ADAS

FOOD, FARMING, LAND AND LEISURE

FINAL REPORT: 1991 & 1992

PROJECT NO: FV66 (ADAS NO. C001078)

PROJECT TITLE:	**Cabbage root fly: Control in swedes/turnips**
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DATE PROJECT COMMENCED:	**1 April 1991**
DATE COMPLETION DUE:	**31 March 1993**
KEY WORDS:	**Cabbage root fly, *Delia radicum*, carbofuran chlorfenvinphos, chlorpyrifos, crop covers, enhanced microbial degradation.**

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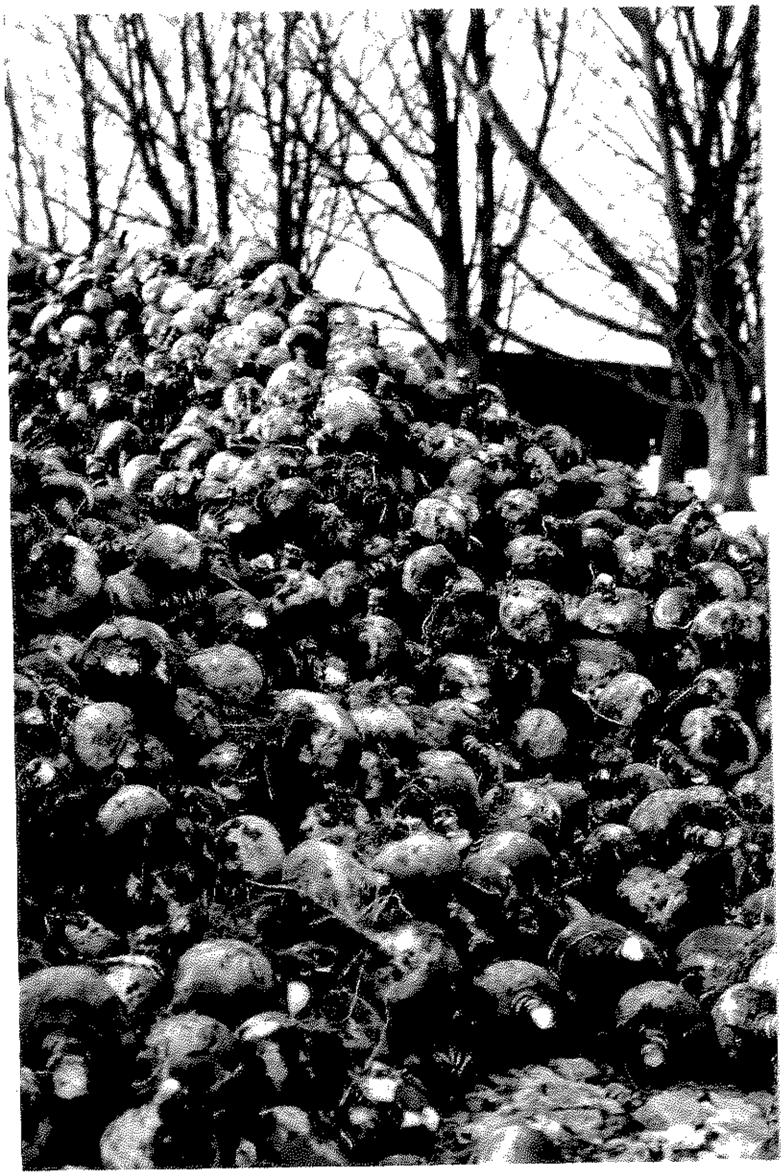

"FRONTISPIECE - THE PROBLEM"

RELEVANCE TO GROWERS AND PRACTICAL APPLICATION

APPLICATION

Objective of project:

- To establish the relative efficacy of carbofuran granules and chlorfenvinphos liquid for control of second generation cabbage root fly larvae.

- To evaluate the role of enhanced microbial degradation in any differences in effectiveness between these insecticides.

- To provide a simple system for farmers to test and monitor the efficacy of these two insecticides as an on-farm decision-making "tool".

In the second year, the objectives were refined to test combinations of the two insecticides to establish whether the pest could be adequately suppressed at sites with high pest incidence. Also to test novel control methods ie crop covers and cell-raised plants treated with pre-planting chlorpyrifos drench.

Key results:

Neither chlorfenvinphos as Birlane 24 nor carbofuran as Yaltox applied alone or in combination at the onset of second generation egg-lay, provided reliable control of second generation attack. Larvae and fresh damage were often present at harvest, suggesting that late second/third generation flies caused significant damage in some years.

Enhanced microbial degradation ranged from 5% to 95%. There was no apparent relationship between effectiveness of Yaltox for control of cabbage root fly or frequency of carbamate usage and rate of carbofuran degradation.

The crop cover treatment produced unreliable pest control often with small roots leading to suppressed yields.

Plants that were raised in cells and drenched with chlorpyrifos as Dursban 4 were usually pest-free at harvest but many roots were small and/or mis-shapen.

Opportunity for application:

To achieve optimum protection over a protracted egg-lay period, the mid-season programmes should include both chlorfenvinphos sprays and the application of carbofuran granules. The timing of first mid-season treatments should be based on capture of adult flies, egg counts or the HDC/HRI model. The timing of late second/third generation treatments should be based on egg counts.

There is little or no apparent merit in analysing fields for enhanced microbial degradation before growing swedes/turnips. The results seem not to assist in selection of suitable insecticide programmes and may bear little relationship to degradation rates in other fields on the farm.

SUMMARY

In the first year of the project located at nine sites, unreplicated field plots were untreated or were treated with chlorfenvinphos liquid (as Birlane 24) or carbofuran (as Yaltox) at the onset of second generation cabbage root fly egg-lay. In both years, egg-lay was monitored, soil samples were analysed in July for enhanced microbial degradation (ED) of carbofuran and roots were assessed at harvest for cabbage root fly larval damage.

The objectives were:

- To establish at a range of sites, the relative efficacy of chlorfenvinphos liquid and carbofuran granules for control of second generation cabbage root fly.
- To evaluate the role of ED of carbofuran in any differences in effectiveness between the two insecticides.
- To provide a simple system for farmers to test and monitor the efficacy of these insecticides as an on-farm decision-making "tool".

In the first year of the project, neither of the two insecticides adequately and reliably controlled cabbage root fly larval attack. The pest pressure was usually protracted with egg-laying at most sites continuing from July until October. Neither chlorfenvinphos liquid nor carbofuran granules applied as recommended at the onset of second generation egg-lay, provided reliable control of the second generation attack. Enhanced degradation ranged from 11% to 95%. These small plot comparisons did not distinguish the better insecticide treatments because neither of the insecticides reliably protected winter harvested roots from attack.

In the second year of the project located at eight sites, the two insecticides were tested in replicated experiments, in combination as sequential elements of a programme. One product was used at the onset of second generation egg-lay in July, and either repeated or the other product was applied at late second/third generation activity usually in September. A non-woven cover (Lutrasil 10G) was also compared with the use of cell-raised plants, drenched pre-planting with chlorpyrifos as Dursban 4. Again, the approved insecticides did not reliably control the larval attack. At one site in Lancashire and two early harvested crops in Suffolk, modest improvements were evident, especially where Birlane liquid was applied at second generation and two weeks later, followed by Yaltox at onset of late generation egg-lay. The cover treatment produced unreliable pest control often with small roots leading to suppressed yields. Plants that were raised in cells and drenched with Dursban 4 were usually pest-free at harvest but many roots were small and/or mis-shapen. Enhanced degradation ranged from 5-95%.

In both years, cabbage root fly larvae and fresh damage were often present at harvest, suggesting that late second/third generation flies caused significant damage close to harvest. There was no apparent relationship in either year between the effectiveness of Yaltox for control of cabbage root fly and rates of carbofuran degradation. Intensity of pest attack at individual sites was similar in both years ie those locations with relatively low pest incidence in 1991 were similarly low in 1992, while at all other sites, attacks were severe in both years.

Action points for growers:

It is apparently not possible to devise fully effective control programmes based on existing recommendations. To achieve the best protection, the mid-season programmes should include both chlorfenvinphos liquid and carbofuran granules.

The timing of first mid-season treatments should be based on capture of adult flies, egg counts or the HDC/HRI model. The timing of late second/third generation treatment should be based on egg counts.

There is little merit in analysing fields for enhanced degradation before growing swedes or turnips. The results seem not to assist in selection of a suitable insecticide programme and may bear little relationship to degradation rates in other fields on the farm.

Until the technique is better understood, the use of non-woven covers to exclude cabbage root fly adults, is not recommended.

There is no approval for the use of chlorpyrifos on cell-raised root brassica seedlings or for four applications of chlorfenvinphos liquid. Results in this study did not justify application for a specific off-label approval (SOLA) for the use of increased numbers of chlorfenvinphos applications. A SOLA may be sought for a pre-planting drench of Dursban 4 to be applied to cell-raised swedes and turnips at a rate of 50ml of product in 5 litres of water per 5,000 plants. The precautions recommended by DowElanco for treatment of market brassicas (ie wetting leaves with water before and after application of Dursban 4) would apply also when treating root brassicas. Members of the HDC Field Vegetables Panel will be consulted regarding the likely merits of this growing system for swedes and turnips.

Practical benefits:

This study has shown that the use of single mid-season insecticide applications is inadequate to protect swedes and turnips from attack by late generation cabbage root fly. The use of programmes, including both chlorfenvinphos and carbofuran should give improved control. The timing of late second /third generation treatment from egg count data should ensure that insecticide applications are made when pest numbers are increasing and not in periods of low pest incidence.

In view of the variable results from this study, benefits are difficult to quantify financially. However, reductions in root damage represent increases in harvestable yield for human consumption. Price differences between sale for culinary use and stock feed use are very significant. In eg Lancashire and Devon, improvements of 13 or 17% in marketable yields from use of the best treatments, on a yield of 15 tonnes per hectare at £210 per tonne, (or 30 tonnes per hectare harvested later in the season at £100 per tonne,) represent savings of £370 or £485 per hectare respectively. This calculation assumes that swedes for stockfeed are worth only £5 per tonne.

EXPERIMENTAL SECTION

INTRODUCTION

The unsightly mines and blemishes caused by cabbage root fly (CRF) larvae, have become an increasingly important source of crop losses for growers of culinary swedes and turnips (1, 4). Some growers now find it uneconomic to continue growing these crops. In recent years, the two most frequently used insecticides for control of second and third generation larvae (chlorfenvinphos as Birlane 24 or Sapecron 240 EC and carbofuran granules, usually as Yaltox) have often given inadequate protection from attack. The most effective treatments have varied from region to region. In Devon, chlorfenvinphos is usually the chosen insecticide. In Yorkshire (ADAS/HRI Stockbridge House trials 1986/89) carbofuran was often effective when chlorfenvinphos was not. However, the best control was rarely good enough and alternative ways have been considered to suppress the problem. Collaborative experiments at HRI Stockbridge House investigated the growing of swedes under crop covers. In the same MAFF-funded Project, module-raised swedes were drenched with chlorpyrifos (as Dursban 4) and grown on as a field-crop (4). These novel techniques have inherent practical disadvantages ie need of irrigation and increased expense, but may yet prove cost-effective if they are shown to reliably protect crops from pest attack.

