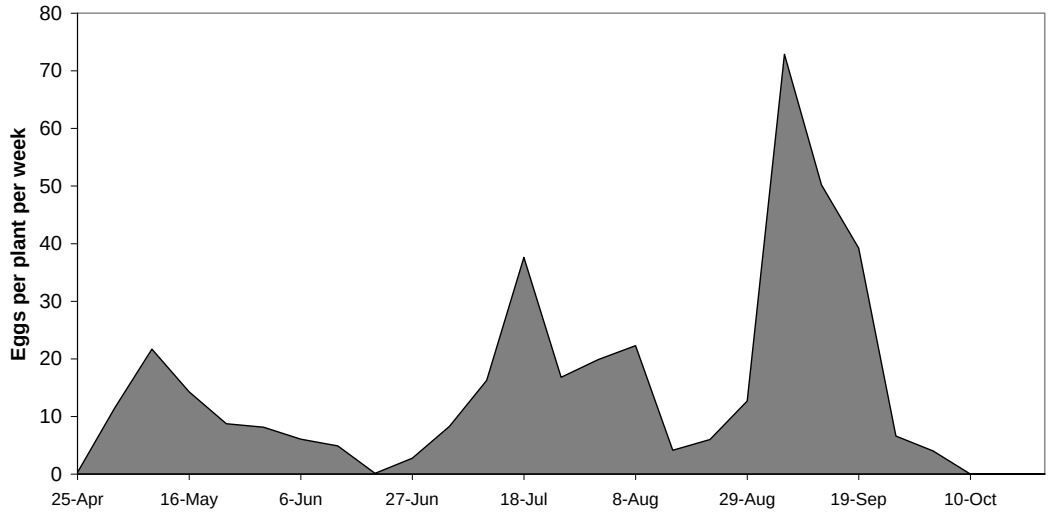
	First drilling	Second drilling
Damage score	Damage description	% of surface area damaged
0	No damage	0
1	Slight damage	< 5
2	Moderate damage	5 – 10

3	Heavy damage	10 – 25
4	Not used	25 – 50
5	Not used	> 50

Results

The numbers of eggs laid on cauliflower plants in the nearby monitoring plot are shown in Figure 1. The second fly generation started in early July and the third generation in mid August.

Figure 1 The numbers of cabbage root fly eggs laid on cauliflower plants in monitoring plots at Warwick HRI, Wellesbourne in 2006.



a) Plant numbers

In the first drilling, there was no evidence of a decrease in plant numbers between the two assessment dates with any of the treatments. In the second drilling, the plant stand was greater at the time of the second assessment in the plots treated with chlorpyrifos than it was in the insecticide-free control plots, although there was no direct evidence to confirm that this was due to cabbage root fly feeding.

Table 3. The effect of treatment on plant numbers. Means followed by the same letter are not significantly different ($p<0.05$).

	Drilling 1				Drilling 2			
Treatment	July 21		July 28		Sept 6		Sep 28	
Untreated	57.0	ab	57.5	a	66.75	a	56.75	a
Chlorpyrifos spray	57.0	ab	56.5	a	69.25	a	63.00	c
Spinosad spray	51.0	a	54.2	a	68.25	a	60.25	bc
Spinosad in-furrow	61.8	b	58.2	a	68.75	a	57.25	ab

F-prob	0.203	0.571	0.779	0.013
SED	4.31	2.88	2.517	1.396
LSD	10.55	7.05	6.158	3.415
df	6	6	6	6

b) Root damage Score

The mean root weights and mean damage scores are presented in Tables 4a (Drilling 1) and 4b (Drilling 2). The mean damage score for Drilling 2 is also shown in Figure 2. There were no statistically significant differences in root weight or mean damage score for either the caged or exposed radish in Drilling 1. Although there was some evidence to suggest that all of the treatments may have reduced damage compared with the insecticide-free control treatment, damage assessment was very difficult due to the condition of the roots at harvest.

