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SID 5 Research Project Final Report

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Project identification

1. Defra Project code: HH3116TFV
2. Project title: Thrips control on outdoor alllium crops
3. Contractor organisation(s): University of Warwick, WarwickHRI, Wellesbourne, Warwick, CV35 9EF
4. Total Defra project costs (agreed fixed price): £ 111,767
5. Project: start date .... 01 January 2004
   end date .... 31 December 2006

6. It is Defra's intention to publish this form.
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Executive Summary

7. The executive summary must not exceed 2 sides in total of A4 and should be understandable to the intelligent non-scientist. It should cover the main objectives, methods and findings of the research, together with any other significant events and options for new work.

Onion thrips (*Thrips tabaci*) is the most important pest of the 2,000 ha of leek grown in the UK. Thrips may also attack other *Allium* crops, particularly salad onion. Large populations of thrips can develop, causing blemishes to the leaves, which reduce quality and may make the crop unmarketable. In 2003, approximately 83% of the area of *Allium* crops treated with insecticides/nematicides in the UK was treated for thrips and the pyrethroid insecticide, deltamethrin, was the main insecticide used. However, there is evidence that thrips cannot be controlled effectively with deltamethrin and insecticide resistance to pyrethroid insecticides in field populations of *T. tabaci* was confirmed by scientists at Rothamsted Research in 2006.

The purpose of this project was to develop an IPM strategy, to include the use of the novel insecticides such as spinosad (Tracer), but supported where possible by non-insecticidal techniques. The objectives of the project were to:

1. Evaluate a day-degree forecast and 'action' threshold for timing spray applications.
2. Determine the efficacy and persistence of 'new' insecticides applied as foliar sprays and the impact of applying sprays in sugar solutions, with sugar products or other spray adjuvants.
3. Determine the efficacy and persistence of potential insecticide seed treatments, so that foliar spray treatments can be targeted subsequently.
4. Evaluate the use of entomopathogenic nematodes as part of an integrated programme.
5. Develop an integrated programme for thrips control on leek

During 2004-2006, thrips numbers were monitored in plots of insecticide-free leek at Warwick HRI, Wellesbourne, Warwickshire and in 10 commercial leek crops in central England (Objective 1). Thrips were monitored at a smaller number of locations in 2006. Adult thrips were monitored using blue sticky traps and adult and larval thrips were monitored on plants taken from an insecticide-free area in each crop.

Thrips numbers on plants were followed through a full year at Wellesbourne. The numbers of thrips larvae declined during late autumn and no larval thrips were present during the main winter period. At about the end of April, the thrips that had overwintered laid eggs, which hatched into larvae. These larvae completed their development and then dispersed to other crops at the beginning of June.

Thrips flight activity appeared to follow a similar pattern in commercial crops within a region and, to a certain extent, between regions, each year, but the overall pattern of activity varied between years. Peak numbers of thrips were captured usually during July-August, whilst the numbers of thrips on plants often peaked in late August-September. In many cases, adult thrips were captured on sticky traps before thrips were found on plants, indicating that traps could be used to provide an early warning of colonisation by thrips. The numbers of thrips captured did not vary greatly between sites and years. However, the maximum numbers of thrips per plant varied approximately 100-fold. Overall, there seems to be little opportunity to use the numbers of thrips captured on traps to predict infestation levels on plants.

The dates when clear peaks in the numbers of thrips on sticky traps occurred were identified. More peaks were evident in 2005 than 2004 and at the sites where thrips flight activity was monitored in 2006, there appeared to be only one peak. For the data collected in 2004 and 2005, accumulated day-degrees above a threshold temperature of 11.5^{o}C (a threshold determined in a North American study) were used to compare peaks of thrips activity in relation to 'physiological time'. Where clear peaks were present, they occurred at approximately the same 'time' in all regions. However, the 'timing' of first activity, and also the first peak, differed between years. Thus, it seems that it may be difficult to predict accurately the timing of peaks in thrips numbers using accumulated day-degrees. Although the phenology of thrips populations is undoubtedly temperature-driven it is likely that reproduction over a period of time, combined with intra-specific variation in development times may be blurring the separation between generations.

Insecticide spray (Objectives 2 & 3) and seed (Objective 3) treatments were evaluated in replicated plot trials at Wellesbourne in 2004 and 2005. In both years, leek plants were grown in modules and transplanted in early June. Up to four sprays were applied to each treatment during mid July – early September. In 2004, spray treatments using Tracer (spinosad), Dursban (chlorpyrifos) and two experimental products were more effective than three pyrethroid insecticide treatments, which provided no control. The addition of sugar or Majestik to the Tracer treatment did not improve control. In 2005, three seed treatments (imidacloprid, two coded treatments) and six insecticides applied as foliar sprays were evaluated. The insecticide sprays included some of the best treatments from the 2004 trial and two novel compounds, plus a pyrethroid (Hallmark with Zeon Technology – lambda-cyhalothrin). As in 2004, Tracer reduced thrips damage compared with the insecticide-free control treatment whilst Hallmark with Zeon Technology did not. Only one of the four other spray treatments appeared to provide thrips control. All three seed treatments provided a reasonable level of thrips control for several weeks after planting. Since the study at Rothamsted Research showed that samples of *T. tabaci* from commercial allium crops in the UK were highly resistant to the pyrethroid insecticide deltamethrin, pyrethroid insecticides are unlikely to provide effective thrips control and, since they are also likely to harm beneficial insects, their use for thrips control should be avoided.

Foliar sprays containing nematodes (*Steinernema feltiae*) were applied to small plots of leek at 100,000 nematodes per m^2 (Objective 4). The nematodes survived in the pools of water at the base of each leaf and the stem. Assessments indicated that significant numbers of nematodes survived for up to five days and that they appeared to do so for longest in the absence of wetter (Silwet l-77). In 2005, nematodes were applied to leek in a plot trial in a commercial crop in the Thames Valley. None of the treatments reduced thrips numbers compared with the water-only control treatment. However, thrips numbers were relatively low. Finally, in 2006, nematode treatments were applied to replicate plots within a larger insecticide trial at Warwick HRI. The application of nematodes did not reduce the numbers of thrips adults and larvae.

In 2006, treatment strategies (Objective 5) were designed to evaluate, in particular, the importance of early thrips control on subsequent damage. These were evaluated in a replicated plot trial at Wellesbourne and two unreplicated demonstration trials at commercial sites. Leek seed was direct-drilled in all three locations. At Wellesbourne, the seed used for two of the treatments was film-coated with imidacloprid (Gaucho). The remaining seed was insecticide-free. At the time of the first assessment, on 27 June, the plants had already suffered damage and plants grown from the seed treated with Gaucho were less damaged than those grown from insecticide-free seed. Over the next few weeks there were few differences between treatments, but, by September, all the plants treated with insecticide were less damaged than the insecticide-free plants. However, the use of a seed treatment prior to the application of sprays appeared to confer no additional advantage with respect to thrips damage at this time.

In the demonstration trials, the programmes consisted of treatments approved currently in the UK. Thrips damage increased appreciably at both sites from the middle of August onwards until mid/late September, when observations stopped. From mid August, two weeks after the application of the third set of sprays, there was more damage on the unsprayed (water only) plots than there was on the sprayed ones, although differences between the treatments were small. Additional treatments applied late in the season reduced damage slightly at both sites.

The project was discussed at seven meetings for growers and agronomists and the project team provided written updates on the project for meetings of the R & D Committees of the Leek Growers Association and the British Onion Producers Association. Representatives of both groups formed the project steering group. Information about the project has been posted on the Warwick HRI website and monitoring information has been available on the HDC Pest Bulletin Website. The network of growers participating in the project provided Rothamsted Research with sites at which to sample *T. tabaci* populations to assess their susceptibility to pyrethroid insecticides. Contact through this project with the Leek Growers Association and British Onion Producers Association R & D Committees have led to the HDC funding a small project in 2006 on the diurnal periodicity of thrips activity in leek crops.

In terms of future research, there is a continuing need to evaluate new insecticides for their efficacy against *T. tabaci*, both as foliar sprays and seed treatments. The population dynamics of *T. tabaci* in the UK is still poorly understood and more detailed experiments are required to determine the temperature requirements (including threshold temperatures) for thrips development, reproduction and flight. In particular, it is important to determine whether the period in July-August when the largest numbers of thrips are captured on sticky traps is the most significant period of migration and therefore whether the most effective control measures should be targeted at this time. A better understanding of thrips overwintering sites and of the pattern of dispersal from these sites would help to identify crops that are particularly at risk from thrips infestation. Experiments should be done to determine whether entomopathogenic nematodes are effective against *T. tabaci* pupae in the soil. Finally, identification of sources of resistance in host plants that could be bred into new varieties would reduce the need for insecticidal control.

Project Report to Defra

8. As a guide this report should be no longer than 20 sides of A4. This report is to provide Defra with details of the outputs of the research project for internal purposes; to meet the terms of the contract; and to allow Defra to publish details of the outputs to meet Environmental Information Regulation or Freedom of Information obligations. This short report to Defra does not preclude contractors from also seeking to publish a full, formal scientific report/paper in an appropriate scientific or other journal/publication. Indeed, Defra actively encourages such publications as part of the contract terms. The report to Defra should include:
   - the scientific objectives as set out in the contract;
   - the extent to which the objectives set out in the contract have been met;
   - details of methods used and the results obtained, including statistical analysis (if appropriate);
   - a discussion of the results and their reliability;
   - the main implications of the findings;
   - possible future work; and
   - any action resulting from the research (e.g. IP, Knowledge Transfer).

<u>Introduction</u>

Onion thrips (*Thrips tabaci*) is the most important pest of the 2,000 ha of leek grown in the UK. Thrips may also attack other *Allium* crops, particularly salad onion, and the incidence of thrips damage in onion crops may be increasing. Large populations of thrips can develop, causing blemishes to the leaves, which reduce quality and may make the crop unmarketable. In 2003, approximately 83% of the area of *Allium* crops treated with insecticides/nematicides in the UK was treated for thrips and the pyrethroid insecticide, deltamethrin, was the main insecticide used (Garthwaite *et al.*, 2004). However, there is evidence that thrips cannot be controlled effectively with deltamethrin and thrips damage invariably reduces crop quality. There is also circumstantial evidence that pyrethroids may sometimes exacerbate control problems in Allium crops, possibly by reducing the impact of natural enemies.