The first generation of CRF adults is usually clearly defined, with a distinct peak in May often followed by a sharp decline to zero in mid/late-June. The second generation is usually of longer duration. Population peaks may be indistinct due to cool weather patterns or to the presence of early and later-developing individuals. A third generation may be evident or it may merge imperceptibly with the protracted second generation. The result is that eggs can be laid continuously from June until late October.

The main problem with control of late-generation CRF on swedes and turnips (as opposed to leaf or flowerhead brassicas) is that this pest attacks the harvested part of the plant. A few superficial mines on the roots of eg a Brussels sprout plant in September, will do no harm. Similar damage to a swede will render it unmarketable. The root crop therefore requires total protection over a period spanning at least three months. Mid-season applications of insecticides to the soil surface, cannot be expected to kill larvae already feeding below ground so applications are directed at egg-laying flies, unhatched eggs and newly-hatched larvae. The availability and persistence of an insecticide will vary with mobility of the product and weather conditions but the efficacy of a spray formulation is unlikely to exceed a fortnight. Assuming continuous pest pressure, even the best treatment timings will leave "windows" enabling eggs to hatch and larvae to survive before, between or after treatments.

The natural degradation of most insecticides depends largely on the activity of soil micro-organisms. Where these insecticides are frequently used, micro-organisms may become adapted so that subsequent rates of degradation are enhanced (ED). This enhanced rate may be measured analytically in sampled soils, and is expressed as the percentage of insecticide that has disappeared after 7 days, under the conditions of the test. In soils with values of less than 50% ED of carbofuran, carbamate insecticides should give satisfactory pest control. From 50-80%, ED is considered as intermediate and at values above 80%, satisfactory pest control with these insecticides is unlikely.

Project FV66, funded by the HDC for two years, began in 1991 to compare the efficacy of Yaltox granules and Birlane 24 for control of CRF in swedes and turnips, to monitor egg-lay and the incidence of enhanced degradation of carbofuran and to assess the feasibility of small plot insecticide evaluations, for grower use.

MATERIALS AND METHODS 1991

Experiments were established in crops of swedes/turnips on eight commercial farms in Northumberland, North Yorkshire, Lancashire, Suffolk (two), Oxfordshire, Somerset and Devon as well as at HRI Stockbridge House, in North Yorkshire

Design and layout:

Three unreplicated plots of 20 x 6m were laid out to match standard 12m wheelings (8-10 beds according to row width). An option was given for one plot of shorter row length (10 x 6m) where growers were unwilling to host the larger area of untreated crop. Guard areas of 3m minimum width were maintained to prevent risk of insecticide drift. Sites were selected where carbamate insecticides had not been applied for control of first generation CRF attack.

Treatments:

- Untreated. No supplementary mid-season treatments.
- Chlorfenvinphos 25% EC as Birlane 24 applied at 3.0 litres of product per hectare in 600 litres per hectare of water; timed at onset of second generation egg-lay and repeated 14 days later.
- Carbofuran 5% granules as Yaltox applied at 12.5g of product per 10m row (26-33 kg per hectare according to row width); timed at onset of second generation egg-lay.

Cabbage root fly egg samples:

Soil samples were taken with a teaspoon from around 10 marked swede/turnip plants each week for at least 5 weeks from 1 July. Clean soil (not egg-infested) was placed around each sampled plant to maintain correct soil depth around the bulb. Cabbage root fly eggs were extracted in the laboratory by flotation (2).

Enhanced microbial degradation:

Soil samples for analysis of degradation of carbofuran were taken in July from 50 sample points at each site. A cheese corer was used to collect not less than 1 kg of soil which was then analysed at ADAS National Pesticide Residues Unit, Cambridge. After the addition of carbofuran (spiked), the soil was incubated at 25-30°C for eight days. The quantity of carbofuran present was assessed from sub-samples one hour after application and 10 days later. Carbofuran was determined by reverse phase high pressure liquid chromatography, using an ultra violet detector.

Insecticide application:

Yaltox was applied with Horstine Farmery microband wheelbarrow applicators at 5 Sites and elsewhere by calibrated "pepper pot" applicators. Birlane 24 sprays were applied from Oxford Precision Sprayers with fan nozzles of 00 aperture, operated at 300 kPa.

Root assessment:

Plants were taken at harvest from the middle 3-5 beds/rows of each plot. They were topped in the field and washed in the laboratory. The pest attack was assessed from not less than 50 roots per plot and expressed as a root infestation index (3). This index is the most reliable for assessment of marketability. A partial key to the root damage scoring system is given below and is simplified in that it assumes all roots in the sample are in the same category ie are similarly damaged. (See also Appendix 6).

King and Forbes infestation index:

Root condition	Index
1 = Clean. No CRF damage	0
2 = With superficial mines only, mainly healed	25
3 = More extensive surface injury or a single deep mine. Suitable for second grade market after light trimming	50
4 = unmarketable. Injury not removable by practical trimming	100

RESULTS 1991

Table 1 gives dates of first significant egg-lay, treatment and harvest at each site, together with values for enhanced degradation and recent usage of carbofuran, and damage indices for the three treatments. Control of larval attack by the insecticides was generally inadequate, often with fresh damage and larvae present at harvest in October/November. At some sites, late developing second generation adults were supplemented by third generation flies to produce a large peak in mid-September. At HRI Stockbridge House and Aughton, Lancashire where egg-lay was monitored throughout the season, large numbers of CRF in mid-September laid eggs whose larvae were probably unaffected by the treatments applied in July (see Appendices 1 and 2). Much of the damage at harvest was recent and CRF larvae were present in the roots. Recent damage at harvest was also noted from Reading.

There was a range of ED values from 11% to 95%. There was no apparent relationship between ED and pest control or frequency of carbamate usage. In Oxfordshire and at HRI Stockbridge House, almost 100% infestation of swedes was recorded irrespective of treatment and with only 29% degradation. Similarly, poor control was recorded at two Northern sites with 95% ED. The pest was adequately controlled only at two early-harvested sites in Suffolk. In both cases, Yaltox gave the better protection. Enhanced degradation in one crop was 11%, in the other 95%. Birlane 24 gave the better (if marginal) control at only one high ED site, in Aughton, Lancashire where an infestation index of 53 was reduced to 38 by Yaltox and to 34 by Birlane 24.

At the end of the first year it was established that the small-plot comparisons did not distinguish the better insecticide treatment because neither insecticide reliably protected winter-harvested roots from CRF attack. Also there was no noticeable improvement in control with Yaltox, at sites with low rates of ED.

There was a need to establish if treatment combinations of the two insecticides, separately timed to coincide with peaks of adult activity, would control CRF adequately. Also to test "novel" methods applied before second generation emergence. In 1992 therefore, replicated trials were set up at eight sites with an increased number of treatments.

TABLE 1 Dates of first significant CRF egg-lay, treatments and harvests; percent enhanced degradation of carbofuran (ED), Carbamate usage in last five years (CU) and mean CRF damage indices for untreated, Birlane 24 and Yaltox, at 9 sites 1991.

SITE	DATES OF:			RESULTS		INFESTATION INDEX		
	1ST EGGS	TREATMENT	HARVEST	ED%	CU	UNTREATED	BIRLANE 24	YALTOX
MORPETH NORTHUMBERLAND	16 July	17 July	29 November	95	1	96	95	97
HRI STOCKBRIDGE HOUSE NORTH YORKSHIRE	16 July	23 July	12 November	29	0	100	100	100
SOUTH MILFORD NORTH YORKSHIRE	19 July	23 July	22 November	95	1	99	100	99
MOULTON SUFFOLK	27 June	22 July	4 September	11	3	33	17	6
BARTON MILLS SUFFOLK	27 June	23 July	17 September	95	2	28	20	11
AUGHTON LANCASHIRE	12 July	18 July	11 November	82	1*	53	34	38
FRILFORD OXFORDSHIRE	23 July	19 July	14 November	29	0	93	97	96
CREDITON DEVON	4 July	9 July	19 December	38	0	59	56	52
WELLINGTON SOMERSET	9 July	13 July	-	95	0	-	-	-

*Oxamyl 1986

MATERIALS AND METHODS 1992

Design and layout:

Six treatments were replicated four times in a randomised block design to give 15 degrees of freedom for error. Plot sizes and guard precautions were as in 1991 above.

Treatments:

1. Untreated. No supplementary mid-season treatments.

2. Birlane 24 as recommended at onset of second generation and two weeks later. Birlane 24 at onset of third generation (or late surge of second generation) and two weeks later.

3. Yaltox as recommended at onset of second generation. Birlane 24 at third generation and two weeks later.

4. Birlane 24 at second generation and two weeks later. Yaltox at third generation.

5. Plants raised in SWC308 cells drenched with Dursban 4 at a rate of 50ml of product in 5 litres of water per 5,000 plants, as recommended for leaf and flowerhead brassicas, applied at the 3-4 true-leaf stage and planted on the same day.

6. Non-woven cover (Lutrasil 10G) laid at onset of second generation.

NB Rates of Birlane 24 and Yaltox were as shown for work in 1991.

Cell-raised plants (eight trays of SWC308 modules) were grown under glass at HRI Stockbridge House and hardened off in a polythene tunnel. They were transported at the two true-leaf stage to participating laboratories on 1 July. Before treatment on the day of transplanting, the leaves were wetted with a light spray of water using 200ml per 500 plants. Dursban 4 was then applied at 5ml product in 500ml water per 500 plants. Immediately after treatment the insecticide was thoroughly washed from the leaves with clean water, using 500ml water per 500 plants. At each site, at least 50 cell-raised plants per plot were transplanted following removal of an equivalent number of the originally sown plants from the plot.

Non-woven covering material (Lutrasil 10G sufficient to prepare four sheets of 6 x 2m at all sites) was supplied from HRI Stockbridge House. At least 100 roots were covered, together with a guard area, 2-3 plants wide. Each cover when fitted covered an area of at least 5.0 x 1.5m.

Analysis of ED, pest assessment and monitoring were as in 1991 except that egg counting continued until September/October to accurately time the application of treatments for control of third generation (or late second generation) larval attack. Where two adjacent sites were operated from the same ADAS laboratory, egg samples were taken at one site only. Where appropriate, treatment decisions were refined by reference to nearby monitoring sites, eg ADAS Cambridge, Reading or Starcross.

