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Signed on behalf of: Warwick HRI

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CONTENTS

Grower Summary

Headline

- Field experiments have highlighted some experimental seed and spray treatments that reduce thrips damage on leek and onion.

- All of the seed treatments evaluated on onion appeared to improve plant stand, presumably because they reduced damage by bean seed fly.

Background and expected deliverables

Onion thrips (*Thrips tabaci*) is the most important pest 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 (Defra-funded project PS2710). 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 available, especially now that resistance to pyrethroids has been demonstrated.

The range of effective alternative treatments is very limited. The persistence of Tracer (spinosad) 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 on traps (usually July-August) or to separate Tracer treatments by a longer interval. Tracer is relatively expensive and it is important that growers know how to get the best out of it. 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 (Defra-funded project HH3116TFV**)**.

Bean seed fly (*Delia* spp.) is also an important pest of Allium crops and can reduce seedling emergence (particularly of salad onion) dramatically. Current control relies on seed treatment with tefluthrin (Force – Specific Off-Label Approval). It is likely that some of the newer seed treatments being developed currently may be effective against bean seed fly.

A successful outcome to this project should:

- provide growers with information about how best to target existing methods of control
- identify new treatments/approaches that might require further development.

The information obtained on thrips control may also be useful to growers producing stored cabbage.

Summary of the project and main conclusions

All experimental work was done at Warwick HRI, Wellesbourne.

Experiment 1 Monitoring thrips in sequentially-sown plots of salad onion

Small plots of salad onion (cv White Lisbon) were sown on 23 April, 23 May, 17 June, 28 July and 27 August 2008. The numbers of thrips were monitored using 2 blue sticky traps per plot. At intervals samples of 10 plants were removed from each plot and taken to the laboratory where they were sampled destructively to determine the number of thrips present on the foliage. The salad onion foliage was also scored for thrips damage.

Experiment 2 Control of thrips on leek with seed treatments and foliar sprays – large plot experiment

This was a large field experiment consisting of 40 plots. Each plot was 5 m x 2 beds (1.83 m) in size and was sown on 2 May 2008 with eight rows of seed which contained 5 different 'seed treatments', consisting of 3 insecticide treatments (Exp A, fipronil, imidacloprid) and appropriate insecticide-free controls. The plots were treated subsequently with programmes of foliar sprays of insecticide and, including an unsprayed control, there were 10 spray treatments (Methiocarb 500 SC (methiocarb), Tracer (spinosad) (2 programmes), Dursban (chlorpyrifos), BASF Dimethoate 40 (dimethoate), Exp SA, Exp SB, Exp X1 and Exp X2). The spray programmes that did not use Tracer exclusively consisted of the following sequence of applications: 1) Tracer, 2) test insecticide, 3) test insecticide, 4) Tracer, 5) test insecticide, 6) test insecticide. Sprays were applied on 30 June, 15 July, 31 July, 15 August, 28 August and 15 September 2008 at a rate of 200 l water/ha. The leek plants (both with and without insecticidal seed treatments) were assessed at regular intervals to estimate levels of feeding damage by thrips.

Experiment 3 Control of thrips on leek with seed treatments and foliar sprays – isolated plot experiment

In this experiment there were 12 'isolated plots of leek of the same dimensions and composition (eight rows containing 5 different 'seed treatments') as Experiment 2. This experiment was also sown on 2 May. There were 3 'spray' treatments (one of which was an unsprayed control) and the other two treatments consisted of the same two programmes of foliar sprays of Tracer (spinosad) applied in Experiment 1. The leek plants were assessed at intervals to estimate levels of feeding damage by thrips.

Experiment 4 Control of bean seed fly and thrips on bulb onions with seed treatments

In this experiment, onion seed was sown on 24-25 April and each plot was 5 m x 1 bed (1.83 m each) in size. There were 4 treatments (Exp B, Exp S, fipronil and Force), each replicated 5 times. Half of each plot was sown with insecticide-treated seed and the other half with insecticide-free seed of the same variety. Organic matter was incorporated uniformly across the experimental area prior to bed preparation to encourage oviposition by female bean seed fly.

Assessments of the number of plants were made on 5 occasions: 16 May, 23 May, 4 June, 18 July, 3 September. The onion plants were also assessed for thrips damage on 1 July.

Main findings

Thrips numbers and development of damage

The aerial population of thrips appeared to distribute itself very effectively. The numbers of adult thrips captured on traps were remarkably consistent between plots and peak numbers were captured during July and early August. The numbers of thrips found by destructive sampling of salad onion plants were relatively low (0-2 thrips per plant) and fluctuated over time.

During the period from late May until mid-August when the aerial population of thrips was increasing, thrips damage to plants in the first three plots increased over time. Although the plot sown on 23 April suffered a small amount of damage early on, in general most of the damage suffered by all three plots was inflicted during the same period, between early July and mid-August.

In the experiments on leek, thrips damage increased from early July onwards, but the greatest increase was in early August, when the largest numbers of thrips were captured on the sticky traps. Heavy rainfall in the latter part of the summer may have suppressed thrips numbers to some extent.

Effect of seed treatments

Previous studies have shown that a number of seed treatments reduce thrips damage to Allium crops but that this effect diminishes in mid-summer. These experiments confirmed that insecticidal seed treatments did provide a certain amount of thrips control in both leek and onion. There are questions about the level of control provided and the 'persistence' of the effect. On leek, both imidacloprid and fipronil reduced damage on a number of occasions, whereas Exp A was less effective. Overall, fipronil appeared to have the greatest impact. There appeared to be more impact on the damage score for the whole plant than on damage to the penultimate (youngest) leaf and this may indicate persistence of the 'effect' (i.e. a reduction in damage earlier on) rather than persistence of the 'treatment' which would be reflected in damage to new foliage.

Foliar sprays

The insecticides evaluated as foliar sprays were applied in 6-spray programmes. This is not intended to represent how they would be used in commercial practice, as the permitted number of sprays of each insecticide would be limited. However, this is the clearest way of demonstrating differences in efficacy, particularly when weather conditions make it difficult to predict when the largest numbers of thrips will occur.

Overall, Methiocarb 500 SC (methiocarb) was the most effective spray treatment and BASF Dimethoate 40 (dimethoate), the least effective (Figure A). Methiocarb 500 SC, Exp X1 and Dursban produced statistically significant treatment effects on overall damage on all five assessment occasions, Exp SA on four occasions, the two Tracer programmes on 3 occasions and the other treatments (Exp X2, Exp SB and BASF Dimethoate 40) on one of them. In terms of damage to the penultimate leaf, Methiocarb 500 SC produced statistically significant treatment effects on all five assessment occasions, Exp X1 and TracerL on four occasions, Tracer2, Dursban and Exp SA on three occasions, Exp SB on two occasions, Exp X2 on one occasion and BASF Dimethoate 40 on none of them. There was no great difference between the two Tracer only programmes, which differed only by one spray (Tracer2 – 6-spray programme starting on 30 June, TracerL – 5-spray programme starting on 15 July).

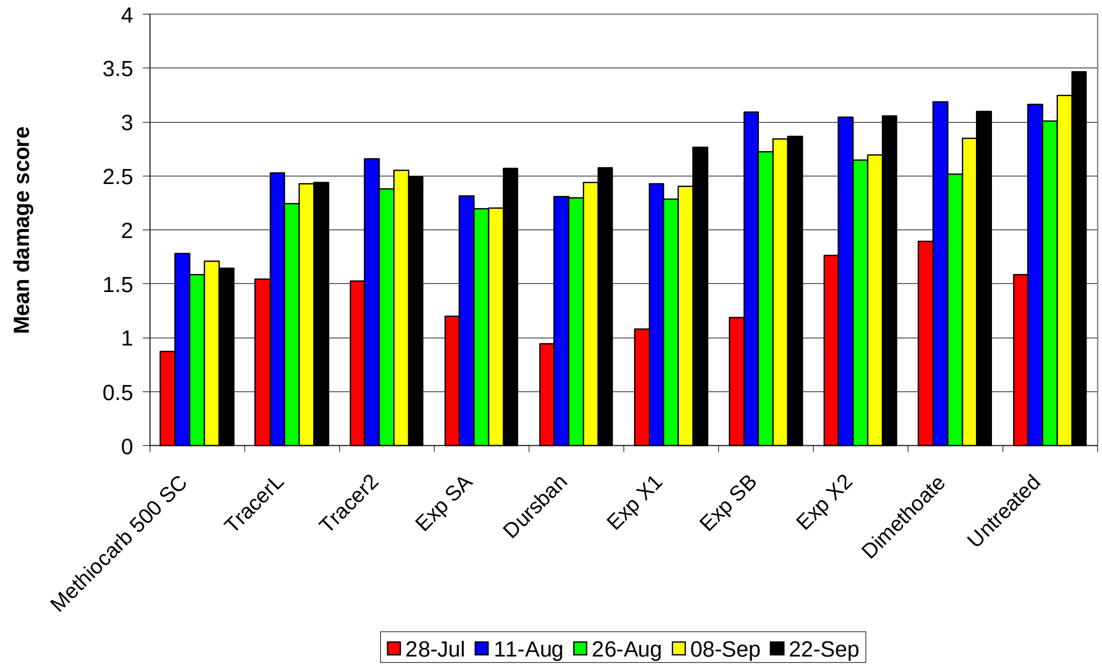

Figure A: Overall thrips damage following insecticide spray treatments. Treatments sorted according to damage on 22 September

The reason for undertaking the isolated plot experiment (Experiment 3) as well as the large plot experiment (Experiment 2) was to determine whether there was any evidence that direct movement of thrips between plots in a large 'block' experiment blurred differences between treatments, and therefore whether the use of isolated plots might provide a more accurate representation of the field situation. Comparison of the two experiments suggests that thrips movement between plots does not have a significant effect on infestation levels compared with the overall impact of the local thrips population.

Control of bean seed fly

All of the seed treatments improved plant stand and this is assumed to be due to a reduction in bean seed fly damage.

Conclusions

- The aerial thrips population appears to distribute itself very effectively.
- Several seed treatments reduced thrips damage to leek early on.
- Methiocarb 500 SC was the most effective foliar spray against thrips and then Tracer. BASF Dimethoate 40 was the least effective. Two novel compounds also appear to have potential.

- Three novel seed treatments reduced seedling losses (assumed to be due to bean seed fly) on onion.

Financial benefits

The aim of this project is to provide growers with information about how best to target existing methods of control and to identify potential treatments/approaches that might require further development – either through SOLAs or through further experimentation.

Action points for growers

- The information obtained to date suggests that there seems to be little benefit in applying sprays 'early' to attempt to suppress the development of thrips infestations and that growers should apply spray treatments when thrips numbers are increasing (indicated by sampling with sticky traps or by sampling plants).
- Previous research in a Defra-funded project indicated that control is required until thrips numbers on plants decrease, and sometimes thrips are abundant until October.
- Of the approved insecticides evaluated as foliar sprays, Dursban and Tracer were the most effective and BASF Dimethoate 40 was the least effective.
- Growers should remember that insecticide resistance to pyrethroid insecticides in field populations of *T. tabaci* was confirmed by scientists at Rothamsted Research in 2006.

SCIENCE SECTION

Introduction

Onion thrips *Thrips tabaci* is the most important pest 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 [1].

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 available, especially now that resistance to pyrethroids has been demonstrated. The range of effective alternative treatments is very limited. The persistence of Tracer spinosad 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 on traps usually July-August or to separate Tracer treatments by a longer interval. Tracer is relatively expensive and it is important that growers know how to get the best out of it. 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 [2].

Bean seed fly *Delia* spp. is also an important pest of Allium crops and can reduce seedling emergence particularly of salad onion dramatically. Current control relies on seed treatment with tefluthrin (Force – Specific Off-Label Approval). It is likely that some of the newer seed treatments being developed currently may be effective against bean seed fly.

The overall aim of the project is to provide growers with information about how best to target existing methods of control and to identify potential treatments/approaches that might require further development.

The specific objectives are to:

1. Evaluate new control methods for *Thrips tabaci* on Allium crops.
2. Determine the relative importance of controlling new invasions of flying thrips versus existing populations that are ‘recycling’ on the crop.

3. Determine the best strategy for controlling thrips throughout the summer.
4. Determine the effectiveness of novel seed treatments for control of bean seed fly on salad onion.

Experiment 1 Monitoring thrips in sequentially-sown plots of salad onion

Materials and methods

Isolated, sequentially-sown plots of salad onion were grown to identify the period of peak immigration/infestation by thrips and relate this to treatment programmes. This is to determine whether it is more important to target the very earliest thrips that arrive in the crop or the major flights that usually occur in July-August. Thrips numbers were assessed at intervals by destructive sampling of plants and by capturing adult thrips on sticky traps.

Plots of salad onion (cv White Lisbon) were sown on 5 occasions during spring and summer 2008. The onions were sown at a rate of 50 seeds per metre and there were 4 rows per bed (1.83 m) with 38 cm between rows. Plots were 2 beds wide x 5 m long. The onions were sown on:

1. 23 April
2. 23 May
3. 17 June
4. 28 July
5. 27 August

The numbers of thrips were monitored using 2 blue sticky traps per plot (Ecospray). At intervals samples of 10 plants were removed from each plot and taken to the laboratory where they were sampled destructively to determine the number of thrips present on the foliage. The salad onion foliage was also scored for thrips damage. Each of the leaves on each plant were examined separately and scored on a 0-10 scale for the presence of thrips feeding damage (0=no damage, 1=10% area affected……….10=100% area affected). The results are summarised in Figures 1.1 – 1.3.

The aerial population of thrips appeared to distribute itself very effectively, as newly-emerged plots of salad onion very soon had the same infestation level (thrips on traps) as older plots (Figure 1.1). The numbers of adult thrips captured on traps were remarkably consistent between plots and peak numbers were captured during July and early August. The numbers of thrips found by destructive sampling of salad onion plants were relatively low (0-2 thrips per plant) and fluctuated over time.

During the period from late May until mid-August when the aerial population of thrips was increasing, thrips damage to plants in the first three plots increased over time. Although the plot sown on 23 April suffered a small amount of damage early on, in general most of the damage suffered by all three plots was inflicted during the same period, between early July and mid-August.

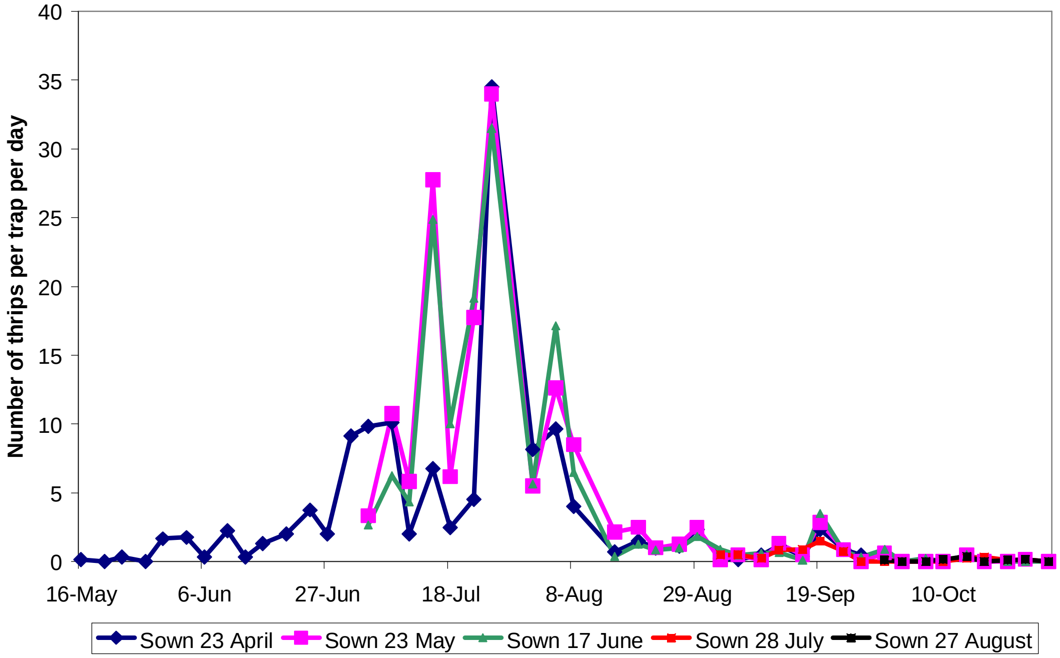

Figure 1.1: Number of thrips per trap per day in sequentially-sown plots of salad onion cv White Lisbon

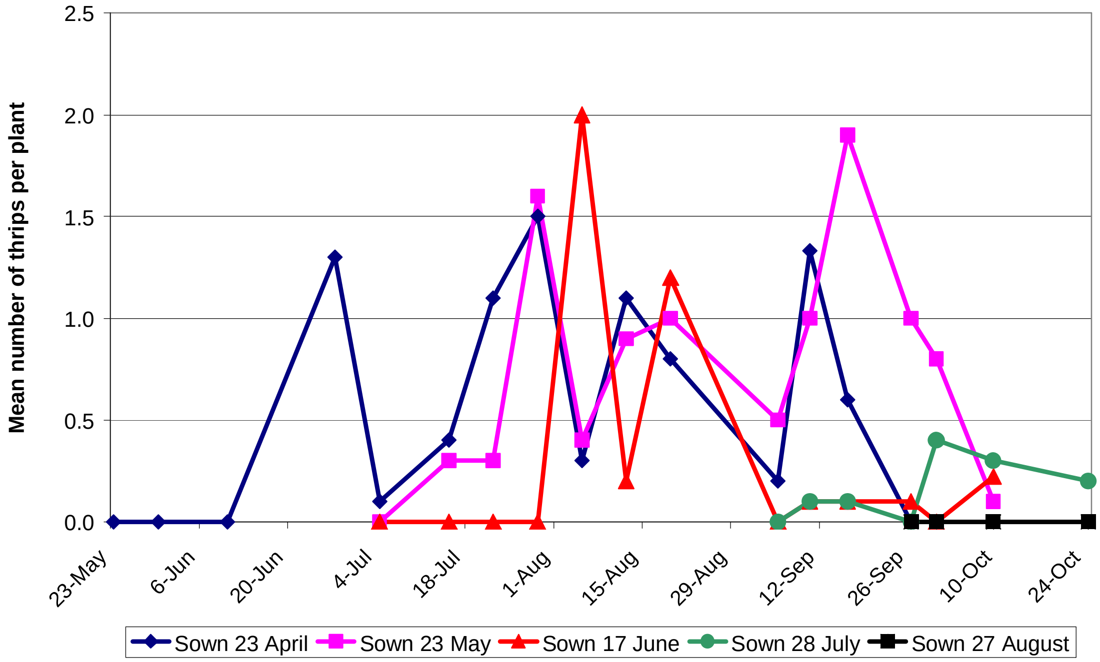

Figure 1.2: Mean number of thrips per plant in sequentially-sown plots of salad onion cv White Lisbon

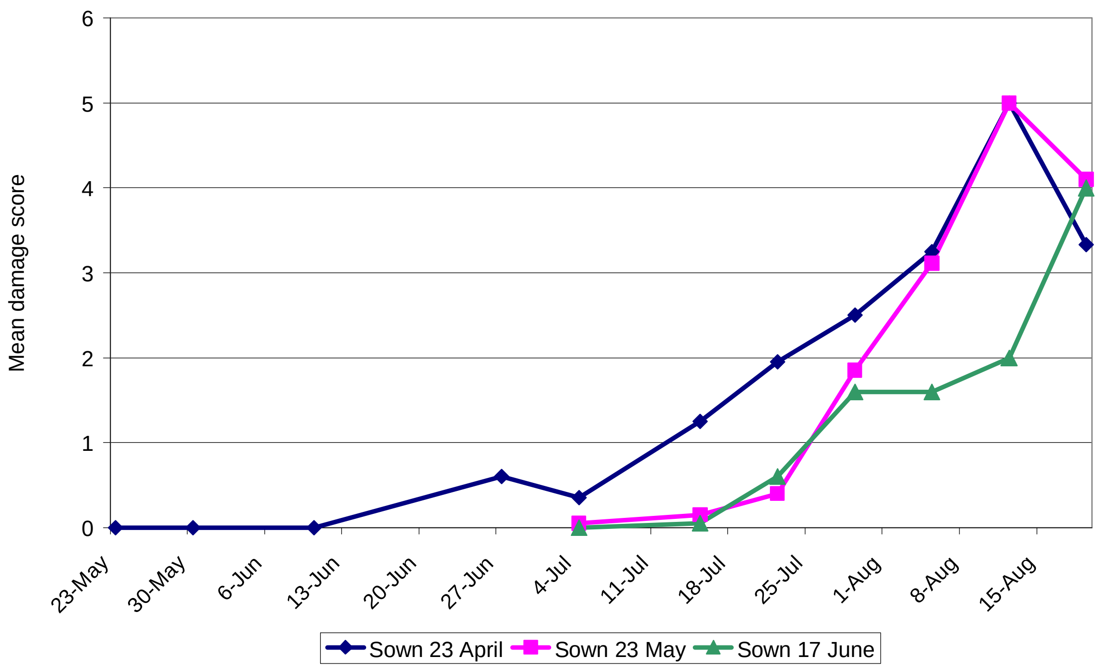

Figure 1.3: Mean damage score in sequentially-sown plots of salad onion cv White Lisbon – first three sowings

Experiment 2 **Control of thrips on leek with seed treatments and foliar sprays – large plot experiment**

<u>Materials and methods</u>

The experiment was done within the field known as Big Cherry at Warwick HRI, Wellesbourne. A population of onion thrips (*Thrips tabaci*) was maintained on an overwintered leek crop in an adjacent field. The experiment was laid out as a partially balanced row and column design with 10 rows and 4 columns. Including an untreated control, there were 10 main plot spray treatments. Each plot was 5 m x 2 beds (1.83 m each in size) and plots were separated by 1 m along beds. There were 4 replicates of each treatment.