For Drilling 2, the chlorpyrifos spray treatment reduced the mean root damage score compared with the insecticide-free control treatment. The spinosad treatments had no effect and there were no statistically significant differences in root weight. The proportion of radish in each damage category were also analysed using Analysis of Variance and the results are shown in Tables 5a (Drilling 1, caged), 5b (Drilling 1, exposed and 5c (Drilling 2, exposed). For Drilling 2, only one root had >50% damage and thus this category has not been analysed. At Drilling 2, the proportion of undamaged plants was higher for treated plots treated with chlorpyrifos (Figure 3). There were no statistically significant differences in the proportion of undamaged plants in Drilling 1.

Table 4a. The mean sample weight and mean damage score of radishes (Drilling 1). Means followed by the same letter are not significantly different ($p<0.05$).

	Drilling 1 - Caged				Drilling 1 - Exposed			
Treatment	Weight		Mean Damage Score		Weight		Mean Damage Score	
Untreated	1521	a	0.532	a	459	a	1.425	a
Chlorpyrifos spray	1502	a	0.526	a	604	a	1.179	a
Spinosad spray	1560	a	0.475	a	524	a	0.922	a
Spinosad in-furrow	1729	a	0.518	a	607	a	0.860	a
F-prob	0.657		0.942		0.341		0.176	
SED	194.1		0.1021		85.7		0.2407	
LSD	475.0		0.2499		209.7		0.5890	
df	6		6		6		6	

Table 4b The mean sample weight and mean damage score of radishes (Drilling 2). Means followed by the same letter are not significantly different ($p<0.05$).

	Drilling 2 - Exposed			
Treatment	Weight		Mean Damage Score	
Untreated	768	a	0.939	b
Chlorpyrifos spray	865	a	0.234	a
Spinosad spray	748	a	1.134	b
Spinosad in-furrow	770	a	1.034	b
F-prob	0.173		0.015	
SED	48.5		0.2004	
LSD	118.6		0.4904	
df	6		6	

Table 5a The proportion of radish roots in each damage category (Drilling 1, caged). Means followed by the same letter are not significantly different ($p<0.05$).

	Drilling 1 - Caged							
Treatment	1 - None		2 - Slight		3 - Medium		4- Heavy	
Untreated	0.627	a	0.215	b	0.158	a	0.000	a
Chlorpyrifos spray	0.631	a	0.213	b	0.157	a	0.000	a
Spinosad spray	0.677	a	0.176	ab	0.142	a	0.005	a
Spinosad in-furrow	0.672	a	0.137	a	0.190	a	0.000	a
F-prob	0.641		0.058		0.862		0.455	
SED	0.0490		0.0247		0.0579		0.0036	
LSD	0.1198		0.0605		0.1417		0.0088	
df	6		6		6		6	

Table 5b The proportion of radish roots in each damage category (Drilling 1, exposed). Means followed by the same letter are not significantly different ($p<0.05$).

	Drilling 1 - Exposed							
Treatment	1 - None		2 - Slight		3 - Medium		4- Heavy	
Untreated	0.204	a	0.278	a	0.406	a	0.112	b

Chlorpyrifos spray	0.296	a	0.304	a	0.324	a	0.076	ab
Spinosad spray	0.404	a	0.285	a	0.296	a	0.015	a
Spinosad in-furrow	0.475	a	0.224	a	0.266	a	0.035	a
F-prob	0.215		0.721		0.477		0.062	
SED	0.1192		0.0722		0.0876		0.0296	
LSD	0.2918		0.1766		0.2143		0.0725	
df	6		6		6		6	

Table 5c The proportion of radish roots in each damage category (Drilling 2, exposed). Means followed by the same letter are not significantly different ($p<0.05$).