RESULTS 1992

Tables 2-8 give infestation indices for all treatments at each site, together with weight g per root and ED values. Dates of onset of second generation CRF egg-lay and treatment application timings are also given. At all but one of the sites (Burscough, Lancashire), performance of all the chemical combinations was poor (Appendix 4, Figs 1 and 3) At the two Yorkshire sites (Tables 2 and 3) the first mid-season treatments were timed very accurately so that relatively few eggs were laid before insecticide application. Appendix 4, Fig 4 shows the egg-laying pattern at HRI Stockbridge House, that initiated treatments on 9 July and 28 August. In spite of this precision, damage indices were extremely high. At Frilford, Oxon (Table 4) due to wet weather conditions, the experiment was set up after the second generation egg-lay period had begun. Large numbers of eggs were laid throughout August with a small peak in September. Again, the approved insecticides gave no control of a very severe infestation. Conversely, at Burscough, (Table 5) a relatively small but protracted larval infestation was well controlled by the approved insecticide programmes, despite a recorded 95% ED. There was a greater range of ED values in 1992, from 5-95%. As in 1991, no clear relationship was evident between ED and efficacy of treatment with Yaltox. There was again no obvious relationship between ED and frequency of carbamate usage. Some sites had received several treatments with Yaltox, in the previous five years yet ED values were low. Others with little or no carbamate usage over that period, had high ED values.

At four of the five sites where cell-raised plants established satisfactorily, the pre-planting drench gave season-long control of CRF larvae but many roots were too small for market or were of unacceptable shape. At Burscough, the larval infestation was not suppressed by the Dursban 4 drench treatment. Crop covers usually provided inadequate control, especially where the material was torn by the wind, but modest improvements were recorded from the two Suffolk sites (Tables 6 and 7). Root weights were generally unaffected by pest incidence or by approved insecticide treatments. The cover treatment usually reduced root weights. Percent yield reduction ranged from 35% in Devon (Table 8) to little or no reduction at the Yorkshire site. Plants raised in cells and drenched with Dursban 4 were usually smaller than other treatments at harvest. However, at the Oxfordshire site, as well as providing improved pest control, this treatment increased mean root weights from 264 to 392g. (Appendix 4, Fig 2).

No harvest data are available from the Somerset site because an employee of the grower harvested the experimental area in error. (See Appendix 5).

For photographs showing example roots from all treatments at HRI Stockbridge House, see Plates 1-4 at Appendix 3.

TABLE 2 INFESTATION INDICES AT HARVEST AND WEIGHTS g PER ROOT 1992

SITE: HRI STOCKBRIDGE HOUSE, NORTH YORKSHIRE

	TREATMENT	INFESTATION INDEX	WEIGHT g PER ROOT
1.	UNTREATED - NO MID SEASON TREATMENTS	98.5c	606.8c
2.	BIRLANE 24 X 2 AT 2ND GEN BIRLANE 24 X 2 AT "3RD" GEN	95.6c	606.3c
3.	YALTOX AT 2ND GEN BIRLANE 24 X 2 AT "3RD" GEN	77.0b	625.3c
4.	BIRLANE 24 X 2 AT 2ND GEN YALTOX AT "3RD" GEN	93.6c	610.8c
5.	DURSBAN 4 TO SWC 308 CELLS	0.9a	289.0a
6.	LUTRASIL 10G LAID AT 2ND GEN	77.0b	480.8b
	SED	6.09	40.48
	CV%	11.7	10.7

Means within a column followed by the same letter do not differ significantly ($\underline{P}<0.05$); Duncan's Multiple Range Test.

Enhanced microbial degradation of carbofuran after 7 days, 95%.
No carbamate usage on the trial area in the previous five years.

Onset of second generation CRF egg-lay, 7 July
Second generation treatment application, 9 July
Late second/third generation treatment, 28 August

TABLE 3 INFESTATION INDICES AT HARVEST AND WEIGHTS g PER ROOT 1992

SITE: SOUTH MILFORD, NORTH YORKSHIRE

	TREATMENT	INFESTATION INDEX	WEIGHT g PER ROOT
1.	UNTREATED - NO MID SEASON TREATMENTS	95.6b	637.8
2.	BIRLANE 24 X 2 AT 2ND GEN BIRLANE 24 X 2 AT "3RD" GEN	95.4b	590.1
3.	YALTOX AT 2ND GEN BIRLANE 24 X 2 AT "3RD" GEN	96.0b	639.1
4.	BIRLANE 24 X 2 AT 2ND GEN YALTOX AT "3RD" GEN	93.6b	606.6
5.	DURSBAN 4 TO SWC 308 CELLS	-	-
6.	LUTRASIL 10G LAID AT 2ND GEN	82.5a	653.9
	SED	4.11	57.16
	CV%	6.3	12.9

Means within a column followed by the same letter do not differ significantly ($\underline{P}<0.05$); Duncan's Multiple Range Test. For columns where no letters are shown, the means were not significantly different.

Enhanced microbial degradation of carbofuran after 7 days, 90%.
One carbamate application (carbosulfan 1989) in the previous five years.

Plants raised in cells did not establish at this site due to drought and absence of irrigation.

Onset of second generation CRF egg-lay 14 July
Second generation treatment application 15 July
Late second/third generation treatment 28 August

TABLE 4 INFESTATION INDICES AT HARVEST AND WEIGHTS g PER ROOT 1992

SITE: FRILFORD, OXFORDSHIRE

	TREATMENT	INFESTATION INDEX	WEIGHT g PER ROOT
1.	UNTREATED - NO MID SEASON TREATMENTS	99.25	264.0b
2.	BIRLANE 24 X 2 AT 2ND GEN BIRLANE 24 X 2 AT "3RD" GEN	97.35c	320.0b
3.	YALTOX AT 2ND GEN BIRLANE 24 X 2 AT "3RD" GEN	98.87c	281.2b
4.	BIRLANE 24 X 2 AT 2ND GEN YALTOX AT "3RD" GEN	96.37c	262.7b
5.	DURSBAN 4 TO SWC 308 CELLS	48.32a	392.5a
6.	LUTRASIL 10G LAID AT 2ND GEN	91.15b	188.2c
	SED	1.80	29.7
	CV%	2.9	14.7

Means within a column followed by the same letter do not differ significantly ($\underline{P}<0.05$); Duncan's Multiple Range Test.

Enhanced microbial degradation of carbofuran after 7 days, 40%.
One carbamate application in the previous five years.

Onset of second generation CRF egg-lay 29 June
Second generation treatment application 10 July
Late second/third generation treatment 28 September

TABLE 5 INFESTATION INDICES AT HARVEST AND WEIGHTS g PER ROOT 1992

SITE: BURSCOUGH, LANCASHIRE

	TREATMENT	INFESTATION INDEX	WEIGHT g PER ROOT
1.	UNTREATED - NO MID SEASON TREATMENTS	12.3a	
2.	BIRLANE 24 X 2 AT 2ND GEN BIRLANE 24 X 2 AT "3RD" GEN	2.9b	
3.	YALTOX AT 2ND GEN BIRLANE 24 X 2 AT "3RD" GEN	1.9b	
4.	BIRLANE 24 X 2 AT 2ND GEN YALTOX AT "3RD" GEN	1.1b	
5.	DURSBAN 4 TO SWC 308 CELLS	10.4a	
6.	LUTRASIL 10G LAID AT 2ND GEN	11.2a	
	SED	3.15	
	CV%	67.5	

Means within a column followed by the same letter do not differ significantly ($\underline{P}<0.05$); Duncan's Multiple Range Test.

Enhanced microbial degradation of carbofuran after 7 days, 95%.
One carbamoyloxime application (Oxamyl) in 1987

Onset of second generation CRF egg-lay probably	1 July (HDC/HRI forecast, 9 July)
Second generation treatment application	9 July
Late second/third generation treatment	9 September

TABLE 6 INFESTATION INDICES AT HARVEST AND WEIGHTS g PER ROOT 1992

SITE: MOULTON 1 SUFFOLK

	TREATMENT	INFESTATION INDEX	WEIGHT g PER ROOT
1.	UNTREATED - NO MD SEASON TREATMENTS	33.8bc	
2.	BIRLANE 24 X 2 AT 2ND GEN BIRLANE 24 X 2 AT "3RD" GEN	25.4abc	
3.	YALTOX AT 2ND GEN BIRLANE 24 X 2 AT "3RD" GEN	40.3c	
4.	BIRLANE 24 X 2 AT 2ND GEN YALTOX AT "3RD" GEN	17.9ab	
5.	DURSBAN 4 TO SWC 308 CELLS	13.5a	
6.	LUTRASIL 10G LAID AT 2ND GEN	17.1ab	
	SED	7.90	
	CV%	45.2	

Means within a column followed by the same letter do not differ significantly ($\underline{P}<0.05$); Duncan's Multiple Range Test.

Enhanced microbial degradation of carbofuran after 7 days, 5%.
One carbamate application to this field in the previous five years.

Onset of second generation CRF egg-lay unclear	**5-21 July**
Second generation treatment application	**16 July**
Late second/third generation treatment	**16 September**

Root weights were not recorded because a virus infection seriously impaired root growth.

TABLE 7 INFESTATION INDICES AT HARVEST AND WEIGHTS g PER ROOT 1992

SITE: MOULTON 2, SUFFOLK

	TREATMENT	INFESTATION INDEX	WEIGHT g PER ROOT
1.	UNTREATED - NO MID SEASON TREATMENTS	24.9	109.4b
2.	BIRLANE 24 X 2 AT 2ND GEN BIRLANE 24 X 2 AT "3RD" GEN	15.9	99.5b
3.	YALTOX AT 2ND GEN BIRLANE 24 X 2 AT "3RD" GEN	10.4	109.0b
4.	BIRLANE 24 X 2 AT 2ND GEN YALTOX AT "3RD" GEN	6.7	111.4b
5.	DURSBAN 4 TO SWC 308 CELLS	-	-
6.	LUTRASIL 10G LAID AT 2ND GEN	10.9	45.4a
	SED	6.94	0.78
	CV%	71.3	23.2

Means within a column followed by the same letter do not differ significantly ($\underline{P}$<0.05); Duncan's Multiple Range Test. For columns where no letters are shown, the means were not significantly different.

Enhanced microbial degradation of carbofuran after 7 days, 5%.
One carbamate application to this field in the previous five years.

Onset of second generation CRF egg-lay unclear	5-21 July
Second generation treatment application	19 July
Late second/third generation treatment	16 September

TABLE 8 INFESTATION INDICES AT HARVEST AND WEIGHTS g PER ROOT 1992

SITE: KENTON, DEVON

	TREATMENT	INFESTATION INDEX	WEIGHT g PER ROOT
1.	UNTREATED - NO MID SEASON TREATMENTS	53.9	767
2.	BIRLANE 24 X 2 AT 2ND GEN BIRLANE 24 X 2 AT "3RD" GEN	42.9	716
3.	YALTOX AT 2ND GEN BIRLANE 24 X 2 AT "3RD" GEN	38.0	719
4.	BIRLANE 24 X 2 AT 2ND GEN YALTOX AT "3RD" GEN	52.4	600
5.	DURSBAN 4 TO SWC 308 CELLS	1.70	119
6.	LUTRASIL 10G LAID AT 2ND GEN	50.2	502
	SED	7.22	47.4
	CV%	25.6	11.7

Means within a column followed by the same letter do not differ significantly ($\underline{P}<0.05$); Duncan's Multiple Range Test.

Enhanced microbial degradation of carbofuran after 7 days, 40%.
Arable land contracted for swedes with no carbamate applications in the previous five years.

