FINAL REPORT

To:
Horticultural Development Council
Bradbourne House
Stable Block
East Malling
Kent, ME19 6DZ

Carrot & parsnip: Alternative strategies for carrot fly control

FV 13f

Andrew Jukes, Rosemary Collier, Marian Elliott
WarwickHRI, University of Warwick, Wellesbourne, Warwick, CV35 9EF

January 2007

Commercial - In Confidence

Grower Summary

FV 13f

Carrot & parsnip: Alternative strategies for carrot fly control

Final report 2007

Project title:	Carrot & parsnip: Alternative strategies for carrot fly control
Project number:	FV 13f
Project Leader:	Rosemary Collier and Andrew Jukes Warwick HRI**,** Wellesbourne, Warwick CV35 9EF
Final report:	2006/2007
Previous reports:	
Key workers:	Mr Andrew Jukes (Insecticide trials/residue analysis) Mr Matthew Mitchell (Insecticide trials) Ms Marian Elliott (Carrot fly trials)
Location of project:	Warwick HRI**,** Wellesbourne, Warwick, CV35 9EF
Project co-ordinators:	John Kenyon, Huntapac
Date project commenced:	1 April 2006
Date project completed:	31 January 2007
Key words:	Carrot fly, *Psila rosae*, carrot, parsnip, Hallmark with Zeon Technology, lambda-cyhalothrin, insecticides, Decis Protech, deltamethrin

Signed on behalf of: **Warwick HRI**

Signature:…… ***Date***: …….
Name Professor Simon Bright
Director and Head of Department

CONTENTS

FV 13f
Carrot & parsnip: Alternative strategies for carrot fly control

Headline

- New restrictions on the use of Hallmark with Zeon Technology should not compromise carrot fly control if timed correctly.
- Four applications of 100 ml Hallmark with Zeon Technology/ha reduced damage due to carrot fly larvae compared with an insecticide-free control treatment and were as effective as a similar programme with four applications of 150 ml product/ha.
- In this trial, four sprays applied at 2-weekly intervals from 26 July to 5 September covered the main period of second generation carrot fly activity. There was no apparent benefit from applying additional treatments (of Decis Protech) after 5 September.

Background and expected deliverables

For almost 10 years, carrot fly has been controlled effectively using pyrethroid insecticides. Foliar sprays of Hallmark with Zeon Technology (lambda-cyhalothrin) have been particularly effective. However, PSD has indicated that to bring this use of Hallmark with Zeon Technology in line with other uses, both the permitted dose and permitted number of spray applications will be reduced. It was decided, after the trial had commenced, that the new permitted dose would be a maximum of 150 ml/ha in any one application with a maximum of 450 ml/ha per crop. This equates to three sprays of 150 ml/ha or three sprays of 100 ml/ha plus one at 150 ml/ha. The industry is concerned that their ability to control carrot fly activity may be reduced considerably.

The aim of a field trial proposed done in summer 2006, was to evaluate revised strategies for carrot fly control based on the new dose and number of applications. This was a replicated plot trial using the carrot fly population at Warwick HRI, Wellesbourne. The trial included strategies using Hallmark with Zeon Technology alone and Hallmark with Zeon Technology in combination with foliar sprays of Decis Protech (deltamethrin), which also kills adult carrot fly but is less effective than Hallmark with Zeon Technology.

The expected deliverables from this work included:

- An evaluation of strategies using Hallmark with Zeon Technology alone and Hallmark with Zeon Technology in combination with foliar sprays of Decis Protech (deltamethrin).
- An evaluation of a novel active ingredient for carrot fly control.

Summary of the project and main conclusions

A single experiment was done in 2006 using three insecticides (Hallmark with Zeon Technology (lambda-cyhalothrin), Decis Protech (deltametrin) and Syngenta A1295Z

An experiment was done to answer the following questions:

1. Can carrot fly be controlled effectively with the new dose and number of applications of Hallmark with Zeon Technology specified by PSD?
2. Can control be increased by additional applications of Decis Protech?

3. How does the timing of application affect control?
4. Can novel insecticides be used for control?

Experiment summaries and main conclusions

To evaluate revised strategies for carrot fly control based on the new dose and number of applications for Hallmark with Zeon Technology specified by PSD.

