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Summary of Crown funded research on onion thrips and onions – 2003-04

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1 Executive summary

In 2003-04, government-funded research on onion thrips focused on three areas: comparing crop monitoring methods for detecting thrips; natural enemies of onion thrips; and bioassays to compare the susceptibility of onions to onion thrips.

1.1 Crop monitoring/scouting

This research focused on monitoring thrips when onion thrips populations are low and the distribution of the thrips in the field reflects the pattern from the initial invasion. We planned to sample onion crops before and after the first cluster of insecticide sprays were applied, and on each occasion two people made independent estimates of thrips numbers and distribution using three sampling methods. The sampling methods were:

- examining 100 randomly selected plants,
- 20 groups of five plants, the five plants being selected randomly from within a circle approximately 1 m in diameter, and
- 20 groups of five plants, the five plants being in the same row and adjacent to one another.

The last method is designed to detect levels of aggregation of thrips-infested plants.

In the Pukekohe area, thrips populations were low in spring and early summer and only one crop was monitored. The two people, who made independent estimates of populations using the three sampling methods, obtained similar results. The thrips population was high, well above the current action threshold, and although there were differences between sampling methods and each observer, data from more crops is required before the sampling methods can be compared mathematically. The real test of the three sampling methods will be when populations are close to or below the action threshold.

1.2 Natural enemies

In 2003-04, the parasitoid *Ceranisus menes* did not appear until January in unsprayed plots of early crop and main crop PLK onions at Pukekohe Research Centre. Numbers of the parasitoid were low and appeared to have no impact on thrips populations.

Male onion thrips were regularly found in the crops.

1.3 Susceptibility of onion bulbs to thrips

A new bioassay is being developed to compare the susceptibility (or resistance) of onion bulbs to onion thrips. Ten mm diameter discs are cut from onion scale. Each disc is caged with one-day-old adult female thrips, which are left to feed and lay eggs for three days. The discs are stained to show the eggs. The greater the number of eggs, the greater the susceptibility of that onion bulb to onion thrips. Using this method it will be possible to estimate the susceptibility of an individual bulb, which can then be allowed to grow, flower and collect seeds. This year the bioassay was tested on onion bulbs of four cultivars, each grown in replicated trials with four nitrogen treatments.

Two early onions, Kiwigold (brown) and Meteor (red), and two main crop onions, May & Ryan (M&R) regular (PLK) and Red Star (red), were grown in adjacent areas and each had 16 plots to which the four nitrogen treatments (50, 100, 150 and 200 kg/ha) were allocated in a Latin square design.

So far one bioassay has compared early crop bulbs of the two cultivars from the lowest and highest nitrogen treatments and a second bioassay has compared bulbs from the main crops cultivars for the same nitrogen treatments. In each bioassay up to 20 discs were tested from each bulb, and each bulb was tested twice to measure between experiment and between bulb variation.

The number of discs per treatment with either more than one or more than three eggs gave the best measure of susceptibility of the bulb to onion thrips. Using these criteria, the brown onions, Kiwigold and M&R Regular, were found to be more susceptible than the red onions, Meteor and Red Star, respectively. Also the bulbs from the high nitrogen treatment (200 g/ha) were more susceptible than bulbs from the low nitrogen treatment (50 g/ha).

Chemical analyses of Kiwigold and M&R Regular bulbs showed that there were no effects of nitrogen treatments on pungency or total nitrogen. Bulbs of Kiwigold, but not M&R Regular, had a lower percentage of fructans with increasing nitrogen applications and a higher percentage of sulfur per bulb dry weight with increased nitrogen.

Red onion bulbs showed signs of shrinkage and obvious thrips damage 5 months after storage. Up to 10 bulbs per plot were assessed for number of skins, thrips damage to innermost skin and outermost scale, sprouting and bulb firmness. The early cultivars had fewer skins and more live thrips, while the red cultivars, Meteor and Red Star, had more thrips damage to the innermost skin, were softer and had more bulbs with external sprouts.

1.4 Conclusions and plans for 2004-05

1.4.1 Crop scouting

The new protocol for testing crop scouting methods gave good data. It will be used on crops with low thrips numbers in 2004 with assistance from Wilcox & Sons Ltd.

1.4.2 *Natural enemies*

Sampling of unsprayed onions again showed that natural enemies of onion thrips are rare in onion crops. Applications of the fungal pathogen, *Verticillium lecanii,* will be tested in 2004-05 if it is registered in time.

1.4.3 *Susceptibility of onion thrips to onion bulbs*

Analysis of the data from the new bioassay showed that both genetic and agronomic factors affect the susceptibility of onion bulbs to onion thrips.