Onset of second generation CRF egg-lay unclear	1 July
Second generation treatment application	1 July
Late second/third generation treatment	17 September

CONCLUSIONS

- To achieve the best protection from CRF larval attack, the mid-season insecticide programmes should involve both chlorfenvinphos and carbofuran.

- The timing of first mid-season treatments should be based on capture of adult flies, egg counts or the HDC/HRI model. The timing of late second/third generation treatments should be based on egg counts.

- The effect of ED appears to be less important than was expected. It is certainly insignificant compared to the poor performance of the approved insecticides, almost irrespective of ED levels. There is no practical merit in analysing fields for degradation before growing swedes/turnips. The results do not assist in selection of a suitable insecticide programme and may bear little relationship to degradation rates in other fields on the farm.

- Results from four mid-season applications of chlorfenvinphos, were not sufficiently good to support a specific off-label Approval (SOLA), for this use.

- At four of the five sites where transplants established satisfactorily, much improved control of CRF resulted from the use of cell-raised swedes treated with chlorpyrifos. A SOLA should be considered for a pre-planting drench of Dursban 4, to be applied to cell-raised swedes and turnips for control of CRF larvae.

- After detecting the onset of second or third generation egg-lay, it is often difficult to apply mid-season treatments quickly enough to protect the crop from attack by the earliest hatched larvae. This problem favours the use of drenched transplants because they are not subjected to the early egg-lay and are fully protected from the time of transplanting. Conversely, non-woven covers applied at that time suffer the disadvantage that they may trap flies or protect eggs and young larvae. Where covers become damaged, the exposed crop seems particularly attractive to egg-laying flies so that the pest attack may be worse than in uncovered areas of the field. Nevertheless, robust non-woven covers may be useful in areas of low pest incidence. They must be applied before the start of the second generation and with the first generation of CRF effectively controlled. There is probably merit in treating the crop with granules or liquid insecticides immediately before cover application. This technique is yet to be experimentally tested. Alternatively, if covers are applied immediately after crop emergence and maintained throughout the season with a minimum damage to the fabric, then flies should be excluded throughout the egg-laying period. A yield penalty may be incurred due to restricted plant growth beneath the covers, but this effect is worsened where the covered area is small. Larger areas of covered crop may yield better and mature earlier than conventionally-grown swedes and turnips. This technique should be tested further.

- Observations at eg Burscough and the Yorkshire sites suggest that larvae of late second/third generation flies in September may be more damaging than earlier-hatched individuals. Future work should address the relative importance of later timing compared to early mid-season treatments.

FURTHER WORK

- The relative importance of late second/third generation CRF should be investigated. Progress and intensity of larval attacks should be monitored by sequenced sampling of the crop for damage assessment at intervals from July to November.

- To assess the practical potential of swedes/turnips sown in cells, their growth, shape and weight at harvest should be compared following propagation in a range of different cells/trays. It is likely that well-shaped bulbs will develop if seedlings are grown in deeper cells that permit uninhibited root growth.

- Recently developed insecticides eg imidacloprid should be evaluated as compost incorporants for cell raised seedlings or as seed treatments.

- The merits of trap plants, eg kale sown alongside swedes/turnips to attract egg-laying female CRF, require investigation.

- The use of non-woven covers applied at drilling or at onset of second generation CRF emergence together with insecticide application, should be evaluated.

ACKNOWLEDGEMENTS

Thanks are extended to the Horticultural Development Council for funding this work and to Mr Michael Holmes, the Project Co-ordinator, for helpful information on commercial aspects of this project.

The co-operation of the growers hosting these experiments including Mr Julian Davies and staff at HRI Stockbridge House, is gratefully acknowledged.

Thanks also to the ADAS site managers for running and reporting these experiments and to Dr Michael Saynor of Saynor Consultancy Services for useful discussions on this topic since his retirement from ADAS.

GLOSSARY

Enhanced degradation (ED):

Accelerated breakdown of insecticides by microbial activity.

Degrees of freedom for error:

Statistical term indicating the potential precision of an experiment based on the number of treatments and replicates. The more degrees of freedom are achieved, the greater is the likelihood of statistical significance in small differences between results.

Guard plants:

Untreated rows of plants, not assessed in an experiment but used as a barrier between experimental plots, to avoid confusion and inaccuracies between treatments.

Spiked (or spiking):

An analytical technique in which a known quantity of the pesticide under test is added to a sample, for subsequent recovery and measurement.

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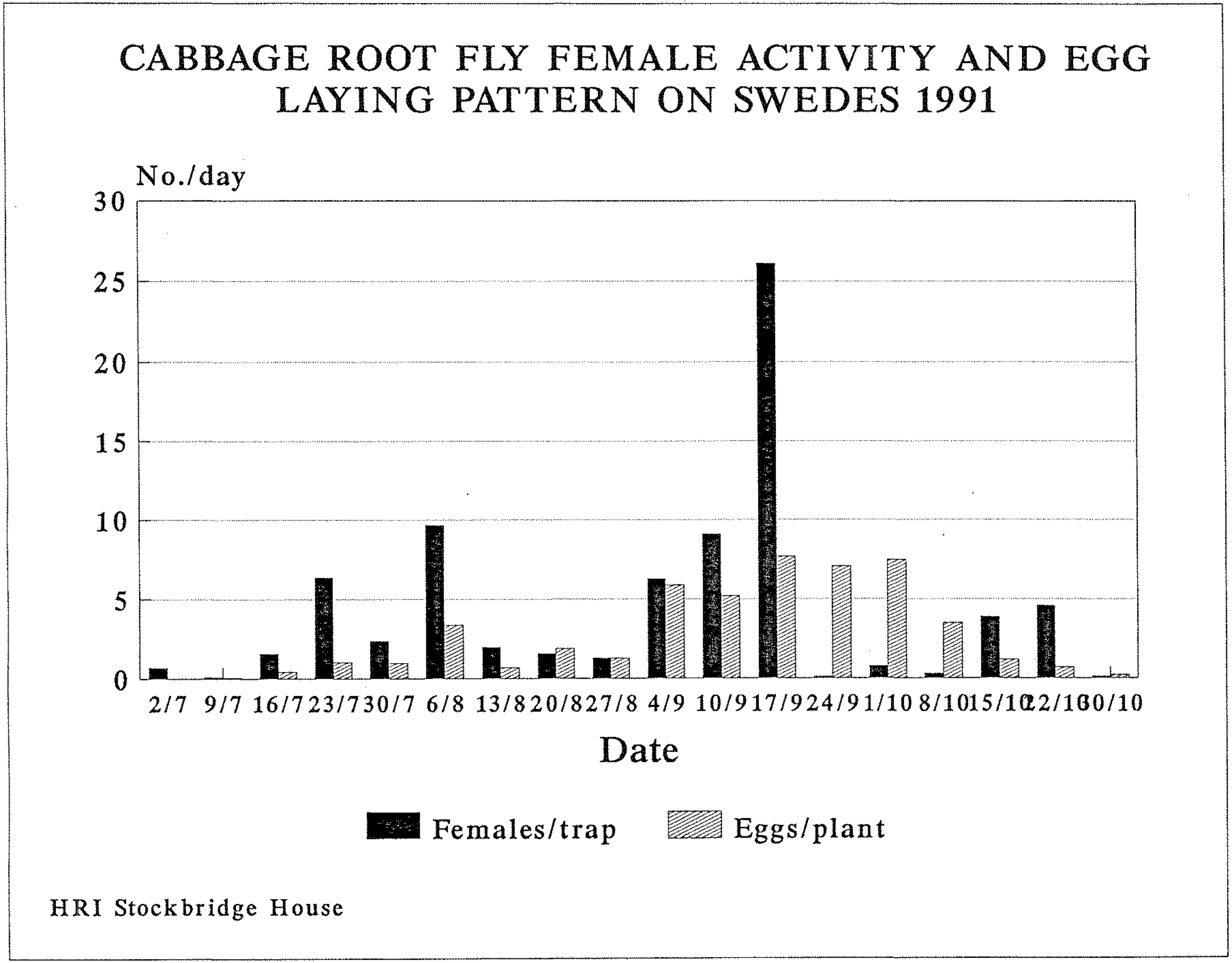
2. Fenwick, D. W. (1940). Journal of Helminthology 18, 155-172

3. King, K. M & Forbes, A. R. (1954). Journal of Economic Entomology 47, 607-615

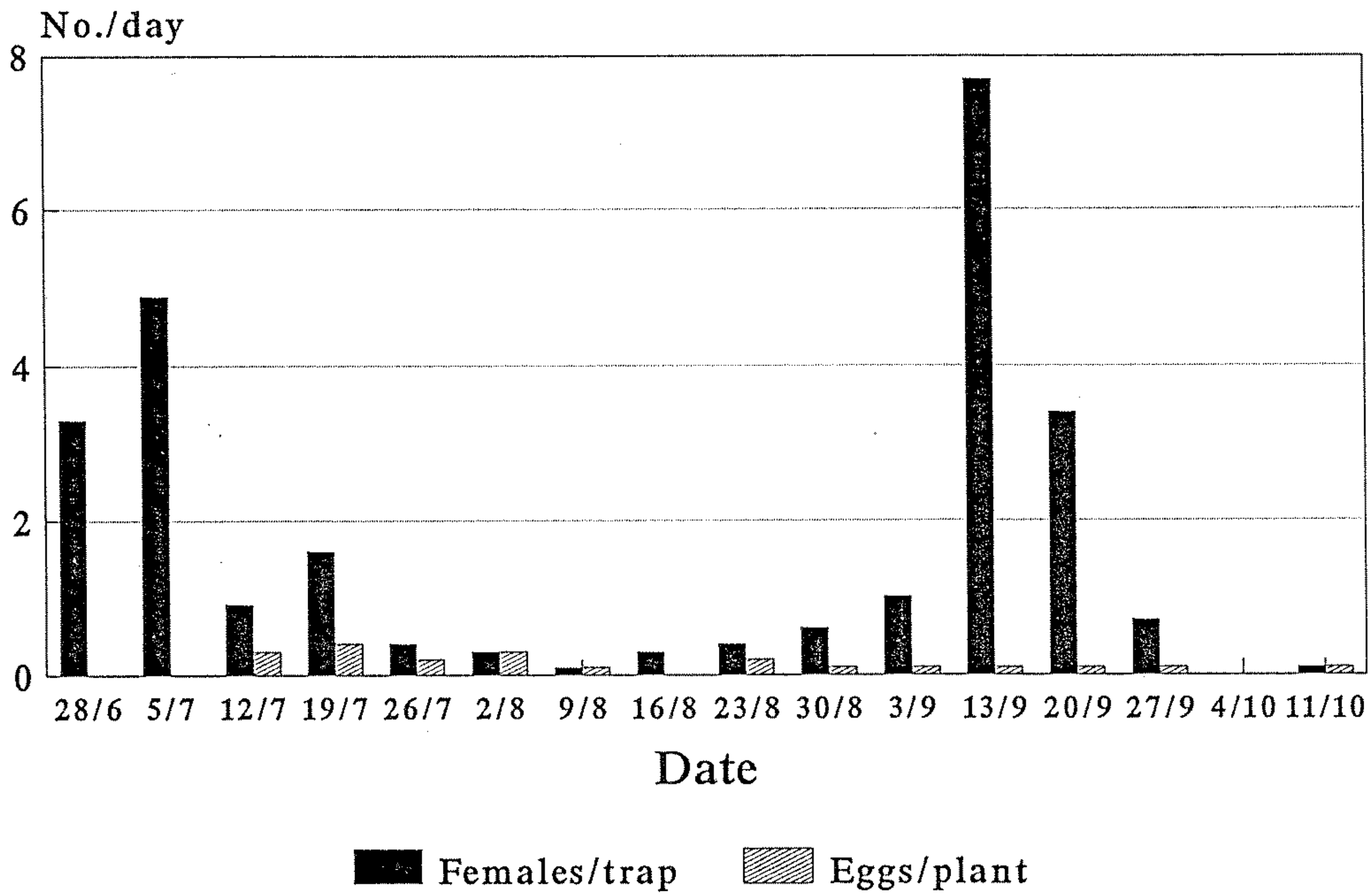
4. Senior, D., Antill, D. N. & Emmett, B. J. (1992). Tests of Agrochemicals and Cultivars Number 13 (Annals of Applied Biology 119, Supplement), 607-615.

