Project title:	**SWEDES: BIOLOGY AND CONTROL OF CABBAGE ROOT FLY**
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Project number:	**FV 66a**
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1. PRACTICAL SECTION FOR GROWERS

Objectives and background

Current practice for the control of cabbage root fly in culinary swedes does not provide reliable control of the pest. Current commercial and legal pressures on the industry increase the risk that even the most effective available products may have a limited future. The objectives of the current work are to investigate the potential to improve the timing of treatments and to evaluate the efficacy of alternative insecticides. In the final years of the project, the improved method for timing treatments will be used to evaluate the most promising new compounds and traditional compounds under field conditions.

Under current supervised control strategies, egg counts and the HDC/HRI model are used to time insecticide treatments. These tools give an indication of the duration of pest activity during each generation but do not identify the critical risk period within a generation. Currently approved insecticides often cannot provide crop coverage for the duration of second generation activity, therefore it is necessary to more accurately identify the period of protection required. The critical risk period is to be determined by studying the progression of damage over the season.

With a clearly identified critical risk period, the most effective control measures can be applied when they will provide the greatest benefit. In past HDC-funded work (Project FV 66) carbofuran and chlorfenvinphos were the most effective compounds available, but neither of them provided sufficiently reliable control. Pot trials will be used to cost-effectively screen a large number of compounds. Those insecticides which are the most effective will then be evaluated in field trials to develop a more reliable control strategy.

Summary of results to date

Please note: **the approval status of insecticides mentioned in this report is listed in appendix 1.**

Damage progression work

These results represent the first year of two years of damage progression work. During the 1997 season, the vast majority of crop damage occurred during the first seven weeks of second generation cabbage root fly activity. Cumulative damage curves graphed against cabbage root fly egg numbers (figures 2,4 and 6) demonstrate that despite continued egg laying at moderate to high levels, there was no increase in damage levels after the end of August.

Pot trials

Initial results from the exposure of cabbage root fly eggs to foliar and granular insecticides show that only carbofuran gave statistically significant levels of control. When eggs were applied to the soil even 5 weeks after carbofuran treatment, no larvae were found alive 5 weeks later, and root damage was kept down to a 0.3% root damage index. None of the other treatments had any statistically significant effects on root damage. While larval mortality was somewhat higher than in the control for about 3 weeks after treatment with Chlorpyrifos as Suscon Green and Experimental compound 60949A in a granular formulation, none of the differences were statistically significant. Furthermore, none of these treatments provided any noticeable reduction in root damage.

These results suggest that only carbofuran has sufficient soil activity to provide effective control of hatching larvae.

Action points for growers

Only tentative conclusions can be drawn from this first year of work. These will be subject to confirmation in later years of the project. Nevertheless, some benefit may already be realised with the careful application of these results to existing control strategies.

- **Timing of second generation treatments:** damage progression studies indicate that the most important control period is the first 7 to 8 weeks of the second generation. The most effective treatments should be applied at this time according to the HDC/HRI development model and egg or trap counts. Since no new damage occurred after the end of August, treatments may not be necessary after this time. As these results are only preliminary, growers could leave a small area of the field untreated after the end of August to test the validity of this approach.

- **Treatment at drilling:** In pot experiments, carbofuran granules were the most effective against hatching larvae. When crops are drilled within a few weeks of the start of second generation activity, carbofuran or related products such as carbosulfan granules are likely to provide some control.

Practical and financial benefits from study

During 1996 roughly 75% of root brassica crops were treated with insecticides for cabbage root fly control. A large proportion of these treatments were timed according to egg counts and the HDC/HRI model. Nevertheless, devastating attacks were reported in many crops during the autumn. Second and third generation cabbage root fly control alone frequently costs the industry about £990,000 per year, but despite this investment, control is still unreliable. During 1995/96, 4,405 ha of swedes and turnip were planted, giving a potential total yield of 147,668T. The average price throughout the year was £133.68/T, assuming an estimated 30% loss in overall value due to cabbage root fly damage, the total losses amount to approximately £5,922,077 (MAFF 1996, C Treble personal communication).

The development of a more effective control programme will reduce the estimated cost of crop damage, and improve the return on investments in pest control. If further work supports the narrowing of the critical risk period, the need for late sprays may also be reduced, allowing subsequent cost savings.

2. EXPERIMENTAL SECTION

A. GENERAL INTRODUCTION

Cabbage root fly larvae continue to cause serious damage to culinary root Brassica crops, and in many areas is the single greatest challenge facing producers. Current control programmes rely on carbofuran and chlorfenvinphos, and even the best control is often inadequate. The industry's reliance on these compounds carries increasing commercial risks. With the introduction of Integrated Crop Management Systems, the multiples are asking growers to use compounds with low persistence and greater selectivity wherever possible. Furthermore, the continual review of pesticide regulations means that products can be lost at short notice, either due to direct revocation of use, or as the result of a commercial decision to discontinue production. Clearly, there is a need for more effective control programmes and the evaluation of alternative products.

