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Onion thrips on lettuce - monitoring infestations and investigating prospects for control

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1 Executive summary

Onion thrips have become resistant to insecticides commonly used by onion growers, creating problems for some lettuce and vegetable brassica growers who have experienced problems with thrips damage during the summer. In year 2 of a Fresh Market Sector (Vegfed) funded research project, Crop & Food Research has conducted a small plot trial, firstly, to see if it is practical to monitor lettuce crops for thrips and thrips damage; secondly, to compare the efficacy of the timing of insecticide spray applications in relation to the lifting of onions at topfall; and, thirdly, to compare the impact of thrips infestation and control measures on small and large lettuce plants.

Two blocks of lettuce were planted (on 12 December 2000 and 16 January 2001) between three blocks of onions which were heavily infested with thrips at topfall. The day after the onions were lifted (31 January 2001), spray treatments started. In the trial, which was replicated four times, plots were either unsprayed, sprayed weekly, or sprayed when thrips numbers or aphid and caterpillar numbers suggested control was needed. The insecticide used was Orthene WSG (80 g/100 litres).

Despite the high numbers of thrips on the onions, the numbers of thrips on the lettuce plants were relatively low, but they still caused unacceptable damage at harvest. By the time the onions were lifted and spraying had started thrips numbers were already so high in the oldest lettuces that there was little chance of successful chemical control. The insecticide controlled thrips on the small plants, but once hearting started it was not sufficiently effective.

The other serious pest of the lettuce plants was looper caterpillars. The data from the trial indicate that there is scope to reduce the number of sprays for caterpillar control if thrips control is not needed.

It was noteworthy that on the older lettuces predators appear to have given good control of aphids. There may also be scope to minimise the number of insecticide applications for aphid control.

In order to reduce insecticide applications for insect control in lettuce crops a reliable monitoring method and action thresholds are required. The presence/absence method for monitoring insects that was tested in this trial is much quicker than counting insects, and may be suitable if used at key times in crop growth. It could form the basis for integrated pest management for the crop. However, the key times to monitor crops need to be identified, and a simple method of monitoring with robust action thresholds needs to be investigated and demonstrated before Integrated Pest Management could be recommended to growers.

This project confirmed that it is unwise to grow lettuce crops near onion crops in the summer—a few thrips can cause a lot of damage.

Spraying lettuce plants after neighbouring thrips-infested onions have been lifted does not provide effective insect control, even on smaller, less infested plants.

A presence/absence method of monitoring pests and beneficials could provide a practical method to guide insecticide application.

This research will contribute to a future integrated pest management programme for lettuce.

2 Introduction

In recent years onion thrips (*Thrips tabaci*) has caused unacceptable damage to lettuce and cabbage plants during the summer in South Auckland. This has coincided with high numbers of onion thrips on mature onion crops, which have been associated with the thrips becoming resistant to key insecticides. The Fresh Market Sector of Vegfed has funded two years of research to help growers minimise their risk from invasions of onion thrips onto cabbage and lettuce crops. In year 1, one project (HortResearch) demonstrated that brassica and lettuce crops are infested from nearby onion fields and that infestation is most likely when onion plants start to senesce, i.e. from topfall until harvest. Thrips populations were higher on lettuce than brassicas. Also in Year 1, Crop & Food Research conducted small plot trials to test monitoring methods and control options for cabbages. At harvest, thrips were more numerous and caused more damage to lettuce than cabbages.

This document reports the results of the small plot trials conducted on lettuce in the second year.

3 Aims

The 2000-2001 project had three aims:

1. to see if it is practical to monitor lettuce crops for thrips and thrips damage,
2. to compare the efficacy of the timing of insecticide spray applications in relation to the lifting of onions at topfall, and
3. to compare the impact of thrips infestation and control measures on small and large lettuce plants.

4 Methods

4.1 Site

A replicated plot trial was conducted at Crop & Food Research's Pukekohe Research Centre, South Auckland, in the 2000-2001 growing season. Fifteen beds of onions were planted in three blocks 60 m long (Fig. 1) in July 2000. Crop management details and pesticide applications are in Appendix I. The onion plants were monitored for thrips at six times from early November until mid January (Table 1). The numbers of adult and larva were recorded. The onion plants were lifted at top fall on 30 January 2001 when some plants had yellowing leaves due to thrips feeding.

Grass access track

Five beds of onions Beds 60 m long	Ten beds of older lettuce Planted 12 December 2000	Five beds of onions	Ten beds of young lettuce Planted 16 January 2001	Five beds of onions

Shelter trees

Figure 1: Layout of onion thrips-lettuce trial at Pukekohe Research Centre (not to scale).

Table 1: Mean number of onion thrips per onion plant during November 2000 to January 2001. Seventy-five plants were sampled on each occasion.

Thrips stage	2-Nov-00	21-Nov-00	7-Dec-00	19-Dec-00	4-Jan-01	16-Jan-01
Adults	1.9	0.3	0.9	1.8	15	34
Larvae	5.4	9.7	4.4	12.9	40	337
Totalthrips	7.3	9.9	5.3	14.8	55	371

4.2 Lettuce plants and treatments

Lettuce transplants (cv. Casino) were planted on 12 December 2000 and 16 January 2001, with 3 rows per bed (60 m long) and plants 400 mm apart in each row. The eight central beds in each block of lettuce were used for the trial. Each plot was 12 m long and 2 beds wide. The four treatments were replicated four times and were arranged in a Latin square; there was one treatment only in every row and column (Fig. 2). The treatments were:

- unsprayed control,
- insecticide sprayed weekly,
- insecticide applied in response to numbers of aphids and caterpillars,
- insecticide applied as soon as possible after the onion crop was lifted and in response to numbers of thrips.

Large lettuce (December planting)

Rows	Columns			
	a	b	c	d
1	Aphids/loopers	Thrips	No spray	Weekly spray
2	Thrips	Aphids/loopers	Weekly spray	No spray
3	Weekly spray	No spray	Thrips	Aphids/loopers
4	No spray	Weekly spray	Aphids/loopers	Thrips

Small lettuce (January planting)				
	Columns			
Rows	a	b	c	d
1	No spray	Aphids/loopers	Weekly spray	Thrips
2	Thrips	Weekly spray	Aphids/loopers	No spray
3	Weekly spray	Thrips	No spray	Aphids/loopers
4	Aphids/loopers	No spray	Thrips	Weekly spray

Figure 2: Layout of the treatments in the two blocks of lettuce plants. See text for treatment details.

Orthene WSG (970 g acephate/kg) was applied at 80 g/100 litres. The insecticide was applied using a backpack sprayer with a hand held boom (620 ml) with 3 "TeeJet®" flat spray tip (XR 11004VP) nozzles at 300 mm spacings. Citowet was added to all applications (25 ml/100 litres). The insecticide was sprayed to run off with about 18 ℓ being used per bed. Application dates are shown in Table 2. No fungicides were applied.

The oldest lettuce were harvested on 13 February and the youngest lettuce on 6 March.

Table 2: Dates of insecticide spray applications of Orthene to the plots of lettuce.

Spray dates	Treatments			
	Weekly	Thrips response	Aphids/caterpillar response	Unsprayed control
31 January	Sprayed	Sprayed	Sprayed	
7 February	Sprayed	Sprayed		
14 February	Sprayed		Sprayed	
21 February	Sprayed	Sprayed		

4.3 Lettuce plant monitoring

The large lettuce plants were monitored before the first insecticide was applied and one week after the first insecticide (Table 3). The smaller lettuce were monitored four times, the last time being two weeks after the last spray (Table 3).

Table 3: Dates when the lettuce plants were sampled and numbers of plants sampled per plot.

Dates lettuce plants sampled	Number of plants sampled on each date	
	Older lettuce	Young lettuce
24 January	3	-
6 February	5	5
13 February	-	5
20 February	-	5
6 March	-	5

The plants were examined in the field. On small lettuce, 10 to 15 leaves were examined while on plants with a heart the first 10 leaves of the heart (the 5 inner wrapper leaves and the next 5 outer leaves) were examined. The presence or absence of damage or insects on each leaf was recorded as follows:

- thrips damage. Minor damage scored 1, damage that would reduce market quality scored 100,
- thrips adults scored 1, thrips larvae scored 1,
- single or a few scattered aphids scored 1, aphid colonies scored 100,
- looper caterpillar damage or frass (faeces) each scored 1, looper caterpillar eggs or larvae each scored 1. Leaf rollers also scored 1,
- leaf mine of the leaf mining fly scored 1,
- syrphid (predatory fly) eggs, larvae and pupae each scored 1,
- lacewing (insect predator) eggs, larvae, pupa and adults each scored 1.

4.4 Data analysis

The data were summarised using spreadsheets. The outer, inner, heart leaves and total leaves were analysed separately and the mean per-plant damage or organism score was calculated for each plot. Where more than one-third of the plot means were zero, no analysis was done to compare treatments.

Each analysis of variance was based on a latin square design which accounts for row and column effects. Where the probability of a treatment effect was $P \leq 0.05$, the least significant difference (between treatment means) squares value was used to compare treatments. The main results

from the analyses are given in the results section. For the complete set of analyses refer to Appendix II.

Differences between the first (old) and second (young) planting of lettuce found on the 5 February were compared using a T-test.

5 Results

The analysis of the trial-data is summarised in Appendix II, which also shows the data sets subject to analysis of variance and the details of the statistical analysis. Appendix III provides details of the comparison between young and old lettuce sampled on 5 February. This section of the report describes the main features of the analyses.

5.1 Onion thrips populations on onions

Two weeks before the onions were lifted, onion thrips populations reached nearly 400 thrips per plant (Table 1). The condition of the onion plants deteriorated and by 30 January 2001, when the onion plants were lifted, populations had declined to just over 200 thrips per plant. Two days after lifting, populations had declined to less than 80 thrips per plant. Most (about 90%) of the thrips present at top fall were juveniles. However, after 16 January, when the second crop of lettuce was planted, it is likely that there was increasing movement of adult thrips from the onions as the plant leaves deteriorated.

5.2 Onion thrips on lettuce

5.2.1 Oldest lettuce

Onion thrips infestation and damage were assessed twice on the oldest lettuce, just before and five days after the first insecticide application (Table 4). The lettuces deteriorated after 5 February and were not worth sampling again. Thrips were present in the heart of the older lettuce on 24 January, but none of the leaves had damage that would be obvious to a customer. There were also low numbers of thrips in the heart of lettuce from all treated plots on 24 January. However, by 5 February the hearts of plants in all plots had unacceptable damage, which included browning of leaves, dead leaf tips and rotten leaf tips. It is possible that this thrips damage was aggravated by water stress.