APPENDICES


CABBAGE ROOT FLY FEMALE ACTIVITY AND EGG LAYING PATTERN ON SWEDES 1991
No./day
30
25
20
15
10
5
0
2/7
9/7
16/7
23/7
30/7
6/8
13/8
20/8
27/8
4/9
10/9
17/9
24/9
1/10
8/10
15/10
22/10
30/10
Date
Females/trap
Eggs/plant
HRI Stockbridge House

APPENDIX 2

CABBAGE ROOT FLY FEMALE ACTIVITY AND EGG LAYING PATTERN ON SWEDES 1991

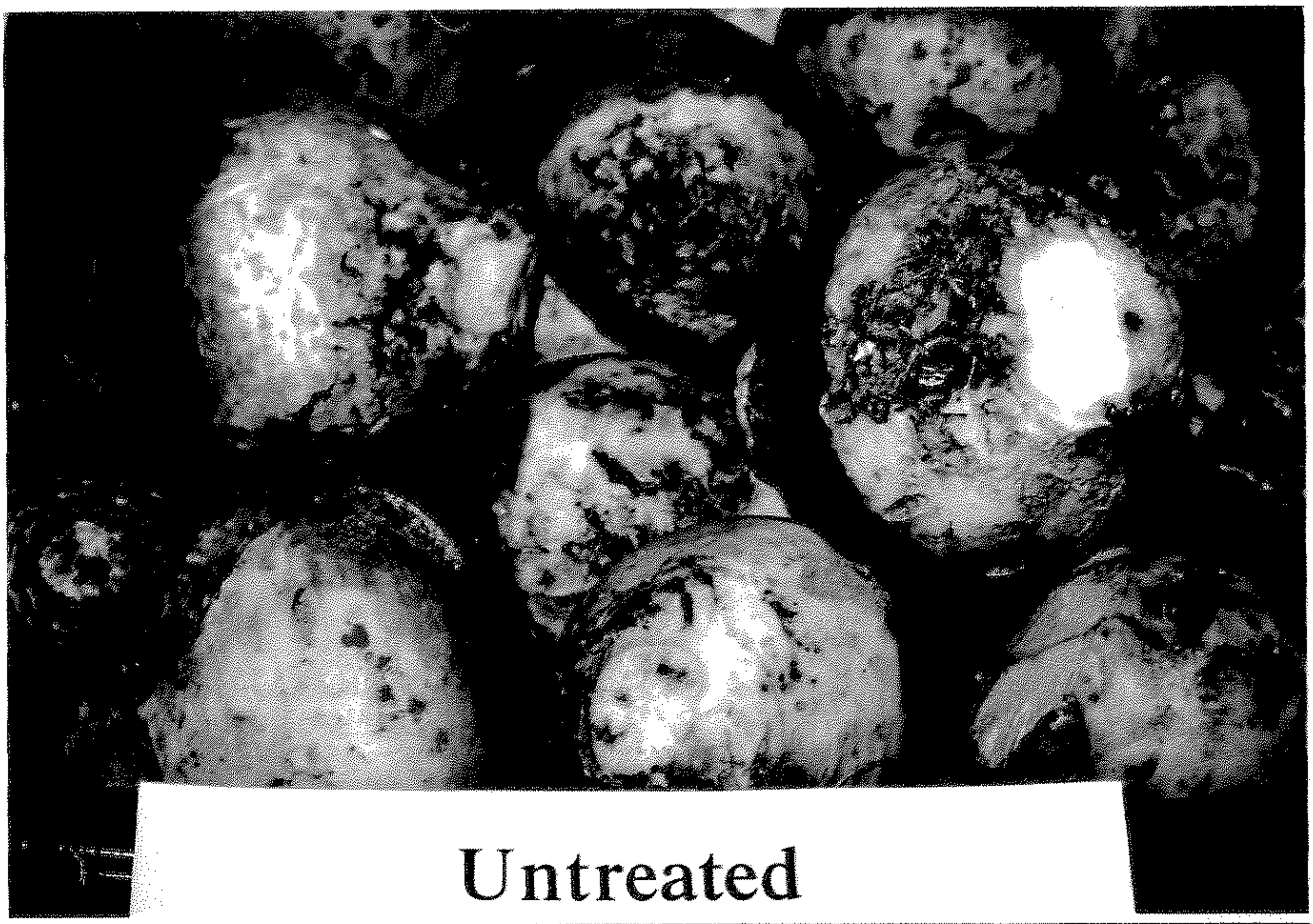


Aughton, Lancashire

APPENDIX 3

PLATE 1

EXAMPLE SWEDES FROM HRI STOCKBRIDGE HOUSE



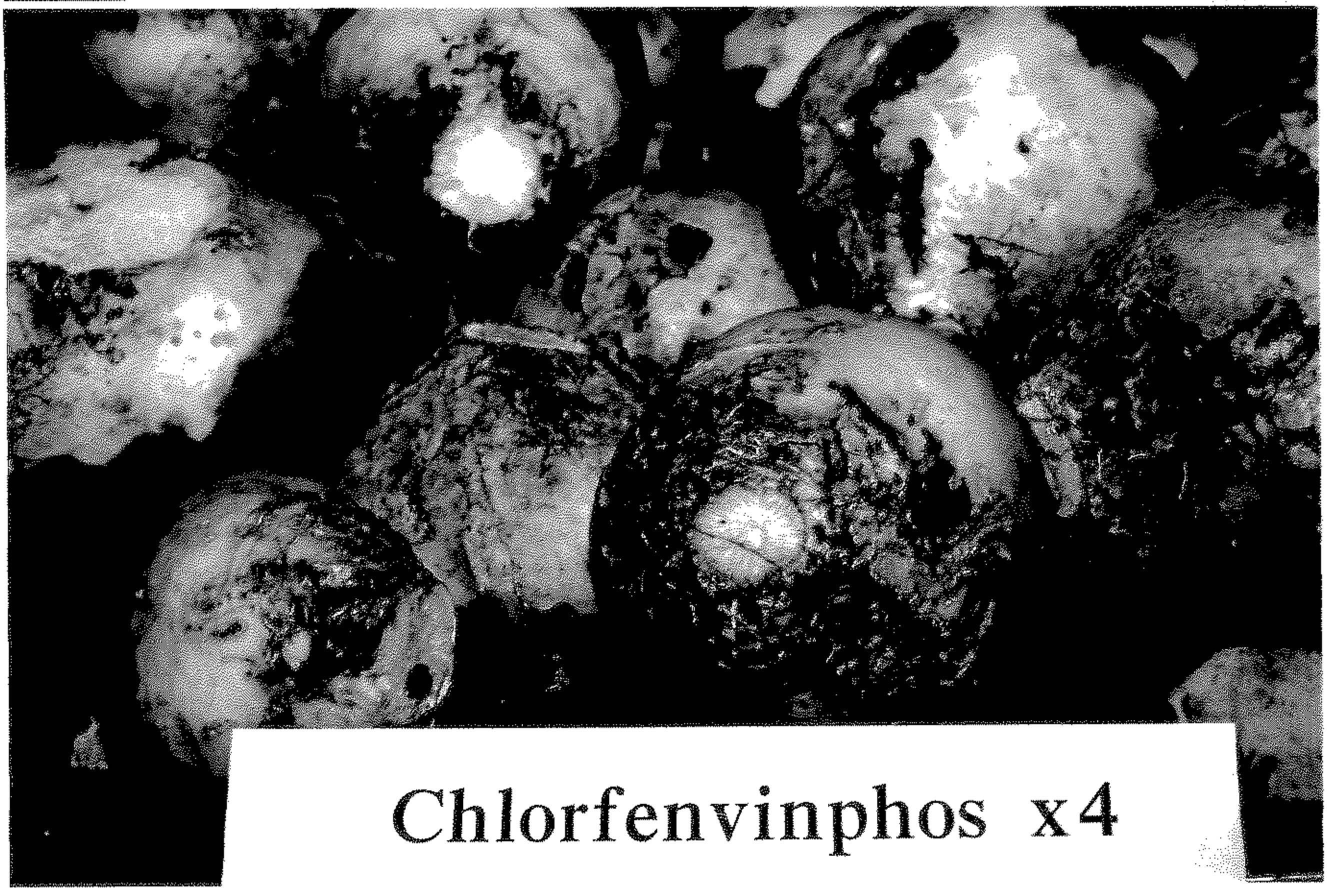
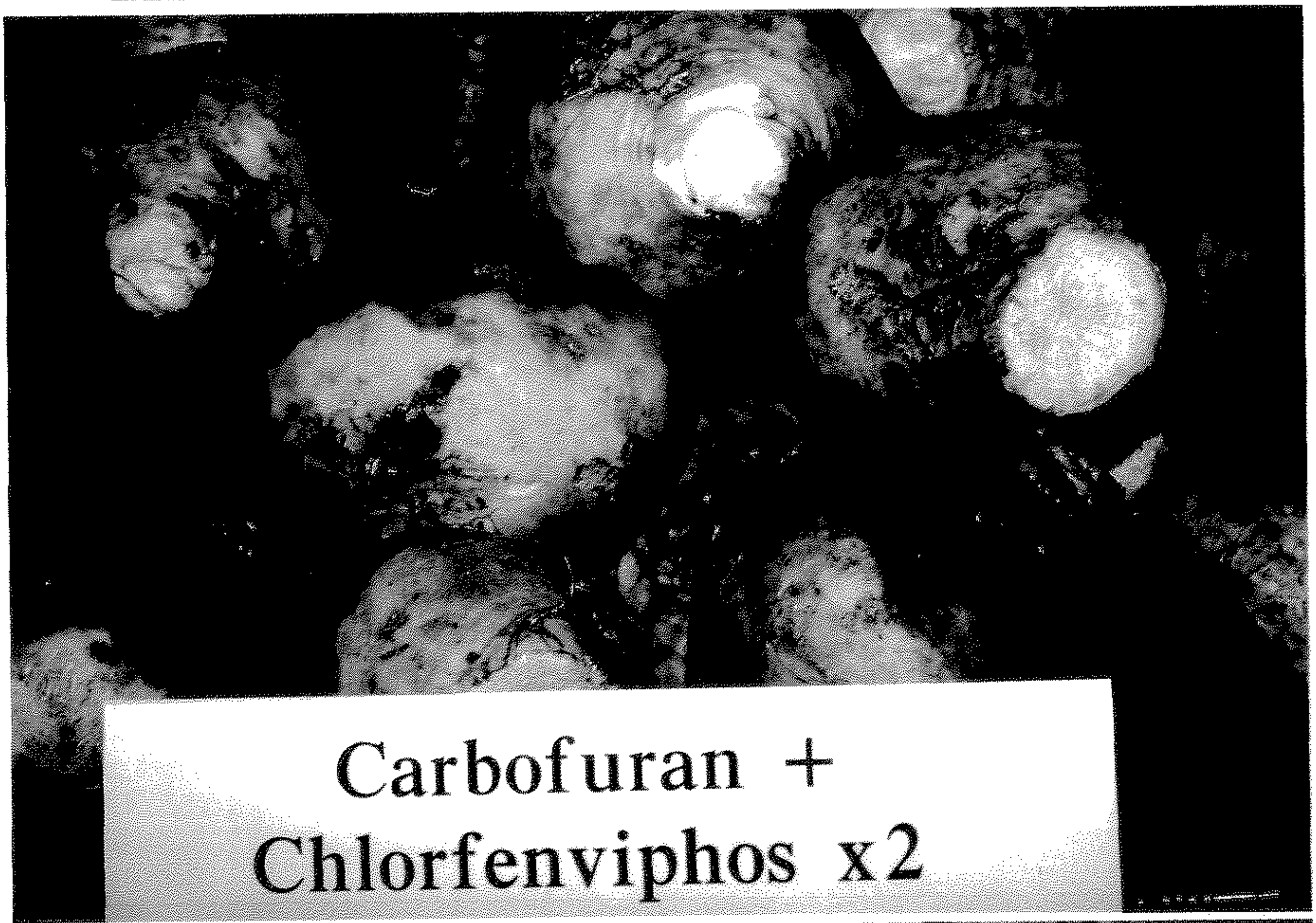