There are several reasons for poor insecticidal control of thrips on leeks. They include:

1) a lack of effective insecticides
2) inaccessibility of thrips adults and larvae to insecticides when they are hidden within the leaves of a plant
3) inaccessibility of the egg and pre-pupal/pupal stages to insecticides
4) poor timing of treatments, often due to the difficulties of seeing and identifying such small insects.

The novel insecticide spinosad (Tracer) is effective against thrips and was approved for use on leek crops during the life of this project. However, there is a risk of insecticide resistance developing if Tracer is used intensively and exclusively. Several non-insecticidal methods of thrips control have been evaluated elsewhere, including undersowing, targeted irrigation and biological control with predators, entomopathogenic fungi or nematodes. Some of these techniques may be viable for UK production systems. The timing of treatments could certainly be improved and there is the opportunity to evaluate a day-degree forecast developed in North America (Edelson & Magaro, 1988) and used in France and Belgium.

The purpose of this project was to develop an IPM strategy, to include the use of the novel insecticides such as spinosad, but supported where possible by non-insecticidal techniques. The objectives of the project were to:

1. Evaluate a day-degree forecast and ‘action’ threshold for timing spray applications.
2. Determine the efficacy and persistence of ‘new’ insecticides applied as foliar sprays and the impact of applying sprays in sugar solutions, with sugar products or other spray adjuvants.
3. Determine the efficacy and persistence of potential insecticide seed treatments, so that foliar spray treatments can be targeted subsequently.
4. Evaluate the use of entomopathogenic nematodes as part of an integrated programme.
5. Develop an integrated programme for thrips control on leek

1. Evaluate a day-degree forecast and 'action' threshold for timing spray applications.

During 2004-2006, thrips numbers were monitored in plots of insecticide-free leek at Warwick HRI, Wellesbourne and in 10 commercial leek crops in central England.

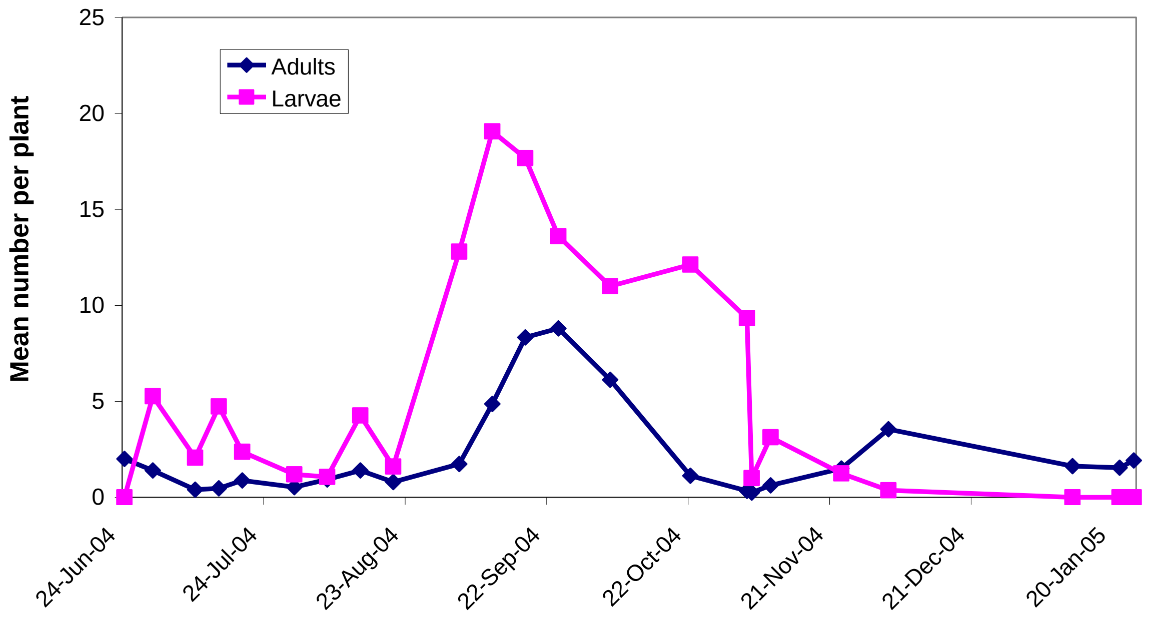
At Wellesbourne, leek plants cv Shelton were grown in modules and transplanted on 9 June 2004 and 16 June 2005. In 2006, cv Shelton seed was direct-drilled on 5 May. The plot was 8 beds (1.83 m width) wide and 15 m long and each bed contained 4 rows of leek plants. Samples of 10-20 leeks were removed from the plot at regular intervals (usually weekly), taken to the laboratory and sampled destructively to record the numbers of adult and larval thrips.

The monitoring sites in commercial crops were located in central England (Cambridgeshire, Lincolnshire, Nottinghamshire, and Worcestershire). In 2004 and 2005, thrips were monitored in five localities and two crops were monitored in each locality in order to obtain information on variation within and between localities. In 2006, thrips were monitored at two sites only (Cambridgeshire, Worcestershire). Adult thrips were monitored using blue sticky traps (Ecospray). Three traps were placed in each crop in late spring and traps were replaced every week until at least September. As far as possible, the thrips captured were separated into *Thrips tabaci* and other thrips species. Adult and larval thrips were monitored on plants by taking 10-20 plants from an insecticide-free area in each crop. The plants were either taken or posted to a laboratory where they were sampled destructively to count the numbers of thrips on each plant.

Weather data (daily records of maximum and minimum air temperatures) were obtained from meteorological stations that were as close as possible to each monitoring site.

<u>Thrips populations at Wellesbourne, Warwickshire</u>
Thrips numbers on the insecticide-free plots at Wellesbourne are shown in Figures 1-3 for plots planted in 2004, 2005 and 2006 respectively.

Figure 1. The numbers of adult and larval *Thrips tabaci* on leek plants at Warwick HRI, Wellesbourne in 2004-5.



In all years, thrips colonised the crops soon after planting, but their numbers did not increase dramatically until late August each year. The numbers of thrips larvae declined during late autumn and no larval thrips were present during the main winter period.

During the winter of 2005-6, the numbers of adult thrips declined gradually (Figure 2). Although their numbers appeared to fluctuate between sampling occasions, this was probably due to sample variation, as the total number of thrips varied considerably from plant to plant and the sample size (10-20 plants) was relatively small. Towards the end of April 2006, the thrips that had overwintered laid eggs, which hatched into larvae. These larvae completed their development on the plot and then dispersed to other crops at the beginning of June.

Figure 2. The numbers of adult and larval *Thrips tabaci* on leek plants at Warwick HRI, Wellesbourne in 2005-6.

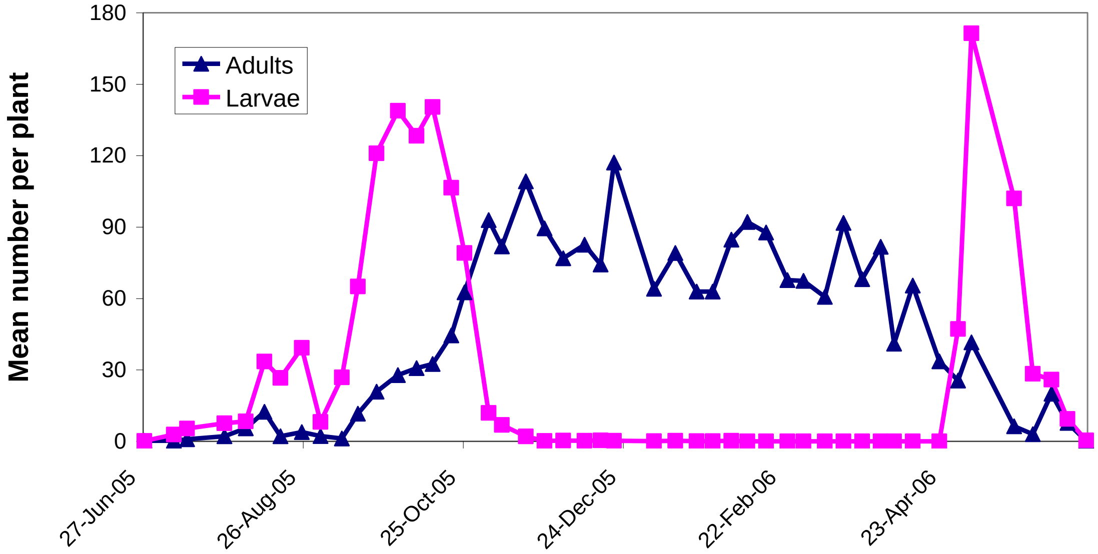
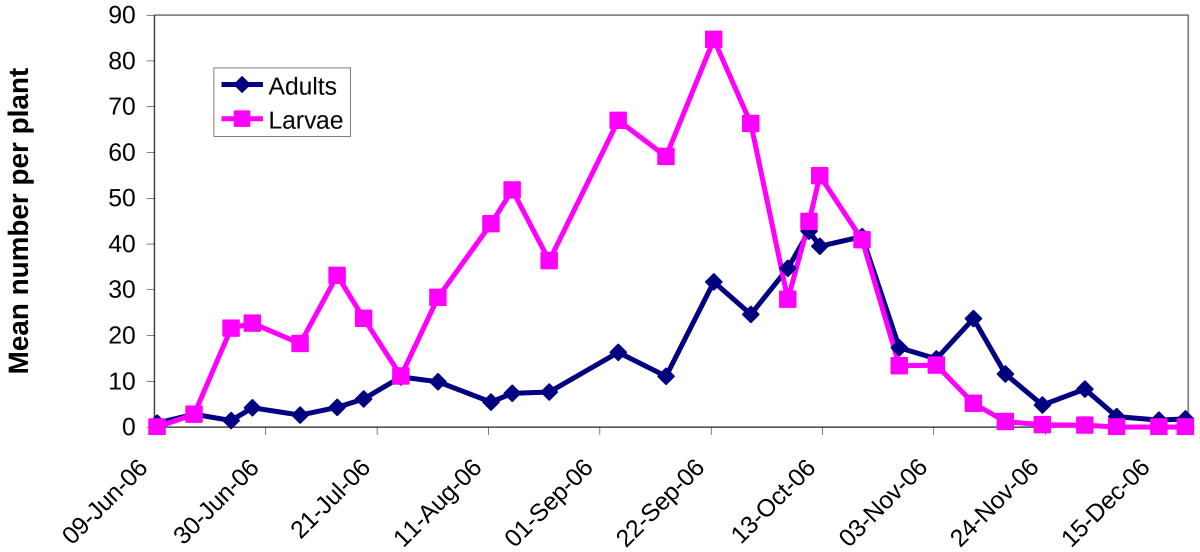


Figure 3. The numbers of adult and larval *Thrips tabaci* on leek plants at Warwick HRI, Wellesbourne in 2006.