Previous MAFF and HDC-funded work has contributed to the background of the present study. The most effective treatments have traditionally varied between regions. In 1986/89 trials at ADAS/HRI Stockbridge House (Senior *et al.* 1992) carbofuran was often more effective than chlorfenvinphos, but in Devon, chlorfenvinphos is usually the favoured compound. Past HDC-funded work in 1991 and 1992 (Project FV 66) compared a range of strategies for the control of second generation cabbage root fly at commercial sites located throughout Britain and evaluated the role of enhanced degradation (ED) of carbofuran. Mid-season insecticide programmes were based on combinations of chlorfenvinphos (as Birlane 24) and carbofuran (as Yaltox). None of the programmes provided adequate control except where infestations were relatively small and it was not possible to devise a fully effective control programme with the available products. Nevertheless, programmes which included both products were thought to provide better control than programmes relying on one product. Larvae and fresh damage were often present at harvest in this work, indicating that the period of protection required was longer than could be given by the currently available insecticides. Enhanced levels of carbofuran degradation were recorded at several sites but there was no correlation between levels of enhanced degradation and control, consequently, it was concluded that there is little value in analysing fields for enhanced degradation. Improved control at some sites was shown to result from the use of cell-raised swedes treated with chlorpyrifos (as Dursban 4), but roots were often small and/or misshapen at harvest. Crop covers (Lutracil 10G laid at the start of 2nd generation) usually provided inadequate control, the material was often torn by the wind and root weights were usually reduced, however, at one site modest improvements were reported. Current MAFF-funded work at HRI is investigating the factors influencing the rate and extent of insecticide uptake by soil-inhabiting larvae ('insecticide transfer'), and will be complementary to this work.

The objectives of the work done in the first year of this project were:

1. To do damage progression experiments to identify the most damaging periods of cabbage root fly activity, and so identify when to concentrate the protection programme during the second and third generations.

2. To evaluate, using pot-based experiments, the efficacy of new active ingredients, formulations and application techniques for controlling cabbage root fly damage on swedes.

Year 2 of the project will repeat this work. In the final two years, the most effective products will be tested in the field with treatments timed to provide protection during the critical risk period identified from the damage progression work.

Please note: the approval status of insecticides mentioned in this report is listed in appendix 1.

B. PART I - DAMAGE ASSESSMENT WORK

Introduction

In replicated field plots sequential sampling techniques were used to deduce the most damaging period of cabbage root fly activity, and determine the optimal time for insecticide treatment -- the critical risk period.

Materials and methods

Plots were set up at the English sites during the last week of June, and in mid July in Berwickshire. In Humberside the grower harvested the crop shortly after 26 August in time for drilling winter wheat, but at the other two sites, the crop remained in the ground longer, and were sampled until 22 November (Somerset) and 21 October (Berwickshire).

Layout

Before the start of second generation egg laying, plots four rows wide by 5m long were marked out in four widely separated randomised blocks, each 30m from the nearest headland.

Cabbage root fly egg sampling

Five plants in each block were labelled and sampled weekly for cabbage root fly eggs until the start of egg laying and fortnightly thereafter. On each occasion, soil was removed to a depth of 2cm and a radius of 5cm around each plant. The soil removed was replaced with silver sand or soil collected from an uninfested field. The sample from each block was washed through a Fenwick can and the organic debris was extracted onto a fine sieve and washed onto a black filter paper. All hatched and unhatched cabbage root fly eggs were identified and counted.

Root sampling and damage assessment

Every two weeks, a sample of 20 roots was taken from each block (80 roots per treatment). The swedes were washed, cabbage root fly damage was assessed, and the root damage index was calculated using a modified version of the technique described by King and Forbes (1954) Throughout the report, crop damage is reported as percent root damage index.

Results to date and discussion

The results from each site are listed in tables 1-6, illustrative graphs (figures 1-6) display the progression of damage at each site and relate damage progression to the phenology of egg laying.

Egg laying

At the Somerset and Humberside sites, egg laying began at low levels in early July (10 and 8 July respectively), the first eggs were collected from the Berwickshire site on 17 July. Egg laying reached an early peak in late July at the Somerset site before declining during August and reaching the highest peak from mid to late September. The shorter monitoring season at Humberside showed a similar pattern with a late July peak followed by lower levels of egg laying throughout August. In Scotland, the number of eggs plateaued at around 20 eggs per plot during much of the second generation with a sharp peak of 91 eggs per plot during the fortnight leading up to 11 August.

Damage progression

Mean cumulative levels of damage increased steadily at all three sites, reaching the peak during the last two weeks of August. In Somerset, cumulative damage levels stayed between 63 and 68% for the rest of the season with no new damage reported. At Berwickshire, the highest levels of damage were 19% recorded on 25 August, subsequent sampling showed slight reductions in damage to between 7 and 13%. Damage progression was limited to August despite continued egg laying which was moderate at the Berwickshire site throughout September, but reached a new peak in September at the Somerset site.