On both sampling dates there were differences between treatments ($P<0.05$) in damage to the five inner wrapper leaves. The differences found on 24 January were evident before insecticides were applied while on 5 February there were no differences in damage levels in the insecticide treated plants (damage scores of 24-49) that had all received a single spray. The unsprayed plants had a damage score of 118.

Table 4: Old lettuce: mean thrips damage score and mean thrips infestation score per plant before and after insecticide application on 31 January. If leaves were damaged to the extent that market quality was affected they scored as 100.

		Mean number of number of leaves per plant with							
		Thrips damage		Thrips		Thrips adults		Thrips larvae	
Treatments		24 Jan	5 Feb	24 Jan	5 Feb	24 Jan	5 Feb	24 Jan	5 Feb
Unsprayed control	5 outer leaves	1.17	0.20	0.25	0.00	0.17	0.00	0.08	0.00
	5 inner leaves	1.25	118.75	0.58	0.50	0.67	0.35	0.00	0.15
	heart	3.42	475.55	1.42	3.80	1.67	2.80	0.17	1.05
	total	5.83	594.50	2.25	4.30	2.50	3.15	0.25	1.20
Weekly spray	5 outer leaves	0.92	0.95	0.08	0.00	0.00	0.00	0.08	0.00
	5 inner leaves	1.00	34.50	0.75	0.15	0.67	0.10	0.08	0.10
	heart	2.00	415.35	1.50	3.60	1.33	2.25	0.25	1.45
	total	3.92	450.80	2.33	3.75	2.00	2.35	0.42	1.55
Aphid & caterpillar response	5 outer leaves	1.25	1.30	0.33	0.00	0.17	0.00	0.17	0.00
	5 inner leaves	0.75	49.45	0.50	0.70	0.25	0.30	0.25	0.45
	heart	2.92	345.50	2.33	3.00	2.00	1.85	0.42	1.55
	total	4.92	396.25	3.17	3.70	2.42	2.15	0.83	2.00
Thrips response	5 outer leaves	0.92	1.30	0.08	0.05	0.08	0.05	0.00	0.05
	5 inner leaves	0.17	24.65	0.08	0.40	0.00	0.20	0.08	0.30
	heart	1.50	281.60	1.50	3.00	1.33	2.35	0.08	1.10
	total	2.58	307.55	1.67	3.45	1.42	2.60	0.17	1.45

5.2.2 *Youngest lettuce*

Despite weekly sprays, the youngest lettuce plants incurred unacceptable thrips damage to the heart leaves (Table 5, Fig. 3). There were very few thrips on the small lettuce plants five days after the first spray (Tables 6-8, Fig. 4) and even at harvest the level of thrips infestation was low.

On 5 February the sprayed plants had less damage than the unsprayed plants ($P<0.05$), while on 13 February the unsprayed plants and the aphid/caterpillar response treated plants had more thrips damage than the other two treatments ($P<0.05$).

On 13 February more leaves were infested with thrips in the unsprayed plants than in the treated plants ($P<0.05$), but there were no clear differences on other dates.

Table 5: Youngest lettuce: mean thrips damage score per plant. If leaves were damaged to the extent that market quality was affected they were scored as 100.

Treatment		5-Feb-01	13-Feb-01	20-Feb-01	6-Mar-01
Unsprayed control	5 outer leaves	5	5	9.35	-
	5 inner leaves	3.5	13.3	4.75	9.85
	10 heart leaves	-	-	5.3	206.65
	total	8.5	18.3	19.4	216.5
Weekly spray	5 outer leaves	4.7	3.15	43.55	-
	5 inner leaves	1.75	0.9	4.05	5
	10 heart leaves	-	-	4.4	132.85
	total	6.45	4.05	52	137.85
Aphids &	5 outer leaves	4.2	4.75	58.05	-
caterpillars	5 inner leaves	1.3	8.5	4.45	9.7
response	10 heart leaves	-	-	4.15	138.15
	total	5.5	13.25	66.65	147.85
Thrips response	5 outer leaves	4.6	3.7	29.05	-
	5 inner leaves	1.35	1.5	4.65	4.55
	10 heart leaves	-	-	5.05	52.35
	total	5.95	5.2	38.75	56.9

Table 6: Youngest lettuce: mean total thrips infestation score per plant (i.e. mean number of leaves infested with adult or larval thrips in each set of leaves).

Treatment		5-Feb-01	13-Feb-01	20-Feb-01	6-Mar-01
Unsprayed control	5 outer leaves	1.45	3	0.5	0
	5 inner leaves	2.9	2.4	0.4	0.5
	10 heart leaves	0	0	1.9	1.85
	total	4.35	5.4	2.8	2.4
Weekly spray	5 outer leaves	0.15	0.2	0.05	0
	5 inner leaves	0.2	0.05	0.55	0.4
	10 heart leaves	0	0	2.45	1.75
	total	0.35	0.25	3.1	2.2
Aphids &	5 outer leaves	0.2	1.2	0.25	0
caterpillars	5 inner leaves	0.3	1.6	0.3	0.4
response	10 heart leaves	0	0	0.7	1.25
	total	0.5	2.8	1.3	1.7
Thrips response	5 outer leaves	0	0.5	0.55	0
	5 inner leaves	0	0.35	1	0.25
	10 heart leaves	0	0	2.6	1.25
	total	0	0.85	4.2	1.5

Table 7: Youngest lettuce: mean adult thrips infestation score per plant (i.e. mean number of leaves infested with adult thrips in each set of leaves).

Treatment		5-Feb-01	13-Feb-01	20-Feb-01	6-Mar-01
Unsprayed control	5 outer leaves	1.25	1.15	0.05	-
	5 inner leaves	2.45	1.15	0.2	0.3
	10 heart leaves	-	-	1.45	0.85
	total	3.7	2.3	1.7	1.15
Weekly spray	5 outer leaves	0.15	0.15	0.1	-
	5 inner leaves	0.2	0	0.4	0.15
	10 heart leaves	-	-	1.55	0.5
	total	0.35	0.15	2.05	0.65
Aphids & caterpillars response	5 outer leaves	0.05	0.45	0.05	-
	5 inner leaves	0.25	0.75	0.25	0.25
	10 heart leaves	-	-	0.35	0.6
	total	0.3	1.2	0.65	0.85
Thrips response	5 outer leaves	0	0.25	0.2	-
	5 inner leaves	0	0.3	0.6	0.1
	10 heart leaves	-	-	2.05	0.35
	total	0	0.55	2.85	0.45

Table 8: Youngest lettuce: mean larval thrips infestation score per plant (i.e. mean number of leaves infested with larval thrips in each set of leaves).

Treatments		5-Feb-01	13-Feb-01	20-Feb-01	6-Mar-01
Unsprayed control	5 outer leaves	0.45	2.45	0.45	-
	5 inner leaves	1	1.9	0.2	0.2
	10 heart leaves	-	-	0.95	1.25
	total	1.45	4.35	1.6	1.45
Weekly spray	5 outer leaves	0	0.05	0.1	-
	5 inner leaves	0	0.05	0.3	0.25
	10 heart leaves	-	-	1.15	1.35
	total	0	0.1	1.55	1.6
Aphids & caterpillars response	5 outer leaves	0.15	0.85	0.2	-
	5 inner leaves	0.05	1.05	0.1	0.15
	10 heart leaves	-	-	0.45	0.7
	total	0.2	1.9	0.75	0.85
Thrips response	5 outer leaves	0	0.45	0.35	-
	5 inner leaves	0	0.05	0.4	0.2
	10 heart leaves	-	-	0.9	0.9
	total	0	0.5	1.65	1.1

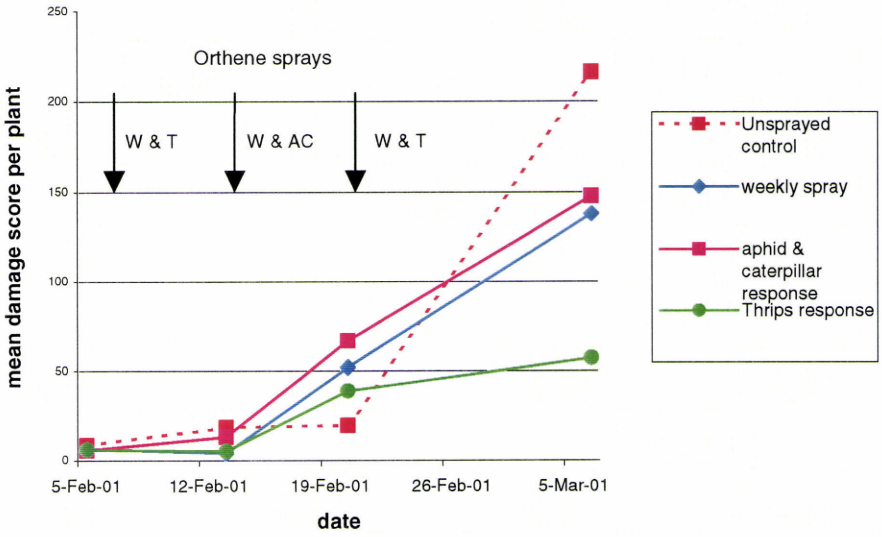

Figure 3: Thrips damage to the youngest lettuce. Damage levels over 15 per plant mean leaves had thrips damage that affected market quality. If leaves were damaged to the extent that market quality was affected, they were scored as 100. Orthene was sprayed on all insecticide treated plots on 31 January. W=weekly spray, T=thrips response spray, AC=aphid and caterpillar response spray.