PLATE 2

EXAMPLE SWEDES FROM HRI STOCKBRIDGE HOUSE



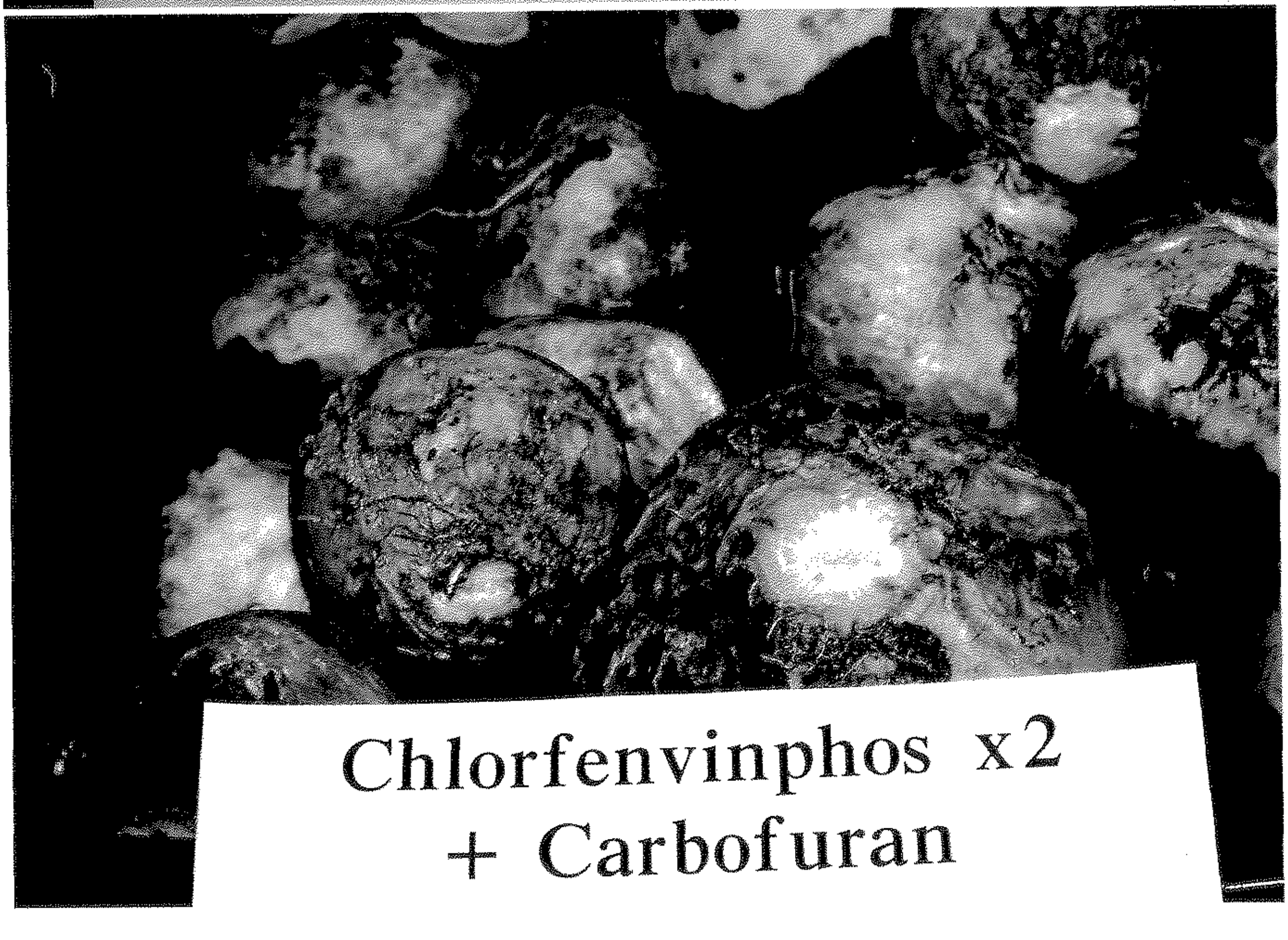


PLATE 3

EXAMPLE SWEDES FROM HRI STOCKBRIDGE HOUSE

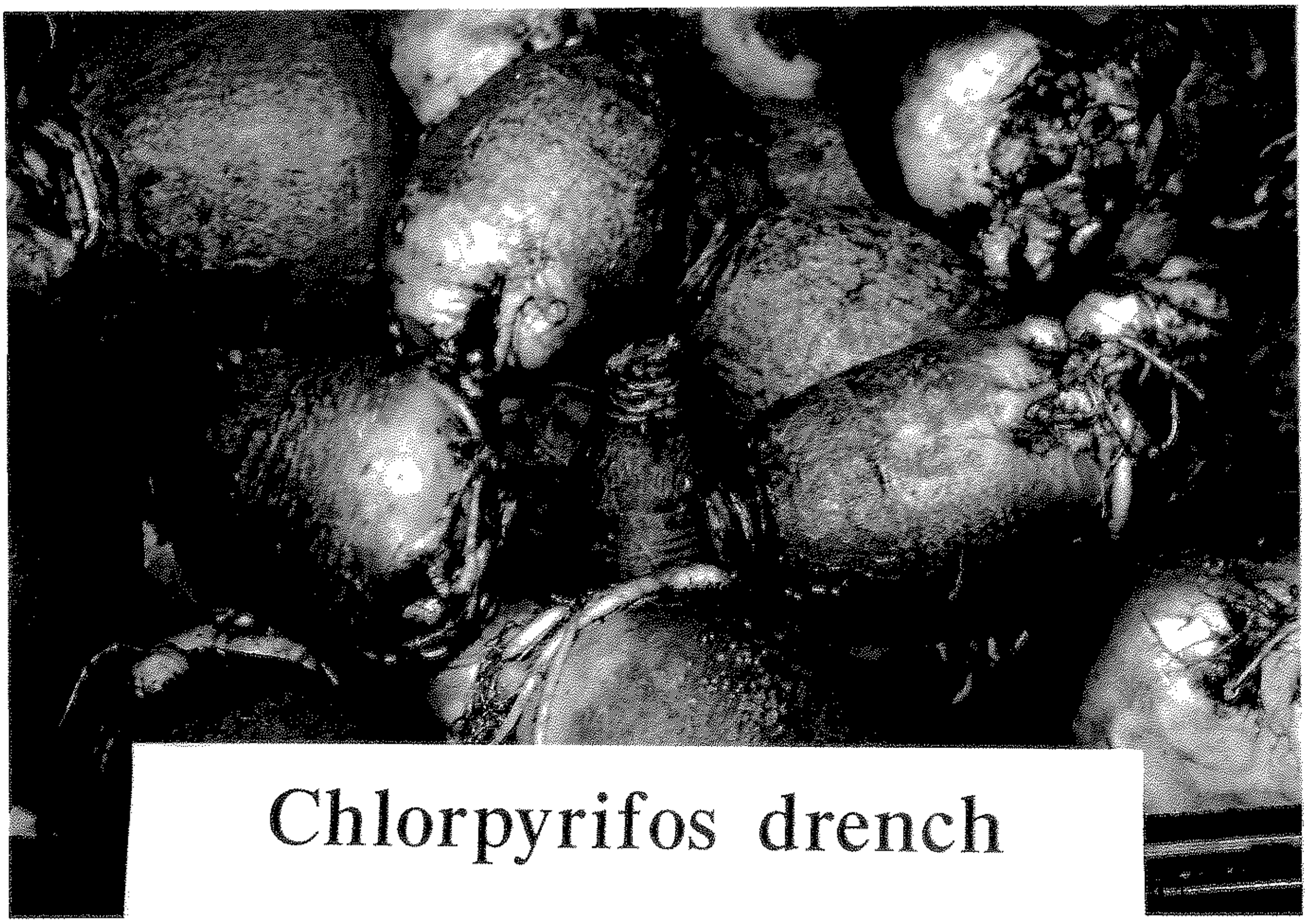
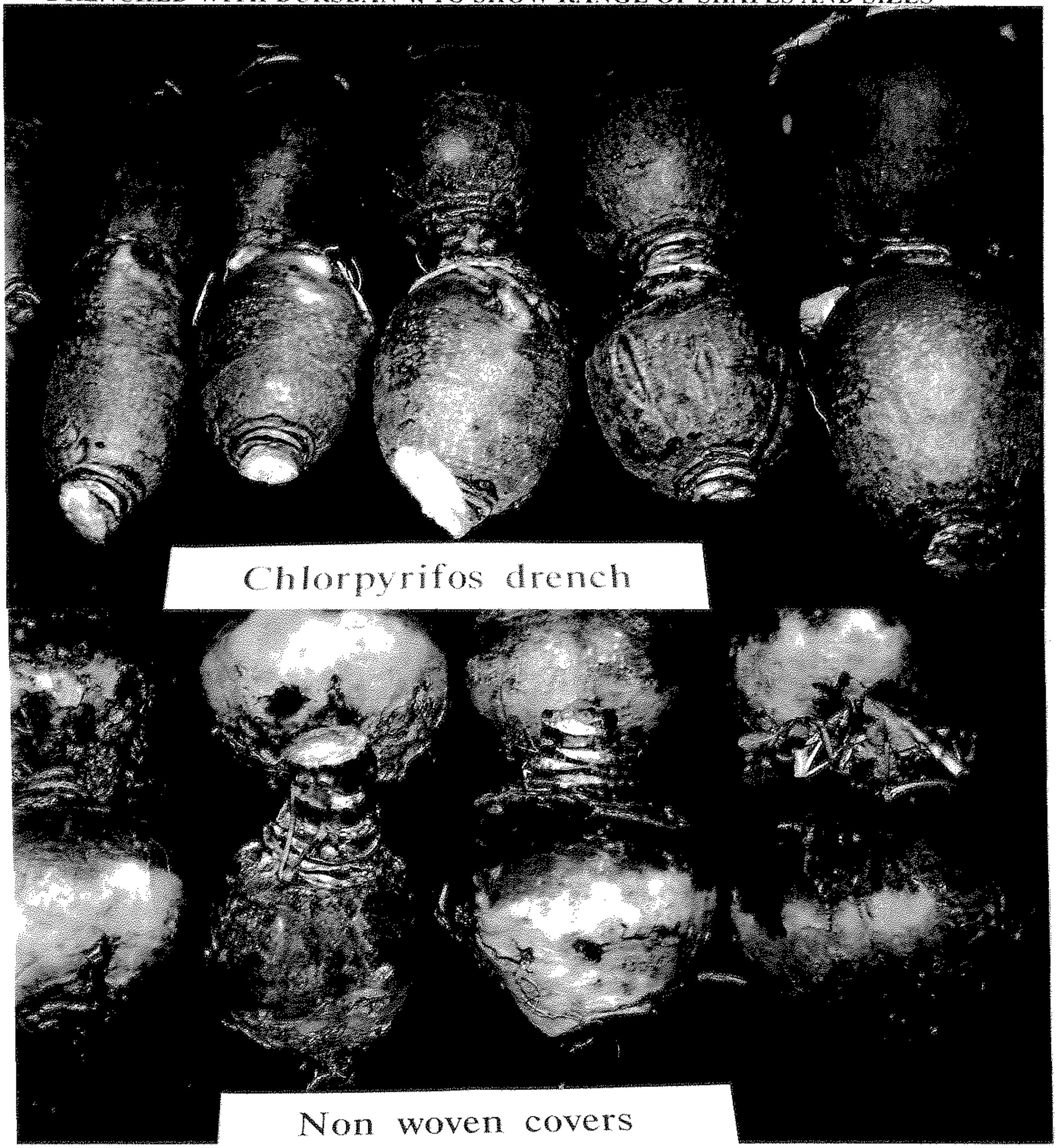