Each plot was sown on 2 May 2008 with eight rows of seed and these contained 5 different 'seed treatments' (Table 2.1). The seed was sown at a spacing of 12 per metre with 4 rows (30 cm spacing) per bed. The layout of each plot is illustrated in Figure 2.1. Each of the spray treatments was a programme of 6 sprays based on Tracer with the additional products listed in Table 2.2. The programmes are specified in Table 2.3

Table 2.1: Seed treatments used within each plot

	Variety		Rate	Code
1	Exp A (cv Artemis)	Treated	25 g a.i./250,000 seeds	Exp A Trt
2	Exp A (cv Artemis)	Untreated		Exp A Unt
3	Shelton	Fipronil	50 g a.i. /250,000 seeds	Shel Fip
4	Shelton	Imidacloprid	50 g a.i. /250,000 seeds	Shel Imid
5	Shelton	Untreated		Shel Unt

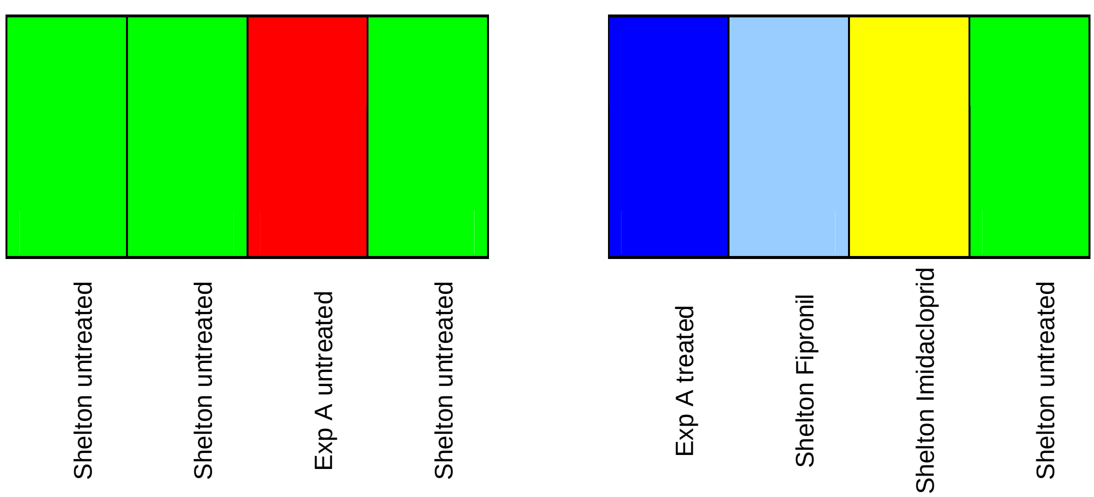

Figure 2.1: Layout of seed treatments in each plot 2 beds x 4 rows

Table 2.2: Foliar spray treatments applied to leek plots

	Treatment/product	Active ingredient	Rate l/ha or kg/ha
1 and 9	Tracer		0.2 l
2	Dursban WG	Chlorpyrifos	1 kg
3	Exp X1		1.5 l
4	Exp X2		0.175 l
5	Exp SA + Phase II		0.5 l + 1 l
6	Methiocarb 500 SC	Methiocarb	1.5
7	BASF Dimethoate 40	Dimethoate	0.6
8	Exp SB		0.4 kg
10	Untreated Control		

Table 2.3: Foliar spray programmes applied to leek plots (Dursban = Dursban WG and Dimeth = BASF Dimethoate 40)

	Programme name	Date					
		30/6	15/7	31/7	15/8	28/8	15/9
1	Tracer 2 (Tracer every 2 weeks)	Tracer	Tracer	Tracer	Tracer	Tracer	Tracer
2	Dursban	Tracer	Dursban	Dursban	Tracer	Dursban	Dursban
3	Exp X1	Tracer	X1	X1	Tracer	X1	X1
4	Exp X2	Tracer	X2	X2	Tracer	X2	X2
5	Exp SA	Tracer	SA	SA	Tracer	SA	SA
6	Methiocarb 500 SC	Tracer	Methiocarb 500 SC	Methiocarb 500 SC	Tracer	Methiocarb 500 SC	Methiocarb 500 SC
7	BASF Dimethoate 40	Tracer	Dimeth	Dimeth	Tracer	Dimeth	Dimeth
8	Exp SB	Tracer	SB	SB	Tracer	SB	SB
9	Tracer L (Tracer started 2 weeks later)		Tracer	Tracer	Tracer	Tracer	Tracer
10	Untreated Control						

Sprays were applied on 30 June, 15 July, 31 July, 15 August, 28 August and 15 September 2008 at a rate of 200l water/ha.

Assessments

The outer rows of the plot were treated as guard rows and were not assessed. The other 6 rows were assessed on some or all occasions. There were two replicates of the ‘Shelton Untreated’ seed treatment. Five plants per seed treatment per plot were assessed. Each of the leaves on each plant were examined separately and scored on a 0-10 scale for the presence of thrips feeding damage 0=no damage, 1=10% area affected……….10=100% area affected.

Analysis

<u>Comparison of seed treatments</u>

The mean overall damage score per plant per plot and the mean damage score of the penultimate leaf per plot were calculated. Comparisons for the seed treatments were made between each seed treatment and its associated untreated control. Analysis was carried out using ANOVA. Square root transformations were used throughout to ensure homogeneity between treatments. Means for each treatment were presented along with associated SEDs and 5% LSDs. Two sets of SEDs and 5% LSDs were presented due to the extra replication of the 'Shelton Untreated' seed treatment at the sub-plot level.

1 July 2008

Only the unsprayed control plots were assessed. Due to the extra replication of the Shelton untreated seed treatment within the experiment, two sets of SED and LSD values are presented Table 2.4. For pair-wise comparisons between the Shelton treated samples Shel Fip and Shel Imid and the Shelton Untreated sample, the 'Shelton T-U' set of values should be used. For comparisons between the Exp A Unt and Exp A Trt seed treatments the 'Exp A T-U' set of values should be used.

Considering the analysis of overall damage, the 'Shel Imid' samples had a mean damage score significantly smaller than the 'Shel Unt' samples. There was no significant difference between the Exp A treatments. There were no significant differences for the analysis of damage to the penultimate leaf.

Table 2.4: Thrips damage on 1 July 2008

		Overall damage		**Penultimate leaf**	
		Back Transformed	**Transformed**	**Back Transformed**	**Transformed**
Exp A Trt		0.7349	0.8573	0.8201	0.9056
Exp A Unt		0.6773	0.8230	0.9136	0.9558
Shel Fip		0.3718	0.6097	0.6812	0.8254
Shel Imid		0.2699	0.5195	0.3436	0.5861
Shel Unt		0.5601	0.7484	0.5457	0.7387
F-Value		4.280		1.380	
P-Value		0.015		0.286	
Shelton T-U	SED	0.085		0.156	
	5% LSD	0.181		0.330	
Exp A T-U	SED	0.099		0.180	
	5% LSD	0.209		0.381	
df		16		16	

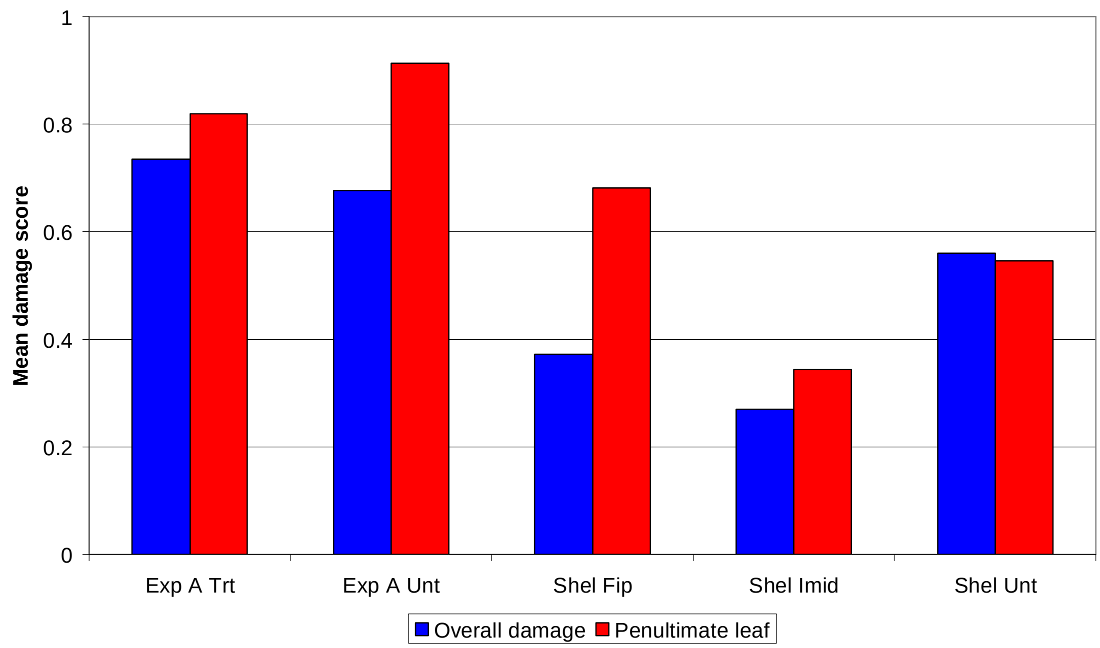

Figure 2.2: Thrips damage on 1 July 2008 (unsprayed plots)

15 July 2008

On 15 July, all seed treatments and two 'spray' treatments were compared Tracer2 and Unsprayed (Table 2.5; Figure 2.3). Considering overall damage, and the differences between seed treatments, for the Shelton treatments, the mean damage score for the Shel Un treatment was significantly larger than for the Shel Fip treatment for both spray treatments but it was only significantly larger than the Shel Imid treatment for the Tracer2 spray treatment. Considering the Exp A treatments, the Exp A U treatment had a larger mean than the Exp A T treatment for the Tracer2 spray treatment only.

There were no significant differences between the Tracer2 spray treatment and the unsprayed control.

Table 2.5: Overall damage on 15 July 2008

	Tracer2		Unsprayed	
	Back Transformed	**Transformed**	**Back Transformed**	**Transformed**
Exp A T	0.811	0.901	0.811	0.901
Exp A U	1.547	1.244	1.135	1.065
Shel Fip	0.303	0.656	0.303	0.551
Shel Imid	0.324	0.569	0.365	0.604
Shel Un	0.814	0.902	0.616	0.785
Within Spray				
Exp A T - U	SED	0.122		
	5% LSD	0.2485		
Shelton T-U	SED	0.1056		
	5% LSD	0.2152		
Between Spray				
Shel Un	SED	0.1126		
	5% LSD	0.2609		
Other Seed	SED	0.1419		
	5% LSD	0.3001		

For the penultimate leaf and Shelton seed treatments, the Shel Un had a mean damage score significantly larger than the Shel Fip and Shel Imid treatments for the Tracer2 spray treatment only Table 2.6; Figure 2.3. For the Exp A treatments, the Exp A U mean was significantly larger than the Exp A T mean for the Tracer2 spray treatment only.

There were no significant differences between the Tracer2 and unsprayed plots for any seed treatment.

Table 2.6: Damage to the penultimate leaf on 15 July 2008

	Tracer2		Unsprayed	
	Back Transformed	**Transformed**	**Back Transformed**	**Transformed**
Exp A T	1.109	1.053	1.109	1.053
Exp A U	2.189	1.48	1.51	1.229
Shel Fip	0.43	0.656	0.43	0.656
Shel Imid	0.27	0.519	0.362	0.602
Shel Un	1.003	1.002	0.609	0.78
Within Spray				
Exp A T - U	SED	0.2003		
	5% LSD	0.4079		
Shelton T-U	SED	0.1734		
	5% LSD	0.3533		
Between Spray				
Shel Un	SED	0.1762		
	5% LSD	0.4		
Other Seed	SED	0.226		
	5% LSD	0.4734		

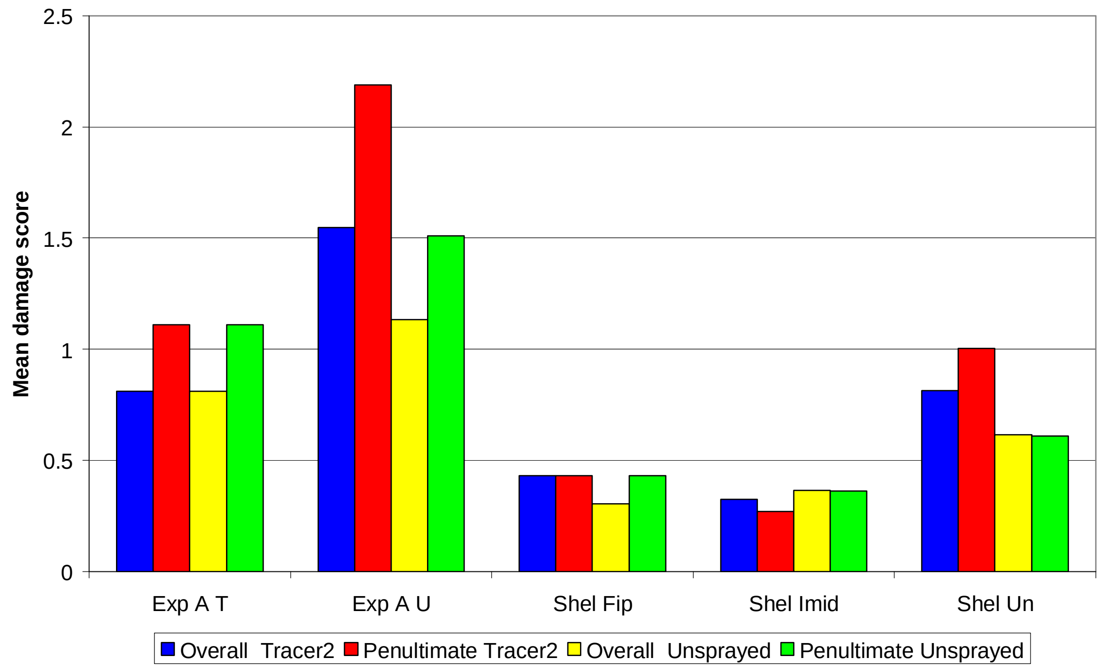

Figure 2.3: Thrips damage on 15 July 2008

28 July 2008

Analysis was carried out on the Tracer2 and TracerL spray treatments as well as the unsprayed control Table 2.7; Figure 2.4. For overall damage and the Shelton seed treatments, the Shel Un treatment had a mean damage score significantly larger than both the Shel Fip and Shel Imid treatments for all spray treatments. Considering the Exp A seed treatments, the mean for Exp A U was significantly larger than the Exp A T for the Tracer2 and TracerL spray treatments but not for the unsprayed control.

There were no significant differences of interest between the different Spray treatments.

Table 2.7: Overall damage on 28 July 2008

	Tracer2		TracerL		Unsprayed	
	Back Transformed	Transformed	Back Transformed	Transformed	Back Transformed	Transformed
Exp A T	1.662	1.289	1.678	1.295	2.784	1.668
Exp A U	2.986	1.728	2.435	1.56	2.779	1.667
Shel Fip	0.826	0.909	0.589	0.767	0.905	0.952
Shel Imid	0.94	0.97	0.888	0.942	1.166	1.08
Shel Un	1.486	1.219	1.375	1.173	1.601	1.265
Within Spray						
Exp A T - U	SED	0.1304				
	5% LSD	0.2621				
Shelton T-U	SED	0.1129				
	5% LSD	0.227				
Between Spray						
Shel Un	SED	0.1545				
	5% LSD	0.3434				
Other Seed	SED	0.1799				
	5% LSD	0.3786				

For damage to the penultimate leaf and for the Shelton seed treatments, the mean damage score for the Shel Un treatment was significantly larger than for the Shel Fip treatment for all spray treatments Table 2.8; Figure 2.4. There were no other significant differences between any seed treatments. There were no significant differences between the spray treatments.