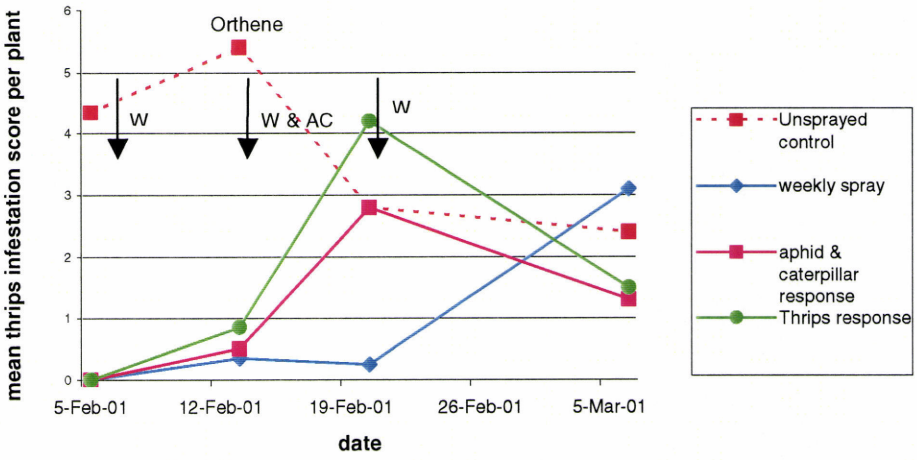

Figure 4: Youngest lettuce: mean number of thrips infested leaves per plant. Orthene was sprayed on all insecticide treated plots on 31 January. W=weekly spray, T=thrips response spray, AC=aphid and caterpillar response spray.

5.3 Other pests on lettuce

In addition to thrips, the lettuce plants were infested with aphids, looper caterpillars, leaf roller caterpillars and leaf mining flies (Table 9). Leaf miners were only found in low numbers on outer leaves and are not discussed further.

5.3.1 Aphids

The oldest lettuce were not sprayed after planting on 12 December, yet aphid numbers were low when the plants were sampled on 24 January and was probably due to the relatively high numbers of predators found on the plants on 24 January (Table 10). Most infested plants had single aphids that would not reduce lettuce quality, although the small number of plants with aphid colonies at harvest on unsprayed lettuce may be unacceptable. There were no differences between treatments in aphid infestation.

Table 9: Infestation of non-thrips pests on the oldest lettuce.

		Mean damage/infestation score per plant due to											
		Aphids		Looper damage		Looper eggs		Looper larvae		Leaf roller larvae		Fly leaf mines	
Treatment		24 Jan	5 Feb	24 Jan	5 Feb	24 Jan	5 Feb	24 Jan	5 Feb	24 Jan	5 Feb	24 Jan	5 Feb
Unsprayed	5 outer leaves	0.67	0.00	0.25	0.10	0.25	0.00	0.25	0.00	0.08	0	0.08	0.00
control	5 inner leaves	8.92	10.40	0.58	1.50	0.25	0.05	0.17	0.10	0.00	0	0.00	0.00
	heart	0.42	0.10	0.00	0.15	0.00	0.00	0.00	0.00	0.08	0	0.00	0.00
	total	10.00	10.50	0.83	1.75	0.50	0.05	0.42	0.10	0.17	0	0.08	0.00
Weekly	5 outer leaves	16.75	0.00	0.08	0.25	0.08	0.00	0.00	0.00	0.00	0	0	0.05
spray	5 inner leaves	0.00	0.10	0.67	0.60	0.17	0.10	0.17	0.00	0.00	0	0	0.05
	heart	0.67	0.15	0.42	0.00	0.00	0.00	0.00	0.05	0.08	0	0	0
	total	17.42	0.25	1.17	0.85	0.25	0.10	0.17	0.05	0.08	0	0	0.1
Aphids/	5 outer leaves	0.17	0.05	0.33	0.50	0.08	0.05	0.25	0.00	0.00	0	0	0.05
caterpillar	5 inner leaves	0.42	0.00	1.25	1.45	0.17	0.05	0.17	0.00	0.00	0	0	0.05
response	heart	8.50	0.10	0.17	0.20	0.08	0.00	0.00	0.00	0.00	0	0	0
	total	9.08	0.15	1.75	2.15	0.33	0.10	0.42	0.00	0.00	0	0	0.1
Thrips	5 outer leaves	0.00	0.05	0.25	0.85	0.00	0.00	0.00	0.00	0.00	0	0	0.05
response	5 inner leaves	0.42	10.25	0.50	1.45	0.08	0.00	0.08	0.00	0.08	0	0	0
	heart	0.08	30.25	0.33	0.20	0.00	0.05	0.00	0.00	0.00	0	0	0
	total	0.50	40.55	1.08	2.50	0.08	0.05	0.08	0.00	0.08	0	0	0.05

Table 10: The beneficial insects found on the oldest lettuce plants when sampled before and five days after the first insecticide application.

		Mean number of leaves per plant with syrphids in each set of leaves						Mean number of leaves per plant with lacewings in each set of leaves							
		Eggs		Larvae		Pupae		Eggs		Larvae		Pupae		Adults	
Treatment		24 Jan	5 Feb	24 Jan	5 Feb	24 Jan	5 Feb	24 Jan	5 Feb	24 Jan	5 Feb	24 Jan	5 Feb	24 Jan	5 Feb
Unsprayed control	5 outer leaves	0.33	0.00	0.42	0.05	0.00	0	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0
	5 inner leaves	0.08	0.15	0.50	0.50	0.08	0	0.08	0.05	0.08	0.00	0.00	0.00	0.08	0
	heart	0.00	0.00	0.50	0.70	0.00	0	0.08	0.05	0.08	0.00	0.00	0.00	0.00	0
	total	0.42	0.15	1.42	1.25	0.08	0	0.17	0.10	0.25	0.00	0.00	0.00	0.08	0
Weekly spray	5 outer leaves	0.00	0.10	0.42	0.05	0	0	0.17	0.10	0.00	0.00	0.08	0.00	0.00	0
	5 inner leaves	0.00	0.20	1.08	0.10	0	0	0.08	0.10	0.00	0.00	0.00	0.00	0.08	0
	heart	0.00	0.15	0.50	0.00	0	0	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0
	total	0.00	0.45	2.00	0.15	0	0	0.25	0.20	0.08	0.00	0.08	0.00	0.08	0
Aphid & caterpillar response	5 outer leaves	0.08	0.05	0.83	0.00	0	0	0.17	0.25	0.00	0.05	0.00	0.00	0.08	0
	5 inner leaves	0.25	0.05	0.83	0.10	0	0	0.00	0.20	0.00	0.00	0.08	0.00	0.00	0
	heart	0.00	0.00	0.25	0.00	0	0	0.17	0.05	0.08	0.00	0.00	0.00	0.00	0
	total	0.33	0.10	1.92	0.10	0	0	0.33	0.50	0.08	0.05	0.08	0.00	0.08	0
Thrips response	5 outer leaves	0.00	0.00	0.92	0.00	0	0	0.17	0.00	0.00	0.05	0.00	0.10	0.00	0
	5 inner leaves	0.08	0.05	0.75	0.05	0	0	0.08	0.10	0.00	0.20	0.00	0.05	0.08	0
	heart	0.08	0.00	0.33	0.00	0	0	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0
	total	0.17	0.05	2.00	0.05	0	0	0.33	0.10	0.00	0.25	0.00	0.15	0.08	0

Table 11: Youngest lettuce: mean aphid infestation score per plant. Leaves with aphid colonies scored as 100.

Treatment		5 Feb 01	13 Feb 01	20 Feb 01	6 Mar 01
Unsprayed	5 outer leaves	5.5	11.1	5.3	-
control	5 inner leaves	0.15	5.7	0.5	0.5
	10 heart leaves	-	-	1.15	5.65
	total	5.65	16.8	6.95	6.15
Weekly	5 outer leaves	0	0	0.05	-
spray	5 inner leaves	0.15	0.05	0	0
	10 heart leaves	-	-	0	0.05
	total	0.15	0.05	0.05	0.05
Aphid &	5 outer leaves	0	0.65	0	-
caterpillar	5 inner leaves	0.1	0.1	0.2	0.3
response	10 heart leaves	-	-	0.15	0.35
	total	0.1	0.75	0.35	0.65
Thrips	5 outer leaves	0	5.1	0.1	-
response	5 inner leaves	0	0	0.35	0
	10 heart leaves	-	-	0.15	0
	total	0	5.1	0.6	0

5.3.2 *Caterpillars*

A few leaf rollers were found on both the old (Table 9) and young lettuces, but the most common lepidopteran pests were loopers (green looper and soybean looper) (Tables 9 and 12-14). In the youngest lettuce, weekly spraying and the thrips response treatments kept caterpillar populations low and reduced damage at harvest compared with other treatments ($P<0.05$) (Tables 12-14, Fig. 4-5).

The young lettuce plants were mainly infested with looper eggs on 5 and 13 February. Larvae appeared to hatch from about 13 February onwards. The efficacy of the insecticide treatments appears to be correlated with the timing of sprays and the stage of insects on the crop (Fig. 4-5). The first two applications of Orthene (31 January, 7 February) occurred when mainly eggs were present, whereas the last two sprays (14 and 21 Feb) were applied when larvae were feeding on the plants. The best caterpillar control and prevention of damage was achieved by two sprays of Orthene on 14 and 21 February, whereas the worst control was achieved by a single spray on 14 February (Fig. 6).

There appears to be good scope to time insecticides for looper caterpillar control based on plant stage and looper moth flights.

Table 12: Youngest lettuce: mean caterpillar damage score per plant.

Treatment		5 Feb 01	13 Feb 01	20 Feb 01	6 Mar 01
Unsprayed control	5 outer leaves	0	1.35	1.65	-
	5 inner leaves	0	0.35	2.45	3.95
	10 heart leaves	-	0	0.45	4.25
	total	0	1.7	4.55	8.2
Weekly spray	5 outer leaves	0	0.5	0.8	0
	5 inner leaves	0	0	1.35	2.35
	10 heart leaves	-	0	0.1	0.65
	total	0	0.5	2.25	3
Aphid & caterpillar response	5 outer leaves	0	1.5	2.05	-
	5 inner leaves	0	0	1.65	3.2
	10 heart leaves	-	-	0.25	2.55
	total	0	1.5	3.95	5.75
Thrips response	5 outer leaves	0	0.7	1.4	-
	5 inner leaves	0	0	1.95	3.5
	10 heart leaves	-	-	0.2	0.7
	total	0	0.7	3.55	4.2

Table 13: Youngest lettuce: mean number of leaves per plant with looper caterpillar eggs.