	Drilling 2 - Exposed									
Treat	None		0 -5%		5-10%		10-25%		25-50%	
Untreated	0.500	a	0.207	a	0.169	b	0.101	ab	0.023	a
Chlorpyrifos spray	0.804	b	0.159	a	0.038	a	0.000	a	0.000	a
Spinosad spray	0.434	a	0.224	a	0.149	ab	0.163	b	0.024	a
Spinosad in-furrow	0.459	a	0.191	a	0.213	b	0.131	b	0.005	a
F-prob	0.002		0.521		0.042		0.086		0.456	
SED	0.0579		0.0431		0.0463		0.0528		0.0175	
LSD	0.1416		0.1055		0.1132		0.1292		0.0427	
df	6		6		6		6		6	

Figure 2. The root damage scores of radish harvested from Drilling 2.

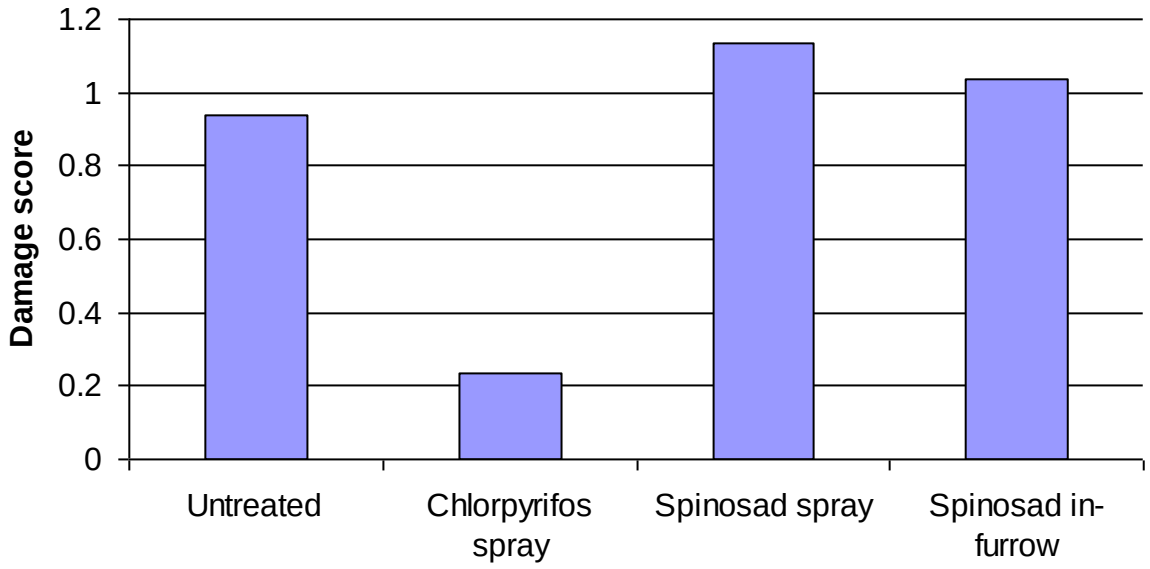
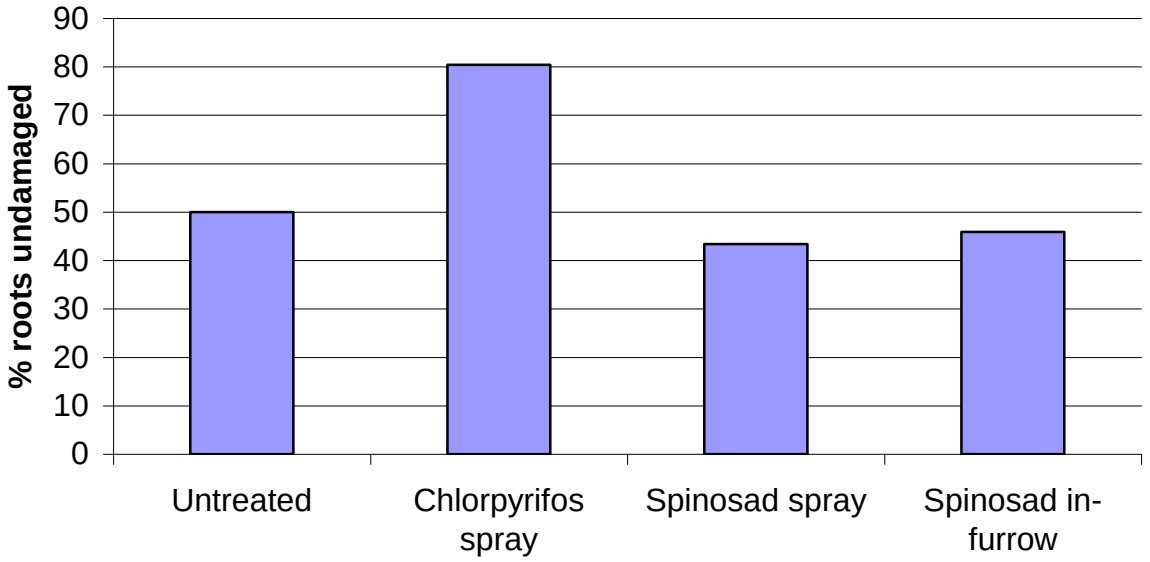