Table 2.8: Damage to the penultimate leaf on 28 July 2008

	Tracer2		TracerL		Untreated	
	Back-transformed	**Transformed**	**Back-transformed**	**Transformed**	**Back-transformed**	**Transformed**
Exp A T	2.019	1.421	1.609	1.268	2.958	1.72
Exp A U	2.888	1.699	1.859	1.363	2.982	1.727
Shel Fip	0.599	0.774	0.373	0.611	0.694	0.833
Shel Imid	0.848	0.921	0.966	0.983	1.362	1.167
Shel Un	1.561	1.249	1.289	1.135	1.86	1.364
Within Spray						
Exp A T - U	SED	0.216				
	5% LSD	0.4343				
Shelton T-U	SED	0.187				
	5% LSD	0.3761				
Between Spray						
Shel Un	SED	0.1993				
	5% LSD	0.4238				
Other Seed	SED	0.2511				
	5% LSD	0.5122				

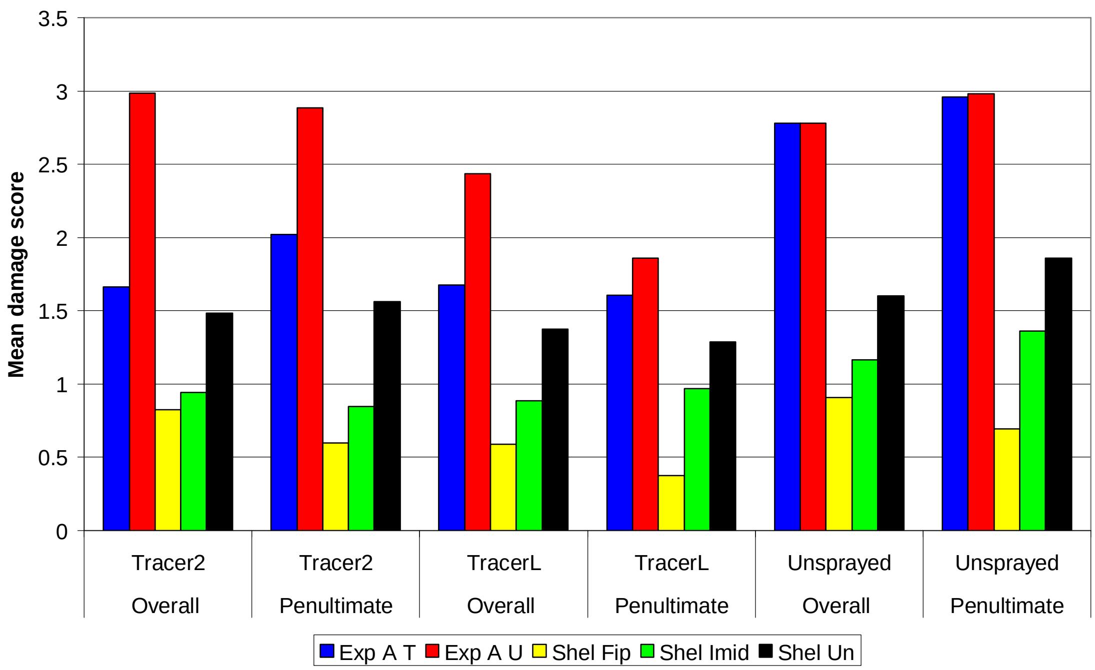

Figure 2.4: Thrips damage on 28 July 2008

11 August 2008

For overall damage and the Shelton treatments, the mean damage score for Shel Un was significantly larger than the mean for Shel Imid for the Tracer2 spray treatment Table 2.9; Figure 2.5. For the TracerL spray treatment and the unsprayed control, the mean damage score for the Shel Un treatment was significantly larger than the mean for the Shel Fip treatment. There were no significant differences between the Exp A treatments.

Considering the differences between the spray treatments, the unsprayed control means were larger than the TracerL means for the Shel Un and Shel Fip seed treatments. For the Exp A T seed treatment, the unsprayed control mean was significantly larger than the Tracer2 spray mean.

Table 2.9: Overall damage on 11 August 2008

	Tracer2		**TracerL**		**Unsprayed**	
	Back-transformed	**Transformed**	**Back-transformed**	**Transformed**	**Back-transformed**	**Transformed**
Exp A T	2.649	1.627	3.061	1.75	3.763	1.94
Exp A U	3.366	1.835	3.205	1.79	3.668	1.915
Shel Fip	1.85	1.36	1.663	1.289	2.396	1.548
Shel Imid	1.83	1.353	2.008	1.417	2.482	1.575
Shel Un	2.677	1.636	2.451	1.566	3.158	1.777
Within Spray						
Exp A T - U	SED	0.1046				
	5% LSD	0.2103				
Shelton T-U	SED	0.0906				
	5% LSD	0.1821				
Between Spray						
Shel Un	SED	0.0923				
	5% LSD	0.1946				
Other Seed	SED	0.1183				
	5% LSD	0.2402				

For the penultimate leaf and considering the differences between seed treatments, the mean damage score for the Shel Un treatment was significantly larger than the mean for the Shel Imid treatment for the Tracer2 spray treatment and unsprayed control Table 2.10; Figure 2.5. The mean damage score for the Shel Un treatment was also significantly larger than the mean for the Shel Fip treatment for the unsprayed control treatment. There were no significant differences for the Exp A treatments.

Considering the differences between the different spray treatments, the unsprayed control treatment had a mean damage score significantly larger than the TracerL treatment for the Shel Un seed treatment. For the Exp A T and the Shel Imid seed treatments, the unsprayed control had means significantly larger than Tracer2.

Table 2.10: Damage to penultimate leaf on 11 August 2008

	Tracer2		**TracerL**		**Unsprayed**	
	Back-transformed	**Transformed**	**Back-transformed**	**Transformed**	**Back-transformed**	**Transformed**
Exp A T	1.715	1.31	2.268	1.506	3.137	1.771
Exp A U	2.044	1.43	2.124	1.457	2.384	1.544
Shel Fip	1.525	1.235	1.173	1.083	1.914	1.383
Shel Imid	1.078	1.038	1.291	1.136	1.997	1.413
Shel Un	2.174	1.475	1.598	1.264	2.956	1.719
Within Spray						
Exp A T - U	SED	0.1638				
	5% LSD	0.3294				
Shelton T-U	SED	0.1419				
	5% LSD	0.2853				
Between Spray						
Shel Un	SED	0.1543				
	5% LSD	0.3294				
Other Seed	SED	0.1929				
	5% LSD	0.3944				

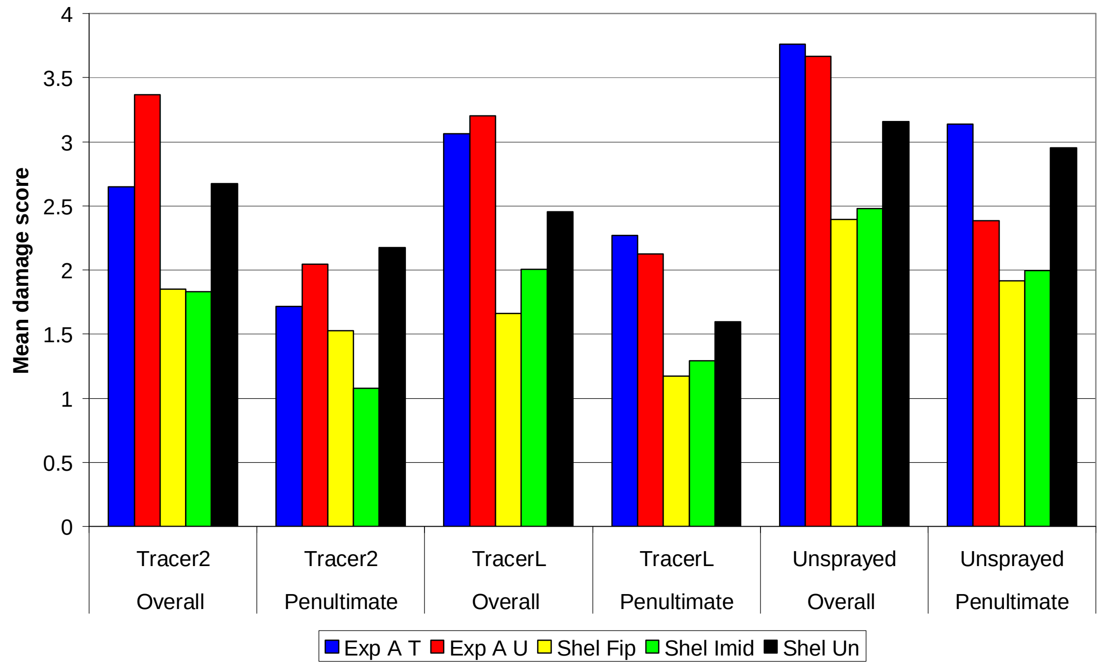

Figure 2.5: Damage on 11 August 2008

26 August 2008

For this, and all remaining assessments, the Methiocarb 500 SC spray treatment was also assessed at a main plot level. For overall damage, and considering the Shelton seed treatments, the mean damage score for Shel Un was significantly larger than both the Shel Fip and Shel Imid treatments for the Tracer2 spray and the unsprayed control Table 2.11; Figure 2.6. The mean damage score for Shel Un was only larger than the Shel Fip seed treatments for the TracerL spray and there were no significant differences for the Methiocarb 500 SC treatment. There were no significant differences for the Exp A seed treatments.

Considering the differences between the different spray treatments, the unsprayed plots had mean damage scores significantly larger than all spray treatments for the Shel Un and Exp A T seed treatments. For the Exp A Un and Shel Fip seed treatments, the unsprayed plots had means larger than the TracerL and Methiocarb 500 SC spray treatments. For the Shel Imid seed treatment, the untreated samples had means that were larger than the Methiocarb 500 SC sample only.

Table 2.11: Overall damage on 26 August 2008

	Tracer2		TracerL		Methiocarb 500 SC		Unsprayed	
	Back-transformed	Transformed	Back-transformed	Transformed	Back-transformed	Transformed	Back-transformed	Transformed
Exp A T	2.819	1.679	3.054	1.747	2.179	1.476	4.063	2.016
Exp A U	3.25	1.803	2.97	1.723	2.135	1.461	4.009	2.002
Shel Fip	1.878	1.37	1.532	1.238	1.281	1.132	2.425	1.557
Shel Imid	1.849	1.36	2	1.414	1.305	1.142	2.547	1.596
Shel Un	2.352	1.534	2.164	1.471	1.618	1.272	3.05	1.747
Within Spray								
Exp A T - U	SED	0.0818						
	5% LSD	0.1634						
Shelton T-U	SED	0.0708						
	5% LSD	0.1415						
Between Spray								
Shel Un	SED	0.0914						
	5% LSD	0.1933						
Other Seed	SED	0.1081						
	5% LSD	0.221						

For the penultimate leaf and considering the differences between seed treatments, the Shel Un treatment had a mean significantly larger than the Shel Imid treatment for the Tracer2 spray treatment and a mean significantly larger than the Shel Fip treatment for the unsprayed control samples Table 2.12; Figure 2.6. There were no differences of significance between the Exp A treatments.

Considering the differences between the spray treatments; the unsprayed control means were significantly larger than all spray products for the Shel Un, Exp A Un and Shel Imid seed treatments. For the Exp A T seed treatment, the unsprayed control means were significantly larger than only the Tracer2 and Methiocarb 500 SC spray treatments. There were no significant differences for the Shel Fip treatment.

Table 2.12: Damage to the penultimate leaf on 26 August 2008

	Tracer2		TracerL		Methiocarb 500 SC		Untreated	
	Back-transformed	Transformed	Back-transformed	Transformed	Back-transformed	Transformed	Back-transformed	Transformed
Exp A T	1.352	1.163	1.69	1.3	1.366	1.169	2.819	1.679
Exp A U	1.28	1.131	1.14	1.068	0.698	0.835	2.557	1.599
Shel Fip	0.668	0.817	0.425	0.652	0.671	0.819	1.188	1.09
Shel Imid	0.28	0.529	0.721	0.849	0.472	0.687	1.661	1.289
Shel Un	0.752	0.867	0.79	0.889	0.453	0.673	1.874	1.369
Within Spray								
Exp A T - U	SED	0.1931						
	5% LSD	0.3857						
Shelton T-U	SED	0.1672						
	5% LSD	0.334						
Between Spray								
Shel Un	SED	0.1655						
	5% LSD	0.3393						
Other Seed	SED	0.2145						
	5% LSD	0.4303						

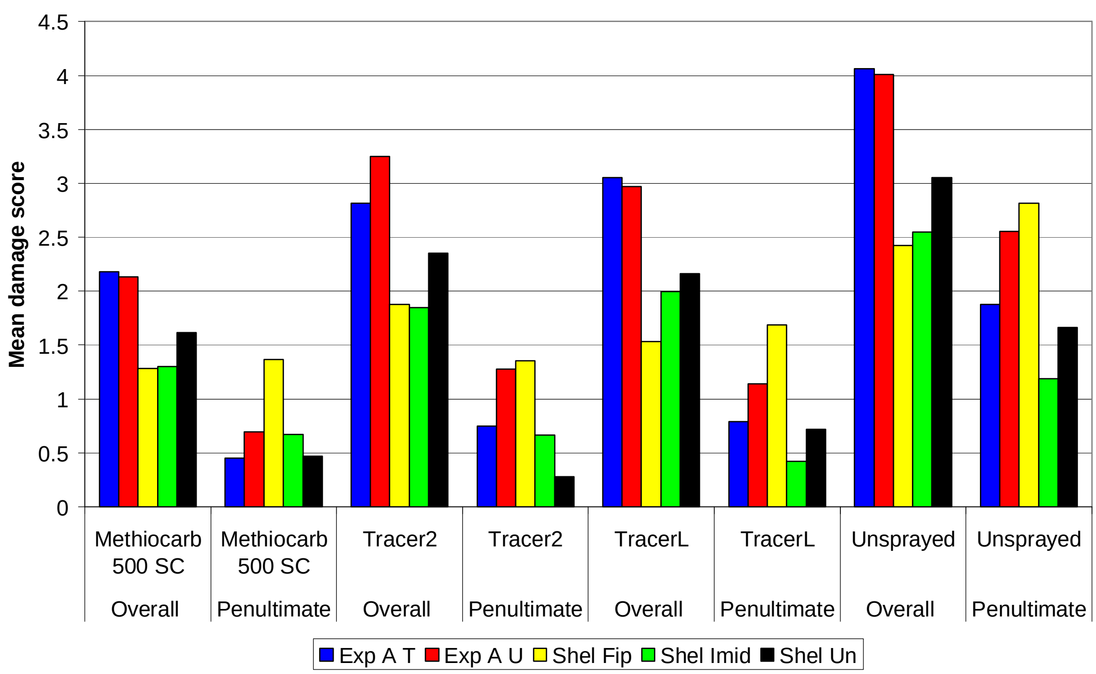

Figure 2.6: Damage on 26 August 2008

8 September 2008

For overall damage and considering the differences between the Shelton seed treatments, the mean for the Shel Un treatment was significantly larger than the means for both the Shel Fip and Shel Imid treatments for the Tracer2 and Methiocarb 500 SC Sprays Table 2.13; Figure 2.7. The mean for the Shel Un treatment was only significantly larger than the Shel Fip treatment for TracerL and the unsprayed control. There were no significant differences between the Exp A treatments.

Considering the differences between the spray treatments, the unsprayed control plots had means that were significantly larger than all other spray treatments for all seed treatments except the Exp A Un treatment.

Table 2.13: Overall damage on 8 September 2008

		Tracer2		TracerL		Methiocarb 500 SC		Untreated	
		Back-transformed	**Transformed**	**Back-transformed**	**Transformed**	**Back-transformed**	**Transformed**	**Back-transformed**	**Transformed**
Exp A T		3.077	1.754	3.239	1.8	2.547	1.596	4.224	2.055
Exp A U		3.255	1.804	3.226	1.796	2.047	1.431	3.951	1.988
Shel Fip		1.799	1.341	1.647	1.283	1.259	1.122	2.684	1.638
Shel Imid		2.008	1.417	2.135	1.461	1.354	1.163	2.978	1.726
Shel Un		2.537	1.593	2.334	1.528	1.75	1.323	3.3	1.817
Within Spray									
Exp A T - U	SED	0.086							
	5% LSD	0.1719							
Shelton T-U	SED	0.0745							
	5% LSD	0.1488							
Between Spray									
Shel Un	SED	0.0772							
	5% LSD	0.1593							
Other Seed	SED	0.0983							
	5% LSD	0.1977							

For damage to the penultimate leaf and considering the differences between the seed treatments, the Shel Un treatment had a mean significantly larger than the Shel Fip treatment for the Tracer2 Spray treatment Table 2.14; Figure 2.7. For the Exp A treatments, the Exp A T treatment had a mean damage score greater than Exp A U for Methiocarb 500 SC and the unsprayed plots.

Considering the differences between the different spray treatments, the unsprayed plots had means significantly larger than all spray treatments for the Shelton seed treatments. For the Exp A seed treatments, the unsprayed plots were significantly more damaged than the plots treated with Methiocarb 500 SC.

Table 2.14: Damage to the penultimate leaf on 8 September 2008

	Tracer2		**TracerL**		**Methiocarb 500 SC**		**Untreated**	
	Back-transformed	**Transformed**	**Back-transformed**	**Transformed**	**Back-transformed**	**Transformed**	**Back-transformed**	**Transformed**
Exp A T	1.594	1.262	2.073	1.44	1.261	1.123	3.085	1.756
Exp A U	1.231	1.109	1.546	1.243	0.331	0.575	2.08	1.442
Shel Fip	0.478	0.691	0.645	0.803	0.45	0.671	1.888	1.374
Shel Imid	0.806	0.898	0.698	0.835	0.399	0.632	1.939	1.392
Shel Un	1.183	1.088	1.084	1.041	0.568	0.753	2.39	1.546
Within Spray								
Exp A T - U	SED	0.1963						
	5% LSD	0.3921						
Shelton T-U	SED	0.17						
	5% LSD	0.3395						
Between Spray								
Shel Un	SED	0.1316						
	5% LSD	0.263						
Other Seed	SED	0.1912						
	5% LSD	0.3811						

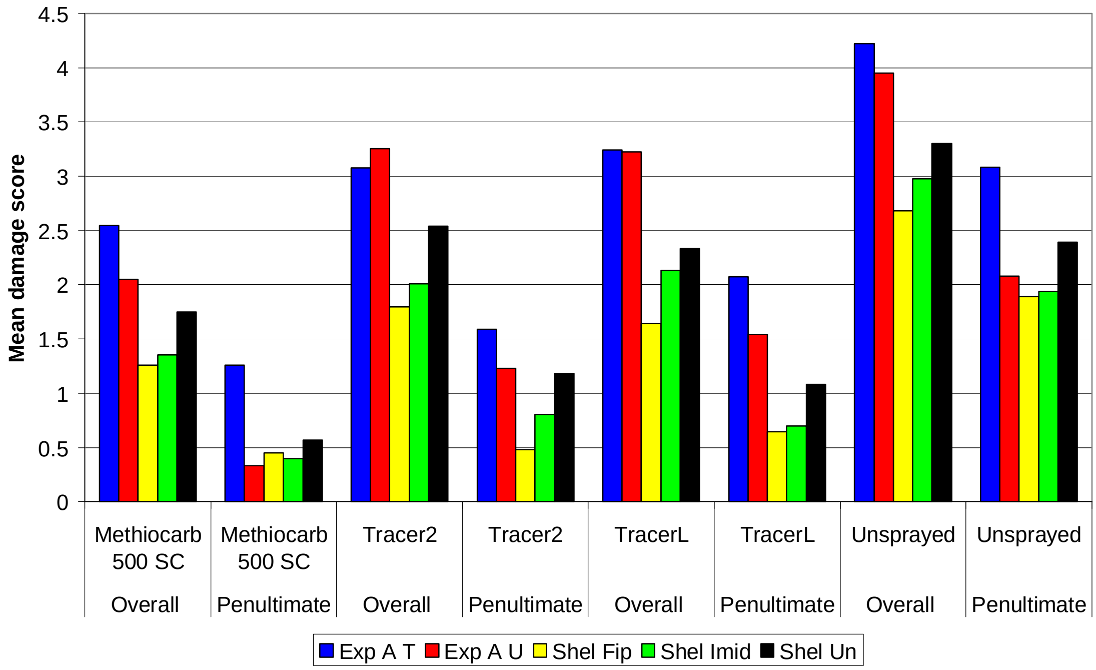

Figure 2.7: Thrips damage on 8 September 2008

22 September 2008

For overall damage and considering the differences between seed treatments, the Shel Un treatment had a mean damage score that was greater than both the Shel Fip and Shel Imid seed treatments for the Tracer2 and TracerL spray treatments Table 2.15; Figure 2.7. For the Methiocarb 500 SC spray treatment, there were only differences between the Shel Un and Shel Imid treatments. For the unsprayed plots, the only significant difference was between the Shel Un and Shel Fip treatments. There were no significant differences between the Exp A seed treatments.