Treatment		5 Feb 01	13 Feb 01	20 Feb 01	6 Mar 01
Unsprayed control	5 outer leaves	0.1	0.75	0.25	-
	5 inner leaves	0.1	0.3	1.2	0.05
	10 heart leaves	-	-	0.35	0
	total	0.2	1.05	1.8	0.05
Weekly spray	5 outer leaves	0	0.9	0.35	-
	5 inner leaves	0.05	0.45	1.65	0.2
	10 heart leaves	-	-	0.1	0
	total	0.05	1.35	2.1	0.2
Aphid & caterpillar response	5 outer leaves	0	0.5	0.2	-
	5 inner leaves	0.05	0.35	1.1	0.1
	10 heart leaves	-	-	0	0
	total	0.05	0.85	1.3	0.1
Thrips response	5 outer leaves	0.05	0.75	0.5	-
	5 inner leaves	0.1	0.45	1.2	0.1
	10 heart leaves	-	-	0.1	0.05
	total	0.15	1.2	1.8	0.15

Table 14: Youngest lettuce: mean number of leaves per plant with looper caterpillars.

Treatment		5 Feb 01	13 Feb 01	20 Feb 01	6 Mar 01
Unsprayed control	5 outer leaves	0.05	0.75	0.85	-
	5 inner leaves	0.05	0.2	2.05	1.2
	10 heart leaves	-	-	0.95	0.7
	total	0.1	0.95	3.85	1.9
Weekly spray	5 outer leaves	0	0	0.2	-
	5 inner leaves	0	0	0.45	0.1
	10 heart leaves	-	-	0.1	0
	total	0	0	0.75	0.1
Aphid & caterpillar response	5 outer leaves	0	1.1	0.2	-
	5 inner leaves	0	0.05	0.4	2.05
	10 heart leaves	-	-	0.2	1
	total	0	1.15	0.8	3.05
Thrips response	5 outer leaves	0	0.05	1.5	-
	5 inner leaves	0	0	2.25	0.15
	10 heart leaves	-	-	0.3	0
	total	0	0.05	4.05	0.15

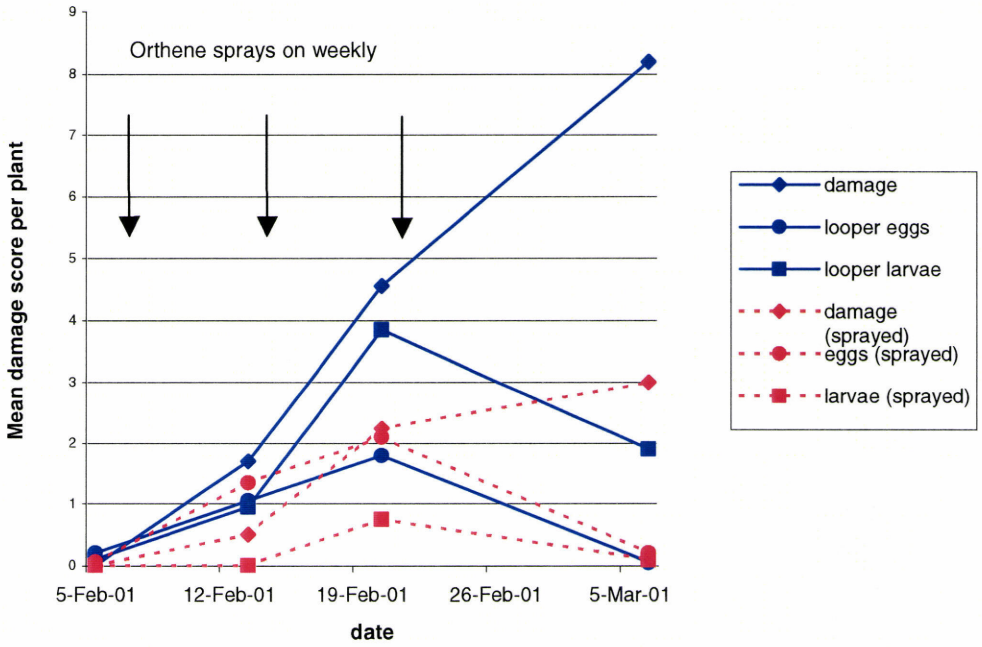

Figure 5: Youngest lettuce: effect of weekly sprays and no sprays on looper caterpillars numbers and damage. Orthene was sprayed on all insecticide treated plots on 31 January. W=weekly spray, T=thrips response spray, AC=aphid and caterpillar response spray.

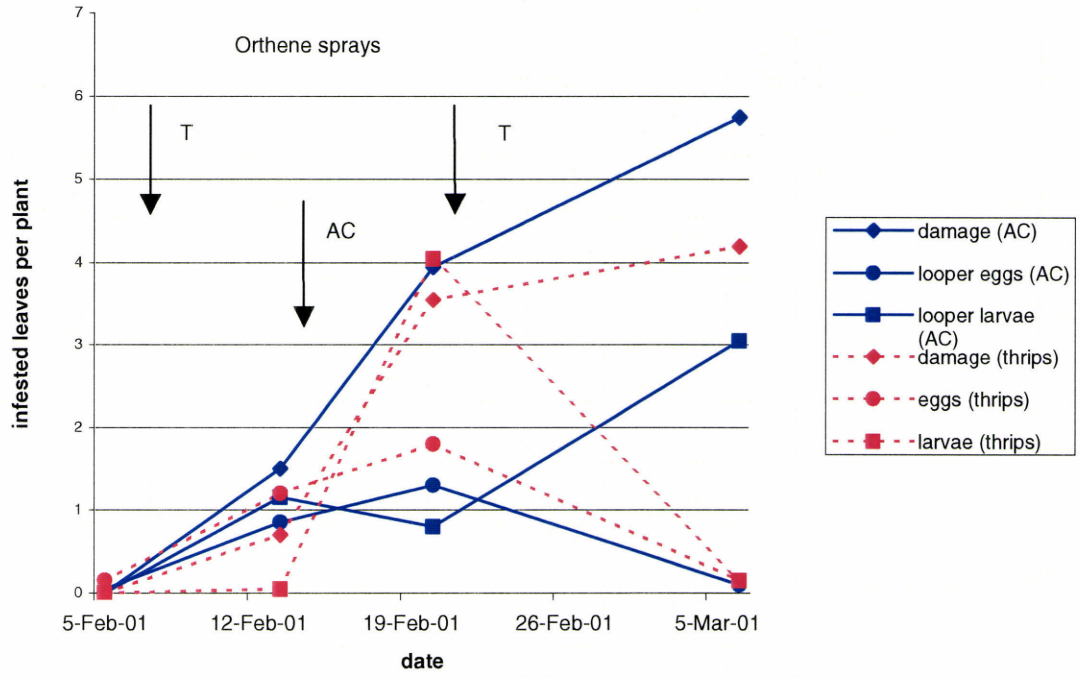

Figure 6: Youngest lettuce: effect of thrips response and aphid/caterpillar response sprays on looper caterpillars numbers and damage. Orthene was sprayed on all insecticide treated plots on 31 January. T=thrips response spray, AC= aphid and caterpillar response spray.

5.4 Beneficial insects

High numbers of two predators were found: syrphid whose larvae feed on aphids and small caterpillars, and lacewings whose larvae feed on aphids. Data are shown for the oldest lettuce (Table 10). The low numbers of aphids on the oldest lettuce plants suggest that these predators helped control aphids. On 5 February there were more syrphid larvae on the old lettuce (infestation score 0.38) than on the recently planted crop (infestation score 0.01)(P<0.05).

6 Discussion

This year's trial confirms the results of last year's research that lettuce is not a favoured host of onion thrips, but that a few thrips can cause a lot of damage. Once the thrips were in the heart of the lettuce, the insecticide, Orthene, was not sufficiently effective at killing the thrips and preventing damage.

Compared with the number of thrips in the adjacent onion blocks, very few thrips established on the lettuce plants, probably fewer than 10 thrips per plant in the unsprayed plots. The thrips started to infest the older lettuce before the onion plants were lifted and spraying commenced. One insecticide application did not reduce plant damage. Insecticide applications initially gave good control of thrips on the youngest lettuce, but populations gradually increased as the heads became more dense. By harvest there was unacceptable damage in plants in all treatments. Unless there is a very effective insecticide available it is unwise to grow lettuce near onions that will mature and be lifted during the second half of the lettuce crop's life.

The other serious pest of the lettuce plants was looper caterpillars. The data from the trial indicate that if thrips control is not needed there is scope to reduce the number of sprays for caterpillar control.

On the older lettuce plants, low numbers of aphids were associated with high numbers of aphid predators. It is presumed that the predators kept aphid numbers below an infestation level that would have caused a marketing problem. There may also be scope to minimise the number of insecticide applications for aphid control.

To reduce insecticide applications for insect control in lettuce crops a reliable monitoring method is required. The presence/absence method tested in this trial is much quicker than counting insects and may be suitable if used at key times in crop growth. It could form the basis for integrated pest management for the crop. However, the key times to monitor crops need to be identified, and a simple method of monitoring, with robust action thresholds, needs to be researched and demonstrated before Integrated Pest Management could be recommended to growers.

Appendices

Appendix I Onion thrips lettuce trial: site management diary

Onions 2000/2001

2.5 t /ha 15% super incorporated before sowing

26/7 sow onions (Pukekohe long keeper)

27/7 spray :

stomp @ 1.5L/ha

diazinon @ 1.5L/ha

roundup @ 4L/ha

25/8 urea @ 100kg/ha

28/9, 10/10 , 13/10, 20/10

Totril @ 300ml/ha

Tribunal @ 300gm/ha

15/10 urea @ 100kg/ha

17/10 , 25/10 Manzate @ 2.5kg/ha

27/10 Frontier @ 1.5L/ha

2/11 Manzate @ 2.5kg/ha

10/11 , 17/11

Ridomil @ 2.5kg/ha

manzate @ 1.5kg/ha

Methamidophos @ 160 ml/100 l @ 500 l/ha

20/11 C.A.N. 200kg/ha

27/11 Acrobat @ 2.5kg/ha

Methamidophos @ 160 ml/100 l @ 500 l/ha

5/12 , 14/12

Acrobat @ 2.5kg/ha

Manzate @ 1kg/ha

8/12 , 12/12

Totril @ 400ml/ha

Tribunal @ 400ml/ha

23/12 , 29/12 Manzate @ 2.5kg/ha

4/1 , 13/1 Acrobat @ 2.5kg/ha

23/1 Manzate @ 2.5kg/ha

Lettuce

Hydro Red incorporated @ 1t/ha

Sprayed with Stomp @ 2L/ha before transplanting

Cell transplants (cv Casino) planted 12 December 2000 and 16 January 2001

In three rows, per bed and 400 mm apart in the row

Weeds were controlled by hoeing

Appendix II Analysis summary

Explanation

The figures are the mean number of leaves with damage or with insects present. Note leaves with market damage caused by thrips and aphid colonies were scored as 100. This some means to be larger than the number of leaves examined.