Carrot seed was drilled in early June 2006 (after the first generation of the carrot fly had ceased to lay eggs). The trial was divided into 28 plots (4 replicates of 7 treatments) and the treatments (Table 1) were applied according to pre-determined programmes between 26 July and 3 October. Roots were harvested and assessed for damage on 23 October 2006 and on 16 January 2007.

Table 1. Treatments to control carrot fly in carrot. Hallmark = Hallmark with Zeon Technology, Decis = Decis Protech

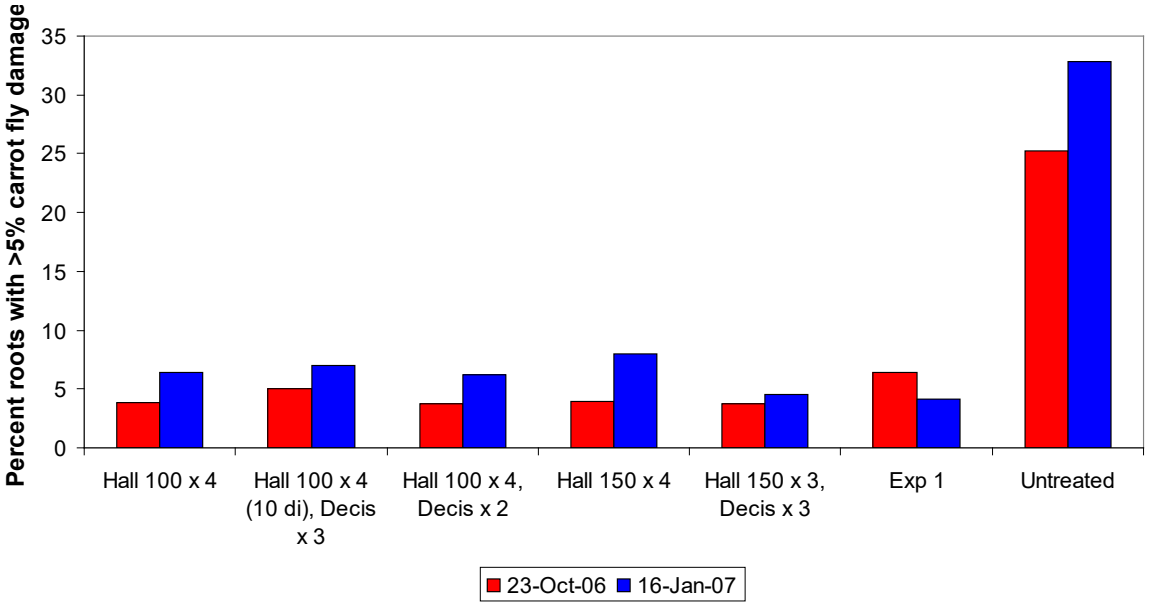
Treatment code		Early sprays	Dose (product/ha)	Late sprays	Dose (product/ha)
1 [3]	Hall 100 x 4	4 x Hallmark [1]	100 ml		
2 [3]	Hall 100 x 4 (10 di), Decis x 3	4 x Hallmark [2]	100 ml	3 x Decis [1]	500 ml
3 [3]	Hall 100 x 4, Decis x 2	4 x Hallmark [1]	100 ml	2 x Decis [1]	500 ml
4 [4]	Hall 150 x 4	4 x Hallmark [1]	150 ml		
5 [3]	Hall 150 x 3, Decis x 3	3 x Hallmark [1]	150 ml	3 x Decis [1]	500 ml
6 [5]	Exp 1	4 x Exp 1 [1]	100 ml + 133 g		
7	Untreated	Untreated			

[1] 14 days between applications
[2] 10 days between applications (10 di)
[3] Permitted under new regulations from PSD
[4] Not permitted under new regulations from PSD
[5] Experimental treatment no current approval

Results

- All of the spray programmes gave good control of carrot fly compared with the insecticide-free control treatment (Figure 1).
- There was little difference between insecticide programmes at the first harvest in October 2006.
- The amount of damage had increased at the second harvest but there was still little difference between the insecticide programmes.