Considering the differences between spray treatments, all spray treatments had means significantly smaller than the untreated control, for all seed treatments.

Table 2.15: Overall damage on 22 September 2008

	Tracer2		TracerL		Methiocarb 500 SC		Untreated	
	Back-transformed	Transformed	Back-transformed	Transformed	Back-transformed	Transformed	Back-transformed	Transformed
Exp A T	3.193	1.787	3.434	1.853	2.338	1.529	4.595	2.143
Exp A U	3.201	1.789	3.211	1.792	2.249	1.5	4.206	2.051
Shel Fip	1.921	1.386	1.906	1.381	1.371	1.171	2.82	1.679
Shel Imid	1.891	1.375	1.804	1.343	1.255	1.12	2.989	1.729
Shel Un	2.449	1.565	2.356	1.535	1.666	1.291	3.487	1.867
Within Spray								
Exp A T - U	SED	0.0878						
	5% LSD	0.1754						
Shelton T-U	SED	0.076						
	5% LSD	0.1519						
Between Spray								
Shel Un	SED	0.0656						
	5% LSD	0.1324						
Other Seed	SED	0.0903						
	5% LSD	0.1803						

For damage to the penultimate leaves, there were no significant differences between the seed treatments Table 2.16; Figure 2.7. Considering the differences between the Spray treatments, for the Shel Un, Exp A T and Shel Imid seed treatments, the unsprayed plots had means significantly higher than all sprayed plots. For the Exp A Un and Shel Fip seed treatments, the unsprayed plots had means significantly larger than the Tracer2 and Methiocarb 500 SC spray treatments only.

Table 2.16: Damage to the penultimate leaf on 22 September 2008

	Tracer2		TracerL		Methiocarb 500 SC		Untreated	
	Back-transformed	Transformed	Back-transformed	Transformed	Back-transformed	Transformed	Back-transformed	Transformed
Exp A T	1.473	1.214	1.763	1.328	0.589	0.767	3.298	1.816
Exp A U	1.388	1.178	1.631	1.277	0.681	0.825	2.4	1.549
Shel Fip	0.964	0.982	1.256	1.121	0.649	0.806	1.782	1.335
Shel Imid	0.934	0.967	0.591	0.769	0.544	0.737	1.765	1.329
Shel Un	0.956	0.978	1.164	1.079	0.731	0.855	2.464	1.57
Within Spray								
Exp A T - U	SED	0.1597						
	5% LSD	0.3191						
Shelton T-U	SED	0.1383						
	5% LSD	0.2764						
Between Spray								
Shel Un	SED	0.1252						
	5% LSD	0.254						
Other Seed	SED	0.1686						
	5% LSD	0.337						

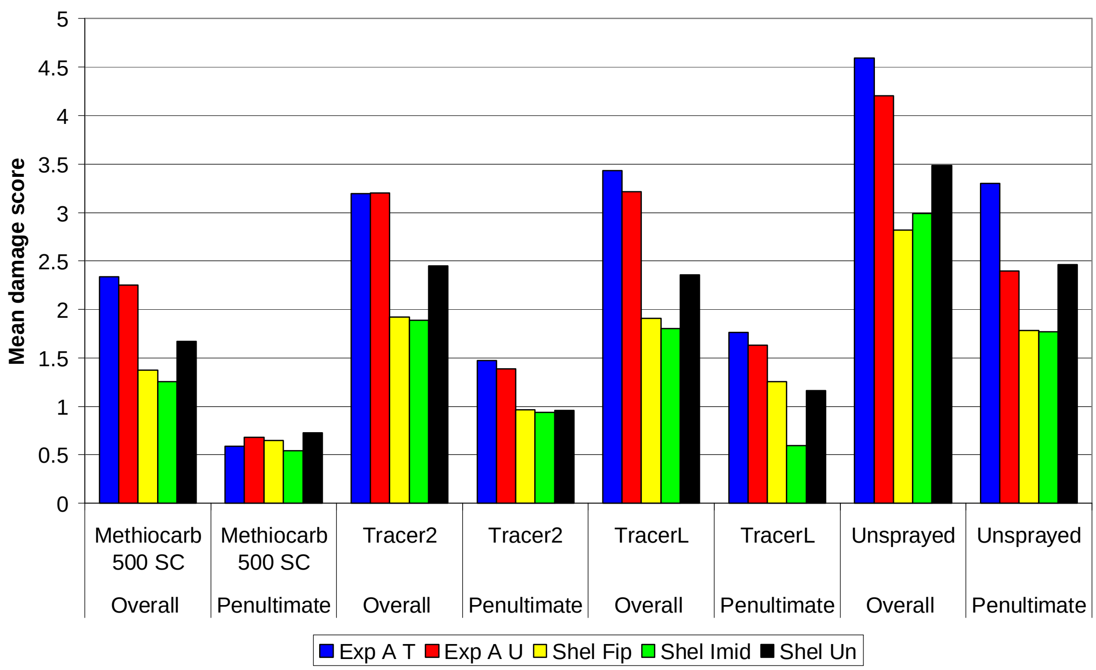

Figure 2.7: Thrips damage on 22 September 2008

Comparison of spray treatments

For this analysis the data were collected only from the rows grown from the Shelton untreated seed. All comparisons were therefore made between the 10 different spray programmes within the experiment. All plots were sprayed with Tracer on 30 June so a full assessment of spray effects was not started until 28 July (after the second spray). Analysis was carried out using ANOVA assuming a partially balanced row and column design with 10 rows and 4 columns with 1 replication of each spray treatment within each row. Square root transformations were used to ensure homogeneity between treatments. Each assessment was analysed separately.

Overall damage

Table 2.17 shows that the 'Spray effect' was significant at the 5% level for each assessment date. Spray treatments which display a mean damage score that was significantly smaller than the untreated control are highlighted. None of the spray treatments had a mean damage score significantly larger than the untreated control on any assessment date Figure 2.8.

Table 2.17: The effect of foliar spray treatments on overall thrips damage on leek plants grown from insecticide-free seed

	28 Jul		11 Aug		26 Aug		8 Sep		22 Sep	
	Back Transformed	**Transformed**	**Back Transformed**	**Transformed**	**Back Transformed**	**Transformed**	**Back Transformed**	**Transformed**	**Back Transformed**	**Transformed**
Tracer2	1.525	1.235	2.660	1.631	2.381	1.543	2.554	1.598	2.496	1.580
Dursban	0.947	0.973	2.307	1.519	2.298	1.516	2.443	1.563	2.576	1.605
ExpX1	1.080	1.039	2.430	1.559	2.283	1.511	2.403	1.550	2.769	1.664
ExpX2	1.764	1.328	3.049	1.746	2.650	1.628	2.693	1.641	3.059	1.749
Exp SA	1.201	1.096	2.316	1.522	2.196	1.482	2.202	1.484	2.570	1.603
Methiocarb 500 SC	0.874	0.935	1.780	1.334	1.583	1.258	1.711	1.308	1.646	1.283
Dimethoate	1.891	1.375	3.190	1.786	2.515	1.586	2.846	1.687	3.101	1.761
Exp SB	1.188	1.090	3.094	1.759	2.723	1.650	2.843	1.686	2.870	1.694
TracerL	1.543	1.242	2.531	1.591	2.247	1.499	2.430	1.559	2.443	1.563
Untreated	1.585	1.259	3.165	1.779	3.010	1.735	3.247	1.802	3.463	1.861
F-Value		5.190		5.330		8.150		10.970		13.930
P-Value		<.001		<.001		<.001		<.001		<.001
SED		0.095		0.091		0.064		0.058		0.060
5% LSD		0.196		0.189		0.132		0.120		0.124
df		23		23		23		23		23

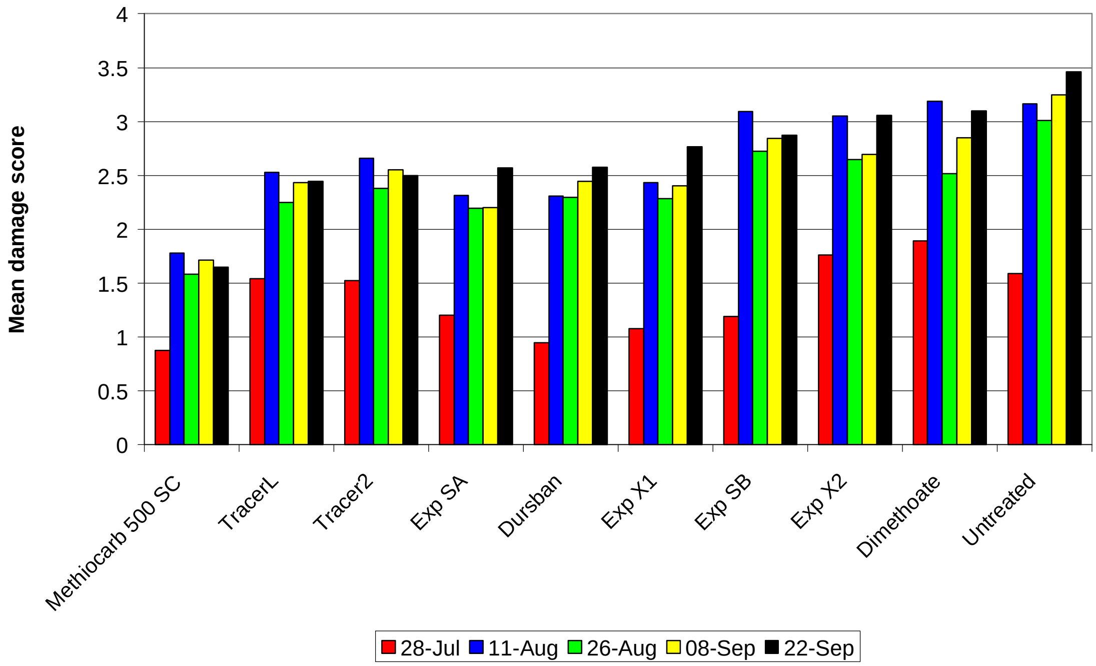

Figure 2.8: Overall thrips damage following insecticide spray treatments. Treatments sorted according to damage on 22 September

Penultimate Leaf

The 'Spray effect' was significant at the 5% level for all assessment dates Table 2.18. Spray treatments at each assessment date are highlighted where they display a mean which is significantly smaller than the untreated control. No Spray treatments had a mean significantly larger than the untreated control for any assessment date Figure 2.9.

Table 2.18: The effect of foliar spray treatments on thrips damage to the penultimate leaf on leek plants grown from insecticide-free seed

	28 Jul		11 Aug		26 Aug		8 Sep		22 Sep	
	Back Transformed	**Transformed**	**Back Transformed**	**Transformed**	**Back Transformed**	**Transformed**	**Back Transformed**	**Transformed**	**Back Transformed**	**Transformed**
Tracer2	1.633	1.278	2.135	1.461	0.841	0.917	1.245	1.116	1.018	1.009
Dursban	1.212	1.101	2.016	1.420	1.090	1.044	1.153	1.074	1.646	1.283
ExpX1	1.192	1.092	1.891	1.375	1.096	1.047	1.149	1.072	1.476	1.215
ExpX2	2.338	1.529	2.941	1.715	1.245	1.116	1.402	1.184	2.307	1.519
Exp SA	1.454	1.206	1.991	1.411	0.880	0.938	1.067	1.033	1.570	1.253
Methiocarb 500 SC	0.819	0.905	1.156	1.075	0.483	0.695	0.591	0.769	0.762	0.873
Dimethoate	2.250	1.500	2.972	1.724	1.279	1.131	1.613	1.270	2.421	1.556
Exp SB	1.548	1.244	2.866	1.693	1.241	1.114	1.481	1.217	1.568	1.252
TracerL	1.454	1.206	1.685	1.298	0.884	0.940	1.201	1.096	1.277	1.130
Untreated	1.850	1.360	2.952	1.718	1.899	1.378	2.316	1.522	2.531	1.591
F-Value		3.550		4.460		3.950		4.220		9.340
P-Value		0.007		0.002		0.004		0.003		<.001
SED		0.144		0.149		0.129		0.134		0.110
5% LSD		0.297		0.308		0.267		0.277		0.227
df		23		23		23	1.245	1.116	1.018	1.009

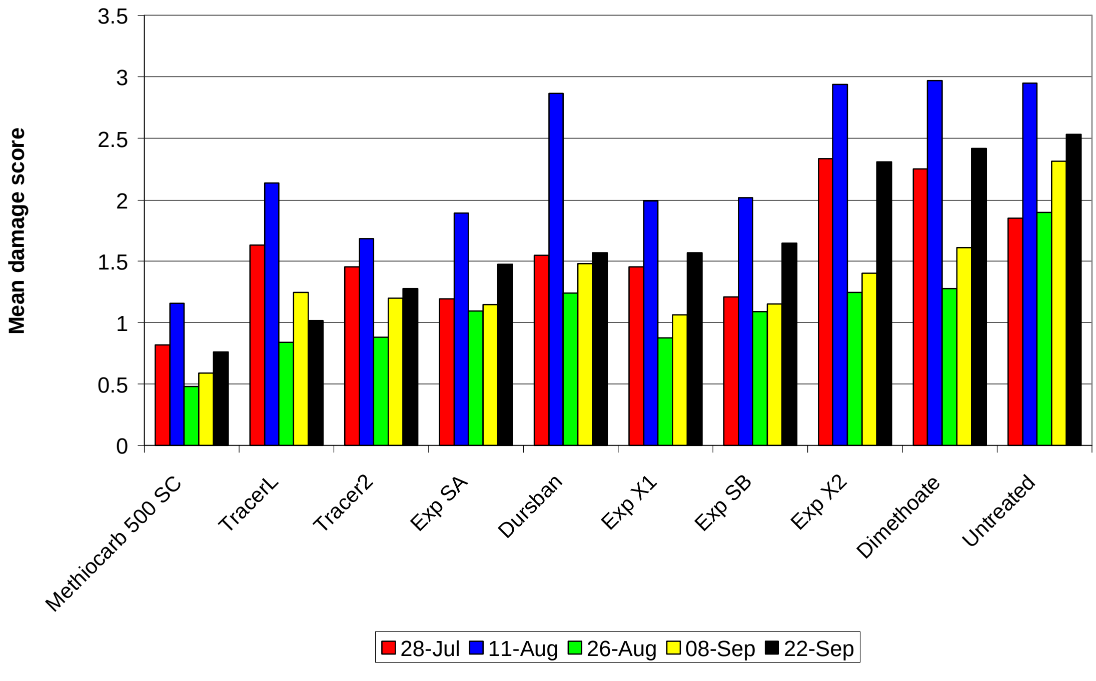

Figure 2.9: Damage to the penultimate leaf following insecticide spray treatments. Treatments sorted according to damage on 22 September

Finally, there was no great difference between the two 'Tracer only' programmes, which differed only by one spray (Tracer2 – 6-spray programme starting on 30 June, TracerL – 5-spray programme starting on 15 July).

Experiment 3 Control of thrips on leek with seed treatments and foliar sprays – isolated plot experiment

The aim of this part of the project was to determine whether experiments on thrips control should be laid out differently in future.

Materials and methods

This experiment was also done in the field known as Big Cherry. The experiment consisted of small, 'isolated' plots of leek (2 beds (1.83 m per bed) x 5 m long). This design avoids direct movement of thrips from one plot to another and may provide a more accurate representation of the field situation. Each plot was sown with eight rows of seed and these contained 5 different 'seed treatments' (as in the large plot experiment (Table 3.1)). The seed was sown on 2 May 2008 at a spacing of 12 per metre with 4 rows (30 cm spacing) per bed. The layout of each plot was the same as that illustrated in Figure 3.1.

There were 12 plots in total, separated into 4 blocks of three well-separated plots. The experiment was designed as a balanced row and column design with 4 rows and 3 columns. Including an untreated control there were 3 main plot treatments (Table 3.1), which were identical to the equivalent treatments applied in Experiment 1.

Table 3.1: Foliar spray treatments applied to isolated plots

1	Tracer - Every 2 weeks	Tracer2
2	Tracer – Spraying started 2 weeks later	TracerL
3	Untreated Control	Untreated

Assessments

Assessments were on seven occasions; 2 July, 15 July, 28 July, 11 August, 26 August, 8 September and 22 September. The outer rows of the plot were treated as guard rows and were not assessed. The other 6 rows were assessed on some or all occasions. There were two replicates of the 'Shelton Untreated' seed treatment. Five plants per seed treatment per plot were assessed. Each of the leaves on each plant were examined separately and scored on a 0-10 scale for the presence of thrips feeding damage (0=no damage, 1=10% area affected……….10=100% area affected).

For the first assessment, data were collected from the unsprayed control plots only. For the second assessment date, data were collected from the ‘Unsprayed control’ and ‘Tracer Every 2 weeks’ plots. For the last 5 assessments, data were collected from every plot.

Analyses were carried out on the overall damage score per plant per plot and the mean thrips damage score on the penultimate leaf per plot.

Analysis

All analyses were carried out using analysis of variance ANOVA. Means are presented for each analysis along with associated standard errors for the differences SED and 5% least significant differences LSD.

At the subplot level, comparisons were made between each seed treatment and its associated control: the Shelton Fipronil and Shelton Imidacloprid were compared with Shelton untreated and Exp A Treated was compared with Exp A Untreated. Due to the extra replication of the Shelton Untreated samples, each set of comparisons Shelton and Exp A has a different SED and 5% LSD associated with it.

2 July

Data were only collected from the unsprayed plots. For each of the analyses, a square root transformation was used to ensure the homogeneity of variances between treatments. The results of the analyses are presented in Table 3.2.

For comparisons between the Shelton treated and untreated seed treatments, the ‘Shelton T-U’ values were used. For differences between the Exp A treated and untreated samples; ‘Exp A T-U’ values were used.

For the penultimate leaf analysis, the Shel Un treatment had a mean significantly larger than the Shel Imid seed treatment.

Table 3.2: Thrips damage scores on 2 July 2008 (unsprayed plots)

		Overall score		**Penultimate leaf**	
		Back Transformed	**Transformed**	**Back Transformed**	**Transformed**
Exp A Un		0.721	0.849	0.580	0.762
Exp A T		0.680	0.825	0.392	0.626
Shel Fip		0.331	0.575	0.292	0.540
Shel Imid		0.280	0.529	0.206	0.454
Shel Un		0.525	0.724	0.562	0.749
F-Value			0.800		2.690
P-Value			0.545		0.069
Exp A T-U	SED		0.229		0.124
	5% LSD		0.486		0.264
Shelton T-U	SED		0.199		0.108
	5% LSD		0.421		0.228
df			16		16

15 July

Data were collected on the unsprayed and Tracer2 treatments. A square root transformation was used to ensure homogeneity between treatments.