Thrips populations in commercial crops

The sticky traps captured several species of thrips and attempts were made in 2004 to separate the catches into *T. tabaci* and other thrips species. On this basis, 89-98% of the thrips captured at each site were *T. tabaci.*

Thrips flight activity appeared to follow a similar pattern at sites within a region (Figure 4) and, to a certain extent, between regions, each year, but the overall pattern of activity varied between years (Figure 5). However, peak numbers of thrips were captured usually during July-August, whilst the numbers of thrips on plants often peaked in late August-September (Figures 1, 2, 3 and 6). In many cases, adult thrips were captured on sticky traps before thrips were found on plants, indicating that trap captures could be used to provide an early warning of thrips colonisation. The numbers of thrips captured did not vary greatly between sites and years (peak numbers ranged from approximately 140-1800 – but 85% of sites were in the range 100-500 thrips per trap per week). However, the maximum numbers of thrips per plant varied 100-fold (from 1 – 110). Overall, there seems to be little opportunity to use the numbers of thrips captured on traps to predict infestation levels on plants.

Figure 4. The numbers of adult thrips captured on sticky traps in four commercial crops in Cambridgeshire in 2005.

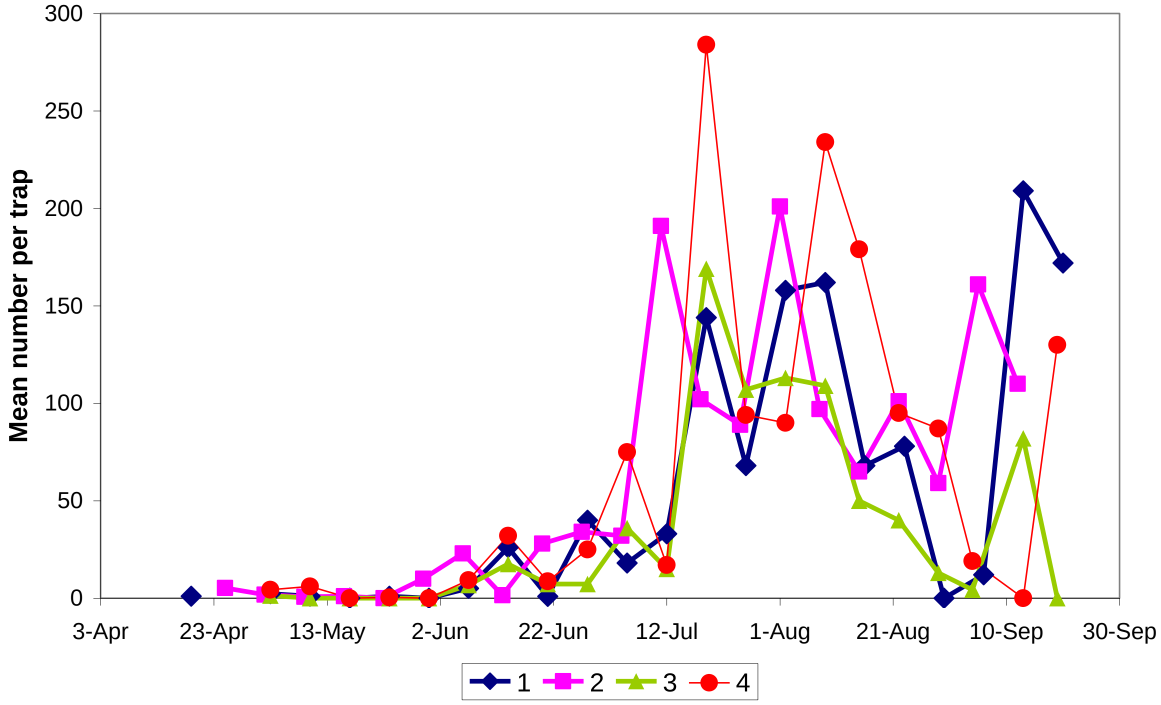


Figure 5. The numbers of adult thrips captured on sticky traps in Cambridgeshire in 2004-6 (data averaged over sites each year).

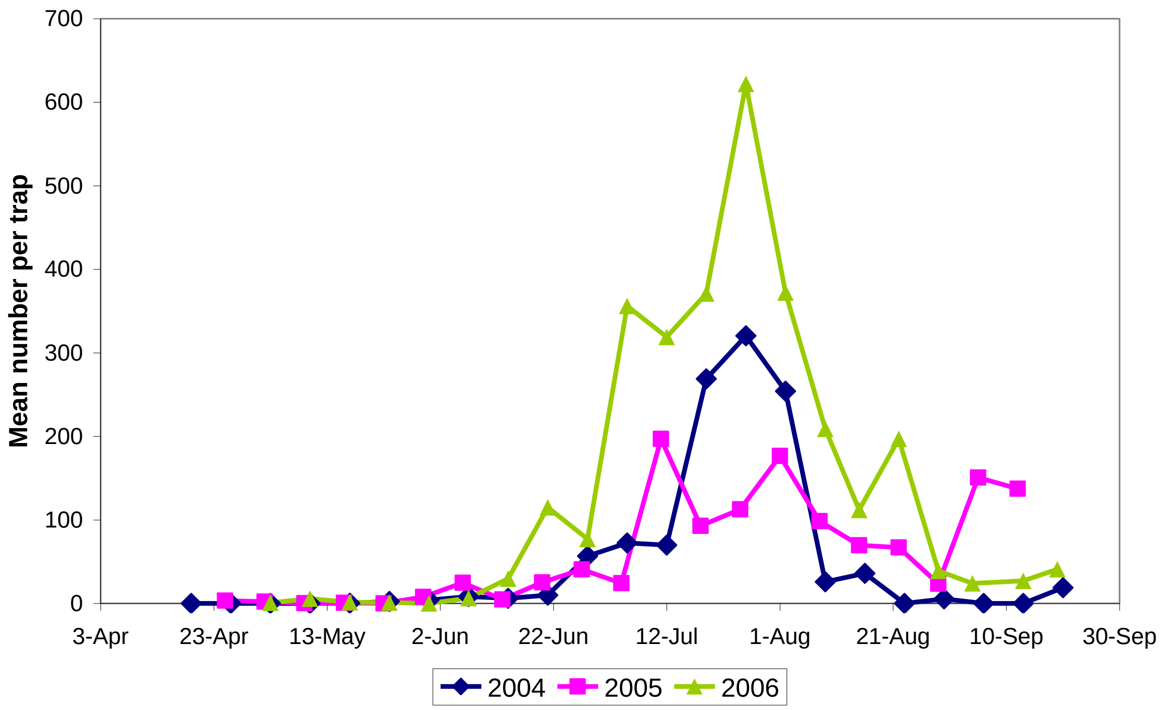
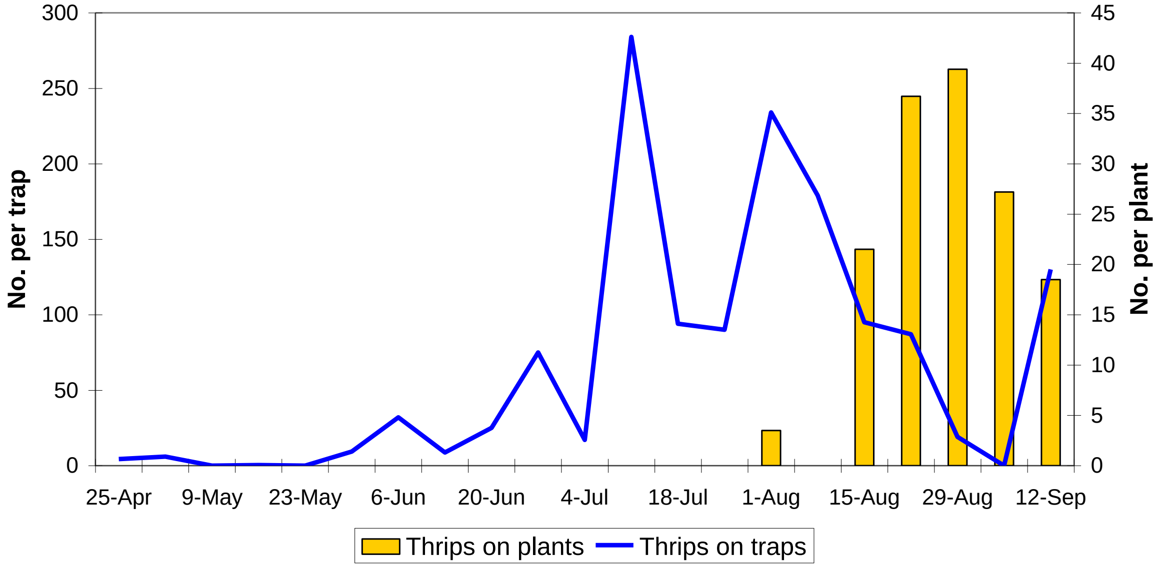


Figure 6. The numbers of thrips captured on sticky traps and adult and larval thrips found on insecticide-free leek plants at one site in Cambridgeshire in 2005.



<u>Comparisons with day-degree sums</u>

The dates in 2004 and 2005 when clear peaks in the numbers of thrips on sticky traps occurred were identified and used to calculate day-degree sums from 1 January each year. Day-degrees were accumulated above a base temperature of 11.5ºC (Edelson & Magaro, 1988). Table 1 shows the day-degree sums accumulated to first activity and to the several peaks of activity in 2004 and 2005. First activity was taken as the date when more than 1 thrips per trap per week was captured.

More 'peaks' were evident in 2005 than 2004. Where clear peaks were present, they occurred at approximately the same 'time' in all regions. The 'timing' of first activity, and also the first peak, differed between years. However, the one consistent factor was that there were approximately 100 day-degrees between successive peaks.

Table 1. Accumulated day-degrees (base 11.5ºC) from 1 January to periods of peak thrips flight activity in 2004 and 2005. Missing data indicate that no clear peak was distinguishable. First = date when more than 1 thrips per trap per week was captured.