* shows that an Analysis of Variance was conducted

Letters by means that statistically significant differences ($P \leq 0.05$) were present. Means with the same letter are not significantly different from each other.

Analysis of old lettuce examined on 24 Jan: heart leaf data

Treatment	thrips damage *	adult thrips *	larval thrips
aphids/caterpillars	2.917	2.000	0.4167
thrips response	1.667	1.333	0.1667
unsprayed control	3.417	1.667	0.1667
weekly spray	2.000	1.333	0.2500

Treatment	all thrips *	aphids	looper caterpillars
aphids/caterpillars	2.333	8.500	0
thrips response	1.500	0.083	0
unsprayed control	1.417	0.417	0
weekly spray	1.500	0.667	0

Treatment	caterpillar frass	caterpillar damage	looper eggs
aphids/caterpillars	0.4167	0.1667	0.08333
thrips response	0.4167	0.3333	0.00000
unsprayed control	0.0833	0.0000	0.00000
weekly spray	0.8333	0.4167	0.00000

Treatment	leaf rollers	syrphid eggs	syrphid larvae
aphids/caterpillars	0.00000	0.00000	0.2500
thrips response	0.00000	0.08333	0.3333
unsprayed control	0.08333	0.00000	0.5000
weekly spray	0.08333	0.00000	0.5000

Treatment	syrphid pupae	lacewing eggs	lacewing larvae
aphids/caterpillars	0	0.16667	0.08333
thrips response	0	0.08333	0.00000
unsprayed control	0	0.08333	0.08333
weekly spray	0	0.00000	0.08333

Treatment	lacewing pupae	lacewing adults	leaf mining flies
aphids/caterpillars	0	0	0
thrips response	0	0	0
unsprayed control	0	0	0
weekly spray	0	0	0

Treatment	number of leaves examined
aphids/caterpillars	10.000
thrips response	9.917
unsprayed control	10.000
weekly spray	10.000

Analysis of old lettuce examined on 24 Jan: five inner wrapper leaf data

Treatment	thrips damage *	adult thrips	larval thrips
aphids/caterpillars	0.7500 a b	0.2500	0.2500
thrips response	0.1667 b	0.0000	0.0833
unsprayed control	1.2500 a	0.6667	0.0000
weekly spray	1.0000 a b	0.6667	0.0833

Treatment	all thrips	aphids	looper caterpillars
aphids/caterpillars	0.5000	0.417	0.1667
thrips response	0.0833	0.417	0.1667
unsprayed control	0.5833	8.917	0.1667
weekly spray	0.7500	0.000	0.1667

Treatment	caterpillar frass *	caterpillar damage *	looper eggs
aphids/caterpillars	1.0000	1.2500	0.1667
thrips response	0.8333	0.8333	0.0833
unsprayed control	0.9167	0.5833	0.2500
weekly spray	0.5000	0.6667	0.1667

Treatment	leaf rollers	syrphid eggs	syrphid larvae*
aphids/caterpillars	0.00000	0.2500	0.8333
thrips response	0.08333	0.0833	0.7500
unsprayed control	0.00000	0.0833	0.5000
weekly spray	0.00000	0.0000	1.0833

Treatment	syrphid pupae	lacewing eggs	lacewing larvae
aphids/caterpillars	0.00000	0.00000	0.00000
thrips response	0.00000	0.08333	0.00000
unsprayed control	0.08333	0.08333	0.08333
weekly spray	0.00000	0.08333	0.00000

Treatment	lacewing pupae	lacewing adults	leaf mining flies
aphids/caterpillars	0.08333	0.00000	0
thrips response	0.00000	0.08333	0
unsprayed control	0.00000	0.08333	0
weekly spray	0.00000	0.08333	0

Treatment	number of leaves examined
aphids/caterpillars	5.000
thrips response	5.000
unsprayed control	5.000
weekly spray	5.000

Analysis of old lettuce examined on 24 Jan: five outer wrapper leaf data

Treatment	thrips damage *	adult thrips	larval thrips
aphids/caterpillars	1.250	0.1667	0.16667
thrips response	0.917	0.0833	0.00000
unsprayed control	1.167	0.1667	0.08333
weekly spray	0.917	0.0000	0.08333

Treatment	all thrips	aphids	looper caterpillars
aphids/caterpillars	0.3333	0.167	0.2500
thrips response	0.0833	0.000	0.0000
unsprayed control	0.2500	0.667	0.2500
weekly spray	0.0833	16.750	0.0000

Treatment	caterpillar frass	caterpillar damage	looper eggs
aphids/caterpillars	0.3333	0.3333	0.0833
thrips response	0.0833	0.2500	0.0000
unsprayed control	0.2500	0.2500	0.2500
weekly spray	0.0000	0.0833	0.0833

Treatment	leaf rollers	syrphid eggs	syrphid larvae*
aphids/caterpillars	0.00000	0.0833	0.8333
thrips response	0.00000	0.0000	0.9167
unsprayed control	0.08333	0.3333	0.4167
weekly spray	0.00000	0.0000	0.4167

Treatment	syrphid pupae	lacewing eggs	lacewing larvae
aphids/caterpillars	0	0.1667	0.00000
thrips response	0	0.1667	0.00000
unsprayed control	0	0.0000	0.08333
weekly spray	0	0.1667	0.00000

Treatment	lacewing pupae	lacewing adults	leaf mining flies
aphids/caterpillars	0.00000	0.08333	0.00000
thrips response	0.00000	0.00000	0.00000
unsprayed control	0.00000	0.00000	0.08333
weekly spray	0.08333	0.00000	0.00000

Treatment	number of leaves examined
aphids/caterpillars	5.000
thrips response	5.000
unsprayed control	4.833
weekly spray	5.000

Analysis of old lettuce examined on 24 Jan: total leaf data

Treatment	thrips damage *	adult thrips *	larval thrips
aphids/caterpillars	4.917	2.417	0.8333
thrips response	2.750	1.417	0.2500
unsprayed control	5.833	2.500	0.2500
weekly spray	3.917	2.000	0.4167

Treatment	all thrips *	aphids *	looper caterpillars
aphids/caterpillars	3.167	9.083	0.4167
thrips response	1.667	0.500	0.1667
unsprayed control	2.250	10.000	0.4167
weekly spray	2.333	17.417	0.1667

Treatment	caterpillar frass *	caterpillar damage *	looper eggs
aphids/caterpillars	1.750	1.750	0.3333
thrips response	1.333	1.417	0.0833
unsprayed control	1.250	0.833	0.5000
weekly spray	1.333	1.167	0.2500

Treatment	leaf rollers	syrphid eggs	syrphid larvae *
aphids/caterpillars	0.00000	0.3333	1.917
thrips response	0.08333	0.1667	2.000
unsprayed control	0.16667	0.4167	1.417
weekly spray	0.08333	0.0000	2.000

Treatment	syrphid pupae	lacewing eggs *	lacewing larvae
aphids/caterpillars	0.00000	0.3333	0.0833
thrips response	0.00000	0.3333	0.0000
unsprayed control	0.08333	0.1667	0.2500
weekly spray	0.00000	0.2500	0.0833

Treatment	lacewing pupae	lacewing adults	leaf mining flies
aphids/caterpillars	0.08333	0.08333	0.00000
thrips response	0.00000	0.08333	0.00000
unsprayed control	0.00000	0.08333	0.08333
weekly spray	0.08333	0.08333	0.00000

Treatment	number of leaves examined
aphids/caterpillars	20.00
thrips response	19.92
unsprayed control	19.83
weekly spray	20.00

Analysis of old lettuce examined on 5 Feb: heart leaf data

Treatment	thrips damage *	adult thrips *	larval thrips *
aphids/caterpillars	345.5	1.850	1.550
thrips response	281.6	2.350	1.100
unsprayed control	475.6	2.800	1.050
weekly spray	415.4	2.250	1.450

Treatment	all thrips *	aphids	looper caterpillars
aphids/caterpillars	3.000	0.100	0.00000
thrips response	3.000	30.250	0.00000
unsprayed control	3.800	0.100	0.00000
weekly spray	3.600	0.150	0.05000

Treatment	caterpillar frass	caterpillar damage	looper eggs
aphids/caterpillars	0.1000	0.2000	0.00000
thrips response	0.0500	0.2000	0.05000
unsprayed control	0.2500	0.1500	0.00000
weekly spray	0.1000	0.0000	0.00000

Treatment	leaf rollers	syrphid eggs	syrphid larvae
aphids/caterpillars	0	0.00000	0.0000
thrips response	0	0.00000	0.0000
unsprayed control	0	0.00000	0.7000
weekly spray	0	0.15000	0.0000

Treatment	syrphid pupae	lacewing eggs	lacewing larvae
aphids/caterpillars	0	0.05000	0
thrips response	0	0.00000	0
unsprayed control	0	0.05000	0
weekly spray	0	0.00000	0

Treatment	lacewing pupae	lacewing adults	leaf mining flies
aphids/caterpillars	0	0	0
thrips response	0	0	0
unsprayed control	0	0	0
weekly spray	0	0	0

Treatment	number of leaves examined
aphids/caterpillars	9.950
thrips response	10.000
unsprayed control	10.000
weekly spray	10.000

Analysis of old lettuce examined on 5 Feb: five inner wrapper leaf data

Treatment	thrips damage *	adult thrips	larval thrips
aphids/caterpillars	49.45 a b	0.3000	0.4500
thrips response	24.65 b	0.2000	0.3000
unsprayed control	118.75 a	0.3500	0.1500
weekly spray	34.50 b	0.1000	0.1000

Treatment	all thrips	aphids	looper caterpillars
aphids/caterpillars	0.7000	0.000	0.00000
thrips response	0.4000	10.250	0.00000
unsprayed control	0.5000	10.400	0.10000
weekly spray	0.1500	0.100	0.00000

Treatment	caterpillar frass *	caterpillar damage *	looper eggs
aphids/caterpillars	0.2500 b	1.450	0.05000
thrips response	0.3500 b	1.450	0.00000
unsprayed control	1.0000 a	1.500	0.05000
weekly spray	0.5000 b	0.600	0.10000