Considering the seed treatments; the Shel Un seed treatment had a mean significantly larger than the Shel Fip and the Shel Imid treatments for the Tracer 2 Spray and significantly larger than the Shel Fip treatments for the untreated spray samples (Table 3.3; Figure 3.1). There were no differences between the Exp A seed treatments.

There was a significant difference between the unsprayed and Tracer 2 spray treatments for the Shel Imid seed treatment only. The unsprayed plots had the larger mean.

Table 3.3: Analysis of overall damage score on 15 July 2008

	Tracer2		Untreated	
	Back-transformed	Transformed	Back-transformed	Transformed
Exp A T	0.5782	0.7604	0.8948	0.9459
Exp A Un	0.7801	0.8833	1.2743	1.1289
Shel Fip	0.2087	0.4569	0.2770	0.5263
Shel Imid	0.1706	0.4130	0.5946	0.7711
Shel Un	0.5059	0.7113	0.8321	0.9122
Within Spray				
Exp A T-U	SED	0.1669		
	5% LSD	0.3399		
Shelton T-U	SED	0.1445		
	5% LSD	0.2944		
Between Spray				
Shel Un	SED	0.1071		
	5% LSD	0.2185		
Other Seed	SED	0.1594		
	5% LSD	0.3235		

Penultimate Leaf

For the Shelton seed treatments, the Shel Un level had a mean significantly larger than the Shel Fip and the Shel Imid seed treatments for the Tracer2 spray and significantly larger than the Shel Fip seed treatment for the unsprayed samples (Table 3.4; Figure 3.1). There were no differences between the Exp A seed treatments.

Considering the differences between the spray treatments, the Shel Un and Shel Imid seed treatments both had significantly larger sample means for the unsprayed plots.

Table 3.4: Damage to penultimate leaf on 15 July 2008

	Tracer2		Untreated	
	Back-transformed	Transformed	Back-transformed	Transformed
Exp A T	0.7630	0.8735	1.5266	1.2356
Exp A Un	1.1949	1.0931	1.8715	1.3680
Shel Fip	0.0729	0.2699	0.3664	0.6053
Shel Imid	0.0729	0.2699	0.8639	0.9294
Shel Un	0.5479	0.7402	1.2399	1.1135
Within Spray				
Exp A T-U	SED	0.1732		
	5% LSD	0.3528		
Shelton T-U	SED	0.1500		
	5% LSD	0.3055		
Between Spray				
Shel Un	SED	0.1343		
	5% LSD	0.2898		
Other Seed	SED	0.1818		
Shel Un	SED	0.3733		

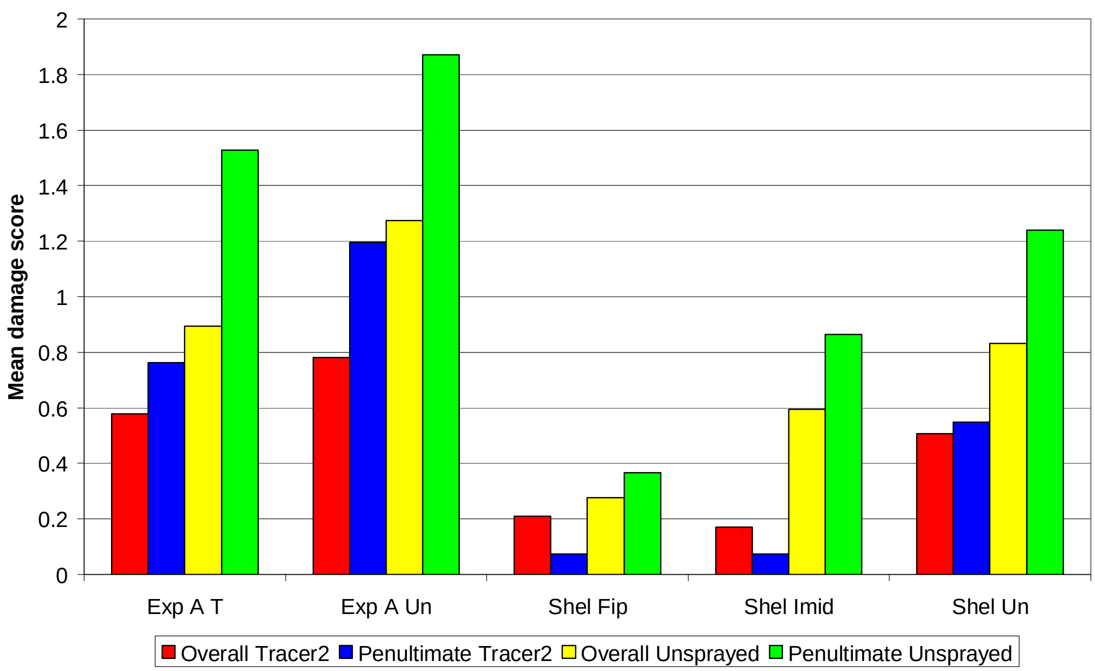

Figure 3.1: Damage scores on 15 July 2008

28 July 2008

For this and all subsequent dates, data were collected from all plots. A square root transformation was used to ensure homogeneity between treatments.

Considering the differences between the seed treatments, the Shel Un level had a mean significantly larger than the Shel Fip treatment for the untreated samples only (Table 3.5; Figure 3.2). The Exp A Un treatment had a mean significantly larger than Exp A for the TracerL Spray.

For the differences between spray treatments, the unsprayed samples had means significantly larger than both the Tracer2 and TracerL treatments for the Shel Un and Exp A T seed treatments. For both the Exp A Un and Shel Imid seed treatments, the untreated samples were significantly larger than the Tracer 2 samples only. There were no significant differences for the Shel Fip seed treatment.

Table 3.5: Overall thrips damage scores on 28 July 2008

	Tracer2		**TracerL**		**Untreated**	
	Back-transformed	**Transformed**	**Back-transformed**	**Transformed**	**Back-transformed**	**Transformed**
Exp A T	0.843	0.918	0.739	0.860	1.961	1.400
Exp A Un	1.026	1.013	1.587	1.260	1.718	1.311
Shel Fip	0.436	0.661	0.369	0.608	0.338	0.581
Shel Imid	0.600	0.774	0.630	0.794	1.114	1.056
Shel Un	0.631	0.795	0.621	0.788	0.990	0.995
Exp A T-U	SED	0.1255				
	5% LSD	0.2545				
Shelton T-U	SED	0.1106				
	5% LSD	0.2266				
Between spray						
Shel Un	SED	0.0840				
	5% LSD	0.1689				
Other Seed	SED	0.1188				
	5% LSD	0.2388				

For damage to the penultimate leaf, the Shel Un seed treatment had a mean significantly smaller than the Shel Imid treatment for the Tracer L spray treatment (Table 3.6; Figure 3.2). For the unsprayed samples, the Shel Un seed treatment had a mean significantly larger than the Shel Fip treatment. The Exp A Un had a mean significantly larger than the Exp A T seed treatments for the Tracer L treatment only.

Considering the differences between the spray treatments, the unsprayed plot means were significantly larger than both the Tracer 2 and Tracer L sample means for the Exp A T seed treatment. For the Shel Un seed treatment, the unsprayed plot means were significantly larger than the TracerL spray only. For The Shel Imid seed treatment, the unsprayed plot means were significantly larger than the Tracer2 spray only.

Table 3.6: Damage to penultimate leaf on 28 July 2008

	Tracer2		**TracerL**		**Untreated**	
	Back-transformed	**Transformed**	**Back-transformed**	**Transformed**	**Back-transformed**	**Transformed**
Exp A T	0.769	0.877	0.758	0.871	1.650	1.285
Exp A Un	0.499	0.707	1.263	1.124	1.079	1.039
Shel Fip	0.390	0.625	0.161	0.401	0.275	0.524
Shel Imid	0.466	0.683	0.694	0.833	1.275	1.129
Shel Un	0.552	0.743	0.137	0.370	0.823	0.907
Within Spray						
Exp A T-U	SED	0.1555				
	5% LSD	0.3125				
Shelton T-U	SED	0.1338				
	5% LSD	0.2695				
Between Spray						
Shel Un	SED	0.1121				
	5% LSD	0.2255				
Other Seed	SED	0.1586				
	5% LSD	0.1121				

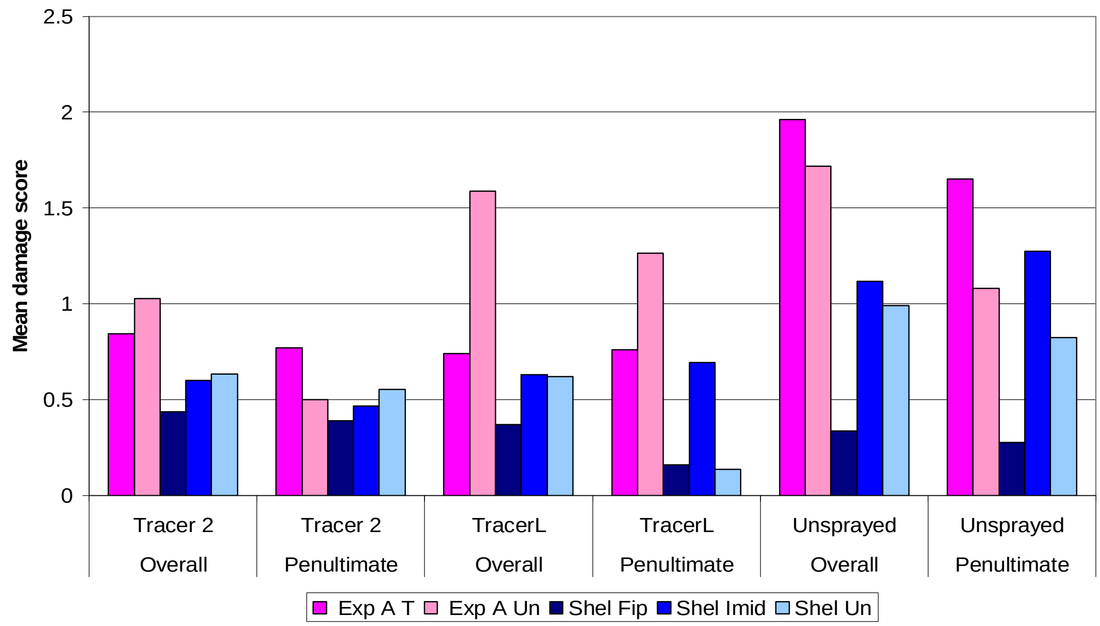

Figure 3.2: Damage scores on 28 July 2008

11 August

The only significant difference between the seed treatments was between the Shel Un And the Shel Fip seed treatments for the unsprayed samples (Table 3.7; Figure 3.3). Here the Shel Un had a larger mean. Considering the differences between the spray treatments, the unsprayed plots had means significantly larger than both the Tracer2 and TracerL spray treatments for all of the seed treatments.

Table 3.7: Overall thrips damage scores on 11 August 2008

	Tracer2		TracerL		Untreated	
	Back-transformed	Transformed	Back-transformed	Transformed	Back-transformed	Transformed
Exp A T	2.826	1.681	3.029	1.740	4.358	2.088
Exp A Un	2.937	1.714	3.131	1.770	4.381	2.093
Shel Fip	2.079	1.442	2.036	1.427	2.762	1.662
Shel Imid	2.426	1.558	2.239	1.496	3.946	1.987
Shel Un	2.664	1.632	2.489	1.578	3.792	1.947
Within Spray						
Exp A T-U	SED	0.1101				
	5% LSD	0.2237				
Shelton T-U	SED	0.0973				
	5% LSD	0.2000				
Between Spray						
Shel Un	SED	0.0729				
	5% LSD	0.1466				
Other Seed	SED	0.1031				
	5% LSD	0.2073				

For damage to the penultmate leaf, the Shel Un seed treatment had a mean significantly larger than the Shel Fip and the Shel Imid treatments for the TracerL spray and significantly larger than the Shel Fip treatment only for the unsprayed samples (Table 3.8; Figure 3.3).

For the differences between spray treatments, the untreated samples had means significantly larger than both the Tracer2 and TracerL spray for the Shel Un, Exp A T and Shel Imid seed treatments. For the Exp A Un treatment, the unsprayed plots were significantly larger than the Tracer2 spray samples only. For the Shel Imid treatments, the untreated samples were significantly larger than the TracerL samples only.

Table 3.8: Damage to penultimate leaf on 11 August 2008

	Tracer2		TracerL		Untreated	
	Back-transformed	**Transformed**	**Back-transformed**	**Transformed**	**Back-transformed**	**Transformed**
Exp A T	2.704	1.644	3.107	1.763	4.560	2.135
Exp A Un	2.175	1.475	2.771	1.665	3.877	1.969
Shel Fip	1.879	1.371	1.497	1.224	2.604	1.614
Shel Imid	2.353	1.534	1.530	1.237	4.244	2.060
Shel Un	2.622	1.619	2.341	1.530	4.245	2.060
Within Spray						
Exp A T-U	SED	0.1495				
	5% LSD	0.3001				
Shelton T-U	SED	0.1277				
	5% LSD	0.2564				
Between Spray						
Shel Un	SED	0.1101				
	5% LSD	0.2213				
Other Seed	SED	0.1557				
	5% LSD	0.3130				

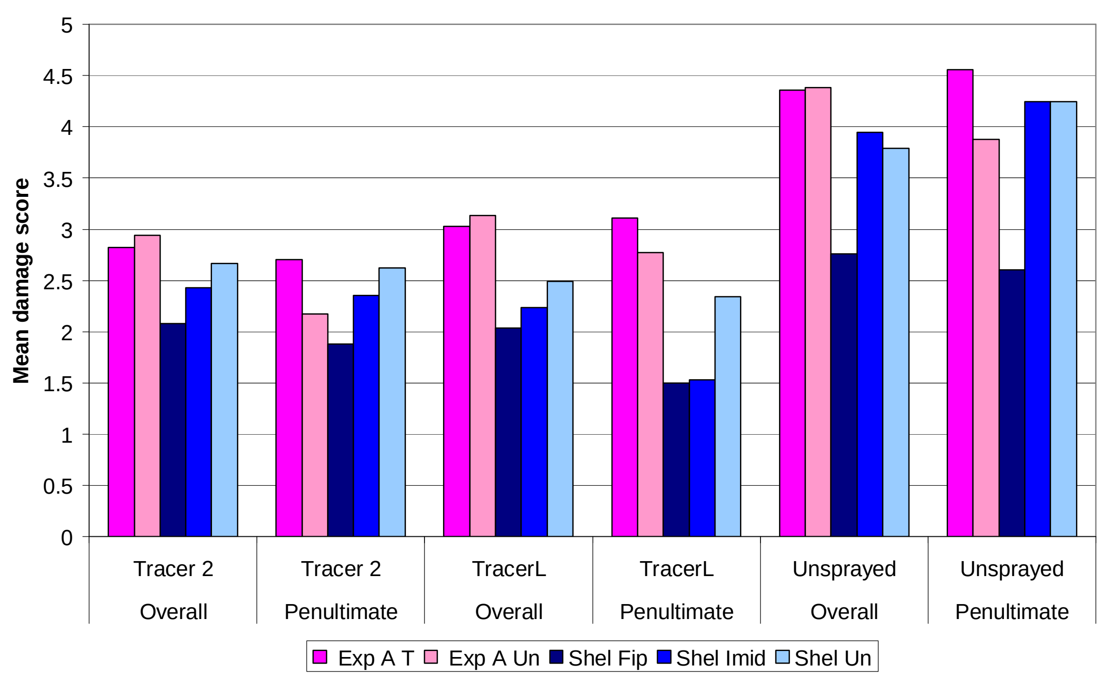

Figure 3.3 Damage scores on 11 August 2008

26 August

For the Shelton seed treatments, the Shel Un seed treatment had a mean significantly larger than the Shel Fip seed treatment for the Tracer2 and unsprayed samples (Table 3.9; Figure 3.4). There were no differences of significance between the Exp A treatments. Considering the differences between the spray treatments, the unsprayed plots had means significantly larger than both the Tracer2 and the TracerL spray treatments for all seed treatments bar the Shel Fip level. Here the untreated sample was significantly larger than the Tracer2 sample only.

Table 3.9: Overall thrips damage scores on 26 August 2008

	Tracer2		**TracerL**		**Untreated**	
	Back-transformed	**Transformed**	**Back-transformed**	**Transformed**	**Back-transformed**	**Transformed**
Exp A T	3.053	1.747	3.068	1.752	4.909	2.216
Exp A Un	2.982	1.727	2.979	1.726	4.403	2.098
Shel Fip	2.006	1.416	2.166	1.472	2.662	1.631
Shel Imid	2.429	1.558	2.334	1.528	3.829	1.957
Shel Un	2.627	1.621	2.604	1.614	3.688	1.920
Within Spray						
Exp A T-U	SED	0.0949				
	5% LSD	0.1964				
Shelton T-U	SED	0.0856				
	5% LSD	0.1808				
Between Spray						
Shel Un	SED	0.0580				
	5% LSD	0.1167				
Other Seed	SED	0.0821				
	5% LSD	0.1651				

For damage to the penultimate leaf, the only significant difference between seed treatments was between the Shel U and Shel Fip seed treatments for the unsprayed plots (Table 3.10; Figure 3.4). For the differences between spray samples, the unsprayed plots had means significantly larger than both the Tracer2 and the TracerL spray treatments for all seed treatments bar the Shel Fip level. There were no significant differences here.