- The fleshy scales of two cultivars of brown onion cultivars, Kiwigold and M&R Regular, were more susceptible to onion thrips than the red onion cultivars, Meteor and Red Star.
- Higher quantities of nitrogen applied to crops increased susceptibility of bulbs to onion thrips.

During storage, the two red onion cultivars exhibited more thrips damage to the innermost skin and were softer than the brown onion cultivars. The greater thrips damage could be associated with greater shrinkage giving thrips more access to the outermost scale while it was shrinking to form a skin, and/or be due to changes in the chemical composition of the scale in the process of forming a skin.

Chemical analysis of Kiwigold and M&R Regular found that in Kiwigold there was a lower percentage of fructans and a higher percentage of sulfur (dry wt) in bulbs from high nitrogen plots than low nitrogen plots.

Another cultivar nitrogen trial has been established for 2004-05, with the same brown onion cultivars and two onion cultivars that are believed to be more susceptible to onion thrips. Bulbs from this trial will be assessed for their susceptibility to onion thrips, bulb quality and chemical analysis. A comparison of the susceptibility of outermost scales while shrinking and internal scales to thrips and their chemical composition may be useful.

2 *Introduction*

In 2003-04 government-funded research on onion thrips focused on three areas: comparing crop monitoring methods for detecting thrips; natural enemies of onion thrips; and bioassays to compare the susceptibility of onions to onion thrips.

3 *Monitoring onion thrips in onion crops*

This research focuses on monitoring thrips at the time of year when onion thrips populations are low and distribution in the field reflects the initial invasion. It is also the time when populations approach or are close to the current action threshold that growers use to start a cluster of insecticide applications.

In 2003-04, three monitoring methods were compared, as in the previous season:

- examining 100 randomly selected plants,
- 20 groups of five plants, the five plants being selected randomly from within a circle approximately 1 m in diameter, and
- 20 groups of five plants, the five plants being in the same row and adjacent to one another.

The last method was designed to detect levels of aggregation of thrips-infested plants.

This year each crop was monitored twice with different sets of randomly selected plants in order to compare the variability within the process. In the Pukekohe area, thrips populations were again low in spring and early summer. Only one crop was monitored (28 Nov 03). Populations were already high and well above the current action threshold (Table 1). At these relatively high populations, the three monitoring methods gave similar results and the results from both scouts were similar. However, when the data was examined for distribution of thrips within the field, there were some major differences between methods and people. This confirms the need for good data from more crops in order to determine a robust field scouting protocol. This research will continue in 2004-05. Assistance from the Allium SFF is anticipated.

Table 1: Number of thrips and numbers of infested plants in one sample from an infested onion crop on 28 November 2003. The current action threshold is 0.1 thrips per plant.

Random sample of 100 plants				Number of infested plants			
Thrips	Adult	Nymph	Total		Adult	Nymph	Total
Total	36	117	153	Total (n=100)	30	35	50
Per plant	0.36	1.17	1.53	% infested	30	35	50
% adults	23.53			% with adults	60.00		

We are grateful for the assistance of Wilcox & Sons, Ltd with this project.

4 Natural enemies of onion thrips in onion crops

The trial to test the efficacy of commercial formulations of Verticillium lecanii was delayed because product was awaiting registration with MAF. A block of early and main crop onions was monitored for natural enemies and thrips populations. Natural enemies did not control the thrips. Ceranisus menes (Hymenpotera: Eulophidae) appeared amongst the plants in January.

There had been a question about whether male Thrips tabaci were present in onion thrips populations in New Zealand onion crops. Males were seen regularly, though in low numbers.

5 Susceptibility of onion bulbs to onion thrips

5.1 Introduction

Early research by Crop & Food Research that compared the susceptibility of onion bulbs to onion thrips used whole bulbs with a ‘window’ cut through the dry skins to expose a fleshy scale. Each bulb was held in a separate ventilated jar and was infested with a known number of adult female thrips. The bulbs were examined after several weeks when larvae had hatched from eggs. This bioassay had several disadvantages: it was time consuming to assess, took several weeks before results were available, required 50-100 bulbs per treatment and took up a lot of space. We are developing a new test that will provide information on the susceptibility of an individual bulb that the plant breeder can then grow on to produce flowers and seed. This year we tested a new bioassay method on four cultivars of onions each grown with four nitrogen treatments.