Figure 3. The percentage of undamaged roots harvested from Drilling 2.



Discussion

The standard (approved) treatment of chlorpyrifos applied as a spray after drilling provided effective control of cabbage root fly larvae. This chlorpyrifos treatment cannot be replaced by spinosad applied, either as a drench in-furrow at drilling or as a spray to the seed bed after sowing, at the recommended rate (200 ml product/ha). This could be because the dose is insufficient to kill cabbage root fly larvae. Spinosad is susceptible to photo-degradation which could diminish the potency of treatments sprayed over the top of crops, but should not affect the in-furrow treatment, which is not exposed to daylight.

Experiment 2

Novel treatments to control cabbage root fly on the roots, stems and spears of calabrese.

Materials and methods

The experiment was done within the field known as Pump Ground at Warwick HRI, Wellesbourne. There were two aspects to the experiment (the effect of planting depth on cabbage root fly control on the roots and lower stem area and the effect of foliar sprays on the control of cabbage root fly in the spears) and different plots (except the insecticide-free control plots) were used for each aspect. The treatments are listed in Table 5.

Calabrese seeds (cv Fiesta) were sown in 308 Hassy trays on 5 May 2006 and kept in a glasshouse. When the plants reached the 4-leaf stage, pre-planting drenches were applied to 270 plants per treatment (treatments B, C, H and I) on 13 June 2006, one day before transplanting. All of the treatments (Table 5) were applied using an automatic pipette and 1 ml of treatment solution was added to each module. The plants used for the foliar spray elements of the trial (treatments D, E, F and G) were drenched with spinosad at 8 mg a.i./plant using a calibrated watering can. The treatments were watered-in with a similar volume of water.

The planting date (14 June 2006) 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 randomised block design and there were 4 replicates of 10 treatments. Plots were 5 m x 1 bed (1.83 m) in size and there were 3 rows of 11 plants (33 plants). Plants were planted at 50 cm spacing within, and 38 cm between, rows.

When the primary (central) spears had reached a diameter of 3-5 cm (23 August 2006), 12 plants in each "spray" 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. One day (24 August 2006) and 9 days (1 September 2006) after inoculation, the treated plots were sprayed using a knapsack sprayer. A spray rate of 300 l water/ha was used initially and this was increased to 400 l/ha for the second spray, to increase penetration. Agral was added to all spray solutions at a rate of 300 ml/1000 l.