Table 3.10: Damage to penultimate leaf on 26 August 2008

	Tracer2		TracerL		Untreated	
	Back-transformed	**Transformed**	**Back-transformed**	**Transformed**	**Back-transformed**	**Transformed**
Exp A T	1.520	1.233	1.583	1.258	3.097	1.760
Exp A Un	1.088	1.043	1.582	1.258	2.484	1.576
Shel Fip	0.856	0.925	0.779	0.882	1.286	1.134
Shel Imid	1.013	1.007	0.807	0.898	2.847	1.687
Shel Un	1.134	1.065	1.218	1.104	2.309	1.520
Within Spray						
Exp A T-U	SED	0.1602				
	5% LSD	0.3257				
Shelton T-U	SED	0.1417				
	5% LSD	0.2916				
Between Spray						
Shel Un	SED	0.1058				
	5% LSD	0.2127				
Other Seed	SED	0.1496				
	5% LSD	0.3383				

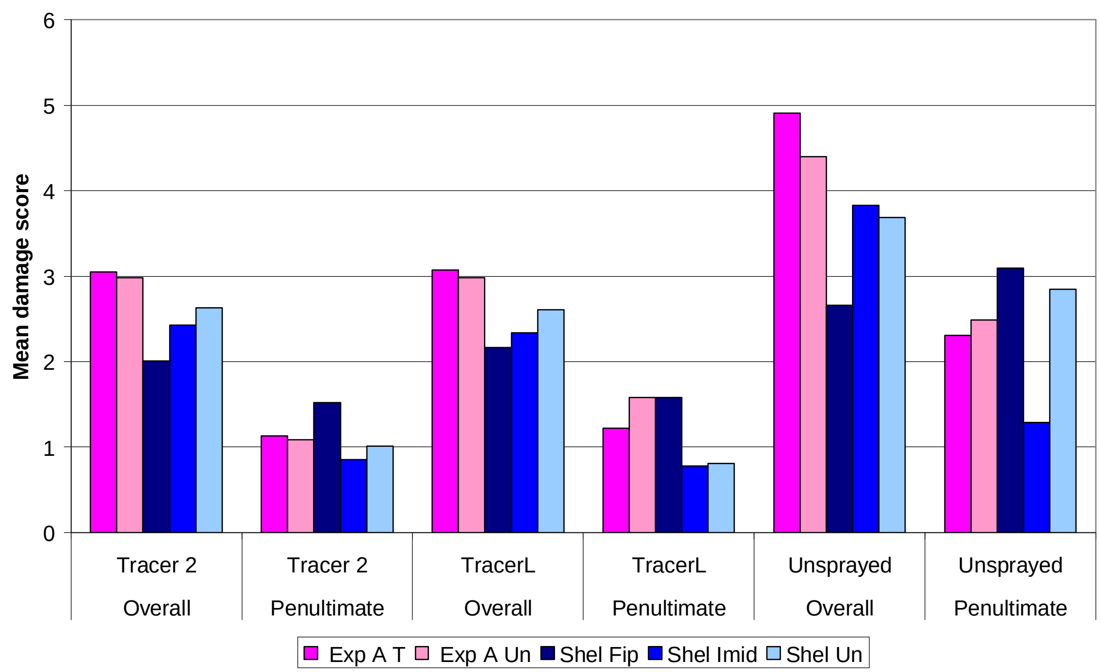

Figure 3.4 Damage scores on 26 August 2008

8 September

A square root transformation was used to ensure homogeneity between treatments. The Shel Un seed treatment had a mean significantly larger than the Shel Fip seed treatment for both the Tracer2 and the unsprayed plots (Table 3.11; Figure 3.5). For the differences between spray treatments, the unsprayed plots had means significantly larger than both the Tracer2 and the TracerL spray treatments for all seed treatments.

Table 3.11: Overall thrips damage scores on 8 September 2008

	Tracer2		TracerL		Untreated	
	Back-transformed	**Transformed**	**Back-transformed**	**Transformed**	**Back-transformed**	**Transformed**
Exp A T	2.896	1.702	2.849	1.688	4.466	2.113
Exp A Un	2.945	1.716	2.955	1.719	4.148	2.037
Shel Fip	1.896	1.377	1.972	1.404	2.667	1.633
Shel Imid	2.357	1.535	2.297	1.516	3.707	1.925
Shel Un	2.706	1.645	2.604	1.614	3.486	1.867
Within Spray						
Exp A T-U	SED	0.1121				
	5% LSD	0.2415				
Shelton T-U	SED	0.1039				
	5% LSD	0.2309				
Between Spray						
Shel Un	SED	0.0596				
	5% LSD	0.1199				
Other Seed	SED	0.0843				
	5% LSD	0.1695				

For damage to the penultimate leaf, the only difference between the seed treatments was between the Shel Un and the Shel Fip levels for the Tracer2 Spray (Table 3.12; Figure 3.5). Here the Shel Un had the larger mean. Considering the differences between the spray treatments, the unsprayed plots had means significantly larger than the Tracer2 and TracerL treatments for all seed treatments.

Table 3.12: Damage to penultimate leaf on 8 September 2008

	Tracer2		TracerL		Untreated	
	Back-transformed	Transformed	Back-transformed	Transformed	Back-transformed	Transformed
Exp A T	1.114	1.056	1.666	1.291	3.068	1.752
Exp A Un	1.090	1.044	1.317	1.147	2.440	1.562
Shel Fip	0.455	0.674	0.722	0.850	1.558	1.248
Shel Imid	0.725	0.852	0.889	0.943	2.410	1.552
Shel Un	1.211	1.100	1.283	1.133	2.293	1.514
Within Spray						
Exp A T-U	SED	0.2052				
	5% LSD	0.4284				
Shelton T-U	SED	0.1864				
	5% LSD	0.3986				
Between Spray						
Shel Un	SED	0.1214				
	5% LSD	0.2440				
Other Seed	SED	0.1716				
	5% LSD	0.3451				

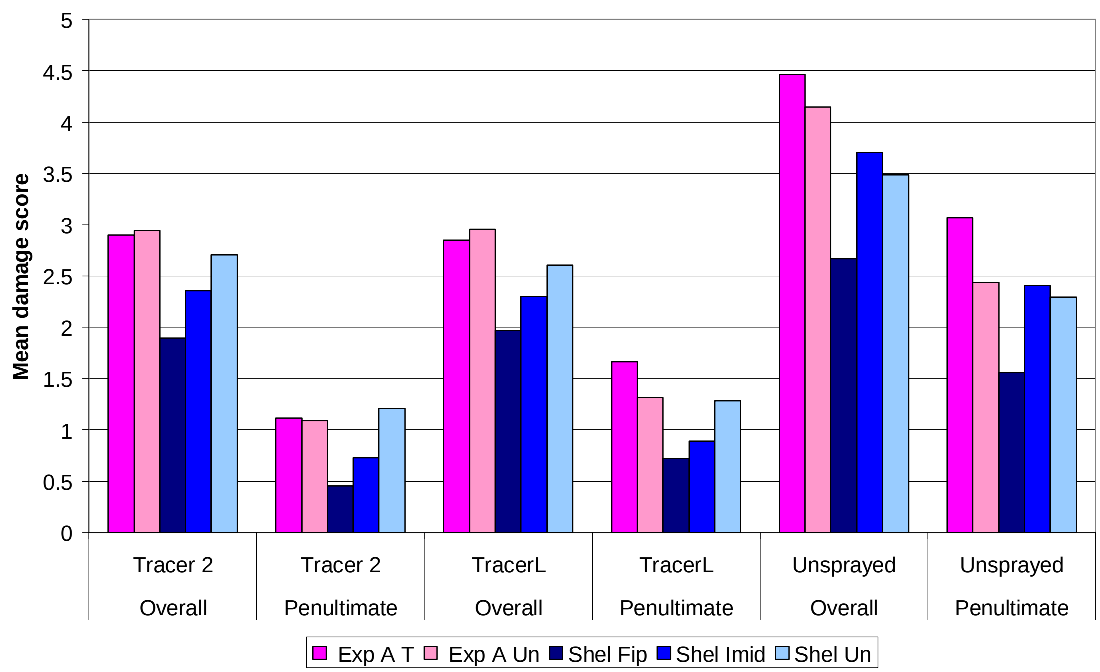

Figure 3.5: Damage scores on 8 September 2008

22 September

A square root transformation was used to ensure homogeneity between treatments.

There were no significant differences of interest between the seed treatments (Table 3.13; Figure 3.6). For the differences between the spray treatments, the unsprayed plots had means significantly larger than the Tracer2 and the TracerL Sprays for all seed treatments.

Table 3.13: Overall thrips damage scores on 26 September 2008

	Tracer2		TracerL		Untreated	
	Back-transformed	**Transformed**	**Back-transformed**	**Transformed**	**Back-transformed**	**Transformed**
Exp A T	2.941	1.715	2.992	1.730	4.553	2.134
Exp A Un	2.887	1.699	2.836	1.684	4.667	2.160
Shel Fip	1.739	1.319	2.034	1.426	2.883	1.698
Shel Imid	2.440	1.562	2.092	1.446	3.607	1.899
Shel Un	2.415	1.554	2.267	1.506	3.539	1.881
Within Spray						
Exp A T-U	SED	0.1193				
	5% LSD	0.2665				
Shelton T-U	SED	0.1125				
	5% LSD	0.2602				
Between Spray						
Shel Un	SED	0.0562				
	5% LSD	0.1130				
Other Seed	SED	0.0795				
	5% LSD	0.1598				

For damage to the penultimate leaf, there were no significant differences of interest between the seed treatment (Table 3.14; Figure 3.6). For the differences between the spray treatments, the unsprayed plots had means significantly larger than the Tracer2 and the TracerL Sprays for all seed treatments.

Table 3.14: Damage to penultimate leaf on 22 September 2008

	Tracer2		TracerL		Untreated	
	Back-transformed	Transformed	Back-transformed	Transformed	Back-transformed	Transformed
Exp A T	0.766	0.875	1.555	1.247	2.587	1.608
Exp A Un	0.673	0.821	1.364	1.168	2.692	1.641
Shel Fip	0.498	0.705	0.609	0.781	1.937	1.392
Shel Imid	0.819	0.905	0.876	0.936	2.285	1.512
Shel Un	0.826	0.909	0.878	0.937	1.790	1.338
Within Spray						
Exp A T-U	SED	0.1993				
	5% LSD	0.4153				
Shelton T-U	SED	0.1808				
	5% LSD	0.3857				
Between Spray						
Shel Un	SED	0.1186				
	5% LSD	0.2385				
Other Seed	SED	0.1677				
	5% LSD	0.3372				

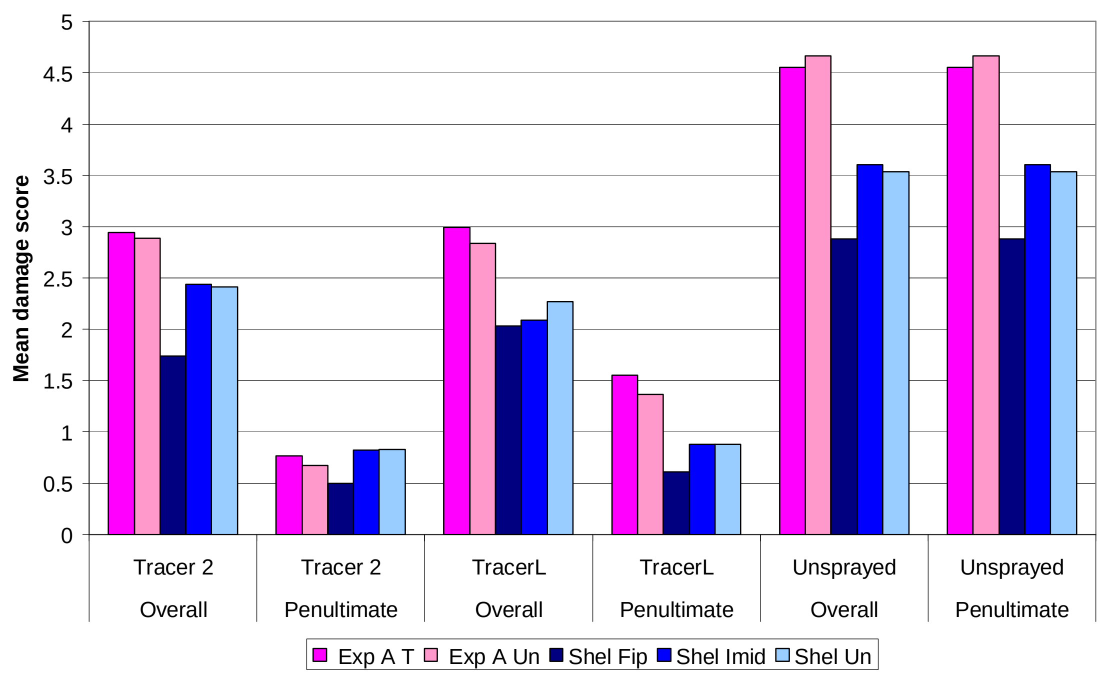

Figure 3.6: Damage scores on 22 September 2008

Assessments 3 – 7

Assessments 3 to 7 were analysed collectively within a single ANOVA. The purpose of this was to determine whether there were any significant differences between assessment dates. No interpretations were made on the Spray and Seed effects though they were included within the analysis (Table 3.15). The ‘Assess’ term was significant at the 5% level for all analyses.

Table 3.15: The P-values for the overall analysis to show the effect of assessment date (Seed = seed treatment; Spray= spray treatment; Assess=assessment date)

	Overall damage score	**Damage to penultimate Leaf**
Spray	**<.001**	**<.001**
Seed	**<.001**	**<.001**
Spray.Seed	0.169	**0.045**
Assess	**<.001**	**<.001**
Assess.Spray	0.589	0.274
Assess.Seed	0.639	0.606
Assess.Spray.Seed	0.995	0.960

There was a significant increase in damage between assessments 3 and 4 (Table 3.16; Figure 3.7). There were no other significant differences. The largest mean was for assessment 5 after which there was an overall reduction in the mean number of thrips per plant per plot.

For the penultimate leaf, there was a significant increase in damage between assessments 3 and 4 (Table 3.16; Figure 3.7). Assessment 4 had the largest overall mean here and there was a significant decrease between assessments 4 and 5. There were no other significant differences between assessments.

Table 3.16: The overall damage score and damage to the penultimate leaf on the 5 dates when all treatments were assessed

Assessment	**Date**	**Overall damage score**		**Damage to penultimate leaf**	
		Back-transformed	**Transformed**	**Back-transformed**	**Transformed**
3	28-Jul	0.829	0.911	0.616	0.785
4	11-Aug	2.960	1.721	2.799	1.673
5	26-Aug	2.993	1.730	1.498	1.224
6	08-Sep	2.893	1.701	1.423	1.193
7	22-Sep	2.844	1.686	1.230	1.109
	SED	0.02783		0.0463	
	5% LSD	0.05483		0.0911	

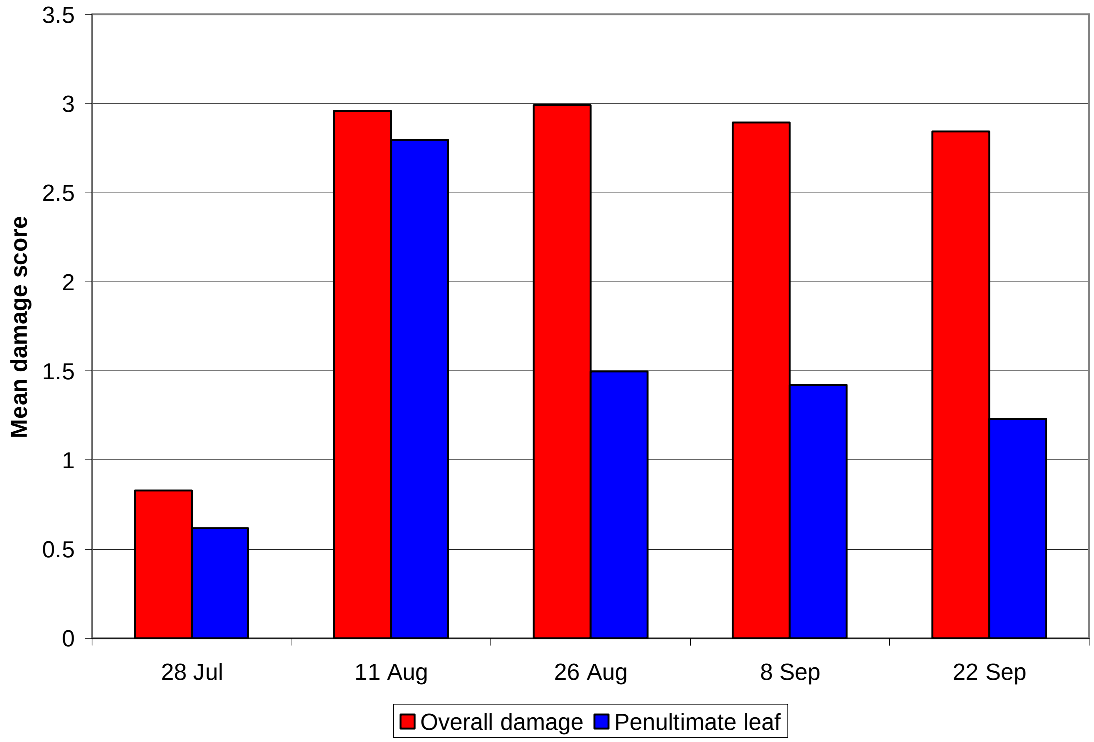

Figure 3.7: The overall damage score and damage to the penultimate leaf on the 5 dates when all treatments were assessed

Experiment 4 Control of bean seed fly and thrips on bulb onions with seed treatments

A replicated field experiment was done to determine the effectiveness of novel seed treatments for control of bean seed fly on bulb onion. The experiment was located in the field know as Big Cherry.

Each plot was 5 m x 1 bed (1.83 m each) in size and there were 20 plots in total. The plots were separated by 1 m along beds. The experiment was designed as a partially balanced row and column design with four rows and 5 columns. There were 4 treatments within the experiment; each replicated 5 times, 1 replicate per column. The treatments are shown in Table 4.1. Half of each plot was sown with treated seed and the other half with insecticide-free seed of the same variety.

Organic matter (spent mushroom compost at approximately 40t/ha) was incorporated before the beds were put in to encourage oviposition by bean seed fly. The onion seed was sown on 24-25 April 2008 at spacing of 20 seeds/m within rows and 0.38 m between rows (4 rows per bed). To further encourage oviposition, bonemeal at 150 kg/ha was applied on 7 May.

Table 4.1: Treatments used in experiment on control of bean seed fly and thrips in bulb onion

Treatment	Active ingredient	Variety	Rate (g a.i./unit[1])
Force	Tefluthrin	Armstrong	Commercial rate
Mundial	Fipronil	Sabroso	25
Exp B	Exp B	Sabroso	30 + 10
Exp S	Exp S	Wellington	25

[1] One unit = 250,000 seeds

Assessments

Assessments on the number of plants were made on 5 occasions; 16 May, 23 May, 4 June, 18 July, 3 September. For the first 4 assessments counts of the number of live and the number of dead plant counts in 2 x 1 m lengths of row were recorded. For the fifth assessment date, counts on the number of live plants only were made.

The onion plants were assessed for thrips damage on 1 July 2008 using the same method as described for Experiments 2 and 3. Five plants were assessed in the inner row of treated plants and five plants in the inner row of insecticide-free plants in each plot.

Analysis

Analysis was carried out using analysis of variance ANOVA assuming a split plot design.

Results

Plant Counts

Table 4.2 shows the counts of dead plants for each assessment date. Large numbers of zero counts within the data meant that no formal analysis using ANOVA was possible. It may be of interest that the majority of dead plants occurred in the untreated plots.

Table 4.2: The numbers of dead plants on each assessment date

	16 May		**23 May**		**4 Jun**		**18 Jul**	
	Treated	**Untreated**	**Treated**	**Untreated**	**Treated**	**Untreated**	**Treated**	**Untreated**
Force	0	0	0	2	0	1	0	0
Fipronil	0	0	0	0	1	0	0	0
Exp B	0	0	0	1	0	0	0	0
Exp S	0	2	1	1	0	0	0	0

The counts of live plants were analysed using ANOVA. No transformations of the data were required. Table 4.3 shows the P-values for the analysis at each assessment. Here the main effects for variety and insecticide-treatment were significant at a 5% level for all assessment dates although the interaction between the two terms was not.

Table 4.3: P-values for analysis of the numbers of live onion plants on 5 occasions

	Assessment				
	16 May	23 May	4 Jun	18 Jul	3 Sep
Variety	**0.002**	**<.001**	**<.001**	**<.001**	**0.005**
Insecticide	**<.001**	**0.002**	**0.001**	**0.049**	**<.001**
Variety.Insecticide	0.738	0.693	0.570	0.304	0.738

16 May 2008

The differences between the treated and untreated samples were significant for all varieties bar Exp S (Table 4.4). Considering only the treated samples, Exp S had a mean significantly smaller than the fipronil and Exp B treatments.