Table 1. Cumulative root damage index (%): Somerset site

Date	Replicate 1	Replicate 2	Replicate 3	Replicate 4	Mean
10/7	0	0	0	0	0
18/7	10	10	13	9	11
1/8	29	26	36	43	34
18/8	70	69	73	83	74
28/8	55	58	76	76	66
12/9	55	54	70	81	65
30/9	49	65	83	56	63
10/10	70	65	73	70	70
27/10	63	56	68	70	64
6/11	65	64	70	65	66
22/11	60	55	70	85	66

Table 2. Cabbage root fly eggs per plot on each sample date: Somerset site

Date	Replicate 1	Replicate 2	Replicate 3	Replicate 4	Mean
27 June	4	0	0	0	1
3 July	0	0	0	0	0
10 July	1	4	15	4	6
18 July	111	38	124	39	78
1 Aug	52	6	60	105	56
18 Aug	11	0	7	28	12
28 Aug	0	0	12	2	4
12 Sept	110	19	220	160	127
30 Sept	106	61	225	151	136
10 Oct	34	9	63	24	33
27 Oct	3	5	3	24	9
6 Nov	5	2.	2	6	4
22 Nov	7	0	0	1	2

Figure 1. Damage progression at the Somerset site

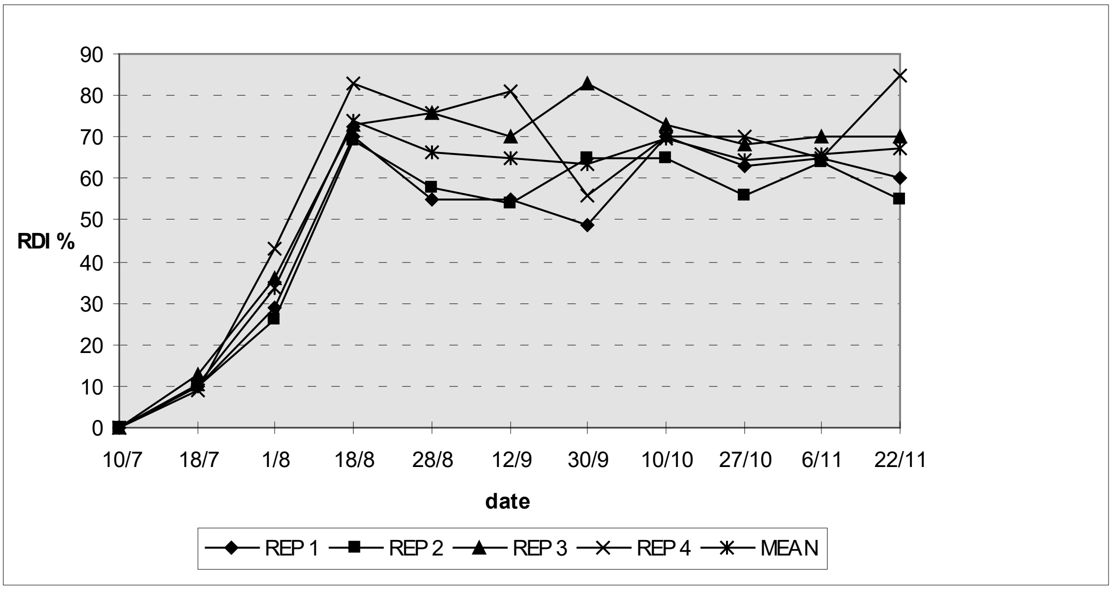


Figure 2. Egg counts and damage progression at the Somerset site.

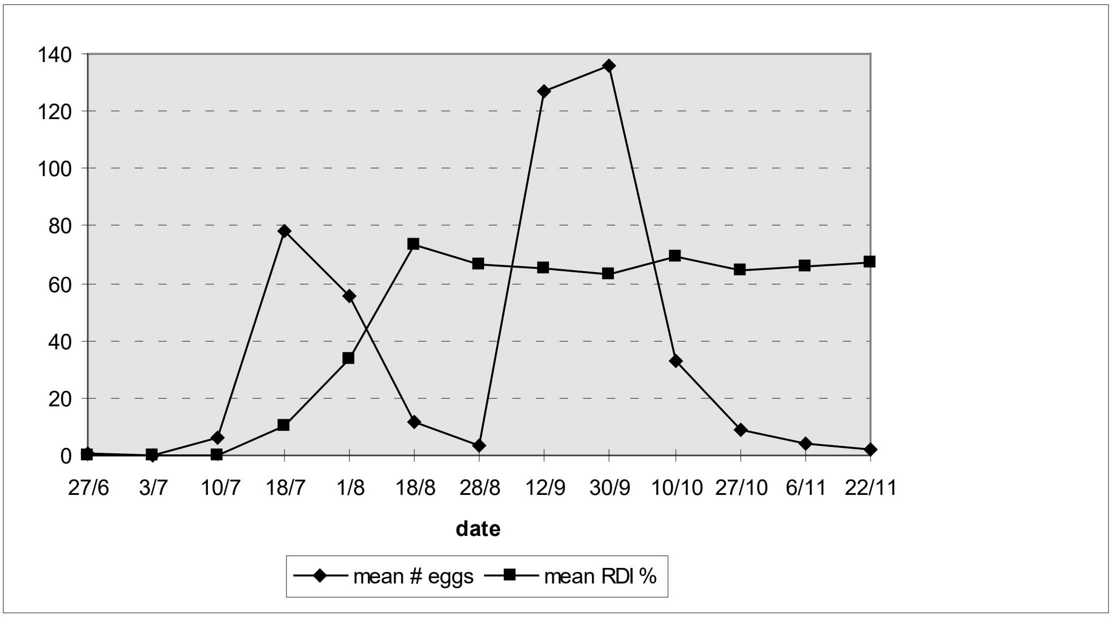


Table 3. Cumulative root damage index (%): Humberside site.