Figure 1. The percentage of carrot roots with >5% damage harvested on 23 October 2006 (Assessment 1) and 16 January 2007 (Assessment 2). Hall = Hallmark with Zeon Technology and Decis = Decis Protech.



Conclusions

- New restrictions on the use of Hallmark with Zeon Technology should not compromise carrot fly control if timed correctly.
- Four applications of 100 ml Hallmark with Zeon Technology/ha reduced damage due to carrot fly larvae compared with an insecticide-free control treatment and were as effective as a similar programme with four applications of 150 ml product/ha.
- In this trial, four sprays applied at 2-weekly intervals from 26 July to 5 September covered the main period of second generation carrot fly activity. There was no apparent benefit from applying additional treatments (of Decis Protech) after 5 September.

Financial benefits

Carrot and parsnip crops occupy about 13,000 ha of land each year and are worth currently about £170M per annum (Defra Basic Horticultural Statistics 2005). Without adequate insecticidal control, a conservative estimate would be that about 10% of roots would be rendered unmarketable by carrot fly. In this case, the Industry would be facing losses of about £17M per annum from the area of crop that needs protecting currently against attacks by carrot fly.

Action points for growers

The main aim of this project was to assess the impact of a reduction in the number of permitted applications of Hallmark with Zeon Technology (lambda-cyhalothrin).

Foliar spray treatment (field experiment - carrot)

- **Hallmark with Zeon Technology** provided good control of carrot fly using just 4 sprays of 100 ml product/ha. Sprays applied at 2-weekly intervals between 26 July and 5 September.
- **Decis Protech** appeared to offer no additional control when applied following the programme of Hallmark with Zeon Technology, (last spray of Halllmark with Zeon Technology applied on 5 September).
- **Experimental product (Exp 1)** did not increase control compared with Hallmark with Zeon Technology.

SCIENCE SECTION

Introduction

The work during this one-year project was “short-term”, and was concerned primarily with assessing the impact of a new PSD regulation which reduces the number of applications of Hallmark with Zeon Technology (lambda-cyhalothrin) permissible for the control of carrot fly. It was decided, after the trial had commenced, that the new permitted dose would be a maximum of 150 ml/ha in any one application, with a maximum of 450 ml/ha per crop. This equates to three sprays of 150 ml/ha or three sprays of 100 ml/ha plus one at 150 ml/ha. The maximum number of Decis Protech applications permitted is three per season.

An experiment was done to answer the following questions:

1. Can carrot fly be effectively controlled with the new dose and number of applications of Hallmark with Zeon Technology specified by PSD.
2. Can control be increased by additional applications with Decis Protech
3. How does timing of application affect control
4. Can novel insecticides be used for control

Experiment 1.

To evaluate revised strategies for carrot fly control based on the new dose and number of applications for Hallmark with Zeon Technology specified by PSD

Materials and methods

The trial was done in Long Meadow Centre at Warwick HRI, Wellesbourne. The experiment was drilled on 7 June 2006 after the first generation of carrot fly had ceased laying eggs. The experiment was laid out as a Randomised Block Design. There were 28 plots, 5 m x 1 bed (1.54 m) in size, and there were 4 replicates of 7 treatments (Table 2). The seed was drilled at a target rate of 100 seeds per metre using a Stanhay Singulaire drill unit and there were 4 rows/bed. An error occurred with drill calibration and as a result of this the seed rate was higher than the target and only 5 of the 7 beds were drilled before the seed ran out. Additional seed was ordered and the final 2 beds were drilled on 12 June (without changing seed-drill settings).

The spray treatments were applied between 26 July until 3 October as described in the spray timetable (Table 3) using a knapsack sprayer with medium nozzles at 300 l water/ha.