All of the non-inoculated primary spears were harvested (11 September 2006) to encourage the development of the secondary spears. When enough of the secondary spears had reached a diameter of 2-5 cm (25 September 2006), 12 spears per "spray" plot were selected and the inoculation procedure was repeated. Spear development was uneven, so in some cases more than one spear was selected from a single plant. This set of spears were less elastic and failed to spring back completely around the inserted eggs. One day (26 September 2006) and 10 days (5 October 2006) after inoculation the treated plots were sprayed using a knapsack sprayer. A spray rate of 600 l water/ha was used on both occasions in an attempt to maximise penetration, as no problems with run-off had been observed at

the 400 l/ha rate used previously. Agral was added to all spray solutions at a rate of 300 ml/1000 l.

Table 5 Pre-planting drench and foliar treatments applied to calabrese to control cabbage root fly in the soil and in the spears.

Treatment code	Pre-planting treatment	Dose mg a.i./plant	Planting depth	Spray treatment	Dose g a.i./ha	Part of plant assessed
A	Insecticide free	0	Surface[1]	none		Root, stem and spears
B	Spinosad	8	Surface[1]	none		Root and stem
C	Spinosad	8	Deep[2]	none		Root and stem
D	Spinosad	8	Not applicable	Spinosad	96	Spears
E	Spinosad	8	Not applicable	Chlorpyrifos	900	Spears
F	Spinosad	8	Not applicable	Lambda-cyhalothrin	10	Spears
G	Spinosad	8	Not applicable	Exp A	100	Spears
H	Chlorpyrifos	4.5	Surface[1]	none		Root and stem
I	Chlorpyrifos	4.5	Deep[2]	none		Root and stem
J	Insecticide-free	0	Deep[2]	none		Root, stem and spears

[1] Top of plant propagation module at the soil surface
[2] Top of plant propagation module 3 – 5 cm below the soil surface

Mid-season and harvest assessments

a) Root assessments

At the end of the second generation of cabbage root fly (14 August 2006), and after the third generation of cabbage root fly (24 October 2006), samples of 12 roots were harvested from each root-assessment plot. The roots were kept in a cold store until the assessment was made. The roots were washed and the stems and roots were scored for larval damage (0 – 5 scale, Table 6). The data were subjected to Analysis of Variance.

Table 6. Cabbage root fly damage scoring system for calabrese roots and stems.

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

b) Spear assessments

The first set of inoculated spears was cut from the plants 28 days after inoculation (20 September 2006) and stored in a cold room until 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 number of larvae in each spear was recorded.

The second set of spears were cut 24 days after inoculation (19 October 2006) and assessed as the first set. The data were subjected to Analysis of Variance.

Results

The second generation of cabbage root fly started in early July, soon after planting, and the third generation in mid August (Figure 1).

The trial was designed as a Trojan square, but as only subsets of the treatments were sampled for root/stem or spear damage it has been analysed as a randomised complete block design. No data transformations were required.

a) Root and stem assessments

The mean damage scores for each plot were analysed separately for each occasion using Analysis of Variance and the key points from the analyses are given in Table 7a and Figure 4a (5 October) and Table 7b and Figure 4b (8 November). Both treatments reduced root damage compared with the insecticide-free controls, on both occasions and irrespective of planting depth. There was no effect of planting depth on root damage.

For the 5 October assessment, none of the treatments reduced stem damage compared with the insecticide-free controls, but there was more damage to stems planted deep than those planted at the surface. Damage had increased by the time of the second assessment and there was no treatment effect, but there was still more damage to stems of plants planted deep than those planted at the surface.

Table 7a. Root and stem damage scores for calabrese plants planted at two depths following the application of pre-planting drench treatments and harvested on 5 October 2006. Means followed by the same letter are not significantly different (p<0.05).