2004	**First**	**Peak 1**	**Peak 2**	**Peak 3**			
Cambridgeshire	128	245	341				
Cambridgeshire	96	245	303				
Cambridgeshire	79	219	341				
Cambridgeshire	96	219	341				
Nottinghamshire	82		349				
Nottinghamshire	82		309	465			
Lincolnshire	141			381			
Lincolnshire	66		294				
Worcestershire	93	197	346	441			
Worcestershire	117	251	385				
Mean	**98**	**229**	**334**	**429**			

2005	First	Peak 1	Peak 2	Peak 3	Peak 4	Peak 5	Peak 6
Cambridgeshire	26	100	165	277	387		578
Cambridgeshire	26	100	205	277	387	492	578
Cambridgeshire	26	100	205	277			578
Cambridgeshire	26	100	205	277	387		
Nottinghamshire	36		204	334	415		568
Nottinghamshire	36			334	415		568
Lincolnshire	24	110		279	387	493	
Lincolnshire	24		242	334		493	
Worcestershire	53	130	240	320			
Worcestershire	53	130	240	320	444	561	649
Mean	**33**	**110**	**213**	**303**	**403**	**510**	**587**

2. Determine the efficacy and persistence of 'new' insecticides applied as foliar sprays and the impact of applying sprays in sugar solutions, with sugar products or other spray adjuvants.

The aim of the first trial, in 2004, was to compare insecticide treatments applied as foliar sprays. The insecticides were provided by a number of companies. The trial was located in the experimental area at Wellesbourne, close to a plot of insecticide-free leeks which were left over the winter 2003-4 to provide a source of thrips.

The new leeks (cv Shelton) were grown in modules in a greenhouse and transplanted on 9 June 2004. There were 10 treatments and each treatment was replicated 4 times. The treatments were arranged in a randomised design. Each plot was 6 m x 2 beds (1.83 m each) in size. The leeks were transplanted at a spacing of 8 per metre with 4 rows (30 cm spacing) per bed. The insecticide spray treatments were applied at a rate of 200 l per ha using O2F110 110° flat fan nozzles. Table 2 summarises the treatments applied.

Table 2. Treatments applied as foliar sprays in 2004. Exp = experimental product.

Product	Active ingredient	Rate (product)
Dursban WG	Chlorpyrifos	1.0 kg per ha
Decis	Deltamethrin	300 ml per ha
Hallmark with Zeon Technology	Lambda-cyhalothrin	100ml per ha
Tracer	Spinosad	200 ml per ha
Tracer + Majestik	Spinosad	200 ml per ha for Tracer, 5 l per ha Majestik
Tracer + sugar	Spinosad	200 ml per ha for Tracer, 200 g per ha for sugar
Exp A + Phase II		1 kg per ha
Exp C		200 ml per ha
Exp D		2 kg per ha
Insecticide-free control		

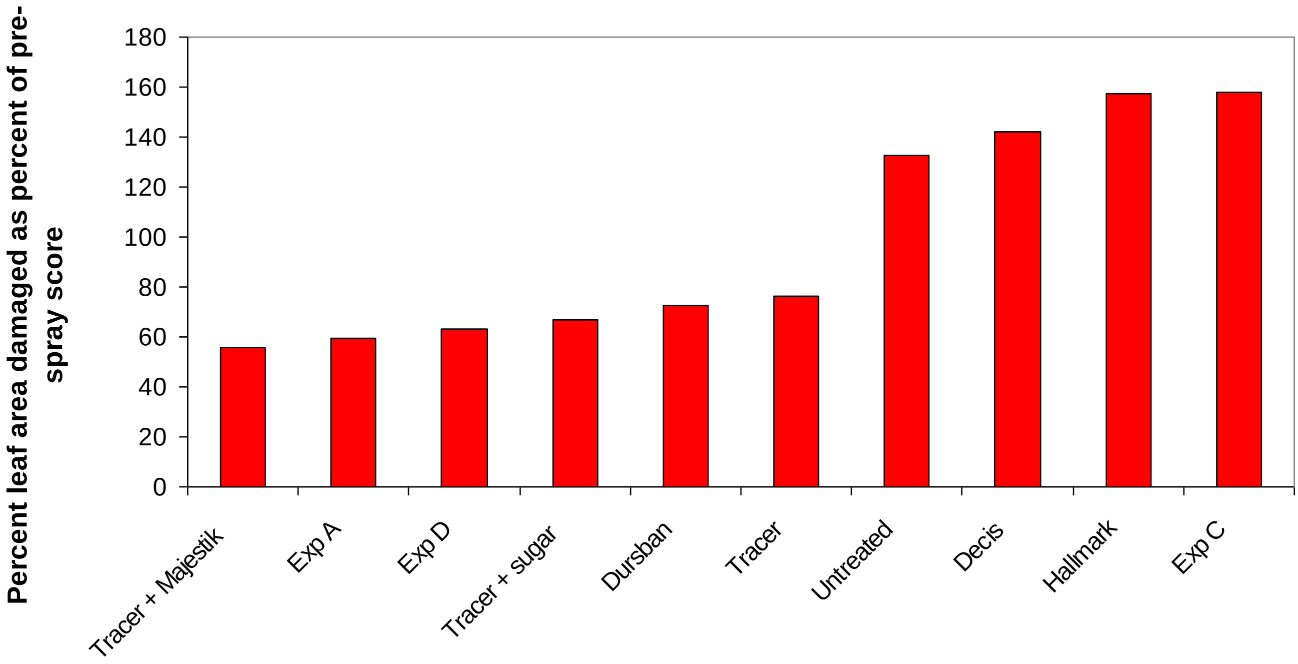
Thrips numbers increased very slowly, but a decision was made to apply the first spray on 20 July. On the day before the first spray was applied, damage was assessed in each plot. This was done by examining the leaves of 10 marked plants in each plot and assessing the percentage of the surface area of each leaf affected by thrips. Sprays were applied on 20 July, 30 July, 11 August and 1 September. Thrips numbers increased considerably in late August-September and this was reflected in damage levels (Table 3). The plots were assessed on five occasions, usually a week after spray application. The final assessment was made 2 weeks after the last spray application.

Thrips damage levels following treatment were compared with the pre-spray assessment. The Tracer treatments, Dursban, Exp A and Exp D reduced damage as the plants grew and were more effective than the three pyrethroid treatments (Decis, Hallmark with Zeon Technology, Exp C), which were no different from the insecticide-free control. The addition of sugar or Majestik to the Tracer treatments did not appear to improve efficacy.

Table 3. Effect of insecticide treatments applied as foliar sprays on thrips damage to leek at Warwick HRI, Wellesbourne in 2004. The values given are the percentage leaf area damaged as a percentage of the pre-spray damage score.

	Sampling date				
	27-Jul	**06-Aug**	**19-Aug**	**09-Sep**	**16-Sep**
Decis	107.40	100.50	105.40	98.90	142.20
Dursban	108.90	81.90	82.30	60.30	72.40
Exp A	101.00	81.80	58.10	47.00	59.70
Exp C	93.50	93.90	100.50	103.20	158.10
Exp D	90.80	77.70	63.80	56.70	63.20
Hallmark with Zeon Technology	113.20	110.00	112.10	111.50	157.40
Tracer	115.10	93.90	86.80	55.80	76.10
Tracer + Majestik	104.40	89.30	65.80	47.20	55.90
Tracer + sugar	93.80	94.50	68.20	48.20	66.70
Untreated	112.70	122.90	101.40	85.90	132.60
df	*23.00*	*23.00*	*23.00*	*23.00*	*23.00*
Fpr	*0.66*	*0.17*	*0.01*	*<0.001*	*<0.001*
SED	*14.77*	*15.49*	*14.58*	*11.55*	*19.01*
t	*2.07*	*2.07*	*2.07*	*2.07*	*2.07*
LSD (p<0.05)	*30.56*	*32.05*	*30.17*	*23.90*	*39.33*

Figure 7. Effect of insecticide treatments applied as foliar sprays on thrips damage to leek at Warwick HRI, Wellesbourne on 16 September 2004. The values given are the percentage leaf area damaged as a percentage of the pre-spray damage score.



3. Determine the efficacy and persistence of potential insecticide seed treatments, so that foliar spray treatments can be targeted subsequently.

The aim of the second insecticide trial at Warwick HRI, in 2005, was to compare insecticide treatments applied to leek as seed treatments or foliar sprays. There were 40 plots altogether (10 treatments x 4 replicates) and these were used to evaluate three seed treatments (imidacloprid, two coded treatments) and six insecticides applied as foliar sprays. The tenth treatment was the insecticide-free control. The insecticide sprays included some of the best treatments from the 2004 trial and two novel compounds, plus a pyrethroid (Hallmark with Zeon Technology). The leeks were grown in modules in a greenhouse and transplanted on 16-17 June 2005 at a spacing of 8 per metre, 4 rows per bed. Plots were 6 m x 2 beds (1.83 m each) in size. The seed treatments and insecticide-free control plots were assessed regularly for thrips damage after planting.

Table 4. Seed treatments or treatments applied as foliar sprays in 2005. Exp = experimental product.

Product	**Active ingredient**	**Rate (product)**
Gaucho	Imidacloprid	50 g a.i. per 250,000 seeds
Exp F		50 g a.i. per 250,000 seeds
Exp T		50 g a.i. per 250,000 seeds
Exp A + Phase II		1000 ml per ha
Exp L		500 ml per ha
Exp T		400 g per ha
Exp U		480 ml per ha
Hallmark with Zeon Technology	Lambda-cyhalothrin	100ml per ha
Tracer	Spinosad	200 ml per ha
Insecticide-free control	Untreated	

The first spray treatments were applied on 14 July and three subsequent sprays were applied on 29 July, 9 August and 23 August. Assessments were made before spraying (27 June, 8 July (seed treatments only), 13 July) and a week after each spray was applied. A final assessment was made 3 weeks after the last spray was applied. Thrips numbers were low during July and August and only started to increase considerably in September.

Table 5. Mean percentage leaf area damaged by thrips – leek trial at Warwick HRI, Wellesbourne in 2005.

	Sampling date							
	27-Jun	08-Jul	13-Jul	20-Jul	04-Aug	17-Aug	01-Sep	13-Sep
Exp F (seed)	2.17	2.89	3.50	5.09	7.39	9.75	14.22	21.68
Exp T (seed)	2.45	2.86	2.72	6.39	8.62	9.81	14.53	23.57
Gaucho (seed)	1.7	2.59	3.37	6.09	10.17	9.50	15.31	20.62
Exp A			8.53	7.09	10.35	6.68	13.40	17.18
Exp L			10.04	11.61	12.55	12.85	15.78	22.30
Exp T			8.77	9.06	10.15	11.47	15.64	25.12
Exp U			8.57	10.04	11.64	9.68	14.23	21.44
Hallmark with Zeon Technology			9.74	11.29	11.46	14.94	20.26	27.24
Tracer			8.81	8.87	8.87	9.05	8.66	16.45
Insecticide-free	5.44	7.4	10.03	12.88	11.49	12.91	14.70	24.85
fpr	<0.001	0.141	<0.001	0.004	0.018	0.003	0.089	<0.001
df	9	9	23	23	23	23	23	23
sed	0.473	2.136	1.409	1.89	1.325	1.653	2.836	1.857
t	2.262	2.262	2.07	2.07	2.07	2.07	2.07	2.07
lsd	1.069926	4.831632	2.91663	3.9123	2.74275	3.42171	5.87052	3.84399

Figure 8. Effect of insecticides applied as seed treatments on thrips damage to leek at Warwick HRI, Wellesbourne in 2005.