5.2 Field trial

We grew two early onions, Kiwigold (brown) and Meteor (red), and two main crop onions, May & Ryan regular (PLK-brown) and Red Star (red), in adjacent blocks of 4 beds (60 m long). Each bed was divided into 4 plots (15 m long) giving 16 per cultivar. Plots were allocated to four nitrogen rates (50, 100, 150 and 200 kg/ha) and with four replicates in a Latin square design. The same Latin square was used for each cultivar. Nitrogen (Urea) was applied at the flag leaf stage, 2-3rd true leaf, 6-8 true leaf and 10 true leaves. All cultivars were sown on 20 July 2003 and the nitrogen treatments were applied on 29 August, 8 October, 27 November and 22 December.

The plants received normal fungicide and insecticide programmes. Bulbs were harvested from the central rows of the plots.

5.3 Bioassay summary of method

Day-old female onion thrips were allowed to feed and lay eggs in a disc of onion bulb tissue for three days. The number of eggs laid are counted after staining the disc. Up to 20 discs per onion were assessed in each bioassay. So far (June 2004) we have run one bioassay comparing early onions and a second bioassay comparing main crop onions. In each bioassay we used onion bulbs from two nitrogen treatments, N1 (50 kg/ha) and N4 (200 kg/ha) and only bulbs from two plots per treatment. We also compared the consistency of data from each bulb by testing each half of the bulb on two consecutive days (Table 2). After discs were taken, the rest of each bulb was frozen so that it was available for subsequent chemical analysis.

Table 2: Dates of bioassays.

Dates of bioassays	
Early crop Kiwigold and Meteor	Main crop M&R Regular and Red Star
4/02/2004	3/03/2004
5/02/2004	4/03/2004
11/02/2004	10/03/2004
12/02/2004	11/03/2004
18/02/2004	18/03/2004
19/02/2004	19/03/2004
25/02/2004	25/03/2004
26/02/2004	26/03/2004

5.4 Bioassay results

A summary of the mean number of eggs per disc indicates that the brown onions, Kiwigold and M&R Regular, are more susceptible to onion thrips than the red onions, Meteor and Red Star (Table 3). The data also indicate that the high nitrogen (N4) treatment may make the bulbs more susceptible than the low nitrogen (N1) treatment.

Table 3: Mean number of eggs found in discs of onion bulb flesh.

	Bioassay 1				Bioassay 2			
Cultivar	Kiwigold		Meteor		M&R Regular		Red Star	
Nitrogen treatment	N1	N4	N1	N4	N1	N4	N1	N4
Mean	0.85	1.45	0.45	0.58	1.12	1.91	0.84	1.02

The data were further analysed to compare the number of discs with no eggs, the number of discs with more than 1 egg and the number of discs with more than 3 eggs.

When comparing the proportion of discs with no eggs, Kiwigold (52%) was more susceptible than Meteor (72%) while there was no difference between M&R and Red Star. In the early crop onions, the high nitrogen (N4) onions were more susceptible than the low nitrogen-treated bulbs (58 and 68% respectively).

The proportion of discs with more than one egg also differed between cultivars. There were also considerable differences in susceptibility of bulbs between early crop onions fertilised with different amounts of nitrogen. For this comparison the higher percentage is the more susceptible treatment. Kiwigold (27%) is again more susceptible than Meteor (14%) and M&R (35%) is slightly more susceptible than Red Star (24%). For the early onions the bulbs from the high nitrogen treatment (23%) were more susceptible than low nitrogen (16%). However, in this analysis Kiwigold was more susceptible than Meteor in both low and high nitrogen treatments (Table 4).

Table 4: Proportion of leaf discs with more than one egg.

	Early onions			
Nitrogen treatment	N1		N4	
Cultivar	Kiwigold	Meteor	Kiwigold	Meteor
Percentage of discs	21.03	12.23	34.63	15.33
95% confidence limits	14.22, 29.97	7.23, 19.94	25.87, 44.57	9.61, 23.56

The comparison of the proportion of discs with more than three eggs also shows differences between the cultivars and between nitrogen treatments. For these comparisons the higher percentage is the more susceptible treatment. Kiwigold (9%) was more susceptible than Meteor (2.5%) and M&R Regular (13%) more susceptible than Red Star (7%). The brown onions were more susceptible in the high nitrogen treatment than the low nitrogen treatment (Table 5).

Table 5: Proportion of discs with more than three eggs.

	Early onions			
Nitrogen treatment	N1		N4	
Cultivar	Kiwigold	Meteor	Kiwigold	Meteor
Percentage of discs	5.90	2.88	14.40	2.19
95% confidence limits	3.18, 10.71	1.19, 6.80	9.71, 20.82	0.79, 5.93
	Main crop onions			
Nitrogen treatment	N1		N4	
Cultivar	M&R Regular	Red Star	M&R Regular	Red Star
Percentage of discs	9.06	5.96	19.05	8.93
95% confidence limits	4.86, 16.24	2.78, 12.30	12.60, 27.74	4.86, 15.85

Biometric analysis of the proportion of discs with different numbers of eggs is a useful method for discriminating between treatments in these onion disc bioassays. More information is needed about the variability between onion bulbs in these open pollinated brown onion cultivars and whether there are any correlations between susceptibility to onion thrips and the chemical properties of the bulbs.