Table 2. Treatments to control carrot fly in carrot. Hallmark = Hallmark with Zeon Technology, Decis = Decis Protech

Treatment code		Early sprays	Dose (product/ha)	Late sprays	Dose (product/ha)
1 [3]	Hall 100 x 4	4 x Hallmark [1]	100 ml		
2 [3]	Hall 100 x 4 (10 di), Decis x 3	4 x Hallmark [2]	100 ml	3 x Decis [1]	500 ml
3 [3]	Hall 100 x 4, Decis x 2	4 x Hallmark [1]	100 ml	2 x Decis [1]	500 ml
4 [4]	Hall 150 x 4	4 x Hallmark [1]	150 ml		
5 [3]	Hall 150 x 3, Decis x 3	3 x Hallmark [1]	150 ml	3 x Decis [1]	500 ml
6 [5]	Exp 1	4 x Exp 1 [1]	100 ml + 133 g		
7	Untreated	Untreated			

[1] 14 days between applications
[2] 10 days between applications (10 di)
[3] Permitted under new regulations from PSD
[4] Not permitted under new regulations from PSD
[5] Experimental treatment no current approval

Table 3. Timetable for spray applications – planned timings and actual spray dates

Planned timing from start of 2nd generation (days)	**0**	**10**	**14**	**20**	**28**	**30**	**40**	**42**	**54**	**56**	**68**	**70**
Actual dates	**26 Jul**	**4 Aug**	**9 Aug**	**14 Aug**	**24 Aug**	**24 Aug**	**5 Sep**	**5 Sep**	**15 Sep**	**25 Sep**	**3 Oct**	**3 Oct**
Treatment												
1	H100		H100		H100			H100				
2	H100	H100		H100		H100	D500		D500		D500	
3	H100		H100		H100			H100		D500		D500
4	H150		H150		H150			H150				
5	H150		H150		H150			D500		D500		D500
6	Exp		Exp		Exp			Exp				
7	Untreated											

H100 = Hallmark with Zeon Technology 100 ml product/ha
H150 = Hallmark with Zeon Technology 150 ml product/ha
D500 = Decis Protech 500 ml product/ha
Exp = experimental product

Assessments

The numbers of adult carrot flies (*Psila rosae*) captured on sticky traps were recorded in an adjacent plot of carrots in Long Meadow Centre.

On 23 October 2006 and 16 January 2007, two x 0.5 m portions of row were harvested from the middle two rows of each plot. On both occasions the roots were washed, counted, weighed and scored (0-5 scale, Table 4) for damage due to feeding by carrot fly larvae.

Statistical analysis

The data were subjected to Analysis of Variance.

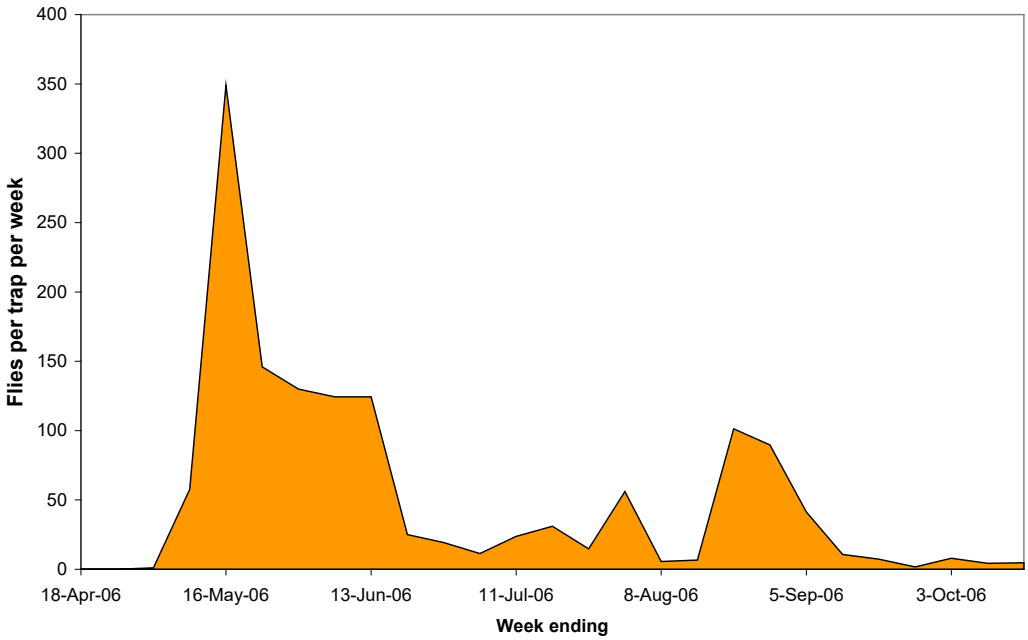
Table 4. Carrot fly damage scoring system

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

Results

Peak numbers of first generation carrot fly were captured in mid-May and peak numbers of second generation carrot fly were captured in mid August 2006 (Figure 2).