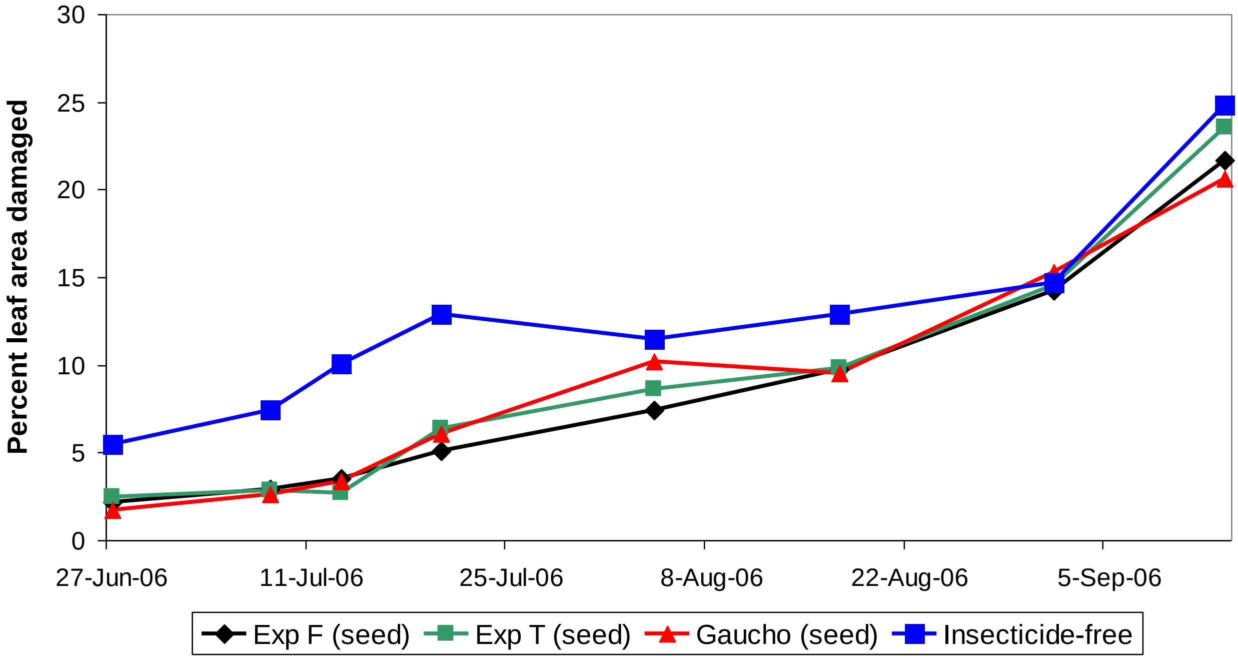
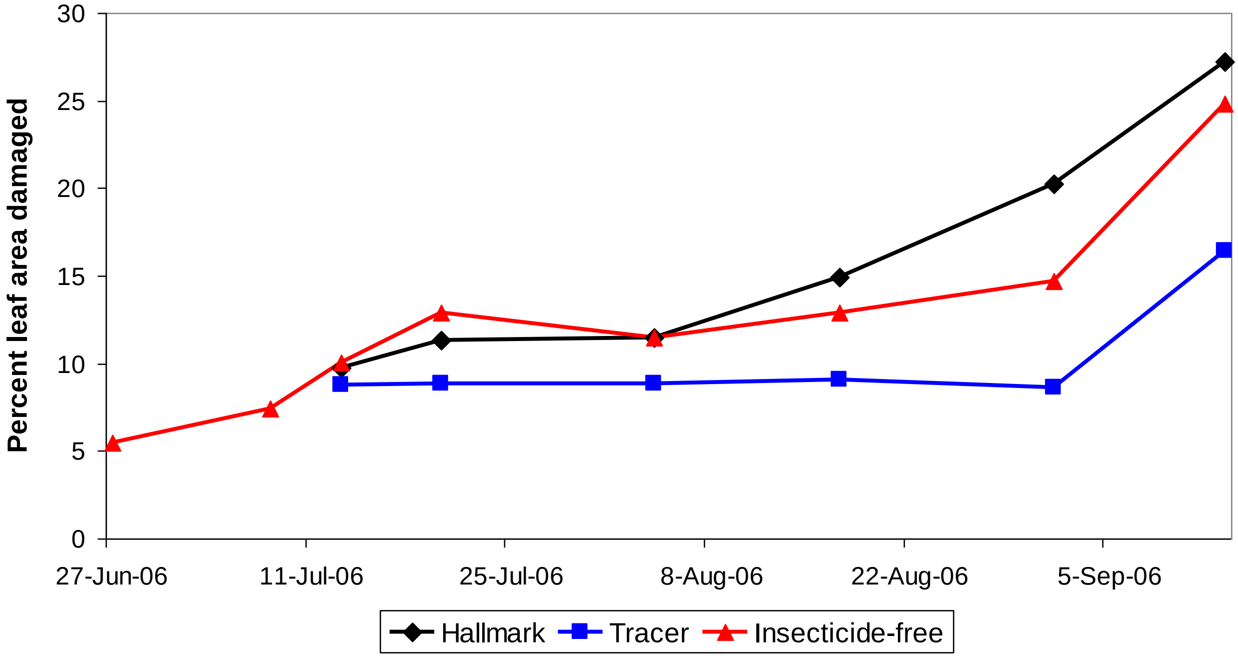


Figure 9. Effect of insecticide treatments applied as foliar sprays on thrips damage to leek at Warwick HRI, Wellesbourne in 2005.



As in 2004, Tracer was the most effective spray treatment and Hallmark with Zeon Technology was the least effective. Only one of the four other spray treatments appeared to provide thrips control. All three seed treatments appeared to give a reasonable level of thrips control for several weeks after planting.

4. Evaluate the use of entomopathogenic nematodes as part of an integrated programme.

<u>Initial studies 2004</u>

Sprays of nematodes (*Steinernema feltiae*) were applied to small plots of leek (5 m x double rows) in different ways at 100,000 nematodes per m^2. The nematodes were applied a) in 1000 litres of water per ha, b) in 1000 litres of water per ha + silicone wetter (Silwet l-77) and c) in 250 litres water per ha + silicone wetter (Silwet l-77), and these were compared with plots sprayed with just water. The treatments were applied 3 times at weekly intervals and assessments were made to see where the nematodes were deposited on the plants and for how long they survived. The numbers of thrips present were relatively low, so little information was gained about the effectiveness of the nematodes against thrips.

Large numbers of nematodes were recovered from the leek plants when the leaves were cut off and agitated in water within minutes of application. Many nematodes were active and so were presumably alive, but the proportion was not assessed accurately. Very few live nematodes were recovered when the procedure was repeated 24 hours later (Table 6).

Table 6. Numbers of live nematodes recovered from leek leaves 24 hours after spraying (numbers from 3 plants)

	Plants			
Treatment	**1**	**2**	**3**	**Mean**
1. Nematodes @ 1000 litres per ha	1	4	11	5
2. Nematodes + wetter @ 1000 litres per ha	14	4	3	7.0
3. Nematodes + wetter @ 250 litres per ha	9	6	5	6.7
4. Control – water only	0	1	0	0.3

When the second application of nematodes was made (in the evening), counts were done to assess the numbers of nematodes still alive about 12 hours after application (the following morning). These assessments showed that significant numbers of nematodes were still alive after 12 hours (Table 7).

Table 7. Numbers of live nematodes per cm^2 of leaf recovered 12 hours after application

	Plants			
Treatment	**1**	**2**	**3**	**Mean**
1. Nematodes @ 1000 litres per ha	0.93	0.28	0.31	0.51
2..Nematodes + wetter @ 1000 litres per ha	0.11	0.30	0.10	0.17
3. Nematodes + wetter @ 250 litres per ha	0.12	0.09	0.12	0.11
4. Control – water only	-	-	-	-

Further assessments were made during the summer to see whether the nematodes survived as well when the light was brighter (UV light is harmful to nematodes). Samples were taken to assess the numbers of live nematodes present in the axils of the leaves of leek plants 15, 24, 48 or 120 (5 days) hours after application (Table 8). Although the results after 24 hours appeared anomalous (very few recovered), the observations suggest that a) significant numbers of nematodes survive for up to 5 days and b) they appeared to do so for longest in the absence of wetter.

Table 8. Numbers of live nematodes recovered from the base of leeks at intervals after spraying.

	Interval after spraying			
Treatment	**15 h**	**24 h**	**48 h**	**120 h (5 Days)**
1. Nematodes @ 1000 litres per ha	59	1.7	96.3	107
2. Nematodes + wetter @ 1000 litres per ha	28	2.3	27.7	42.0
3. Nematodes + wetter @ 250 litres per ha	25	2.2	41.7	15.0
4. Control – water only	-	-	-	-

<u>Plot trial 2005</u>

In late August/early September 2005, nematodes were applied to leeks in a plot trial in a commercial crop in the Thames Valley. There were six treatments (Table 9) and each treatment was replicated four times. Sprays were applied on 23 August and 5 September. Counts of adult and larval thrips were made on 10 plants per plot on 5 and 19-20 September. The data were subjected to Analysis of Variance and the results are summarized in Table 9. Thrips numbers were relatively low and none of the treatments reduced thrips numbers compared with the water-only control treatment.

Plot trial 2006

Nematode treatments were applied to replicate plots within a larger insecticide trial at Warwick HRI, Wellesbourne (see Objective 5). Treatments were applied on 16 August, 14 September, 26 September, 2 October and 12 October and samples of plants were assessed for the presence of thrips before (14 August) and on 3 occasions after treatment (21, 25 August and 26 October). Counts were made of adult and larval thrips (*T. tabaci* and other species) and the data were subjected to Analysis of Variance. The majority of thrips were *T. tabaci*. No statistically significant differences were found for any variables analysed (Table 11). The plants were also assessed for damage as part of the larger insecticide trial (Objective 5; Table 11).