Treatment	leaf rollers	syrphid eggs	syrphid larvae
aphids/caterpillars	0	0.0500	0.1000
thrips response	0	0.0500	0.0500
unsprayed control	0	0.1500	0.5000
weekly spray	0	0.2000	0.1000

Treatment	syrphid pupae	lacewing eggs	lacewing larvae
aphids/caterpillars	0	0.2000	0.00000
thrips response	0	0.1000	0.20000
unsprayed control	0	0.0500	0.00000
weekly spray	0	0.1000	0.00000

Treatment	lacewing pupae	lacewing adults	leaf mining flies
aphids/caterpillars	0.00000	0	0.05000
thrips response	0.05000	0	0.00000
unsprayed control	0.00000	0	0.00000
weekly spray	0.00000	0	0.05000

Treatment	number of leaves examined
aphids/caterpillars	5.000
thrips response	5.000
unsprayed control	5.000
weekly spray	5.000

Analysis of old lettuce examined on 5 Feb: five outer wrapper leaf data

Treatment	thrips damage *	adult thrips	larval thrips
aphids/caterpillars	1.3000	0.00000	0.00000
thrips response	1.3000	0.05000	0.05000
unsprayed control	0.2000	0.00000	0.00000
weekly spray	0.9500	0.00000	0.00000

Treatment	all thrips	aphids	looper caterpillars
aphids/caterpillars	0.00000	0.05000	0
thrips response	0.05000	0.05000	0
unsprayed control	0.00000	0.00000	0
weekly spray	0.00000	0.00000	0

Treatment	caterpillar frass	caterpillar damage	looper eggs
aphids/caterpillars	0.05000	0.5000	0.05000
thrips response	0.05000	0.8500	0.00000
unsprayed control	0.05000	0.1000	0.00000
weekly spray	0.15000	0.2500	0.00000

Treatment	leaf rollers	syrphid eggs	syrphid larvae
aphids/caterpillars	0	0.05000	0.00000
thrips response	0	0.00000	0.00000
unsprayed control	0	0.00000	0.05000
weekly spray	0	0.10000	0.05000

Treatment	syrphid pupae	lacewing eggs	lacewing larvae
aphids/caterpillars	0	0.25000	0.05000
thrips response	0	0.00000	0.05000
unsprayed control	0	0.00000	0.00000
weekly spray	0	0.10000	0.00000

Treatment	lacewing pupae	lacewing adults	leaf mining flies
aphids/caterpillars	0.00000	0	0.05000
thrips response	0.10000	0	0.05000
unsprayed control	0.00000	0	0.00000
weekly spray	0.00000	0	0.05000

Treatment	number of leaves examined *
aphids/caterpillars	1.3000
thrips response	1.3500
unsprayed control	0.2000
weekly spray	1.0500

Analysis of old lettuce examined on 5 Feb: total leaf data

Treatment	thrips damage *	adult thrips *	larval thrips *
aphids/caterpillars	396.3	2.150	2.000
thrips response	307.6	2.600	1.450
unsprayed control	594.5	3.150	1.200
weekly spray	450.8	2.350	1.550

Treatment	all thrips *	aphids	looper caterpillars
aphids/caterpillars	3.700	0.15	0.00000
thrips response	3.450	40.55	0.00000
unsprayed control	4.300	10.50	0.10000
weekly spray	3.750	0.25	0.05000

Treatment	caterpillar frass *	caterpillar damage *	looper eggs
aphids/caterpillars	0.4000	2.150	0.10000
thrips response	0.4500	2.500	0.05000
unsprayed control	1.3000	1.750	0.05000
weekly spray	0.7500	0.850	0.10000

Treatment	leaf rollers	syrphid eggs	syrphid larvae
aphids/caterpillars	0	0.1000	0.1000
thrips response	0	0.0500	0.0500
unsprayed control	0	0.1500	1.2500
weekly spray	0	0.4500	0.1500

Treatment	syrphid pupae	lacewing eggs	lacewing larvae
aphids/caterpillars	0	0.5000	0.05000
thrips response	0	0.1000	0.25000
unsprayed control	0	0.1000	0.00000
weekly spray	0	0.2000	0.00000

Treatment	lacewing pupae	lacewing adults	leaf mining flies
aphids/caterpillars	0.00000	0	0.10000
thrips response	0.15000	0	0.05000
unsprayed control	0.00000	0	0.00000
weekly spray	0.00000	0	0.10000

Treatment	number of leaves examined *
aphids/caterpillars	16.25
thrips response	16.35
unsprayed control	15.20
weekly spray	16.05

Analysis of young lettuce examined on 5 Feb: inner five wrapper leaves

Treatment	thrips damage *	adult thrips	larval thrips
aphids/caterpillars	1.300 b	0.2500	0.0500
thrips response	1.350 b	0.0000	0.0000
unsprayed control	3.500 a	2.4500	1.0000
weekly spray	1.750 b	0.2000	0.0000

Treatment	all thrips	aphids	looper caterpillars
aphids/caterpillars	0.3000	0.1000	0.00000
thrips response	0.0000	0.0000	0.00000
unsprayed control	2.9000	0.1500	0.05000
weekly spray	0.2000	0.1500	0.00000

Treatment	caterpillar frass	caterpillar damage	looper eggs
aphids/caterpillars	0	0	0.05000
thrips response	0	0	0.10000
unsprayed control	0	0	0.10000
weekly spray	0	0	0.05000

Treatment	leaf rollers	syrphid eggs	syrphid larvae
aphids/caterpillars	0	0	0
thrips response	0	0	0
unsprayed control	0	0	0
weekly spray	0	0	0

Treatment	syrphid pupae	lacewing eggs	lacewing larvae
aphids/caterpillars	0	0.00000	0.00000
thrips response	0	0.00000	0.00000
unsprayed control	0	0.05000	0.00000
weekly spray	0	0.00000	0.05000

Treatment	lacewing pupae	lacewing adults	leaf mining flies
aphids/caterpillars	0	0	0
thrips response	0	0	0
unsprayed control	0	0	0
weekly spray	0	0	0

Treatment	number of leaves examined
aphids/caterpillars	4.750
thrips response	5.000
unsprayed control	5.000
weekly spray	5.000

Analysis of young lettuce examined on 5 Feb: outer five wrapper leaves

Treatment	thrips damage *	adult thrips	larval thrips
aphids/caterpillars	4.200 b	0.0500	0.1500
thrips response	4.600 a b	0.0000	0.0000
unsprayed control	5.000 a	1.2500	0.4500
weekly spray	4.700 a b	0.1500	0.0000

Treatment	all thrips	aphids	looper caterpillars
aphids/caterpillars	0.2000	0.000	0.00000
thrips response	0.0000	0.000	0.00000
unsprayed control	1.4500	5.500	0.05000
weekly spray	0.1500	0.000	0.00000

Treatment	caterpillar frass	caterpillar damage	looper eggs
aphids/caterpillars	0	0	0.00000
thrips response	0	0	0.05000
unsprayed control	0	0	0.10000
weekly spray	0	0	0.00000

Treatment	leaf rollers	syrphid eggs	syrphid larvae
aphids/caterpillars	0	0	0.00000
thrips response	0	0	0.00000
unsprayed control	0	0	0.05000
weekly spray	0	0	0.00000

Treatment	syrphid pupae	lacewing eggs	lacewing larvae
aphids/caterpillars	0	0.10000	0.00000
thrips response	0	0.05000	0.00000
unsprayed control	0	0.15000	0.00000
weekly spray	0	0.00000	0.05000

Treatment	lacewing pupae	lacewing adults	leaf mining flies
aphids/caterpillars	0	0	0
thrips response	0	0	0
unsprayed control	0	0	0
weekly spray	0	0	0

Treatment	number of leaves examined
aphids/caterpillars	4.700
thrips response	5.000
unsprayed control	5.000
weekly spray	5.000

Analysis of young lettuce examined on 5 Feb: total leaves

Treatment	thrips damage *	adult thrips	larval thrips
aphids/caterpillars	5.500 b	0.300	0.2000
thrips response	5.950 b	0.000	0.0000
unsprayed control	8.500 a	3.700	1.4500
weekly spray	6.450 b	0.350	0.0000

Treatment	all thrips	aphids	looper caterpillars
aphids/caterpillars	0.500	0.100	0.00000
thrips response	0.000	0.000	0.00000
unsprayed control	4.350	5.650	0.10000
weekly spray	0.350	0.150	0.00000

Treatment	caterpillar frass	caterpillar damage	looper eggs
aphids/caterpillars	0	0	0.0500
thrips response	0	0	0.1500
unsprayed control	0	0	0.2000
weekly spray	0	0	0.0500

Treatment	leaf rollers	syrphid eggs	syrphid larvae
aphids/caterpillars	0	0	0.00000
thrips response	0	0	0.00000
unsprayed control	0	0	0.05000
weekly spray	0	0	0.00000

Treatment	syrphid pupae	lacewing eggs	lacewing larvae
aphids/caterpillars	0	0.10000	0.00000
thrips response	0	0.05000	0.00000
unsprayed control	0	0.20000	0.00000
weekly spray	0	0.00000	0.10000

Treatment	lacewing pupae	lacewing adults	leaf mining flies
aphids/caterpillars	0	0	0
thrips response	0	0	0
unsprayed control	0	0	0
weekly spray	0	0	0

Treatment	number of leaves examined
aphids/caterpillars	9.450
thrips response	10.000
unsprayed control	10.000
weekly spray	10.000

Analysis of young lettuce examined on 13 Feb: inner five wrapper leaves

Treatment	thrips damage *	adult thrips	larval thrips
aphids/caterpillars	8.500	0.7500	1.0500
thrips response	1.500	0.3000	0.0500
unsprayed control	13.300	1.1500	1.9000
weekly spray	0.900	0.0000	0.0500

Treatment	all thrips *	aphids	looper caterpillars
aphids/caterpillars	1.600 a	0.100	0.05000
thrips response	0.350 b	0.000	0.00000
unsprayed control	2.400 a	5.700	0.20000
weekly spray	0.050 b	0.050	0.00000

Treatment	caterpillar frass	caterpillar damage	looper eggs *
aphids/caterpillars	0.00000	0.00000	0.3500
thrips response	0.00000	0.00000	0.4500
unsprayed control	0.15000	0.35000	0.3000
weekly spray	0.00000	0.00000	0.4500