Table 4.4: Mean number of live plants per metre length of row on 16 May 2008

	Treated	**Untreated**
Force	17.23	11.03
Fipronil	22.49	15.89
Exp B	21.35	15.15
Exp S	12.94	9.94
	Within Product	Between Product
SED	2.576	2.338
5% LSD	5.461	4.817

23 May 2008

The differences between the treated and untreated samples were significant for the fipronil and Exp B treatments (Table 4.5). Considering only the treated samples, Exp S had a mean score smaller than all other varieties.

Table 4.5: Mean number of live plants per metre length of row on 23 May 2008

	Treated	**Untreated**
Force	20.3	15.3
Fipronil	26.1	19.9
Exp B	23.6	17.2
Exp S	13.2	10.8
	Within variety	Between variety
SED	2.625	2.315
5% LSD	5.564	4.767

4 June 2008

Significant differences between the treated and untreated means were observed for the fipronil and Exp S treatments (Table 4.6). Considering only the treated samples, Exp B had a mean which was significantly smaller than all other treatments.

Table 4.6: Mean number of live plants per metre length of row on 4 June 2008

	Treated	**Untreated**
Force	20.1	16.9
Fipronil	25.3	19.7
Exp B	23.6	16.8
Exp S	12.6	9.8
	Within variety	Between variety
SED	2.307	2.219
5% LSD	4.89	4.579

18 July 2008

The fipronil and Exp B treatments both had significantly larger means for the treated samples than for the untreated samples (Table 4.7). Considering only the treated samples, Exp S variety had a mean significantly smaller than the Exp B and fipronil treatments.

Table 4.7: Mean number of live plants per metre length of row on 18 July 2008

	Treated	**Untreated**
Force	16.1	17.3
Fipronil	23.5	18.5
Exp B	22.2	16.0
Exp S	11.5	9.3
	Within variety	Between variety
SED	2.869	2.478
5% LSD	6.082	5.104

3 September 2008

There were no significant differences between any of the varieties or between the treated and untreated samples (Table 4.8).

Table 4.8: Mean number of live plants per metre length of row on 3 September 2008

	Treated	Untreated
Force	9.5	7.9
Fipronil	11.9	9.1
Exp B	12.2	8.6
Exp S	8.66	5.9
	Within variety	Between variety
SED	1.265	1.16
5% LSD	2.681	2.39

The plant counts for all assessment dates are summarised in Figure 4.1.

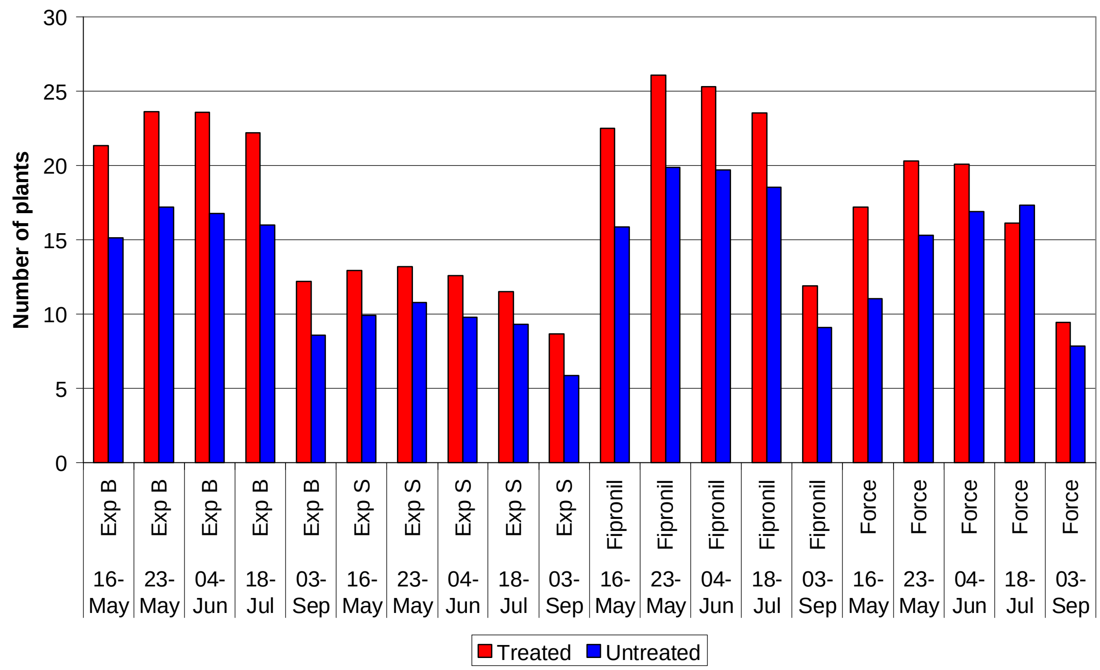

Figure 4.1: Mean number of plants per metre length of row on 5 assessment dates

<u>Thrips damage – 1 July 2008</u>

Analyses were carried out using ANOVA. Square root transformations were used throughout to ensure homogeneity between treatments.

Overall damage

The main effect for Variety and the Variety and Insecticide interaction were both significant at the 5% level although the main effect for insecticide was not. There was significantly less thrips damage on the treated sample for Exp B only. Considering the treated samples only, the Exp B and fipronil treatments both had means significantly smaller than the Force and Exp S treatments Table 4.9.

Table 4.9: Overall damage score on onions grown from seed with and without insecticide treatments on 1 July 2008

	Treated		Untreated	
	Back-transformed	**Transformed**	**Back-transformed**	**Transformed**
Force	1.947	1.395	1.520	1.233
Fipronil	0.730	0.854	1.102	1.050
Exp B	1.034	1.017	1.524	1.235
Exp S	2.125	1.458	1.907	1.381
	Within variety	Between variety		
SED	0.0961	0.0956		
5% LSD	0.2037	0.1977		

Penultimate Leaf

The Variety and Variety and Insecticide interaction terms were significant at the 5% level, the main effect for Insecticide was not. There were no significant differences between the treated and the untreated plants. Considering the treated samples only, the fipronil and Exp B varieties had means significantly smaller than the Force and Exp S treatments (Table 4.10). The results for overall damage and damage to the penultimate leaf are summarised in Figure 4.2.

Table 4.10: Damage to the penultimate leaf of onions grown from seed with and without insecticide treatments on 1 July 2008

	Treated		**Untreated**	
Force	2.140	1.463	1.79	1.338
Fipronil	0.866	0.93	1.264	1.124
Exp B	1.204	1.097	1.667	1.291
Exp S	3.019	1.737	2.384	1.544
	Within variety	Between variety		
SED	0.1042	0.1174		
5% LSD	0.221	0.2451		

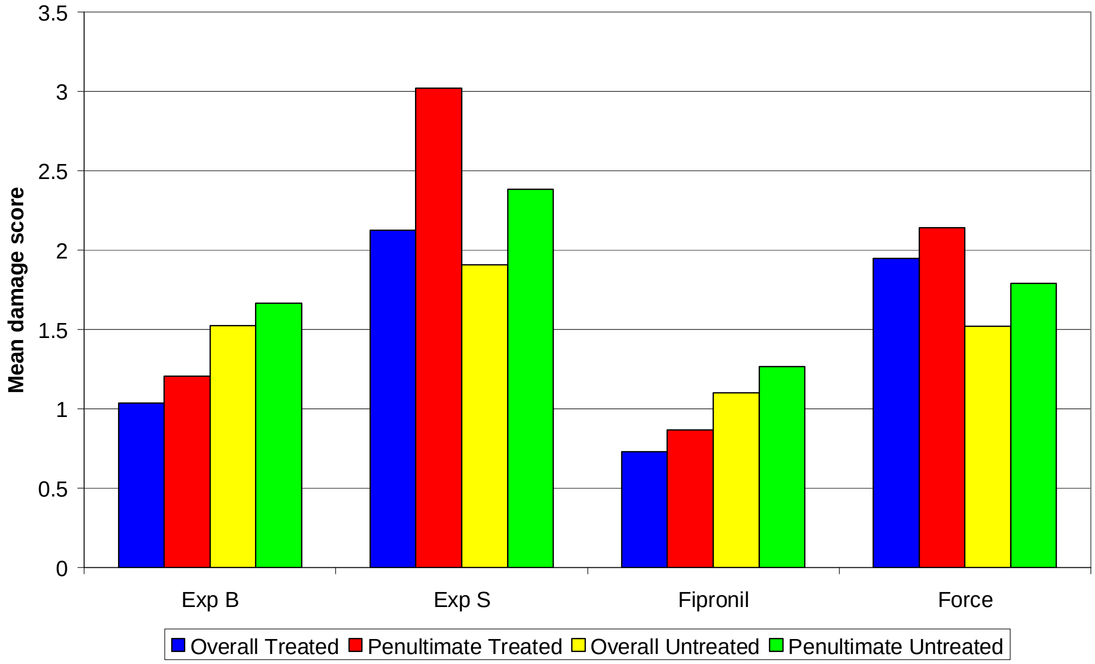

Figure 4.2: Thrips damage to onions grown from seed with and without insecticide treatments on 1 July 2008

<u>Discussion</u>

Adult thrips were most numerous from mid July until early August (Figure 1.1). Thrips damage increased from early July onwards but the greatest increase was in early August (Figures 1.3 and 5.1). Not surprisingly, therefore, most damage was caused when thrips were most abundant. The heavy rainfall in the latter part of the summer may have suppressed thrips numbers to some extent.

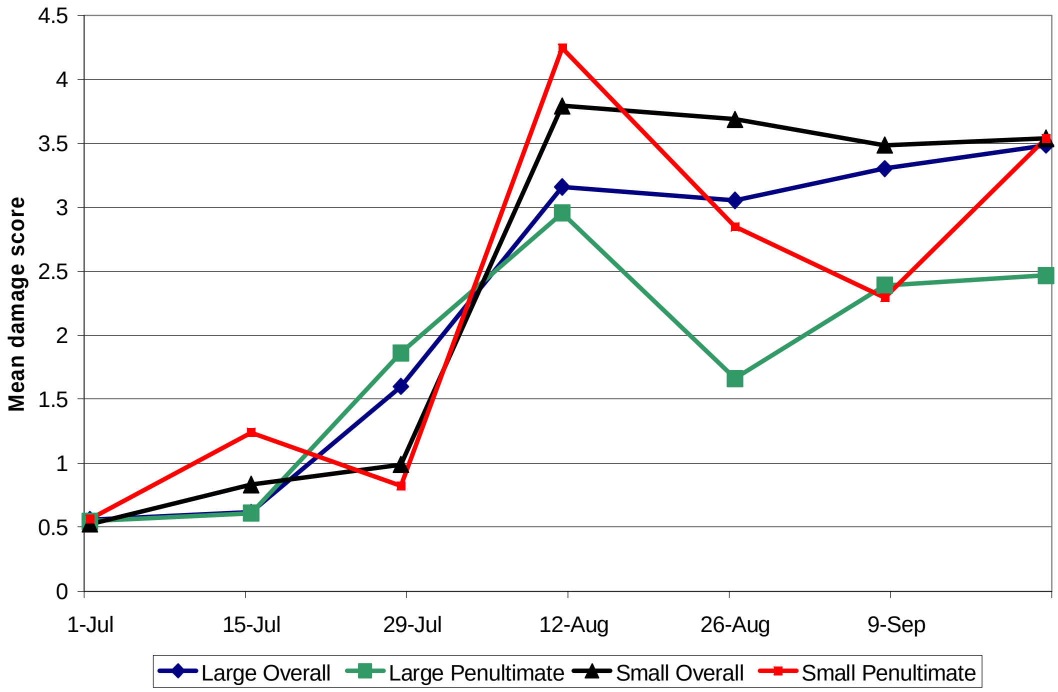

Figure 5.1: Mean damage score (overall damage and damage to penultimate leaf) on insecticide-free, unsprayed rows of cv Shelton. Small=isolated plot experiment; large=large plot experiment)

The mean damage score represents the development of damage over a period of several months, as it is based on an assessment of all the foliage on the plant. Damage to the penultimate leaf gives an impression of the current level of thrips pressure, as this is the newest leaf. However, this assessment is based on a smaller 'sample' – only one leaf per plant compared with several, so it may be expected to be more variable.
The reason for undertaking the isolated plot experiment on thrips control was to determine whether there was any evidence that direct movement of thrips between plots in a large 'block' experiment blurred differences between treatments, and therefore whether the use of isolated plots might provide a more accurate representation of the field situation. All of the seed treatments and three of the spray treatments (unsprayed, Tracer2, TracerL) were identical in the two experiments.

Comparison of large and isolated plot experiments

By the middle of the summer, there were similar levels of damage on insecticide-free, unsprayed leeks in both the large and isolated plot experiments ((Figure 5.2).

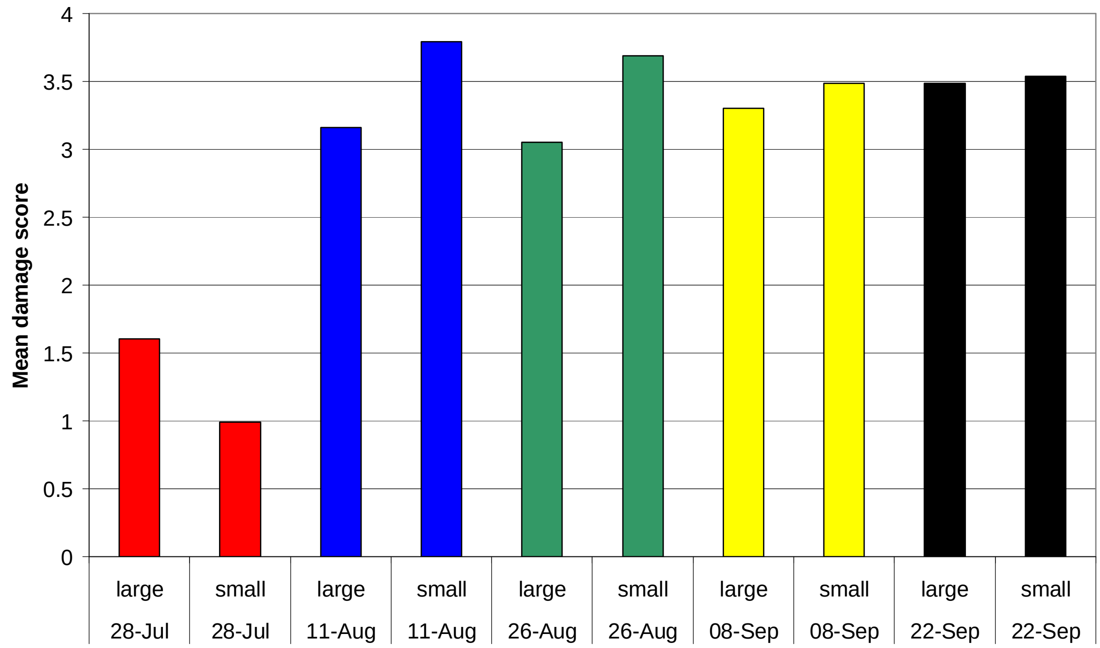

Figure 5.2: Mean damage score (overall damage) on insecticide-free, unsprayed rows of cv Shelton. Small= isolated plot experiment; large=large plot experiment

If thrips movement was ‘blurring’ treatment differences between plots then it would be expected that the ‘difference’ between the sprayed and unsprayed plots for the two spray treatments (Tracer2 and TracerL) would be different in the two experiments. Figures 5.3 and 5.4 show the ratio of thrips damage in the sprayed plots to damage in the unsprayed control plots (Untreated cv Shelton) for the Tracer2 and TracerL treatments respectively. Generally, damage levels in the sprayed plots were about 70% of those in the unsprayed plots, but there was no evidence of any difference between the two experiments. Figures 5.5 and 5.6 show similar graphs for the Shelton seed treated with Fipronil and there is a similar pattern.

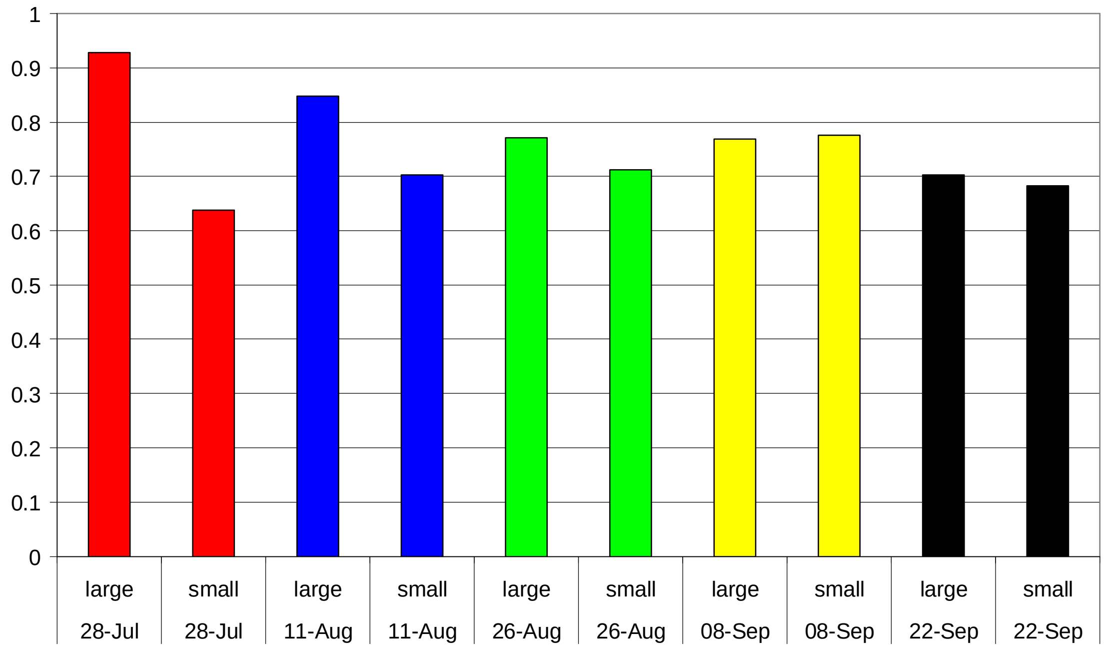

Figure 5.3: The ratio of thrips damage in the Tracer2 sprayed plots to damage in the unsprayed control plots (cv Shelton untreated seed). Small= isolated plot experiment; large=large plot experiment