Table 9 Application of nematodes (EPNS) to leek plants infested with thrips in a plot trial in a commercial crop in the Thames Valley in 2005.

	5 September			19/20 September		
Treatment	**Adults**	**Larvae**	**Adults + larvae**	**Adults**	**Larvae**	**Adults + larvae**
Untreated - water only	0.4	4.7	5.1	0.6	6.2	6.7
Spinosad ('Tracer' @200 mls per ha)	0.5	2.0	2.5	0.2	0.7	0.9
EPNs in 1000 l per ha	0.6	6.8	7.5	1.0	5.1	6.1
EPNs in 1000 l per ha + wetter	0.6	5.1	5.7	0.7	4.8	5.5
EPNs in 1000 l per ha + wetter + Irrigation	0.5	3.8	4.3	0.4	4.2	4.5
EPNs in 250 l per ha + wetter	0.48	4.6	5.0	0.4	5.4	5.8
F-prob	0.77	0.05	0.06	0.19	0.54	0.51
SED	0.18	1.32	1.40	0.30	2.98	3.16
df	15	15	15	15	15	15
LSD	0.37	2.82	2.98	0.64	6.36	6.74

Table 10. Numbers of adult thrips and thrips larvae recovered per plant following application of nematode treatments at Warwick HRI, Wellesbourne in 2006.

		Nematodes applied	**Untreated control**	**F-probability**
14-Aug	Adults	4.1	3.88	0.964
	Larvae	17.9	15.6	0.6
21-Aug	Adults	3.3	3.3	0.998
	Larvae	20.2	17.4	0.451
25-Aug	Adults	7.2	5.75	0.4
	Larvae	8.8	13.2	0.495
26-Oct	Adults	0.9	0.9	0.948
	Larvae	0.2	0.1	0.488

5. Develop an integrated programme for thrips control on leek

In 2006, treatment strategies were designed to evaluate, in particular, the importance of early thrips control on subsequent damage. These were evaluated in a replicated plot trial at Warwick HRI, Wellesbourne and two unreplicated demonstration trials at commercial sites.

At Wellesbourne, leek seed (cv Shelton) was direct drilled at a spacing of 12 per metre on 4-5 May 2006. There were 40 plots altogether (10 treatments x 4 replicates). Plots were 6 m x 2 beds (1.83 m each) in size and there were four rows of leek plants in each bed. The seed used in two of the treatments was film-coated with imidacloprid (Gaucho) at Warwick HRI. The remaining seed was insecticide-free.

The programme of spray treatments was designed to evaluate the importance of early thrips control on subsequent damage. Treatments were timed to be applied at approximately 100 day-degree intervals based on the information obtained in Objective 1. The treatment programme is shown in Table 11. Tracer was applied at 200 ml product per ha, Exp A at 10000 ml per ha, Dursban at 1 kg per ha and imidacloprid (Gaucho) was applied to seed at a rate of 50 g a.i. per 250,000 seeds.

The nematode treatments were not included as part of the overall programme, but were applied in a separate programme towards the end of the season (Objective 4).

Table 11. Seed treatments and treatments applied as foliar sprays in 2006. Exp = experimental product.

		Date applied						
Name	**Seed treated**	**12-Jun**	**29-Jun**	**12-Jul**	**28-Jul**	**10-Aug**	**24-Aug**	**15-Sep**
ST, Tx4	Gaucho				Tracer	Tracer	Tracer	Tracer
ST, TX5	Gaucho			Tracer	Tracer	Tracer	Tracer	Tracer
AX2,TX4			Exp A	Exp A	Tracer	Tracer	Tracer	Tracer
DX2,TX4			Dursban	Dursban	Tracer	Tracer	Tracer	Tracer
TX2,AX2,TX2			Tracer	Tracer	Exp A	Exp A	Tracer	Tracer
TX5				Tracer	Tracer	Tracer	Tracer	Tracer
TX6			Tracer	Tracer	Tracer	Tracer	Tracer	Tracer
Tx7		Tracer	Tracer	Tracer	Tracer	Tracer	Tracer	Tracer
Nematode treatments								
Insecticide-free control								

Thrips damage was assessed on 7 occasions – 27 June, 11, 19 July, 7, 22 August, 4, 27 September. The data were subjected to Analysis of Variance. The results are summarised in Table 13. At the time of the first assessment, on 27 June, the plants had already suffered damage and there was a statistically significant difference in the percentage leaf area damaged by thrips between the plants grown from seed treated with Gaucho and the plants grown from insecticide-free seed (Table 13; Figure 10). Over the next few weeks there were few differences between treatments. However, by September, all the plants treated with insecticide were less damaged than the insecticide-free plants (Table 13). The data for 27 September are shown in Figure 11.

Table 13. Mean percentage leaf area damaged by thrips – leek trial at Warwick HRI, Wellesbourne in 2006.

	Assessment date						
Treatment	**27 Jun**	**11 Jul**	**19 Jul**	**7 Aug**	**22 Aug**	**4 Sep**	**27 Sep**
ST, Tx4	10.31	14.66	25.19	22.70	21.25	31.00	26.71
ST, TX5	9.97	21.75	24.71	19.12	21.59	32.89	25.30
AX2,TX4	19.00	19.43	18.75	18.64	22.97	28.97	27.37
DX2,TX4	23.84	24.95	30.15	25.49	27.06	36.06	29.19
TX2,AX2,TX2	21.52	27.99	23.85	21.52	24.57	33.27	27.47
TX5	19.59	24.78	25.54	21.15	17.15	34.77	28.55
TX6	24.05	24.91	28.97	24.39	26.98	31.87	26.66
Tx7	18.14	24.57	23.69	22.36	18.87	32.60	26.65
Nematodes (Objective 4)	18.61	26.48	27.06	24.38	20.09	39.82	37.22
Insecticide-free control	25.05	28.61	27.84	25.30	31.91	41.78	39.46
F-prob	0.002	0.034	0.248	0.069	0.138	0.001	<0.001
SED	3.527	3.737	3.846	2.347	4.85	2.612	2.47
df	23	23	23	23	23	23	23
LSD (95%)	7.296	7.731	7.956	4.855	10.03	5.404	5.11

Figure 10. Percentage of leaf area damaged by thrips on 27 June 2006.

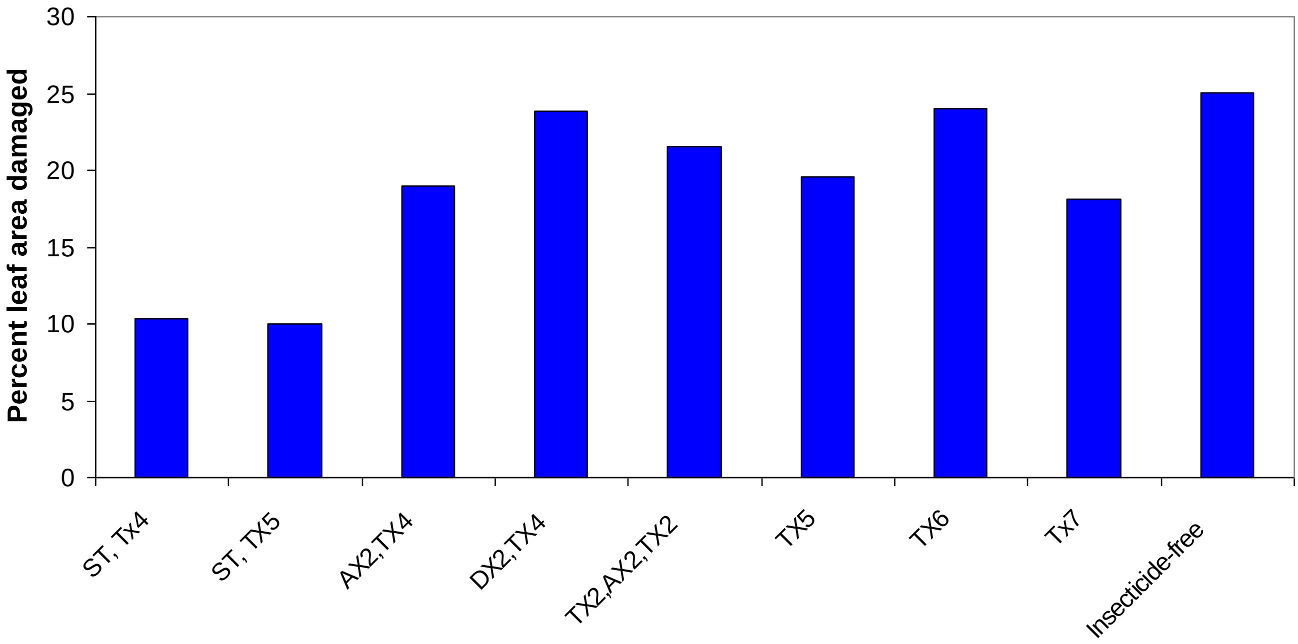
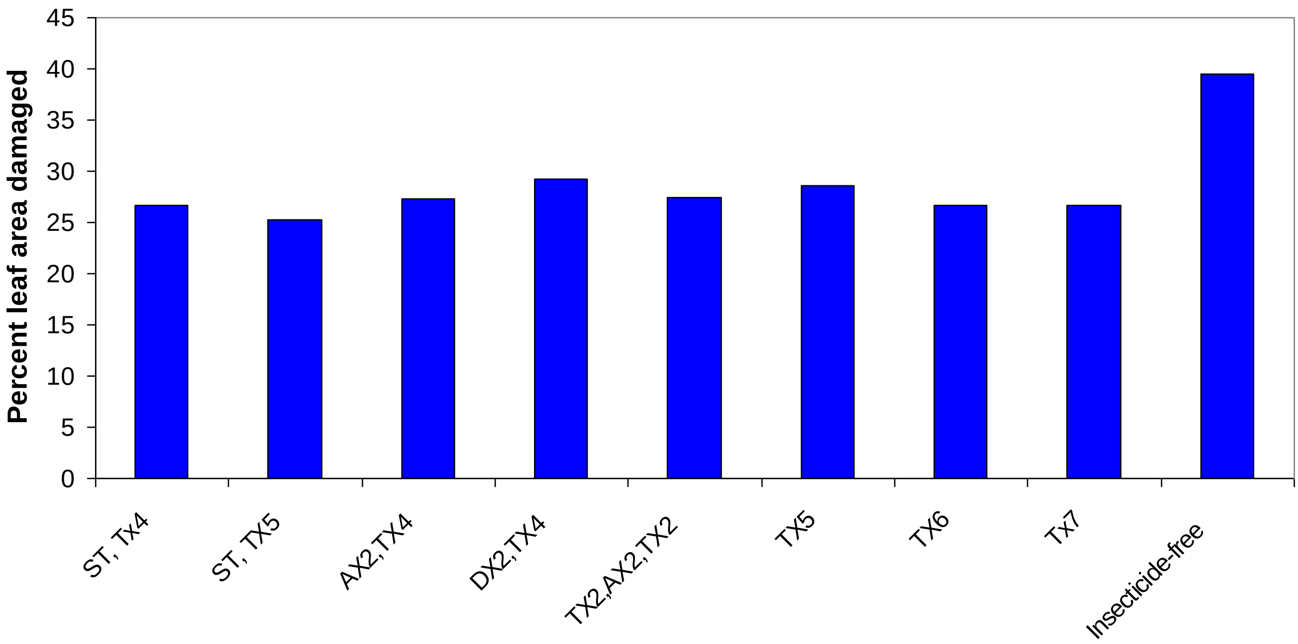


Figure 11. Percentage of leaf area damaged by thrips on 27 September 2006.