Treatment	leaf rollers	syrphid eggs	syrphid larvae
aphids/caterpillars	0	0.20000	0.00000
thrips response	0	0.10000	0.00000
unsprayed control	0	0.00000	0.15000
weekly spray	0	0.00000	0.00000

Treatment	syrphid pupae	lacewing eggs	lacewing larvae
aphids/caterpillars	0	0.05000	0.00000
thrips response	0	0.00000	0.00000
unsprayed control	0	0.10000	0.00000
weekly spray	0	0.00000	0.05000

Treatment	lacewing pupae	lacewing adults	leaf mining flies
aphids/caterpillars	0	0.00000	0
thrips response	0	0.00000	0
unsprayed control	0	0.05000	0
weekly spray	0	0.00000	0

Treatment	number of leaves examined
aphids/caterpillars	5.000
thrips response	5.000
unsprayed control	5.000
weekly spray	5.000

Analysis of young lettuce examined on 13 Feb: outer five wrapper leaves

Treatment	thrips damage *	adult thrips *	larval thrips
aphids/caterpillars	4.750 a	0.4500 b	0.8500
thrips response	3.700 b	0.2500 b	0.4500
unsprayed control	5.000 a	1.1500 a	2.4500
weekly spray	3.150 b	0.1500 b	0.0500

Treatment	all thrips *	aphids	looper caterpillars
aphids/caterpillars	1.200 b	0.650	1.1000
thrips response	0.500 b	5.100	0.0500
unsprayed control	3.000 a	11.100	0.7500
weekly spray	0.200 b	0.000	0.0000

Treatment	caterpillar frass	caterpillar damage *	looper eggs *
aphids/caterpillars	0.00000	1.500	0.5000
thrips response	0.00000	0.700	0.7500
unsprayed control	0.15000	1.350	0.7500
weekly spray	0.00000	0.500	0.9000

Treatment	leaf rollers	syrphid eggs *	syrphid larvae
aphids/caterpillars	0.00000	0.4500	0.1000
thrips response	0.00000	0.3000	0.3000
unsprayed control	0.05000	0.2000	0.1500
weekly spray	0.05000	0.4000	0.0500

Treatment	syrphid pupae	lacewing eggs	lacewing larvae
aphids/caterpillars	0	0.1000	0.05000
thrips response	0	0.0000	0.00000
unsprayed control	0	0.3500	0.00000
weekly spray	0	0.0500	0.10000

Treatment	lacewing pupae	lacewing adults	leaf mining flies
aphids/caterpillars	0	0.05000	0
thrips response	0	0.00000	0
unsprayed control	0	0.00000	0
weekly spray	0	0.00000	0

Treatment	number of leaves examined
aphids/caterpillars	5.000
thrips response	5.000
unsprayed control	5.000
weekly spray	5.000

Analysis of young lettuce examined on 13 Feb: total leaves

Treatment	thrips damage *	adult thrips *	larval thrips
aphids/caterpillars	13.25	1.200 b	1.900
thrips response	5.20	0.550 bc	0.500
unsprayed control	18.30	2.300 a	4.350
weekly spray	4.05	0.150 c	0.100

Treatment	all thrips *	aphids *	looper caterpillars
aphids/caterpillars	2.800 b	0.750	1.1500
thrips response	0.850 c	5.100	0.0500
unsprayed control	5.400 a	16.800	0.9500
weekly spray	0.250 c	0.050	0.0000

Treatment	caterpillar frass	caterpillar damage *	looper eggs *
aphids/caterpillars	0.00000	1.500	0.850
thrips response	0.00000	0.700	1.200
unsprayed control	0.30000	1.700	1.050
weekly spray	0.00000	0.500	1.350

Treatment	leaf rollers	syrphid eggs *	syrphid larvae
aphids/caterpillars	0.00000	0.6500	0.1000
thrips response	0.00000	0.4000	0.3000
unsprayed control	0.05000	0.2000	0.3000
weekly spray	0.05000	0.4000	0.0500

Treatment	syrphid pupae	lacewing eggs	lacewing larvae
aphids/caterpillars	0	0.1500	0.05000
thrips response	0	0.0000	0.00000
unsprayed control	0	0.4500	0.00000
weekly spray	0	0.0500	0.15000

Treatment	lacewing pupae	lacewing adults	leaf mining flies
aphids/caterpillars	0	0.05000	0
thrips response	0	0.00000	0
unsprayed control	0	0.05000	0
weekly spray	0	0.00000	0

Treatment	number of leaves examined
aphids/caterpillars	10.00
thrips response	10.00
unsprayed control	10.00
weekly spray	10.00

Analysis of young lettuce examined on 20 Feb: heart leaves

Treatment	thrips damage *	adult thrips *	larval thrips *
aphids/caterpillars	4.150	0.350	0.4500
thrips response	5.050	2.050	0.9000
unsprayed control	5.300	1.450	0.9500
weekly spray	4.400	1.550	1.1500

Treatment	all thrips *	aphids	looper caterpillars*
aphids/caterpillars	0.700 a	0.1500	0.2000 b
thrips response	2.600 b	0.1500	0.3000 b
unsprayed control	1.900 a b	1.1500	0.9500 a
weekly spray	2.450 a b	0.0000	0.1000 b

Treatment	caterpillar frass	caterpillar damage	looper eggs
aphids/caterpillars	0.2000	0.2500	0.0000
thrips response	0.2000	0.2000	0.1000
unsprayed control	0.1000	0.4500	0.3500
weekly spray	0.0500	0.1000	0.1000

Treatment	leaf rollers	syrphid eggs	syrphid larvae
aphids/caterpillars	0	0.00000	0.0000
thrips response	0	0.00000	0.1000
unsprayed control	0	0.05000	0.3000
weekly spray	0	0.00000	0.0500

Treatment	syrphid pupae	lacewing eggs	lacewing larvae
aphids/caterpillars	0	0.05000	0.00000
thrips response	0	0.05000	0.05000
unsprayed control	0	0.15000	0.10000
weekly spray	0	0.00000	0.00000

Treatment	lacewing pupae	lacewing adults	leaf mining flies
aphids/caterpillars	0	0	0
thrips response	0	0	0
unsprayed control	0	0	0
weekly spray	0	0	0

Treatment	number of leaves examined *
aphids/caterpillars	6.300
thrips response	6.900
unsprayed control	7.050
weekly spray	6.000

Analysis of young lettuce examined on 20 Feb: inner five wrapper leaves

Treatment	thrips damage *	adult thrips *	larval thrips *
aphids/caterpillars	4.450	0.2500 a b	0.1000
thrips response	4.650	0.6000 b	0.4000
unsprayed control	4.750	0.2000 a	0.2000
weekly spray	4.050	0.4000 a b	0.3000

Treatment	all thrips *	aphids	looper caterpillars*
aphids/caterpillars	0.3000 a	0.2000	0.400 b
thrips response	1.0000 b	0.3500	2.250 a
unsprayed control	0.4000 a	0.5000	2.050 a b
weekly spray	0.5500 a	0.0000	0.450 b

Treatment	caterpillar frass	caterpillar damage *	looper eggs *
aphids/caterpillars	0.5000	1.650 a b	1.100
thrips response	0.4000	1.950 a b	1.200
unsprayed control	0.3000	2.450 a	1.200
weekly spray	0.4000	1.350 b	1.650

Treatment	leaf rollers	syrphid eggs	syrphid larvae
aphids/caterpillars	0	0.0000	0.0500
thrips response	0	0.1500	0.4000
unsprayed control	0	0.1000	0.4000
weekly spray	0	0.1500	0.0500

Treatment	syrphid pupae	lacewing eggs	lacewing larvae
aphids/caterpillars	0	0.1500	0.00000
thrips response	0	0.1000	0.05000
unsprayed control	0	0.2000	0.00000
weekly spray	0	0.2000	0.05000

Treatment	lacewing pupae	lacewing adults	leaf mining flies
aphids/caterpillars	0	0.00000	0
thrips response	0	0.00000	0
unsprayed control	0	0.05000	0
weekly spray	0	0.00000	0

Treatment	number of leaves examined
aphids/caterpillars	4.950
thrips response	5.000
unsprayed control	4.950
weekly spray	5.000

Analysis of young lettuce examined on 20 Feb: outer five wrapper leaves

Treatment	thrips damage *	adult thrips	larval thrips
aphids/caterpillars	58.05	0.0500	0.2000
thrips response	29.05	0.2000	0.3500
unsprayed control	9.35	0.0500	0.4500
weekly spray	43.55	0.1000	0.1000

Treatment	all thrips	aphids	looper caterpillars
aphids/caterpillars	0.2500	0.000	0.2000
thrips response	0.5500	0.100	1.5000
unsprayed control	0.5000	5.300	0.8500
weekly spray	0.0500	0.050	0.2000

Treatment	caterpillar frass	caterpillar damage *	looper eggs *
aphids/caterpillars	0.4000	2.050	0.2000
thrips response	0.1500	1.400	0.5000
unsprayed control	0.2500	1.650	0.2500
weekly spray	0.2500	0.800	0.3500

Treatment	leaf rollers	syrphid eggs	syrphid larvae
aphids/caterpillars	0	0.0500	0.1000
thrips response	0	0.2000	0.1500
unsprayed control	0	0.0500	0.4000
weekly spray	0	0.1000	0.0500

Treatment	syrphid pupae	lacewing eggs	lacewing larvae
aphids/caterpillars	0	0.1000	0.00000
thrips response	0	0.4500	0.05000
unsprayed control	0	0.2500	0.05000
weekly spray	0	0.2500	0.00000

Treatment	lacewing pupae	lacewing adults	leaf mining flies
aphids/caterpillars	0	0.00000	0
thrips response	0	0.00000	0
unsprayed control	0	0.05000	0
weekly spray	0	0.00000	0

Treatment	number of leaves examined *
aphids/caterpillars	3.900
thrips response	4.300
unsprayed control	4.450
weekly spray	3.650

Analysis of young lettuce examined on 20 Feb: total leaves

Treatment	thrips damage *	adult thrips *	larval thrips *
aphids/caterpillars	66.65	0.650 b	0.750
thrips response	38.75	2.850 a b	1.650
unsprayed control	19.40	1.700 a	1.600
weekly spray	52.00	2.050 a b	1.550

Treatment	all thrips *	aphids	looper caterpillars*
aphids/caterpillars	1.250 b	0.350	0.800
thrips response	4.150 a	0.600	4.050
unsprayed control	2.800 a b	6.950	3.850
weekly spray	3.050 a	0.050	0.750