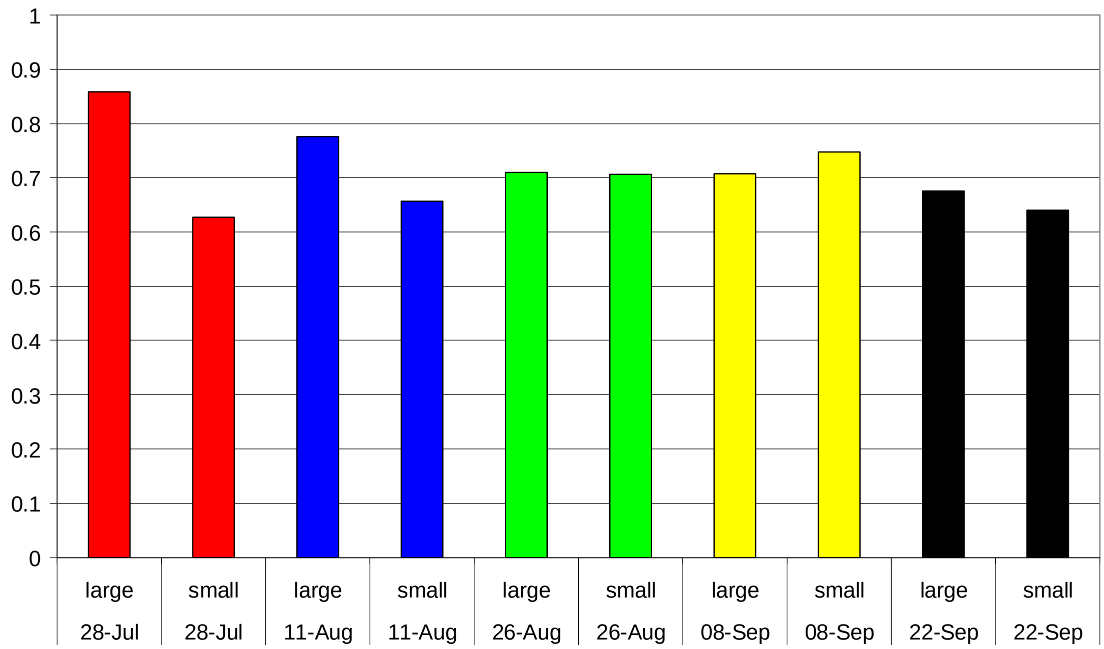

Figure 5.4: The ratio of thrips damage in the TracerL sprayed plots to damage in the unsprayed control plots (cv Shelton untreated seed). Small= isolated plot experiment; large=large plot experiment

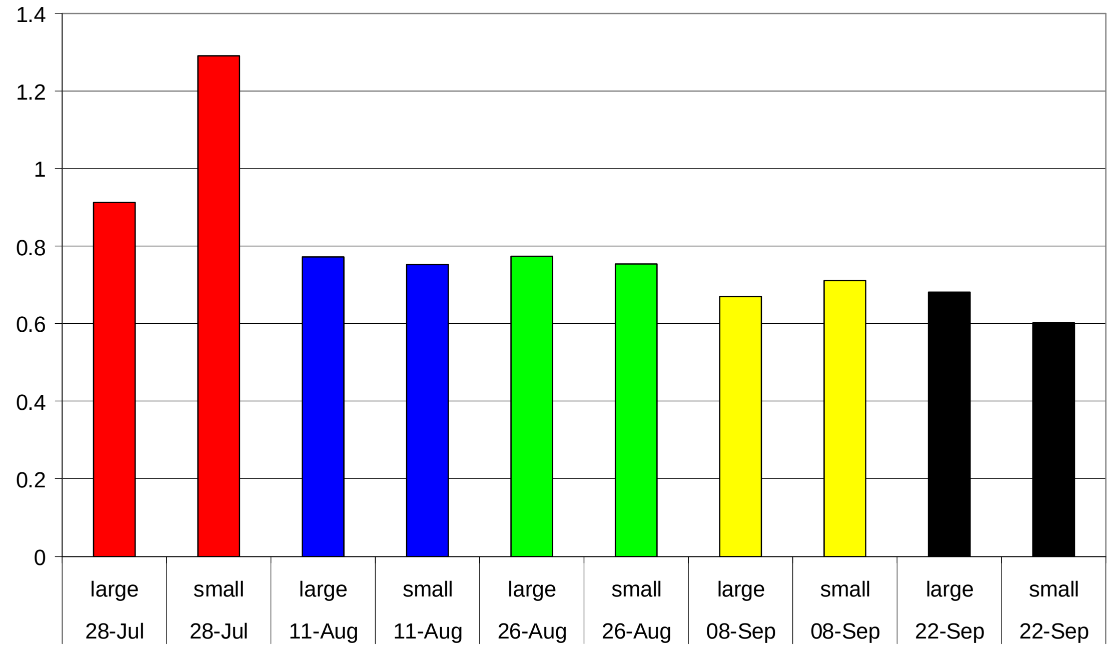

Figure 5.5: The ratio of thrips damage in the Tracer2 sprayed plots to damage in the unsprayed control plots (cv Shelton fipronil-treated seed). Small= isolated plot experiment; large=large plot experiment

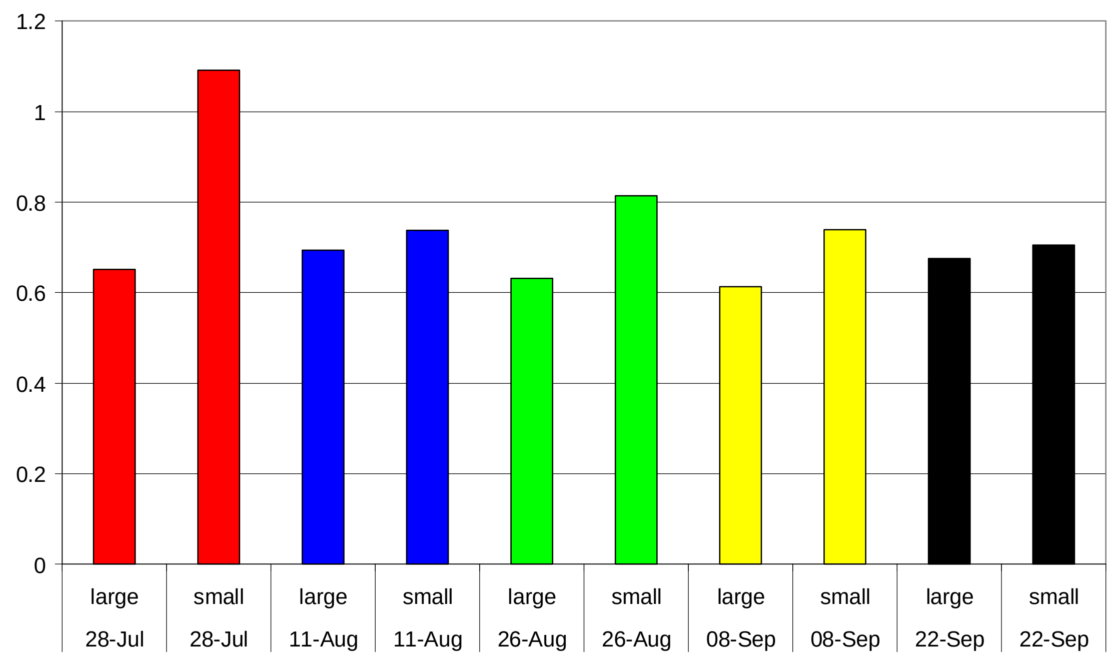

Figure 5.6: The ratio of thrips damage in the TracerL sprayed plots to damage in the unsprayed control plots (cv Shelton fipronil-treated seed). Small=isolated plot experiment; large=large plot experiment

Comparison of the two insecticide experiments suggests that thrips movement between plots does not have a significant effect on infestation levels compared with the overall impact of the local thrips population. The data collected using blue sticky traps located in the sequentially-sown plots of salad onion (Figure 4.1) suggest that the aerial population is homogeneous over the experimental area and is not affected by the condition of the crop, although thrips numbers on plants may be. Together, these data suggest that adult thrips disperse by taking off into the air and that they may be carried some distance before they land, rather than 'hopping' from plant to plant. This fits in with what is known about thrips dispersal behaviour.

Effect of seed treatments

Previous studies have shown that a number of seed treatments may reduce thrips damage to Allium crops but that this effect diminishes in mid-summer. These experiments confirmed that some seed treatments did provide a certain amount of thrips control in both leek and onion.

There are questions about the level of control provided and the 'persistence' of the effect. Table 5.1 summarises the occasions when the seed treatments applied to leek were effective (statistically significant reduction in damage). Both imidacloprid and fipronil reduced damage on a number of occasions, whereas Exp A was less effective. Overall, fipronil appeared to have the greatest impact. There appeared to be more impact on the overall damage score than on damage to the penultimate leaf and this may indicate persistence of the 'effect' i.e. a reduction in damage earlier on rather than persistence of the 'treatment' which would be reflected in damage to new foliage. It may also reflect the greater variability in the data for damage to the penultimate leaf discussed above.

Table 5.1: Occasions when seed treatments applied to leek were effective (statistically significant reduction in damage. Data for overall damage and damage to the penultimate leaf are shown. Sig=statistically significant ($p<0.05$); Imid=imidacloprid; Fip=fipronil)

Large experiment												
Damage assessment	**Overall**						**Penultimate**					
Spray programme	**Untreated**			**Tracer2**			**Untreated**			**Tracer2**		
	Imid	Fip	Exp A	Imid	Fip	Exp A	Imid	Fip	Exp A	Imid	Fip	Exp A
01-Jul	sig											
15-Jul		sig		sig	sig					sig	sig	sig
28-Jul	sig	sig		sig	sig	sig		sig			sig	
11-Aug		sig		sig			sig	sig		sig		
26-Aug	sig	sig		sig	sig			sig		sig		
08-Sep		sig		sig	sig						sig	
22-Sep		sig		sig	sig							

Isolated plots												
Damage assessment	**Overall**						**Penultimate**					
Spray programme	**Untreated**			**Tracer2**			**Untreated**			**Tracer2**		
	Imid	Fip	Exp A	Imid	Fip	Exp A	Imid	Fip	Exp A	Imid	Fip	Exp A
01-Jul							sig					
15-Jul		sig		sig	sig			sig		sig	sig	
28-Jul		sig						sig				
11-Aug		sig						sig				
26-Aug		sig			sig			sig				
08-Sep		sig			sig						sig	
22-Sep												

As an indication of the impact of spray and seed treatments together, Figure 5.7 shows the ratio of overall thrips damage in the Tracer2 sprayed plots to damage in the unsprayed plots for insecticide-free seed and fipronil-treated seed and Figure 5.8 shows the same relationship for the TracerL sprayed plots. The effect of the addition of a seed treatment appeared to persist throughout.

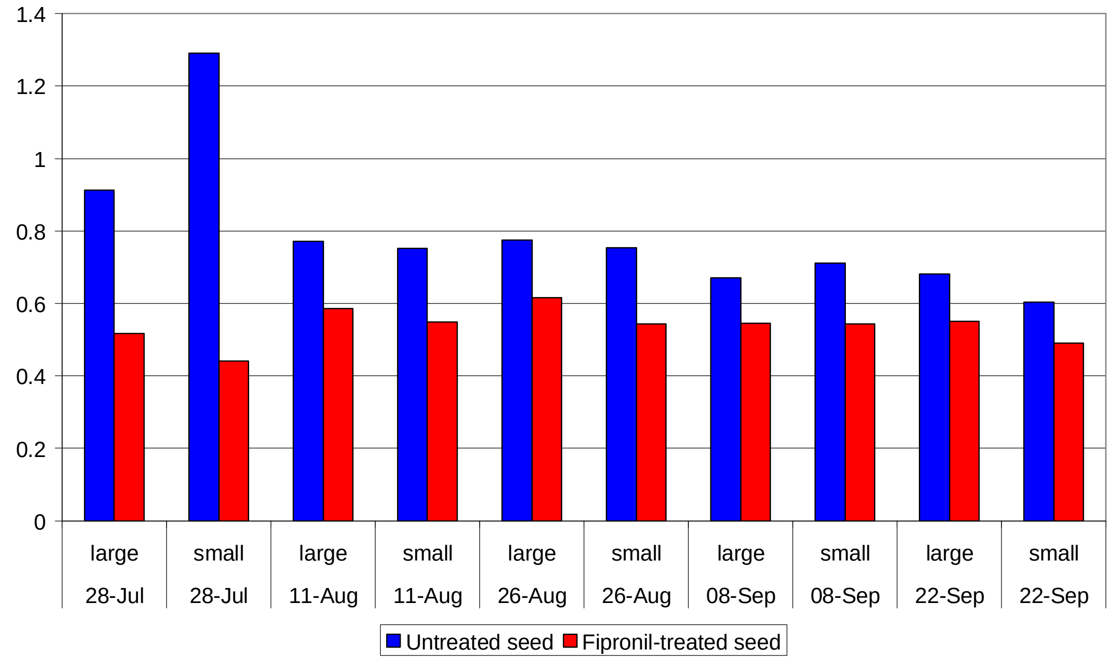

Figure 5.7: The ratio of overall thrips damage in the Tracer2 sprayed plots to damage in the unsprayed plots for insecticide-free seed and fipronil-treated seed

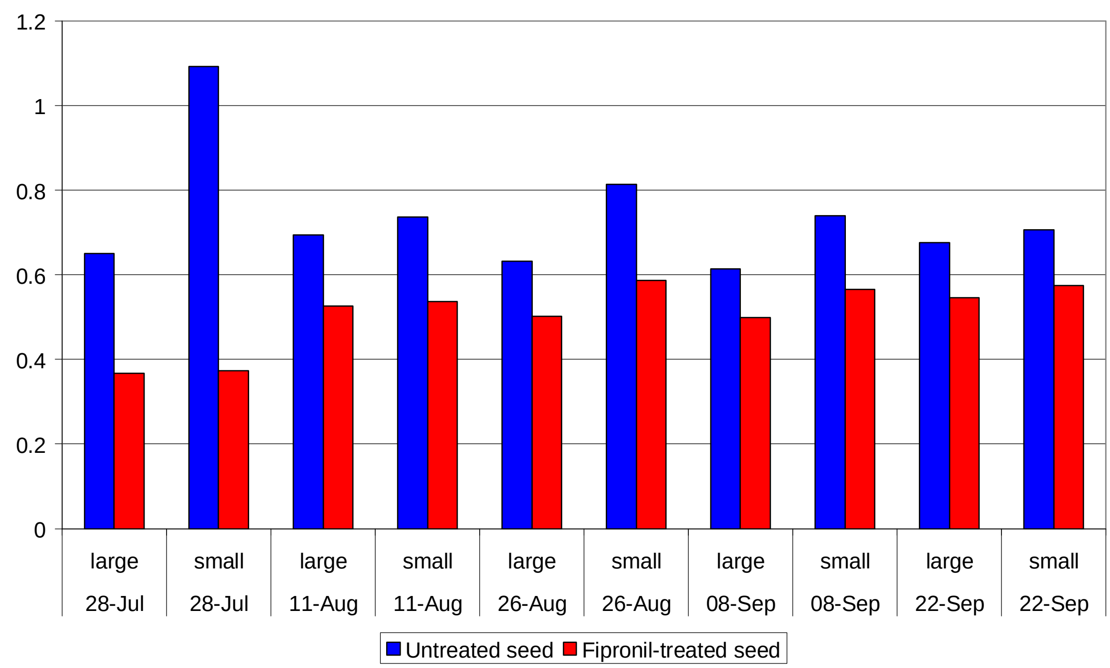

Figure 5.8 : The ratio of overall thrips damage in the TracerL sprayed plots to damage in the unsprayed plots for insecticide-free seed and fipronil-treated seed

Foliar sprays

The insecticides evaluated as foliar sprays were applied in 6-spray programmes. This is not intended to represent how they would be used in commercial practice, as the permitted number of sprays of each insecticide would be limited. However, this is the clearest way of demonstrating differences in efficacy, particularly when weather conditions make it difficult to predict when the largest numbers of thrips will occur.

Overall, the programme containing 4 applications of Methiocarb 500 SC (methiocarb) was the most effective treatment and the programme containing 4 sprays of BASF Dimethoate 40 , the least effective (Figure 5.9). The Methiocarb 500 SC, Exp X1 and Dursban programmes produced statistically significant treatment effects in overall damage on all five assessment occasions, Exp SA programme on four occasions, the two Tracer programmes on 3 occasions and the other programmes (Exp X2, BASF Dimethoate 40, Exp SB) on one occasion. In terms of damage to the penultimate leaf, the Methiocarb 500 SC programme produced statistically significant treatment effects on all five assessment occasions, the Exp X1 and TracerL programmes on four occasions, the Tracer2, Dursban and Exp SA programmes on three occasions, the Exp SB programme on two occasions, the Exp X2 programme on one occasion and the BASF Dimethoate 40 programme on none of them.

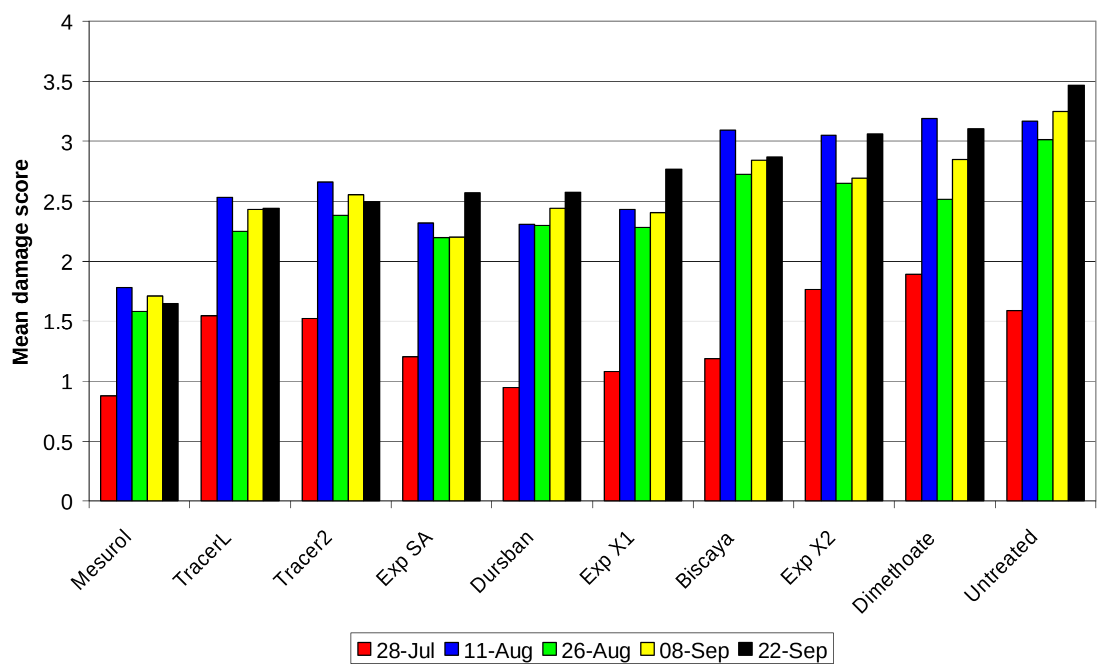

Figure 5.9: Overall thrips damage following insecticide spray treatments. Treatments sorted according to damage on 22 September

Control of bean seed fly

All of the seed treatments improved plant stand and this is assumed to be due to a reduction in bean seed fly damage.

Conclusions

- The local thrips population appeared to distribute itself very effectively – e.g. newly emerged plots (salad onion) soon had the same infestation level (thrips on traps) as older plots.
- Several seed treatments reduced thrips damage early on and the effects appeared to persist for some time.
- Methiocarb 500 SC was the most effective foliar spray against thrips and then Tracer. BASF Dimethoate 40 was the least effective. Two novel compounds also look as if they may have potential.
- At least two novel seed treatments reduced seedling losses (bean seed fly damage) on onion.

Acknowledgements

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