Trials in commercial crops

Two unreplicated 'demonstration' trials were done in commercial leek crops in Cambridgeshire and Worcestershire. The programmes consisted of treatments approved currently in the UK and these were applied to single plots 15 m long x 6 beds (each of 4 rows) wide at each site. The treatments compared, applied at two-week intervals from early July in 300 litres/ha, are shown in Table 14. The amount of thrips damage (percent leaf area damaged) was recorded on 15 plants per plot before the first sprays were applied and either immediately before or after subsequent sprays were applied, and two weeks after the final applications. The amount of damage was also recorded on plants on each side of the demonstration plots, to compare the effectiveness of the growers' spray programmes.

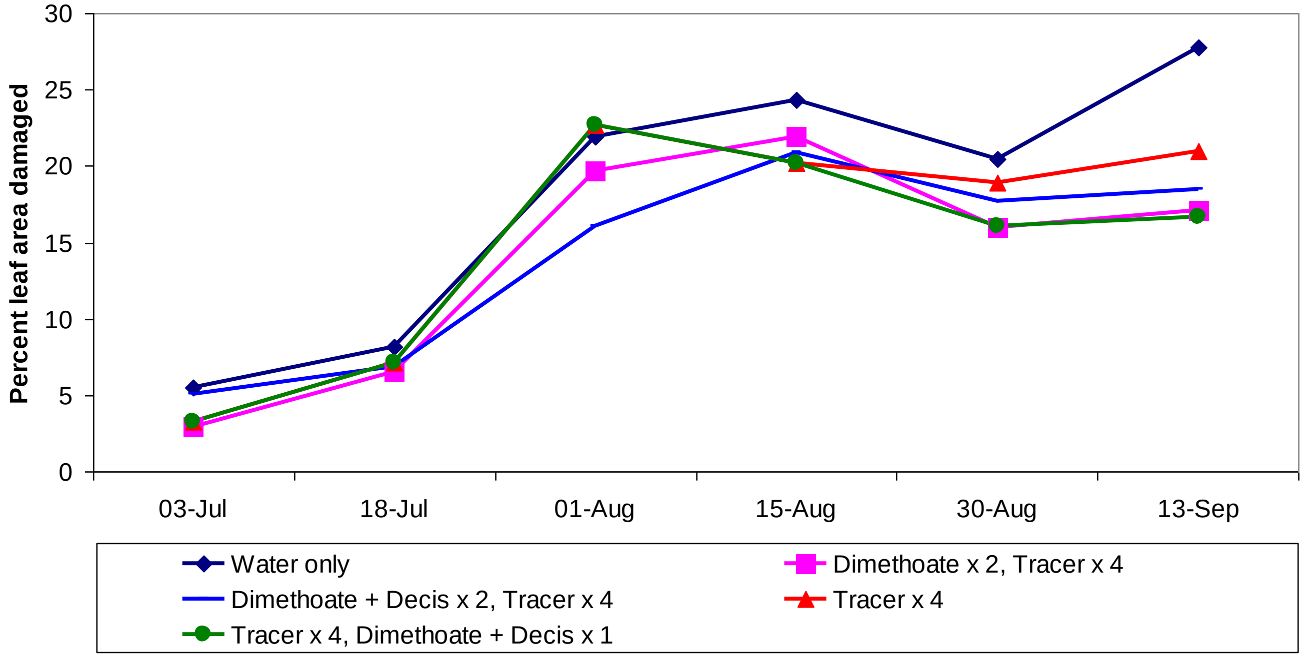
Table 14. Treatments used in demonstration trials in commercial leek crops in 2006.

1.	Untreated control – water only
2.	Dimethoate x 2, Tracer x 4
3.	Dimethoate + Decis Protech x 2, Tracer x 4
4.	Tracer x 4
5.	Tracer x 4, Dimethoate + Decis Protech x 1 (Cambridgeshire) or x 2 (Worcestershire)

Thrips damage increased appreciably at both sites from the middle of August onwards until mid/late September, when observations stopped. From mid August, two weeks after the application of the third set of sprays, there was more damage on the unsprayed (water only) plots than there was on the sprayed ones, although differences between the treatments were small (Figures 12-13). This was perhaps not surprising because on the third occasion the same insecticide, Tracer, had been applied to the plots – see Table 14.

An additional one (Cambridgeshire) or two (Worcestershire) sprays of Dimethoate + Decis Protech, applied late in the season to half of each of the plots that had already been sprayed 4 times with Tracer, reduced damage slightly at both sites.

Figure 12. Assessment of thrips damage in a commercial crop in Cambridgeshire.



DISCUSSION

Overwintering biology

Overwintered leeks may be a primary overwintering site for *Thrips tabaci* (Villeneuve *et al.*, 1997). Observations made on leek plants at Wellesbourne during 2004-6 indicated that *T. tabaci* populations probably overwinter as adults in the UK. A similar situation occurs in the Netherlands (J. Theunissen, personal communication). In contrast, Villeneuve *et al.* (1996; 1997) observed that both adult and larval thrips overwintered on various plant species in the Basse-Normandie region of France. The difference in overwintering biology between France and the Netherlands and UK may merely reflect differences in winter temperatures.

Pattern of activity/day-degree forecasts

Thrips flight activity appeared to follow a similar pattern at sites within a region and, to a certain extent, between regions, each year. Indeed, as all the monitoring sites were in central England, temperature differences between them were unlikely to be great. It may be sufficient to trap thrips at one or two locations within a region as the pattern of activity appeared to be consistent in any year. However, the overall pattern of activity varied between years. Peak numbers of thrips were captured usually during July-August, whilst the numbers of thrips on plants often peaked in late August-September. In many cases, adult thrips were captured on sticky traps before thrips were found on plants, indicating that traps could be used to provide an early warning of colonisation by thrips. Surprisingly, the numbers of thrips captured on sticky traps did not vary greatly between sites and years.

However, the maximum numbers of thrips per plant varied 100-fold. Overall, there seems to be little opportunity to use the numbers of thrips captured on traps to predict infestation levels on plants.

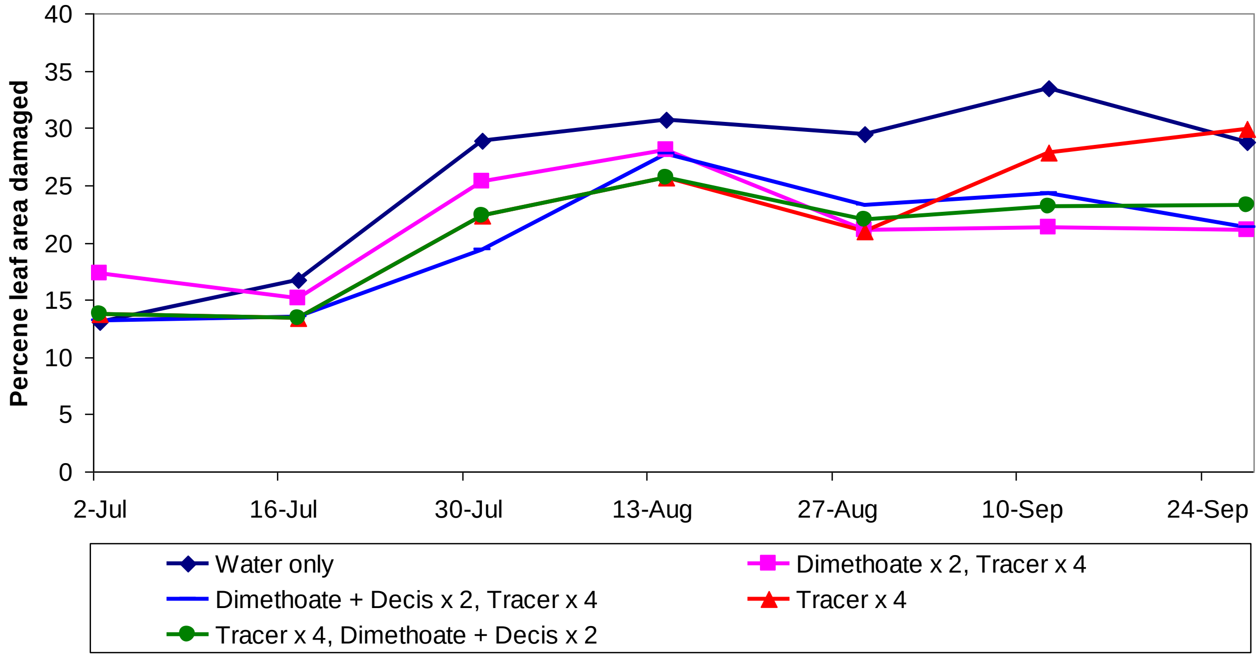
In the commercial crops, thrips were first captured (>1 thrips per trap per week) after 98 (2004) and 33 (2005) day-degrees. The first peaks were also very different (229 day-degrees in 2004 and 110 in 2005). The only consistent feature was that, averaged over 10 sites each year, peaks were generally separated by about 100 day-degrees.