Treatment	caterpillar frass	caterpillar damage *	looper eggs *
aphids/caterpillars	1.1000	3.950 a b	1.300 b
thrips response	0.7500	3.550 a b	1.800 a b
unsprayed control	0.6500	4.550 a	1.800 a b
weekly spray	0.7000	2.250 b	2.100 a

Treatment	leaf rollers	syrphid eggs	syrphid larvae
aphids/caterpillars	0	0.0500	0.1500
thrips response	0	0.3500	0.6500
unsprayed control	0	0.2000	1.1000
weekly spray	0	0.2500	0.1500

Treatment	syrphid pupae	lacewing eggs	lacewing larvae
aphids/caterpillars	0	0.3000	0.00000
thrips response	0	0.6000	0.15000
unsprayed control	0	0.6000	0.15000
weekly spray	0	0.4500	0.05000

Treatment	lacewing pupae	lacewing adults	leaf mining flies
aphids/caterpillars	0	0.00000	0
thrips response	0	0.00000	0
unsprayed control	0	0.10000	0
weekly spray	0	0.00000	0

Treatment	number of leaves examined *
aphids/caterpillars	15.15
thrips response	16.20
unsprayed control	16.45
weekly spray	14.65

Analysis of young lettuce examined on 6 Mar: heart leaves

Treatment	thrips damage *	adult thrips *	larval thrips *
aphids/caterpillars	138.2	0.6000	0.700
thrips response	52.3	0.3500	0.900
unsprayed control	206.7	0.8500	1.250
weekly spray	132.9	0.5000	1.350

Treatment	all thrips *	aphids	looper caterpillars
aphids/caterpillars	1.250	0.350	1.0000
thrips response	1.250	0.000	0.0000
unsprayed control	1.850	5.650	0.7000
weekly spray	1.750	0.050	0.0000

Treatment	caterpillar frass *	caterpillar damage *	looper eggs
aphids/caterpillars	3.000 b	2.550 a b	0.00000
thrips response	0.300 c	0.700 b	0.05000
unsprayed control	4.050 a	4.250 a	0.00000
weekly spray	0.250 b	0.650 b	0.00000

Treatment	leaf rollers	syrphid eggs	syrphid larvae
aphids/caterpillars	0	0.00000	0.00000
thrips response	0	0.00000	0.00000
unsprayed control	0	0.05000	0.25000
weekly spray	0	0.00000	0.05000

Treatment	syrphid pupae	lacewing eggs	lacewing larvae
aphids/caterpillars	0	0.00000	0.00000
thrips response	0	0.00000	0.00000
unsprayed control	0	0.10000	0.05000
weekly spray	0	0.00000	0.00000

	lacewing pupae	lacewing adults	leaf mining flies
aphids/caterpillars	0	0	0
thrips response	0	0	0
unsprayed control	0	0	0
weekly spray	0	0	0

Treatment	number of leaves examined
aphids/caterpillars	10.00
thrips response	10.00
unsprayed control	10.00
weekly spray	10.00

Analysis of young lettuce examined on 6 Mar: inner five wrapper leaves

Treatment	thrips damage *	adult thrips *	larval thrips *
aphids/caterpillars	9.700	0.2500	0.1500
thrips response	4.550	0.1000	0.2000
unsprayed control	9.850	0.3000	0.2000
weekly spray	5.000	0.1500	0.2500

Treatment	all thrips *	aphids	looper caterpillars*
aphids/caterpillars	0.4000	0.3000	2.0500 a
thrips response	0.2500	0.0000	0.1500 c
unsprayed control	0.5000	0.5000	1.2000 b
weekly spray	0.4000	0.0000	0.1000 c

Treatment	caterpillar frass *	caterpillar damage *	looper eggs
aphids/caterpillars	2.150 a	3.200 a b	0.1000
thrips response	0.250 b	3.500 a	0.1000
unsprayed control	2.450 a	3.950 a	0.0500
weekly spray	0.150 b	2.350 b	0.2000

Treatment	leaf rollers	syrphid eggs	syrphid larvae
aphids/caterpillars	0.00000	0.00000	0.05000
thrips response	0.00000	0.05000	0.05000
unsprayed control	0.00000	0.00000	0.05000
weekly spray	0.05000	0.10000	0.05000

Treatment	syrphid pupae	lacewing eggs	lacewing larvae
aphids/caterpillars	0	0.05000	0
thrips response	0	0.25000	0
unsprayed control	0	0.00000	0
weekly spray	0	0.05000	0

Treatment	lacewing pupae	lacewing adults	leaf mining flies
aphids/caterpillars	0	0.05000	0
thrips response	0	0.00000	0
unsprayed control	0	0.10000	0
weekly spray	0	0.00000	0

Treatment	number of leaves examined
aphids/caterpillars	5.000
thrips response	5.000
unsprayed control	5.000
weekly spray	5.000

Analysis of young lettuce examined on 6 Mar: total leaves

Treatment	thrips damage *	adult thrips *	larval thrips *
aphids/caterpillars	147.9	0.8500	0.850
thrips response	56.9	0.4500	1.100
unsprayed control	216.5	1.1500	1.450
weekly spray	137.9	0.6500	1.600

Treatment	all thrips *	aphids	looper caterpillars*
aphids/caterpillars	1.650	0.650	3.050 a
thrips response	1.500	0.000	0.150 c
unsprayed control	2.350	6.150	1.900 b
weekly spray	2.150	0.050	0.100 c

Treatment	caterpillar frass *	caterpillar damage *	looper eggs
aphids/caterpillars	5.150 b	5.750 a b	0.1000
thrips response	0.550 c	4.200 b	0.1500
unsprayed control	6.500 a	8.200 a	0.0500
weekly spray	0.400 c	3.000 b	0.2000

Treatment	leaf rollers	syrphid eggs	syrphid larvae
aphids/caterpillars	0.00000	0.00000	0.0500
thrips response	0.00000	0.05000	0.0500
unsprayed control	0.00000	0.05000	0.3000
weekly spray	0.05000	0.10000	0.1000

Treatment	syrphid pupae	lacewing eggs	lacewing larvae
aphids/caterpillars	0	0.0500	0.00000
thrips response	0	0.2500	0.00000
unsprayed control	0	0.1000	0.05000
weekly spray	0	0.0500	0.00000

Treatment	lacewing pupae	lacewing adults	leaf mining flies
aphids/caterpillars	0	0.05000	0
thrips response	0	0.00000	0
unsprayed control	0	0.10000	0
weekly spray	0	0.00000	0

Treatment	number of leaves examined
aphids/caterpillars	15.00
thrips response	15.00
unsprayed control	15.00
weekly spray	15.00

Appendix III Two-sample T-test and confidence intervals comparing old and young lettuce on 24 January

Tests where $P \leq 0.05$.

5 outer wrapper leaves,thrips damage

Group	N	Mean	StDev	SE Mean
Old	16	0.937	0.984	0.25
Young	16	4.625	0.644	0.16

Difference = mu (Old) - mu (Young)
Estimate for difference: -3.688
95% CI for difference: (-4.293, -3.082)
T-Test of difference = 0 (vs not =): T-Value = -12.54 P-Value = 0.000 DF = 25

5 outer wrapper leaves,thrips infested leaves

Group	N	Mean	StDev	SE Mean
Old	16	0.0125	0.0500	0.012
Young	16	0.450	0.717	0.18

Difference = mu (Old) - mu (Young)
Estimate for difference: -0.438
95% CI for difference: (-0.821, -0.054)
T-Test of difference = 0 (vs not =): T-Value = -2.43 P-Value = 0.028 DF = 15

5 outer wrapper leaves, numbers of leaves

Group	N	Mean	StDev	SE Mean
Old	16	0.97	1.05	0.26
Young	16	4.925	0.252	0.063

Difference = mu (Old) - mu (Young)
Estimate for difference: -3.950
95% CI for difference: (-4.522, -3.378)

T-Test of difference = 0 (vs not =): T-Value = -14.63 P-Value = 0.000 DF = 16

5 inner wrapper leaves,thrips damage

Group	N	Mean	StDev	SE Mean
Old	16	56.8	60.1	15
Young	16	1.98	1.07	0.27

Difference = mu (Old) - mu (Young)
Estimate for difference: 54.9
95% CI for difference: (22.8, 86.9)
T-Test of difference = 0 (vs not =): T-Value = 3.65 P-Value = 0.002 DF = 15

Total leaves,thrips damage

Group	N	Mean	StDev	SE Mean
Old	16	437	321	80
Young	16	6.60	1.56	0.39

Difference = mu (Old) - mu (Young)
Estimate for difference: 430.7
95% CI for difference: (259.7, 601.7)
T-Test of difference = 0 (vs not =): T-Value = 5.37 P-Value = 0.000 DF = 15

Total leaves, leaves infested with adult thrips

Group	N	Mean	StDev	SE Mean
Old	16	2.563	0.950	0.24
Young	16	1.09	1.75	0.44

Difference = mu (Old) - mu (Young)
Estimate for difference: 1.475
95% CI for difference: (0.445, 2.505)
T-Test of difference = 0 (vs not =): T-Value = 2.96 P-Value = 0.007 DF = 23

Total leaves, leaves infested with larval thrips

Group	N	Mean	StDev	SE Mean
Old	16	1.55	1.04	0.26
Young	16	0.413	0.721	0.18

Difference = mu (Old) - mu (Young)
Estimate for difference: 1.138
95% CI for difference: (0.489, 1.786)
T-Test of difference = 0 (vs not =): T-Value = 3.60 P-Value = 0.001 DF = 26

Total leaves, leaves infested with adult or larval thrips

Group	N	Mean	StDev	SE Mean
Old	16	3.800	0.918	0.23
Young	16	1.30	2.01	0.50

Difference = mu (Old) - mu (Young)
Estimate for difference: 2.500
95% CI for difference: (1.347, 3.653)
T-Test of difference = 0 (vs not =): T-Value = 4.52 P-Value = 0.000 DF = 20

Total leaves, leaves with syrphid larvae

Group	N	Mean	StDev	SE Mean
Old	16	0.388	0.667	0.17
Young	16	0.0125	0.0500	0.012

Difference = mu (Old) - mu (Young)
Estimate for difference: 0.375
95% CI for difference: (0.018, 0.732)
T-Test of difference = 0 (vs not =): T-Value = 2.24 P-Value = 0.041 DF = 15