DATE	Replicate 1	Replicate 2	Replicate 3	Replicate 4	Mean
15-Jul	0	5	3	4	3
29-Jul	14	5	8	33	15
12-Aug	28	28	21	25	25
26-Aug	36	38	38	58	42

Table 4. Cabbage root fly eggs per plant: Humberside site.

DATE	Replicate 1	Replicate 2	Replicate 3	Replicate 4	Mean
27-Jun	0	0	0	0	0
02-Jul	0	0	0	0	0
08-Jul	0	5	1	3	2
15-Jul	0	29	2	0	8
29-Jul	39	13	10	24	22
12-Aug	4	4	1	4	3
26-Aug	11	18	8	7	11

Figure 3. Damage progression at the Humberside site.

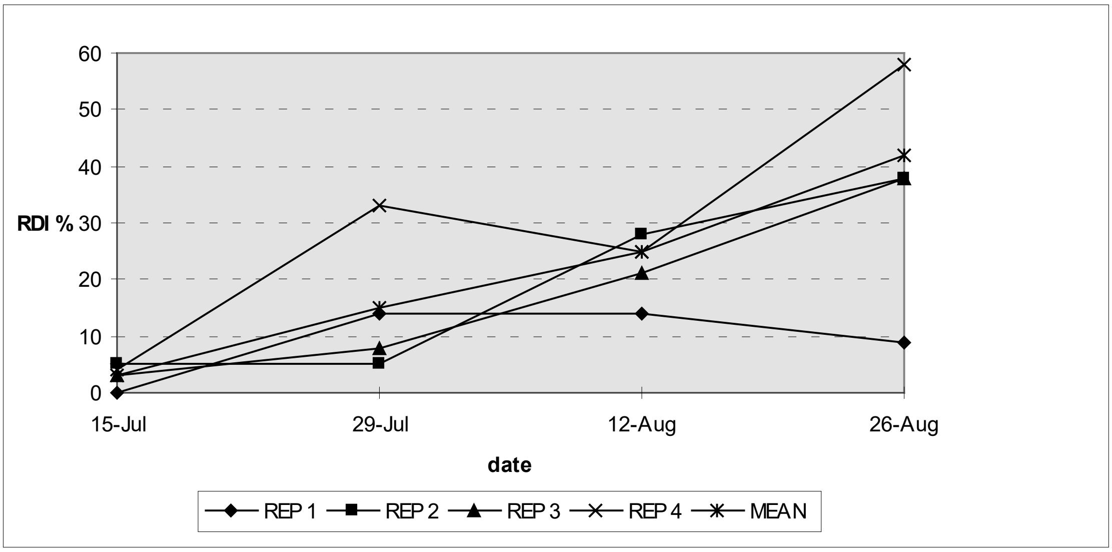


Figure 4. Egg counts and damage progression at the Humberside site.

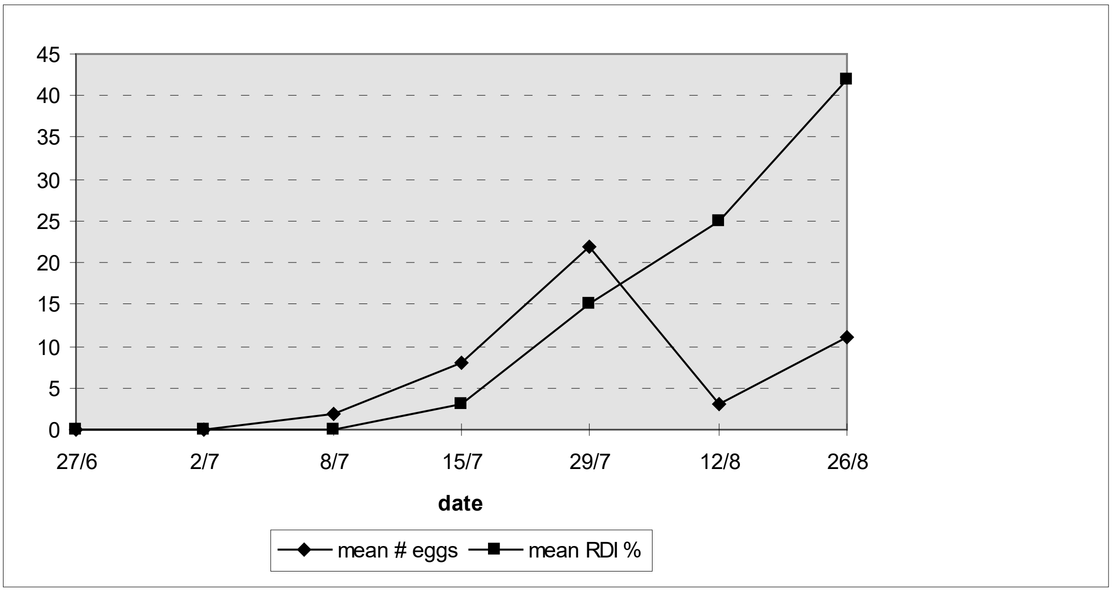


Table 5. Cumulative root damage index (%): Berwickshire site.