Villeneuve *et al* (1996) attempted to relate the thrips monitoring data collected in leek fields in Basse-Normandie to accumulated day-degrees. They calculated accumulated day-degrees above a base temperature of 11.5ºC from 1 January each year, to determine when population peaks could be expected, using the 228 Dº/generation, and 133 Dº for development from larva to adult, estimated by Edelson & Magaro (1988) for development under fluctuating temperatures. They used both sums because both adult and larval thrips overwinter in this region. The model indicated that there would be two periods of adult emergence, the first at the end of June and the second between 20-25 July. In 1995, the timing of thrips captures on the traps agreed closely with that predicted by the forecast. Overwintering larvae became adults towards the end of June and gave rise to the first peak of adult emergence. A second generation that developed from the progeny of overwintering adults was expected towards the end of July and this was confirmed by sticky trap captures. Although agreement was good in 1995, subsequent studies showed that the discrepancy between observed and forecast activity could sometimes be as much as 10 days (Villeneuve *et al.*, 1999).

Thus whilst it is possible to obtain 'fits' between trap catches of *Thrips tabaci* and accumulated temperature sums, it is also possible to find seasons where the 'model' does not fit. This begs the question whether the peaks (e.g. in Figure 4) are 'real' peaks reflecting thrips phenology or whether they merely reflect weather conditions that are favourable for flight activity. Indeed, comparisons of monitoring data for Cambridgeshire in 2004-6 (Figure 5) suggest that the number of peaks can be very variable and in 2006 there appeared to be only a single peak in late July. This would tie in with observations in other parts of Europe. For example, in the Basse-Normandie region of France, data from sticky traps indicated that there was one large flight period, and that this occurred in late July – early August (Villeneuve *et al.*, 1996; 1997). Smaller 'flights' occurred in May, at the end of June and in October (Villeneuve *et al*., 1999). In Belgium in 2004, the main period of flight activity occurred around 15 August (K. Martens & N. Plovie, personal communication). In Germany, peak numbers of infested plants were found usually in early August (Hommes, 1992).

Thus, it seems that it may be difficult to predict accurately the timing of peaks of thrips generations using accumulated day-degrees. Although the phenology of thrips populations is undoubtedly temperature-driven it is likely that reproduction over a period of time, combined with intra-specific variation in development times may be blurring the separation between generations, initially so clear in early spring (Figure 2). However, this does not completely obviate the value of using a phenological model to time treatments since, at the very least; this approach will separate treatments on a physiological time-scale and may also take into account the effect of temperature on pesticide degradation.

Figure 13. Assessment of thrips damage in a commercial crop in Worcestershire in 2006.



Insecticides
The data collected in 2004 showed that, at Wellesbourne at least, pyrethroid sprays were completely ineffective. In 2006, Rothamsted Research sampled populations of *Thrips tabaci* from eight commercial allium crops in the UK. All samples were highly resistant to deltamethrin, although the type of resistance is as yet unknown (Stephen Foster, personal communication). This confirms that pyrethroid insecticides are unlikely to provide effective thrips control in commercial crops and since they are also likely to harm beneficial insects, their use for thrips control should be avoided.

Of the non-pyrethroid insecticides evaluated as foliar sprays, several, including Tracer (spinosad), provided at least partial thrips control. Of the experimental products, Exp A performed consistently and at a level similar to Tracer and this could be a useful alternative if Approval is possible. Similarly, Dursban (chlorpyrifos) provided an equivalent level of control.

All three of the seed treatments evaluated provided partial thrips control for a number of weeks after sowing. Their efficacy dwindled gradually, in 2005 in particular. This provides positive evidence to support earlier studies (Saynor, 1999), where results were more variable.

Nematodes
These studies showed that significant numbers of nematodes were still alive in the pool of water at the junction of the leaf and the stem of leek plants 5 days after they were applied to leek foliage. Few survived on the leaves after 24 hours, although significant numbers of live nematodes were recovered after 12 hours when the nematodes were applied in the evening. This is in line with the results reported by Bennison *et al.* (2005), who found that when the same nematodes were evaluated for the control of western flower thrips under glass, they were all inactive two hours after application. Despite the fact that nematodes appeared to survive for longer at the base of leek leaves, there was no evidence that they reduced thrips numbers. Nematodes have been used to provide effective control of western flower thrips in glasshouses. However, it is likely that they are killing the soil-dwelling stages of thrips, rather than the stages that live on the foliage.

Integrated control strategy
The most effective strategy for season-long control of *T. tabaci* has yet to be determined. Effective control is constrained by the limited range of treatments and treatment applications (4 for Tracer) available, especially now that resistance to pyrethroids has been demonstrated. The range of effective alternative treatments is very limited. The persistence of Tracer on foliage is likely to be approximately 7-10 days and thus growers must decide whether to apply this treatment intensively during the period when thrips are most numerous or to separate Tracer treatments by a longer interval. Seed treatments certainly appear to reduce thrips numbers early in the season and would obviate the need for very early sprays. However, in 2006, the use of a seed treatment (imidacloprid) prior to the application of sprays appeared to confer no additional advantage with respect to thrips damage in late September. Registration of alternative active ingredients would provide additional components of a control strategy and might help to reduce the risk of the development of resistance to Tracer.

Conclusions

- *Thrips tabaci* overwintered in the adult stage in central England and leek provided a good overwintering host. Overwintering populations of thrips started to reproduce in late spring.
- Blue sticky traps can be used to monitor the flight activity of adult *T. tabaci*. Trap catches were usually highest in July-August whilst, on plants, thrips numbers were highest in August-September.
- The pattern of thrips flight activity (the number of peaks and their timing) appeared to be very similar within a region and even between regions, but varied considerably from year to year. It may be sufficient to trap thrips at one or two locations within a region as the pattern of activity appeared to be consistent in any year.
- In many cases, adult thrips were captured on sticky traps before thrips were found on plants, indicating that traps could be used to provide an early warning of colonisation by thrips.
- The numbers of thrips captured did not vary greatly between sites and years. However, the maximum numbers of thrips per plant varied 100-fold. Overall, there seems to be little opportunity to use the numbers of thrips captured on traps to predict infestation levels on plants.
- There appeared to be no consistent relationship between peaks of thrips flight activity and physiological time (accumulated day-degrees).
- Foliar sprays of Tracer (spinosad) reduced thrips numbers compared with insecticide-free control treatments in all replicated plot trials at Wellesbourne. Dursban (chlorpyrifos) and an experimental product also reduced thrips numbers on leek.

- All three of the seed treatments evaluated provided partial control of *T. tabaci* for a number of weeks after sowing. However, in 2006, the use of a seed treatment prior to the application of sprays appeared to confer no additional advantage with respect to thrips damage in September.
- At Wellesbourne, foliar sprays of pyrethroid insecticides were completely ineffective and in a separate study, samples of *T. tabaci* from eight commercial allium crops in the UK were highly resistant to deltamethrin. Consequently, pyrethroid insecticides are unlikely to provide effective thrips control and, since they are also likely to harm beneficial insects, their use for thrips control should be avoided.
- Despite the fact that nematodes appeared to survive for several days in water droplets at the base of the leaves of leeks they did not do so on the foliage and there was no evidence that they reduced thrips numbers.
- The most effective strategy for season-long control of *T. tabaci* has yet to be determined. It is constrained by the limited range of treatments and treatment applications available, especially now that resistance to pyrethroids has been demonstrated.

Future research

- There is a continuing need to evaluate new insecticides for their efficacy against *Thrips tabaci*, both as foliar sprays and seed treatments.
- The population dynamics of *T. tabaci* in the UK is still poorly understood and more detailed experiments are required to determine the temperature requirements (including threshold temperatures) for thrips development, reproduction and flight.
- In particular, it is important to determine whether the period in July-August when the largest numbers of thrips are captured on sticky traps is the most significant period of migration and therefore whether the most effective control measures should be targeted at this time.
- A better understanding of thrips overwintering sites and of the pattern of dispersal from these sites would help to identify crops that are particularly at risk from thrips infestation.
- Experiments should be done to determine whether entomopathogenic nematodes are effective against *T. tabaci* pupae in the soil.
- Identification of sources of resistance in host plants, which could be bred into new varieties, would reduce the need for insecticidal control.

Knowledge transfer

Publications

Collier, R.H. (2003). Integrated Pest Management in field vegetable crops. Plant it! Issue 4 December 2003.

Collier, R.H. (2004). Project focuses on thrips control on outdoor Allium crops. Vegetable Farmer, October 2004, 27-28.

Collier, R.H. & Saynor, M. (2006). Thrips control in allium crops. Vegetable Farmer, July 2006, 11-12.

Collier, R.H., Saynor, M. & Burnstone, J. (2007). Thrips control on *Allium* crops. IOBC/WPRS Bulletin Integrated Control in Field Vegetable Crops, in press.

The project was described in presentations at the following meetings:

HDC Vegetable Roadshow Stockbridge Technology Centre 9 February 2005
HDC Vegetable Roadshow Warwick HRI Kirton 2 March 2005
HDC Vegetable Roadshow Llanelli 8 November 2005
Syngenta Allium Meeting 15 March 2005
West Midlands Fresh Produce Forum 2 November 2005
Syngenta Training Day, 23 January 2006
Vegetable Consultants Association Technical Conference, 6 December 2006

The project team has provided a written update on the project for meetings of the R & D Committees of the Leek Growers Association and the British Onion Producers Association. Representatives of both groups have formed the project steering group.

The project team met with DOW AgroSciences (the manufacturer of Tracer) in 2006 and 2007 to discuss approaches to the use of Tracer to control thrips in leek crops.

Rosemary Collier attended a meeting of the IOBC (International Organisation for Biological and Integrated Control of Noxious Animals and Plants) Working Group on Integrated Control in Field Vegetable Crops in October 2006 and made a presentation on control of *Thrips tabaci* in allium crops. There were a number of presentations on *Thrips tabaci* in leek and onion crops and a group of researchers from the UK, France, Belgium, the Netherlands and Slovenia met again in November 2006 discuss ways of collaborating and exchanging information.

Information about the project has been posted on the Warwick HRI website and monitoring information has been available on the HDC Pest Bulletin Website http://www2.warwick.ac.uk/fac/sci/hri2/hdcpestbulletin/leek_onion/ which is managed by Warwick HRI.

Contact through this project with the Leek Growers Association and British Onion Producers Association R & D Committees have led to them funding a small project in 2006 through the HDC on the diurnal periodicity of thrips activity in leek crops: FV 296 Leek and onion: targeting insecticide treatments against *Thrips tabaci.*

The network of growers participating in the project provided Rothamsted Research with sites at which to sample *T. tabaci* populations to assess their susceptibility to pyrethroid insecticides.

References to published material

9. This section should be used to record links (hypertext links where possible) or references to other published material generated by, or relating to this project.

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