	Roots					
Treatment			Depth		Treatment x Depth	
Control	0.844	c	Deep	0.410	a	Control - Deep	0.708
Chlorpyrifos	0.147	a	Surface	0.473	a	Chlorpyrifos - Deep	0.188
Spinosad	0.333	b				Spinosad – Deep	0.333
						Control –Surface	0.979
						Chlorpyrifos – Surface	0.106
						Spinosad- Surface	0.333
F-prob	<0.001			0.337			0.092
SED	0.0779			0.0636			0.1101
LSD	0.1660			0.1355			0.2348
df	15			15			15

	Stems					
Treatment			Depth		Treatment x Depth	
Control	2.083	a	Deep	2.667	b	Control - Deep	2.354
Chlorpyrifos	1.930	a	Surface	1.738	a	Dursban - Deep	2.500
Spinosad	2.594	b				Spinosad – Deep	3.146
						Control –Surface	1.813
						Dursban – Surface	1.360
						Spinosad- Surface	2.042
F-prob	0.019			<0.001			0.322
SED	0.2144			0.1751			0.3033
LSD	0.4571			0.3732			0.6464
df	15			15			15

Table 7b. Root and stem damage scores for calabrese plants planted at two depths following the application of pre-planting drench treatments and harvested on 8 November 2006. Means followed by the same letter are not significantly different (p<0.05).

	Roots					
Treatment			Depth		Treatment x Depth	
Control	0.766	b	Deep	0.309 a	Control - Deep	0.574
Chlorpyrifos	0.177	a	Surface	0.451 a	Dursban - Deep	0.250
Spinosad	0.198	a			Spinosad – Deep	0.104
					Control –Surface	0.958
					Dursban – Surface	0.104
					Spinosad- Surface	0.292
F-prob	<0.001			0.177		0.126
SED	0.1227			0.1002		0.1736
LSD	0.2616			0.2136		0.3700
df	15			15		15

	Stems					
Treatment			Depth		Treatment x Depth	
Control	2.637		Deep	3.001 a	Control - Deep	3.044
Chlorpyrifos	2.771		Surface	2.501 b	Dursban - Deep	3.042
Spinosad	2.845				Spinosad – Deep	2.917
					Control –Surface	2.229
					Dursban – Surface	2.500
					Spinosad- Surface	2.773
F-prob	0.684			0.022		0.392
SED	0.2389			0.1950		0.3378
LSD	0.5092			0.4157		0.7201
df	15			15		15

Figure 4a. Root and stem damage scores for calabrese plants planted at two depths following the application of pre-planting drench treatments and harvested on 5 October 2006.