date	Replicate 1	Replicate 2	Replicate 3	Replicate 4	Mean
28/7	0	8	5	3	4
11/8	18	14	12.5	24	17
25/8	19	13	15	30	19
8/9	14	11	12.5	15	13
22/9	8	8	8.75	4	7
6/10	8	9	7.5	4	7
21/10	9	14	5	13	10

Table 6. Cabbage root fly eggs per plot: Berwickshire site.

date	Replicate 1	Replicate 2	Replicate 3	Replicate 4	Mean
17/7	0	4	6	2	3
24/7	7	25	13	30	19
28/7	24	20	27	6	19
11/8	134	108	65	56	91
25/8	13	8	26	39	22
8/9	13	18	2	31	16
22/9	5	0	7	15	7
6/10	1	6	1	11	5
21/10	0	0	2	6	2

Figure 5. Damage progression at the Berwickshire site.

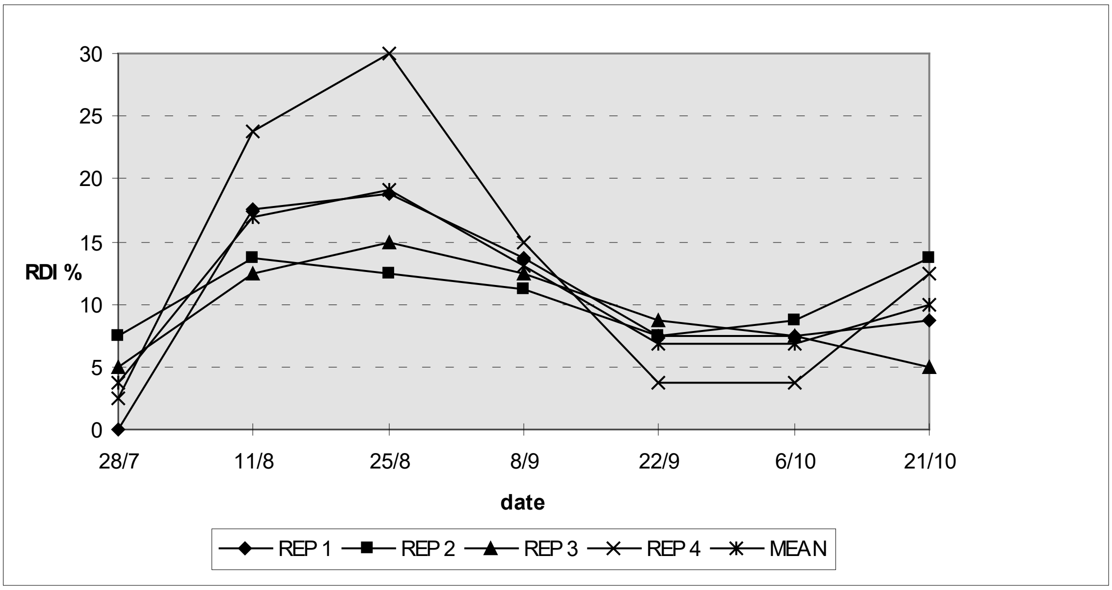
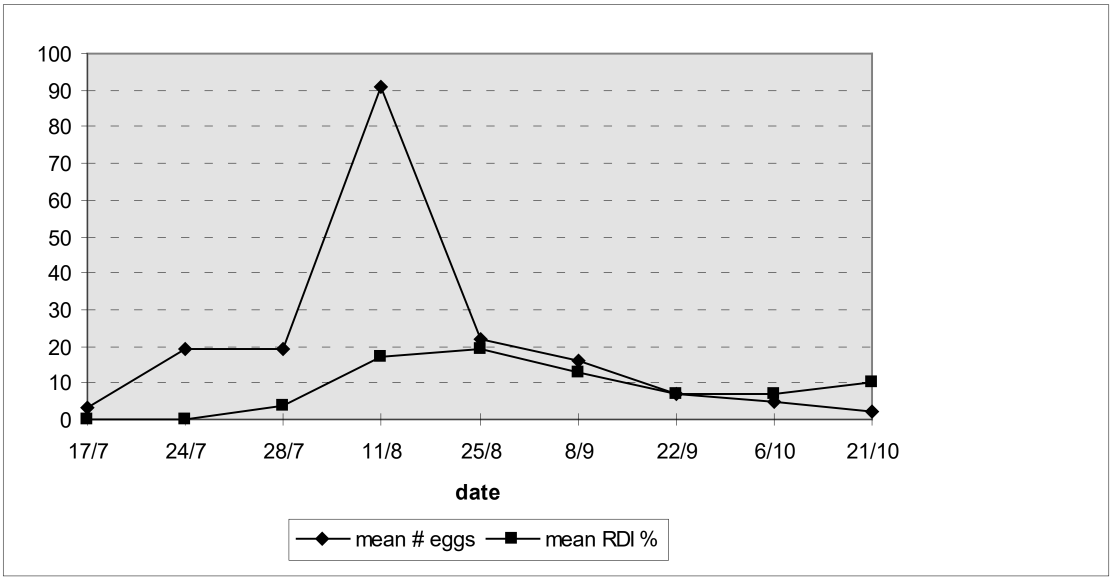