Figure 2. The numbers of carrot flies captured on orange sticky traps in Long Meadow Centre, Warwick HRI, Wellesbourne in 2006.



The results from both carrot root harvests are summarised in Tables 5a (Assessment 1) and 5b (Assessment 2) and the damage scores are presented in Figure 3. The results suggest that

the insecticide-free plots (Treatment 7) have significantly more damage than the other treatments on both assessment occasions. There was a small increase in damage in all treatments between Assessment 1 and Assessment 2 indicating that the carrot fly larvae present in the soil and roots had continued to feed.

At the time of the first assessment, Treatment 1 (4 x 100ml product/ha Hallmark with Zeon Technology) appeared to have produced many small roots, while Treatment 7 (insecticide-free control) had produced fewer roots, but with a higher mean weight. This pattern was not repeated at Assessment 2, so it can be assumed that this was probably due to within plot variation rather than treatment effects.

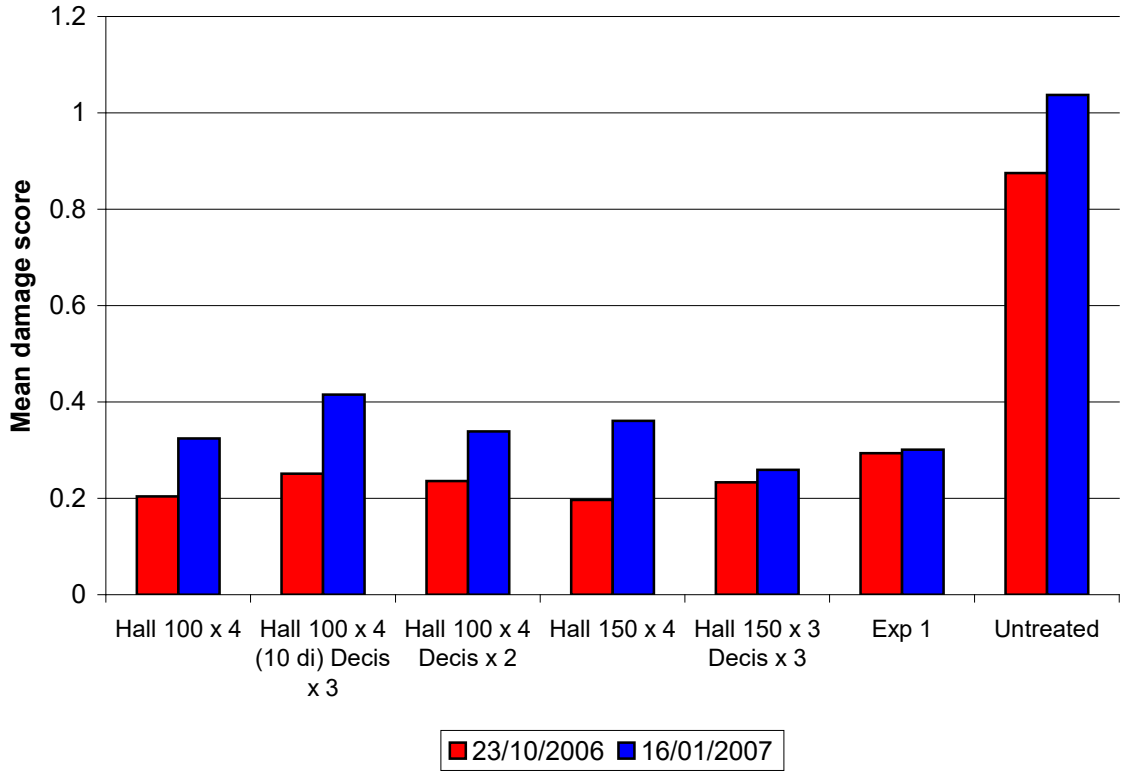
Table 5a. The total weight, mean weight, total root count and mean damage score of carrot roots harvested on 23 October 2006. Means followed by the same letter are not significantly different ($p<0.05$).