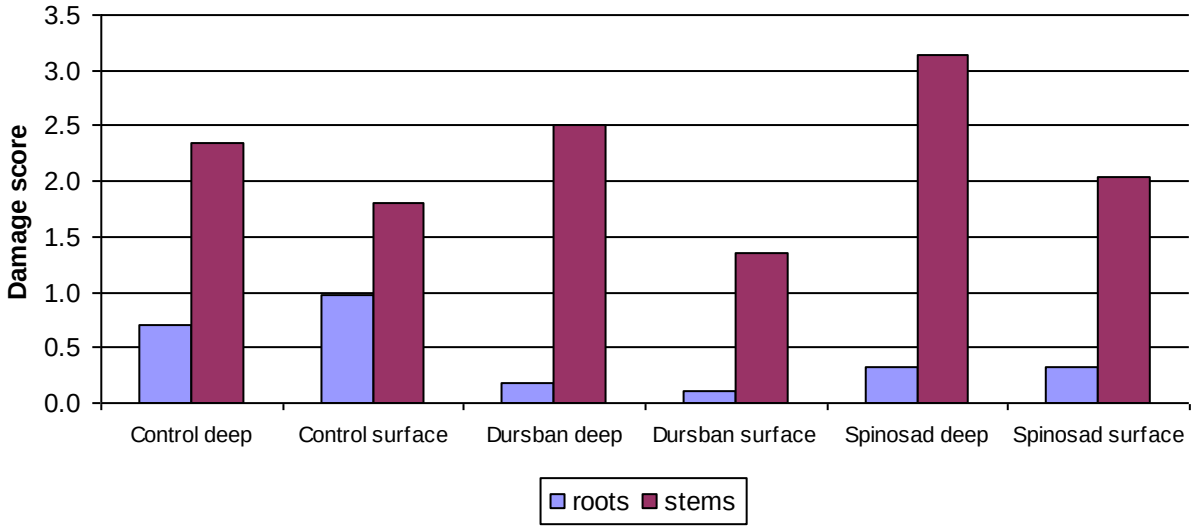
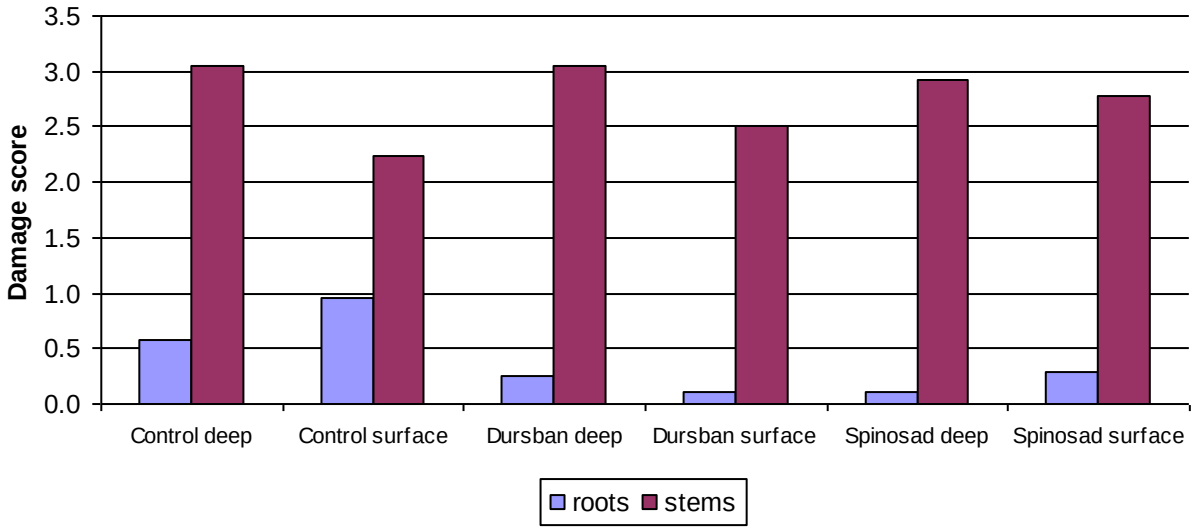


Figure 4b. Root and stem damage scores for calabrese plants planted at two depths following the application of pre-planting drench treatments and harvested on 8 November 2006.



Spear assessments

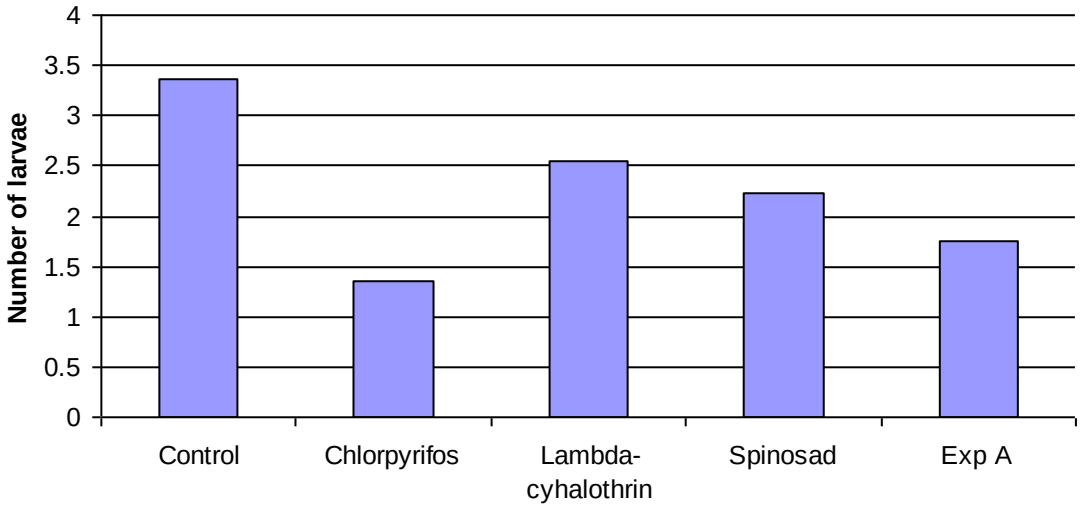
Sprays of spinosad, chlorpyrifos, lambda-cyhalothrin and Exp A all reduced the survival of larvae compared with the insecticide-free control (Table 8, Figure 5) in Assessment 1. Chlorpyrifos appeared to be the most effective treatment, reducing larval numbers by 60%. Further trials would need to be done to elucidate the efficacy of the other treatments. Larval survival was too low to observe any statistically significant differences in Assessment 2, but chlorpyrifos appeared to have been very effective and the other three treatments ineffective.