PLATE 4

SELECTION OF ROOTS GROWN FROM MODULE-RAISED TRANSPLANTS DRENCHED WITH DURSBAN 4, TO SHOW RANGE OF SHAPES AND SIZES



SELECTION OF ROOTS GROWN UNDER NON-WOVEN CORNERS, TO SHOW ACCEPTABLE SHAPE AND SIZE

APPENDIX 4

FIG 1

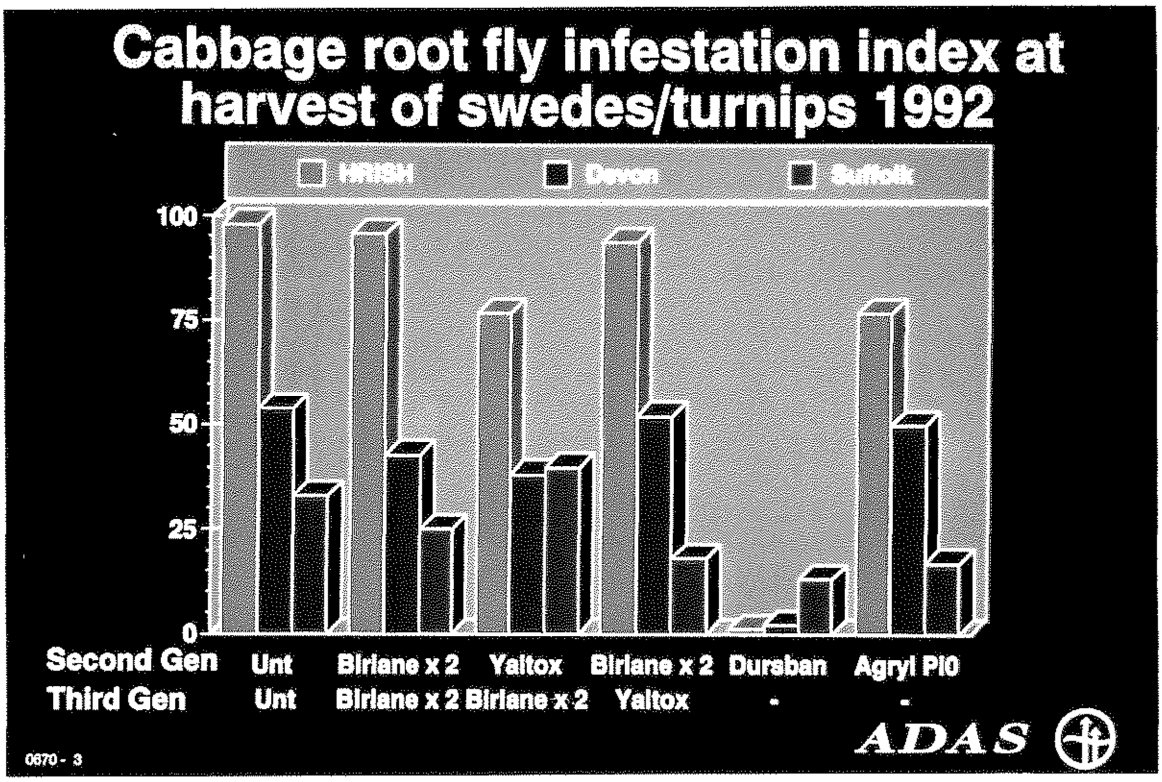


FIG 2

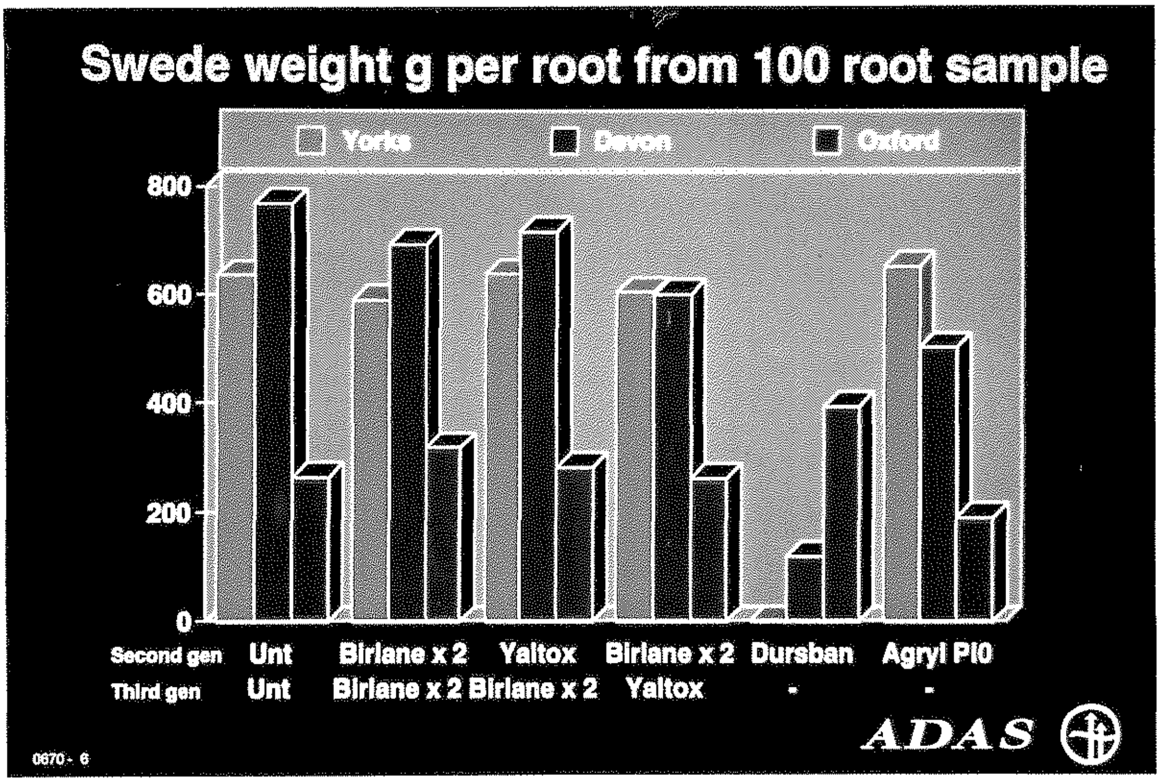


FIG 3

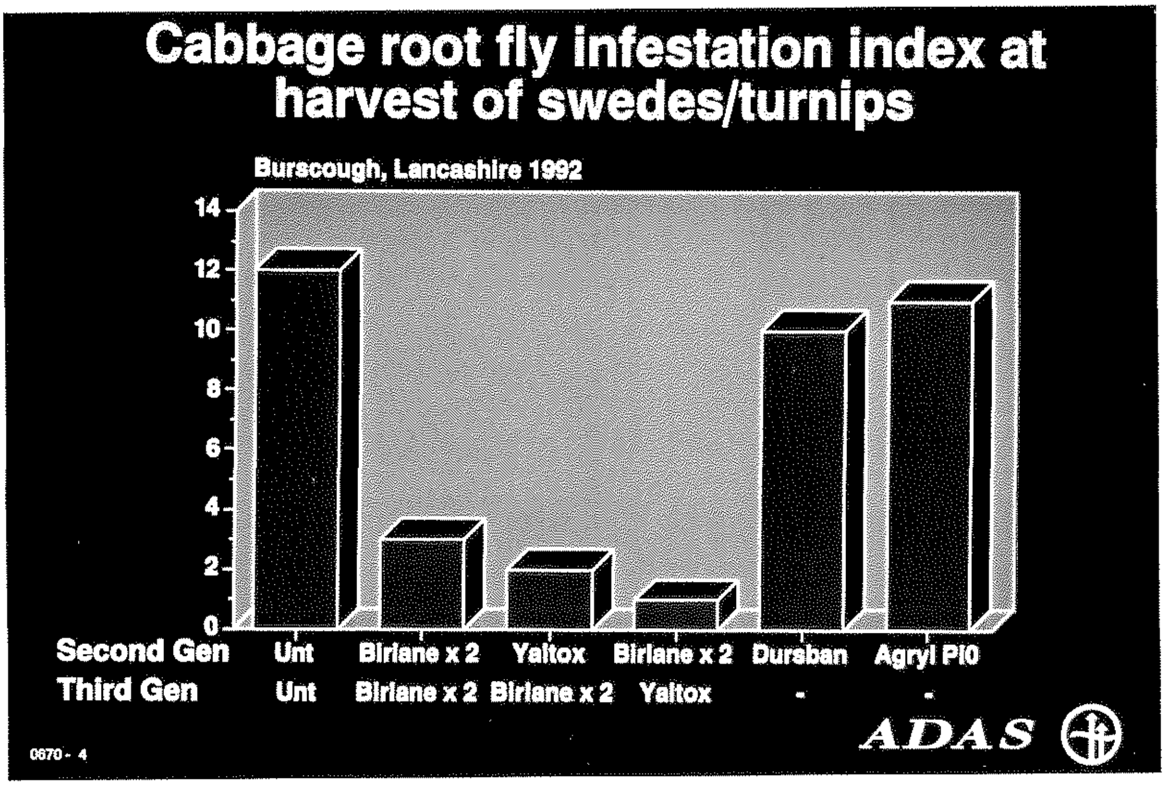
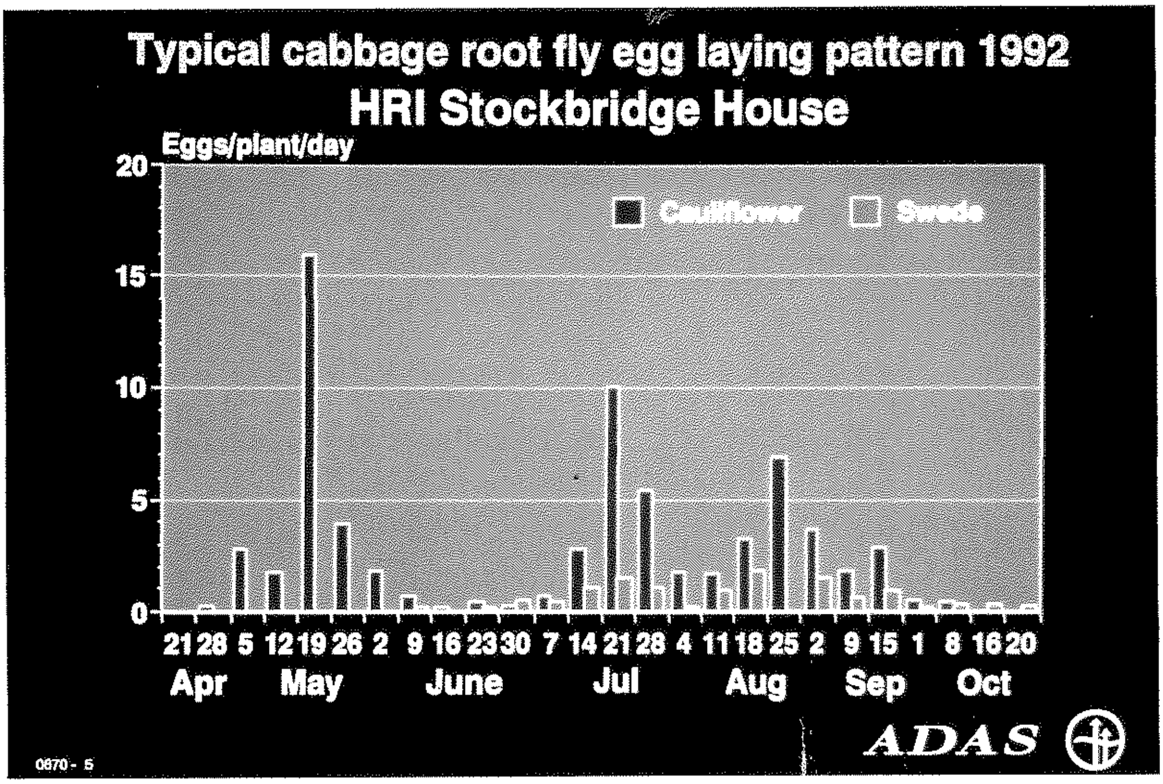

Cabbage root fly infestation index at harvest of swedes/turnips
Burscough, Lancashire 1992
14
12
10
8
6
4
2
0
Second Gen
Third Gen
Unt
Unt
Birlane x 2
Birlane x 2
Yaltox
Birlane x 2
Birlane x 2
Yaltox
Dursban
-
Agryl P10
-
ADAS
0670 - 4

FIG 4


Typical cabbage root fly egg laying pattern 1992
HRI Stockbridge House
Eggs/plant/day
20
15
10
5
0
Cauliflower
Swede
21 28 5 12 19 26 2 9 16 23 30 7 14 21 28 4 11 18 25 2 9 15 1 8 16 20
Apr
May
June
Jul
Aug
Sep
Oct
ADAS
0670 - 5

APPENDIX 5

ADAS
FOOD, FARMING, LAND & LEISURE

ADAS STARCROSS
STAPLAKE MOUNT
STARCROSS
DEVON
EX6 8PE

TEL: (0626) 890481
FAX: (0626) 891259

Mr K Coles
Chelston House Farm
WELLINGTON
Somerset

21 December 1992

Dear Mr Coles

HDC-FUNDED SWEDE TRIAL

I was most disappointed to learn that the cabbage root fly trial we had sited at Eastcombe Farm this year has recently been destroyed. This means that we have wasted several hundred pounds on fruitless labour, laboratory analyses, etc, in carrying out all the work done to date, and I am now left me in the extremely embarrassing position of being unable to fulfill my contractual obligation to the HDC.

I understand that you have been most helpful in attempting to ensure a successful trial this year, and that our demise was brought about by the actions of an errant employee, whom you have since dismissed as a result.

Under the circumstances, I ask you to confirm in writing what has happened, so that I can submit this as documentary evidence to the HDC.

I thank you for your continued cooperation, and I look forward to receiving your reply.

Yours sincerely

Stephen Tones
Senior Research Consultant Entomologist

Copy: Ben Emmett (Contract Manager), ADAS Leeds

ASSESSMENT OF CABBAGE ROOT FLY DAMAGE ON SWEDES AT HARVEST

Taken from: King, A. M and Forbes, A R 1954 -"Control of Root Maggots in Rutabagas" J. econ. Ent. 47 (4) 607-15.

Category		**Description of Damage**
0	Clean	No evidence on the root of even the slightest feeding.
1	Slight	Maggot injury limited to superficial early feeding of slight extent and fully healed over ie definite evidence of maggot attack but effect negligible commercially even if all roots were so affected.
2	Moderate	Marketable for second grade after special trimming limited to one stroke just above the top root to remove a single deep penetration or a moderately extensive surface injury; if maggot injury present at middle or upper part of the fleshy root it must be fully healed over, no deeper than would be completely removed by normal peeling and must not involve more than one-fifth of the surface area.
4	Severe	Unmarketable for table use, injury not removable by any practicable amount of trimming. Except as defined for moderate, a single deep penetration or the presence of a maggot in the root at harvest or any extensive unhealed surface injury grades a root as severe.

Infestation Index is calculated as follows:

Work out percent roots in each category. Multiply each percent figure by category number and add together, then divide total by 4.

Example	**0**	**1**	**2**	**4**	**Total**
No. roots	7	5	6	2	20
% in each category	35	25	30	10	

$$\text{Infestation Index} = (35x0) + (25x1) + (30x2) + (10x4)$$

$$= \frac{0 + 25 + 60 + 40}{4}$$