	Assessment 1							
Treatment	Total Weight		Mean Weight		Mean Damage Score		Total Root Count	
Hall 100 x 4	3379	a	27.08	a	0.204	a	125.8	b
Hall 100 x 4 (10 di), Decis x 3	3574	a	30.98	ab	0.251	a	115.8	ab
Hall 100 x 4, Decis x 2	3243	a	27.39	ab	0.236	a	120.8	ab
Hall 150 x 4	3336	a	29.47	ab	0.197	a	112.8	ab
Hall 150 x 3, Decis x 3	3466	a	28.87	ab	0.233	a	121.8	ab
Exp 1	3695	a	33.38	ab	0.294	a	112.2	ab
Untreated	3409	a	34.37	b	0.875	b	99.8	a
F-prob	0.831		0.275		<0.001		0.364	
SED	317.4		3.406		0.1324		11.16	
LSD (95%)	666.7		7.157		0.2781		23.45	
df	18		18		18		18	

Table 5b. The total weight, mean weight, total root count and mean damage score of carrot roots harvested on 16 January 2007. Means followed by the same letter are not significantly different (p<0.05).

	Assessment 2							
Treatment	Total Weight		Mean Weight		Mean Damage Score		Total Root Count	
Hall 100 x 4	3706	a	32.75	a	0.324	a	113.5	a
Hall 100 x 4 (10 di), Decis x 3	3754	a	36.97	a	0.415	a	104.5	a
Hall 100 x 4, Decis x 2	4259	a	34.93	a	0.339	a	124.2	a
Hall 150 x 4	3716	a	30.85	a	0.361	a	120.5	a
Hall 150 x 3, Decis x 3	3647	a	33.17	a	0.259	a	113.0	a
Exp 1	3928	a	35.17	a	0.301	a	111.2	a
Untreated	3804	a	35.14	a	1.037	b	110.8	a
F-prob	0.607		0.783		<0.001		0.819	
SED	338.1		3.94		0.1127		13.46	
LSD (95%)	710.2		8.28		0.2368		28.27	
df	18		18		18		18	

Figure 3. The mean damage score of carrot roots harvested 23 October 2006 (Assessment 1) and 16 January 2007 (Assessment 2). Hall = Hallmark with Zeon Technology and Decis = Decis Protech.



An angular transformation was applied to the proportion of roots in each damage category to improve the assumption of homogeneity of variance and the results are presented in Tables 6a (Assessment 1) and 6b (Assessment 2). There was not enough non-zero data for the proportion of seedlings with 25-50% and more than 50% damage to be analysed for both assessments. The means in italics represent the back-transformed means on the original scale. The cumulative proportions of roots damaged have also been analysed, but no data transformations were needed and the results are also summarised in Tables 6a and 6b.

For both assessments, the insecticide-free plots (Treatment 7) appear to have significantly fewer roots with no damage and significantly more roots with more than 5% damage. There was no statistically significant difference between any of the treated plots. Figure 4 shows the percentage of carrot roots with >5% damage harvested on 23 October 2006 (Assessment 1) and 16 January 2007 (Assessment 2).

Table 6a. The proportion of roots in each damage category and the cumulative proportion of roots in damage categories on the first assessment date (23 October 2006). Back-transformed means are shown in italics. Means followed by the same letter are not significantly different ($p<0.05$).