Table 8. The numbers of larvae recovered from calabrese spears inoculated with cabbage root fly eggs on 23 August (Assessment 1) and 25 September

(Assessment 2). Means followed by the same letter are not significantly different ($p<0.05$).

	Assessment 1		Assessment 2	
Treatment	Larvae		Larvae	
Control	3.37	c	0.286	a
Chlorpyrifos	1.36	a	0.042	a
Lambda-Cyhalothrin	2.54	b	0.347	a
Spinosad	2.22	b	0.375	a
Exp A	1.76	ab	0.392	a
F-prob	0.001		0.504	
SED	0.367		0.2164	
LSD	0.800		0.4716	
df	12		12	

Figure 5. The numbers of larvae recovered from calabrese spears inoculated with cabbage root fly eggs on 23 August (Assessment 1).



Discussion

All of the test insecticides appeared to control cabbage root fly larvae in calabrese spears to some extent. Chlorpyrifos was clearly the best treatment and was the only treatment that showed (not statistically significant) control of larvae in the second assessment. Lambda-cyhalothrin would appear to be the least effective insecticide tested. Improvements may be possible if the water rate is optimised and/or a different adjuvant used.

CONCLUSIONS

Spinosad on radish

The standard chlorpyrifos spray treatment proved to be the only effective treatment tested. Spinosad provided no control when sprayed over the seed bed after drilling or when pumped directly into the furrow at drilling. Since spinosad has been shown to control cabbage root fly effectively (Jukes *et al*., 2003, 2004, 2005, 2006) it must be assumed that the dose present at the time of cabbage root fly egg hatch was insufficient to provide control. This may in some part be due to the photo-sensitivity of spinosad applied as a spray treatment, but the in-furrow treatment was not exposed to sunlight. For the foreseeable future it seems that chlorpyrifos is the best solution for cabbage root fly control on radish.

Depth of planting (calabrese)

Most of the visible damage occurred on the calabrese stem, immediately above the root system. This is the part of the plant which is immediately below the soil surface (and to some extent just above the soil surface). Clearly, if more of the stem is below the soil surface (due to deep planting) then it is more susceptible to feeding by cabbage root fly larvae. Both chlorpyrifos and spinosad reduced damage to the

roots, but only surface-planted calabrese treated with chlorpyrifos showed any evidence of a reduction in stem damage.

Control in calabrese spears

These trials have demonstrated that calabrese (and probably cauliflower curds and possibly Brussels sprout buttons) can be infested with cabbage root fly artificially 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.

All of the treatments appeared to have some effect on cabbage root fly numbers from the first set of inoculations. Only chlorpyrifos controlled cabbage root fly larvae when the trial was repeated. Further trials are required to establish if there is an alternative control measure to chlorpyrifos.

TECHNOLOGY TRANSFER

Date	Description
16 Jan 2007	Brassica pest control – presentation. HDC meeting, Hesketh Bank, Lancashire

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