Figure 6. Egg counts and damage progression at the Berwickshire site.



Conclusions

In 1997, the majority of crop damage was caused by early second generation larvae. At all three sites the highest levels of damage occurred within seven weeks of the start of egg laying, despite protracted egg laying which was recorded for an additional 13 weeks in Somerset and 8 weeks in Berwickshire. Soil temperatures may have played a role in this abrupt end to crop damage in 1997 if they were sufficient to cause high larval mortality during late August. Collier and Finch (1988) propose 'day degree' (D°) calculations for each stage of the cabbage root fly life-cycle, development from egg hatch to pupation was determined to be 250 D°. Using their formula for D° calculations (Finch and Collier 1986) and an average of approximately 12 D°/day during August, larval development would have taken roughly 3 weeks; consequently, the last damaging larvae would have hatched in late July to early August during the 1997 season.

PART II - POT TRIAL EXPERIMENTS

Introduction

The objective of this experiment was to identify, using pot trials, the most effective soil applied granules and spray treatments for control of cabbage root fly and their persistence.

Materials and methods

A total of 300 swede seedlings (cv Marion), raised from seed, were potted up individually in Fisons Levington No 2 compost in 15 cm diameter plastic plant pots on 1 July 1997. Pots were then maintained in an insect-proofed glass house. In mid-July, at the start of second generation cabbage root fly egg laying, and when plants had reached the 4/5 leaf stage, a range of nine insecticide treatments were prepared and an untreated control. Batches of 30 plants were given one of the insecticide treatments, 20 experimental plants and 10 spares. The complete treatment list is given in Table 1.

Table 1. Insecticide treatments

Code	a.c.	Product	Product rate/ha
P1	Untreated	-	-
Spray treatments			
P2	Chlorfenvinphos	Sapecron 240 ec (standard)	3 l/ha
P3	Diflubenzuron	Dimilin	400 g/ha
P4	Teflubenzuron	Nemolt	670-ml/ha
P5	Exp 61096A	-	4 l/ha
P6	Fonofos	Cudgel	3.18 l/ha
P7	λ Cyhalothrin	Hallmark	300 ml
Granule treatments			
P8	Carbofuran	Yaltox (standard)	27.5 kg/ha (0.18 g/plant)
P9	Chlorphyrifos	Suscon Green	50 kg/ha (0.33 g/plant)
P10	Exp 60949A	-	26.7 kg/ha (0.18 g/plant)

Please note: the approval status of insecticides mentioned in this report is listed in appendix 1.

Spray treatments were applied in 500 l/ha water equivalent using an Oxford Precision sprayer equipped with a 2 m boom and five 03F110 nozzles calibrated to operate at 2.0 bar pressure. Each batch of 30 plants was placed within an area of 5 x 2 m (10m^2) and the entire area was treated. With granular insecticide formulations individual pot doses of the product were weighed out in glass tubes. The chemical was then shaken around the base of the plant. All treated plants and the untreated control were maintained in an insect-proof glass house.

On five occasions after insecticide treatment swede seedlings were inoculated with cabbage root fly eggs. The egg inoculation dates were:

A. Immediately post treatment
B. 1 week post treatment
C. 2 weeks post treatment
D. 3 weeks post treatment
E. 5 weeks post treatment

Cabbage root fly eggs were collected by taking soil samples from around the base of brassica plants using a dessert spoon. Eggs were extracted from the soil using a Fenwick can. On each inoculation date four plants of each insecticide treatment were inoculated with cabbage root fly eggs, each replicate consisted of one plant. The aim was to inoculate each test plant with 30 eggs. Due to the low numbers of eggs recovered from soil this was only possible at the first inoculation date (A). On inoculation dates B, C, D and E, 22, 17, 17 and 25 eggs were inoculated respectively. Once plants had been inoculated they were returned to the glasshouse and arranged in a randomised block design. Each inoculation date was treated as a separate experiment.

Spare eggs from each inoculation date were maintained in a covered Petri dish on moist black filter paper at room temperature. These were observed daily and the number hatched recorded to determine egg viability. This continued until all eggs had hatched or there was no change in the number hatched on five consecutive days.