	Assessment 1								
Treatment	No Damage			<5%			5-10%		
Hall 100 x 4	5.276	b	*0.846*	1.928	a	*0.113*	0.874	a	*0.023*
Hall 100 x 4 (10 di), Decis x 3	5.203	b	*0.822*	1.908	a	*0.111*	0.831	a	*0.021*
Hall 100 x 4, Decis x 2	5.165	b	*0.811*	2.192	a	*0.146*	0.810	a	*0.020*
Hall 150 x 4	5.288	b	*0.849*	1.841	a	*0.103*	0.938	a	*0.027*
Hall 150 x 3, Decis x 3	5.189	b	*0.818*	2.113	a	*0.136*	0.821	a	*0.021*
Exp 1	5.074	b	*0.782*	2.111	a	*0.136*	1.167	a	*0.042*
Untreated	4.043	a	*0.497*	2.780	b	*0.235*	1.984	b	*0.120*
F-prob	0.001			0.032			0.001		
SED	0.2546			0.2579			0.2422		
LSD	0.5350			0.5418			0.5089		
df	18			18			18		

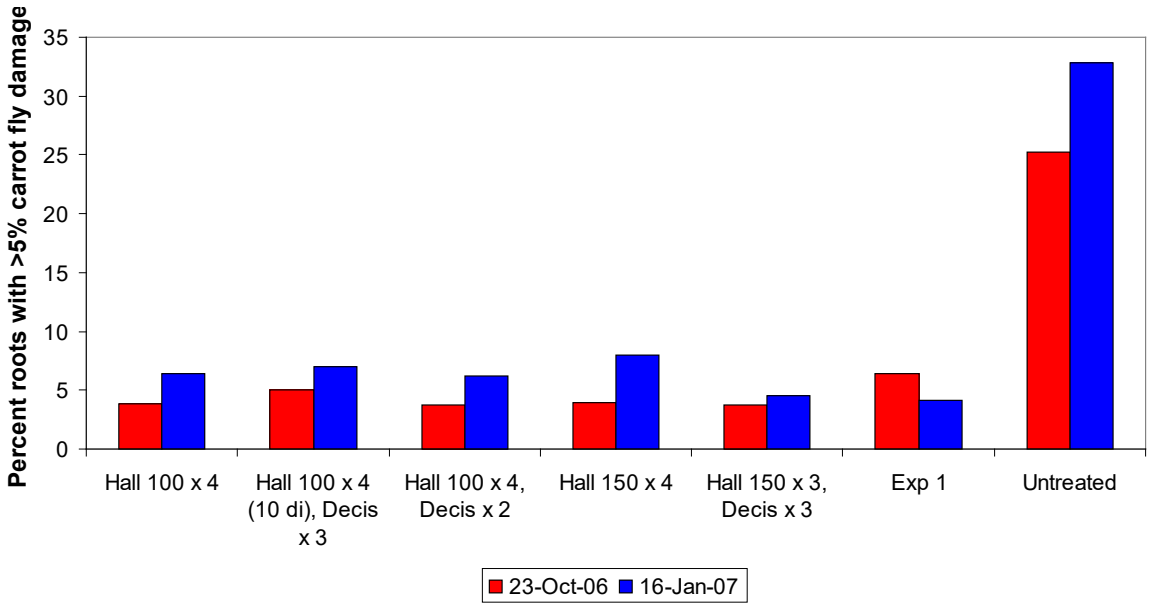
	Assessment 1								
Treatment	10-25%			No damage + <5%			<10%		
Hall 100 x 4	0.520	a	*0.008*	0.962	b		0.987	b	
Hall 100 x 4 (10 di), Decis x 3	0.856	a	*0.022*	0.950	b		0.974	b	
Hall 100 x 4, Decis x 2	0.379	a	*0.004*	0.963	b		0.990	b	
Hall 150 x 4	0.253	a	*0.002*	0.961	b		0.992	b	
Hall 150 x 3, Decis x 3	0.674	a	*0.014*	0.963	b		0.984	b	
Exp 1	0.517	a	*0.008*	0.936	b		0.983	b	
Untreated	1.911	b	*0.111*	0.748	a		0.872	a	
F-prob	0.004			<0.001			0.004		
SED	0.3586			0.0416			0.0276		
LSD	0.7534			0.0874			0.0580		
df	18			18			18		

Table 6b. The proportion of roots in each damage category and the cumulative proportion of roots in damage categories on the second assessment date (16 January 2007). Back-transformed means are shown in italics. Means followed by the same letter are not significantly different (p<0.05).