$$\text{Final Index} = 31.25$$

ADAS

Contract between ADAS (hereinafter called the "Contractor") and the Horticultural Development Council (hereinafter called the "Council") for a research/development project.

PROPOSAL

1. TITLE OF PROJECT **Contract No: FV 66**

CABBAGE ROOT FLY: CONTROL IN SWEDES

2. BACKGROUND

Within project FV/13/87, over 2 years, various timings and control measures were compared. In this work and also studies funded by CSG in 1982/87, the best timed treatments always coincided with the appearance of second generation CRF eggs as counted from soil samples. In Devon, chlorfenvinphos generally worked well. In Yorkshire, carbofuran was effective and chlorfenvinphos almost useless. In Devon there have also been advisory problems following the use of chlorfenvinphos. Comparison will be made of these 2 insecticides in a number of swede crops nationally to determine the incidence and distribution of problem sites where either (or both) of these insecticides is/are ineffective. From these data it will also be possible to develop a simple assessment method that farmers could operate to select the best insecticides for use on their own farms.

3. POTENTIAL BENEFIT TO THE INDUSTRY

From results of experiments in 1987 and 1988 it is expected that unreplicated field tests of this type should provide reliable guidance for control of this pest. The final result from the second stage of this HDC funded project will be a simple test for farmer use, to select the most effective insecticides, appropriately timed to give better control of CRF than has been available in the past. This information will also be available as required for HRI, Wellesbourne to confirm their predictive model of CRF development.

4. SCIENTIFIC AND COMMERCIAL OBJECTIVES

a. To establish at a range of sites, the relative efficacy of carbofuran granules and chlorfenvinphos liquid for control of second generation CRF.

b. To evaluate the role of accelerated degradation in any differences in effectiveness between these insecticides.

c. To provide a simple system for farmers to test and monitor the efficacy of these 2 insecticides as an on-farm decision making "tool".

5. **DESCRIPTION OF WORK**

At 8 sites/year:

i. Trap adult CRF and/or collect egg samples over 4-5 weeks in mid-July to determine appropriate treatment timing.

ii. Establish three (unreplicated) plots for application of a. carbofuran granules or b. chlorfenvinphos spray treatments repeated 14 days later and c. untreated control.

iii. Collect roots from each plot in October/November and assess for CRF larval damage.

iv. Analyse soils for accelerated degradation of carbofuran.

6. **COMMENCEMENT DATE AND DURATION**

1.7.91, for 2 years.

7. **STAFF RESPONSIBILITIES**

Project Leader: Ben Emmett, Entomology, ADAS, Leeds RO.

Other staff: depending on availability of staff resource and suitable sites - staff at ADAS, Cambridge RO; ADAS, Reading RO: ADAS, Wolverhampton RO; ADAS, Kirton and ADAS, Starcross.

HDC project co-ordinator: Mr M Holmes, Trent Farm, Owston Ferry, Doncaster, DN9 1RN.

8. **LOCATION**

Commercial holdings: 2 sites in each of 4 regions as outlined in 7. above.

TERMS AND CONDITIONS

The Council's standard terms and conditions of contract shall apply.

Signed for the Contractor (s)	Signature.......[signature].......
	Position..R&D Manager..
	Date......22/4/91.........
Signed for the Contractor (s)	Signature.....................
	Position.....................
	Date.........................
Signed for the Council	Signature..[signature].........
	Position.CHIEF EXECUTIVE.....
	Date......19.4.91............