Approximately five weeks after egg inoculation the pots for each inoculation date were assessed for the presence of cabbage root fly larvae or pupae and their damage. This was done by immersing the compost from each pot within a 60-mesh sieve in saturated magnesium sulphate. Any larvae or pupae that floated to the surface were removed and counted. The plant from each pot was also assessed to determine the percentage root area damaged by the pest. This was recorded using a root damage as previously defined (sectio 2B: *root sampling and damage assessment*).

Statistical analysis

Data sets for both numbers of cabbage root fly larvae or pupae and root damage were subjected to statistical analysis. The basis upon which statistical inferences were made was the analysis of variance. This assumes that experimental errors are normally distributed. Where data sets were not normally distributed, the data was transformed to square root values, and the parametric analysis of variance was used. Multiple comparison of treatments were made using Duncan's Multiple Range Test. The results from this should be interpreted with caution but are useful when considering the merits of any statistical inferences arising from the analysis of variance.

Results to date and discussion

Egg viability

The results of egg viability testing are shown in Table 2. Viability ranged from 60-95%. In view of the numbers of eggs inoculated on each occasion this should have been sufficient to ensure that enough larvae emerged from eggs and were potentially available to attack the plants. At egg inoculation date D (3 weeks post treatment) there were too few eggs to undertake viability testing.

Table 2. Viability of eggs used to inoculate test plants immediately after insecticide treatment or up to five weeks subsequently

Egg inoculation date	Number of eggs tested	Number hatched	% viability	Source of eggs
0 WAT†	100	84	84	ADAS High Mowthorpe and HRI Stockbridge House
1 WAT	59	56	95	ADAS High Mowthorpe and HRI Stockbridge House
2 WAT	20	14	70	ADAS High Mowthorpe and HRI Stockbridge House
3 WAT	14	11	79	Huttons Ambo, North Yorkshire
5 WAT	40	24	60	HRI Wellesbourne
5 WAT	12	11	92	ADAS Starcross
Mean viability	-	-	80	-

† WAT = weeks after treatment.

Numbers of cabbage root fly larvae/pupae

The mean numbers of cabbage root fly larvae or pupae recovered from each treatment are given in Table 3. Numbers of larvae and pupae differed significantly between treatments for egg inoculations made immediately, one week, two weeks and five weeks after insecticide treatment. Carbofuran was the best insecticide and was significantly better ($P < 0.05$) than all others for egg inoculations immediately after treatment and two and five weeks subsequently. One week after insecticide application carbofuran was significantly better than the control, chlorfenvinphos, diflubenzuron, teflubenzuron, fonofos and λ cyhalothrin. Although numbers of larvae and pupae did not differ significantly between treatments where eggs were inoculated three weeks post treatment, there was a trend to find fewest where granular insecticides were applied.

Table 3. Mean numbers of cabbage root fly larvae and pupae (✓*x* values). Values in brackets are back transformed data

Treatment	Egg inoculation date 0 WAT†	1 WAT	2 WAT	3 WAT	5 WAT
P1 Untreated	4.7 b (22.1)	2.9 b (8.4)	2.7 b (7.3)	2.3 (5.3)	2.0 b (4.0)
P2 Chlorfenvinphos	4.2 b (17.6)	2.9 b (8.4)	2.0 b (4.0)	2.7 (7.3)	2.5 b (6.3)
P3 Diflubenzuron	3.6 b (13.0)	3.9 b (15.2)	2.1 b (4.4)	2.8 (7.8)	3.2 b (10.2)
P4 Teflubenzuron	4.7 b (22.1)	3.7 b (13.7)	2.0 b (4.0)	3.7 (13.7)	2.5 b (6.3)
P5 Exp 61096A	4.6 b (21.2)	2.2 ab (4.8)	2.2 b (4.8)	1.9 (3.6)	2.1 b (4.4)
P6 Fonofos	3.3 b (10.9)	3.9 b (15.2)	2.0 b (4.0)	2.5 (6.3)	2.3 b (5.3)
P7 λ Cyhalothrin	5.2 b (27.0)	3.2 b (10.2)	2.2 b (4.8)	3.0 (9.0)	2.6 b (6.8)
P8 Carbofuran	0.9 a (0.8)	0.7 a (0.5)	0 a (0)	1.5 (2.3)	0 a (0)
P9 Chlorpyrifos	3.3 b (10.9)	2.2 ab (4.8)	2.5 b (6.3)	0.6 (0.4)	2.1 b (4.4)
P10 Exp 60949A	3.8 b (14.4)	2.4 ab (5.8)	1.7 b (2.9)	1.6 (2.6)	2.4 b (5.8)
SEM (27 DF)	0.64	0.64	0.38	0.71	0.37
P<	0.01	0.05	0.01	n/s	0.001

† WAT = weeks after treatment. A and b are Duncans Multiple Range Test indices, values followed by the same letter are not significantly different $P < 0.05$.