	Assessment 2								
Treatment	No Damage			<5%			5-10%		
Hall 100 x 4	5.016	b	*0.765*	2.365	a	*0.170*	1.133	a	*0.039*
Hall 100 x 4 (10 di), Decis x 3	4.770	b	*0.692*	2.783	a	*0.236*	0.885	a	*0.024*
Hall 100 x 4, Decis x 2	4.951	b	*0.745*	2.510	a	*0.192*	1.127	a	*0.039*
Hall 150 x 4	4.952	b	*0.745*	2.331	a	*0.165*	1.286	a	*0.050*
Hall 150 x 3, Decis x 3	5.113	b	*0.794*	2.271	a	*0.157*	1.001	a	*0.031*
Exp 1	4.981	b	*0.754*	2.563	a	*0.200*	0.909	a	*0.025*
Untreated	3.842	a	*0.449*	2.664	a	*0.216*	2.363	b	*0.170*
F-prob	<0.001			0.400			<0.001		
SED	0.1986			0.2524			0.2791		
LSD	0.4173			0.5304			0.5863		
df	18			18			18		

	Assessment 2								
Treatment	10-25%			No damage + <5%			<10%		
Hall 100 x 4	0.867	ab	*0.023*	0.936	b		0.975	b	
Hall 100 x 4 (10 di), Decis x 3	1.094	b	*0.036*	0.930	b		0.963	b	
Hall 100 x 4, Decis x 2	0.784	ab	*0.019*	0.938	b		0.978	b	
Hall 150 x 4	0.941	ab	*0.027*	0.920	b		0.972	b	
Hall 150 x 3, Decis x 3	0.376	a	*0.004*	0.955	b		0.991	b	
Exp 1	0.350	a	*0.004*	0.959	b		0.985	b	
Untreated	2.120	c	*0.137*	0.672	a		0.845	a	
F-prob	<0.001			<0.001			<0.001		
SED	0.3071			0.0428			0.0258		
LSD	0.6452			0.0899			0.0543		
df	18			18			18		

Figure 4. The percentage of carrot roots with >5% damage harvested on 23 October 2006 (Assessment 1) and 16 January 2007 (Assessment 2). Hall = Hallmark with Zeon Technology and Decis = Decis Protech.



Discussion

All of the treatment programmes reduced damage considerably compared with the insecticide-free control treatment. There was no evidence of any dose effect with Hallmark with Zeon Technology in this trial. However, based on their own data, Syngenta insecticide specialists believe that the 150 ml dose is generally more effective than 100 ml (Michael Tait, Syngenta, personal communication). Extending the spray programme with Decis Protech appeared to offer no additional control and the experimental product (Exp 1) did not increase control compared with Hallmark with Zeon Technology.

Obviously, with a maximum limit of four applications of Hallmark with Zeon Technology, the timing of treatments is more critical than with the six applications allowed previously. In this trial, four sprays applied at 2-weekly intervals from 26 July to 5 September covered the main period of second generation carrot fly activity (Figure 2).

Interestingly, none of the treatments provided complete control of carrot fly. This may well be due to a combination of the relatively high carrot fly pressure and the design of the small plot trial. With this small plot design, there were insecticide-free areas amongst the treated areas, which could have allowed carrot fly to move within the experimental area without accumulating a toxic dose of insecticide, thus increasing the 'pool' of carrot fly compared with a plot or crop which had been treated throughout.

CONCLUSIONS

- This initial study suggests that the total dose of Hallmark with Zeon Technology can be safely reduced to 450 ml product/ha, as specified by PSD, without a significant loss of carrot fly control as long as sprays are timed to coincide with the peak activity period of the second generation of carrot fly. In this trial, four sprays applied at 2-weekly intervals from 26 July to 5 September covered the main period of second generation carrot fly activity. There was no apparent benefit from applying additional treatments (of Decis Protech) after 5 September.

TECHNOLOGY TRANSFER

Date	
25 January 2007	Presentation at an HDC meeting for the carrot industry, PGRO, Peterborough
Deadline 1 March 2007	Article for HDC News

ACKNOWLEDGEMENTS

We thank the HDC for funding this work, Andrew Mead for designing the trial, Marian Elliott for collecting some of the data, Carole Wright for the statistical analysis and David Martin and Michael Tait for their advice .