Root damage index

Root damage differed significantly between treatments on all egg inoculation dates except one week after treatment (Table 4). Plants treated with carbofuran had significantly lower (P <0.05) levels of root damage than all other treatments two and five weeks after treatments. Where eggs were inoculated immediately after insecticide application carbofuran significantly reduced larval damage (P <0.05) in comparison with all other treatments except Exp 61096A. Three weeks after insecticide treatment pots to which carbofuran or chlorpyrifos were applied had significantly less (P <0.05) damage than those receiving diflubenzuron, teflubenzuron and λ cyhalothrin.

Table 4. Mean root damage index (%)

Treatment	Egg inoculation date				
	0 WAT†	1 WAT	2 WAT	3 WAT	5 WAT
P1 Untreated	2.8 b	2.3	2.0 b	1.8 abc	1.5 bc
P2 Chlorfenvinphos	2.0 b	1.8	2.0 b	2.8 c	1.8 bc
P3 Diflubenzuron	1.8 b	2.0	2.3 b	2.0 bc	2.0 bc
P4 Teflubenzuron	2.5 b	2.3	2.3 b	2.0 bc	2.3 c
P5 Exp 61096A	1.5 ab	1.5	1.3 b	1.3 ab	1.5 bc
P6 Fonofos	2.3 b	2.0	1.5 b	1.5 ab	1.3 b
P7 λ Cyhalothrin	2.5 b	2.5	2.3 b	2.3 bc	1.8 bc
P8 Carbofuran	0.3 a	1.5	0 a	0.8 a	0.3 a
P9 Chlorpyrifos	1.8 b	1.3	1.8 b	0.8 a	1.5 bc
P10 Exp 60949A	2.5 b	1.5	1.8 b	1.5 ab	1.8 bc
SEM (27 DF)	0.44	0.35	0.32	0.36	0.29
P<	0.05	n/s	0.001	0.01	0.01

† WAT = weeks after treatment. A, b and c are Duncan's Multiple Range test indices. Values followed by the same letter are not significantly different (*P* <0.05).

Conclusions

Pot experimentation was an effective means of screening a range of insecticide treatments for control of cabbage root fly larvae in swedes. Eggs of the pest collected from the field or from laboratory based cultures produced sufficient larvae to demonstrate differences between treatments. The roots of some pot grown swedes were elongated and failed to produce a bulb. However, in every case there was sufficient plant material to provide a food source for cabbage root fly larvae.

Carbofuran was consistently the best treatment at controlling larvae and minimising root damage throughout the study. This treatment was equally effective when eggs were inoculated either immediately or five weeks after insecticide application. However, control levels may be reduced if carbofuran is used in soil which shows enhanced degradation of the product, rather than in compost, as was the case in this study.

In these experiments a possible trend emerged showing better control with granular formulations than with foliar sprays; however, this conclusion requires confirmation by further work. It is likely that a large proportion of the spray was intercepted by the foliage of the swede with a much smaller quantity making contact with the root/bulb.

Also eggs were inoculated around the swede root/bulb so were less likely to be affected by pesticide residue on the leaves. The effectiveness of foliar applications for deterring oviposition or killing adult flies could be evaluated by exposing treated pots to natural oviposition in the field. Insecticide application would need to be staggered to ensure that all pots could be exposed to flies at the peak of second generation activity. Such a technique would provide a better comparison of granular and foliar treatments. However, as leaves which emerge after insecticide application would not be protected, and the foliage would intercept a proportion of the active ingredient, a granular formulation may prove to be the best option for control of the pest.

Chlorfenvinphos spray gave very poor control of cabbage root fly despite being a standard treatment for the pest in the field. It is possible that the active ingredient was bound on organic matter in the compost and would have given better control if the plants had been grown in soil.

While coded product Exp 61096A gave the best performance of the foliar sprays, the difference did not reach statistical significance, any possible benefits associated with this product will have to be confirmed by further work. Control with the granular formulation was not noticeably different from the foliar spray but the granules were observed to remained intact on the surface of the compost throughout the experiment.

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GLOSSARY

Critical risk period: the period during which a crop must be protected in order to avoid the most significant levels of pest damage.

Damage progression: the development of pest damage over time.

Foliar insecticide: an insecticide formulation usually applied as a liquid to the crop canopy, may or may not have soil activity.

Granular insecticide: an insecticide formulation which is applied as a solid to the crop, usually having soil activity in the case of non-systemic active ingredients, and root or foliar activity in the case of systemic active ingredients.

Pot trial: an experimental method using plants in pots treated with an insecticide product or control and exposed to non dispersing life stages of the pest insect to test the efficacy of the product.

APPENDIX 1

Active ingredient	Product name	Approval status
λ Cyhalothrin	Hallmark	none
Carbofuran	Yaltox (standard)	on label
Chlorfenvinphos	Sapecron 240 ec (standard)	on label
Chlorfenvinphos	Birlane 24	on label
Chlorpyrifos	Dursban 4	none
Chlorpyrifos	Suscon Green	none
Diflubenzuron	Dimilin	none
Exp 60949A	-	none
Exp 61096A	-	none
Fonofos	Cudgel	none (module drenches only)
Teflubenzuron	Nemolt	none

Chemical names, product names and approval status on swedes for insecticides mentioned in this report, as confirmed by the Pesticides Safety Directorate 23 March 1998.

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