5.5 *Onion bulb quality after storage*

In July 2004, a cursory examination of the red and brown bulbs from the trial indicated that the red bulbs had shrunk more than the brown bulbs, skins were looser and there were signs of extensive thrips damage. The bulbs were removed from the field on 10 March 2004 and stored in open brown paper bags in a cool airy room. Up to 10 bulbs from each plot of each cultivar were examined in August 2004. The following features of each bulb were recorded:

- number of skins
- number of intact skins
- extent of thrips damage on the innermost skin (proportion of skin affected estimated to the nearest 5%)
- extent of thrips damage on the outermost fleshy scale (proportion of scale affected estimated to the nearest 5%)
- presence of live thrips (larvae and adults recorded separately)
- external sprouting (score of 1 <50 mm, 2 = 50-150 mm, 3 = >150 mm)
- internal sprouting (scores of 1 (least), 2 and 3 (leaves reaching neck))
- firmness of bulb (two measurements per bulb with an Imada penetrometer, pressure (kg of force) when the top of the cone tip was level with the surface of the bulb)

Data were tabulated and graphed.

No strong trends were associated with the nitrogen treatments, but differences between cultivars were observed for several factors, though the data needs biometric analysis to determine which are statistically significant.

The number of skins and the proportion of intact skins were less on early onions than on main crop onions, while early onions had higher numbers of live thrips present (Table 6).

Table 6: Mean number of skins, intact skins and numbers of live thrips in four cultivars of onions after 5 months' storage.

Cultivar	Cropping time	Colour	Number of skins	No. intact skins	Proportion intact skins	Mean no. live thrips
Kiwigold	Early	Brown	3.52	0.19	0.05	0.11
Meteor	Early	Red	3.69	0.25	0.07	0.06
M&R Regular	Main	Brown	4.24	0.80	0.19	0.02
Red Star	Main	Red	4.14	0.44	0.11	0.03

Difference between red and brown cultivars were associated with thrips damage and firmness of the bulbs. Red onions had more thrips damage to the innermost skin than brown onions (Table 7). There were only very slight indications that the outer fleshy scale was more heavily damaged by thrips in red onions than brown onion. However, red onions were much softer than brown onions and a higher proportion of red onions than brown onions had external sprouts (Table 7).

Table 7: Thrips damage to innermost skin and onion firmness after 5 months' storage.

Cultivar	Cropping time	Colour	Proportion of innermost skin with thrips damage	Proportion of innermost skins damaged	Proportion of area of damaged innermost skins with damage	Onion firmness (kg of force)	Proportion of bulbs with external sprouts
Kiwigold	Early	Brown	0.06	0.55	0.11	56.7	0.06
M&R Regular	Main	Brown	0.07	0.45	0.14	56.4	0.01
Meteor	Early	Red	0.24	0.71	0.35	35.2	0.99
Red Star	Main	Red	0.34	0.82	0.42	42.2	0.63

Red onions were selected for the nitrogen trial because it was believed that they were more susceptible to onion thrips. However, the bioassays of bulbs showed that the bulbs of red onions were more resistant to onion thrips than the bulbs of brown onions (Section 5.4). The observations on bulbs after 5 months' storage show that the two red onion cultivars had developed more signs of thrips feeding damage to the innermost skin than the brown onions. This damage explains why these two red cultivars were believed to be more susceptible than brown PLK-type onion bulbs. There appear to be two interlinked explanations for the greater thrips damage to the innermost skin of red onions. Firstly, as the outermost fleshy scale shrinks and dries to become a skin, nutrients within the scale are mobilised. The changes in composition of the nutrients in the scale make it more attractive for thrips to feed and possibly lay eggs. Secondly, red onions were softer and appeared to shrink more than the brown onions. This shrinking may have opened gaps between the then innermost skin and the outermost fleshy scale. A gap between the skin and scale would allow thrips access to feed on the scale, which later became the innermost skin.

These results suggest that it would be useful to know if there are chemical differences between the outermost scale and the inner scales. In addition, if the shrinking outermost scale is more favourable for thrips feeding and breeding, this might provide an explanation for the variable susceptibility of PLK-type onions, especially those harvested early season and at different stages of maturity.

5.6 *Chemical analysis data*

Dr John McCallum (Crop & Food Research, Lincoln) conducted chemical analyses on Kiwigold and M&R Regular bulbs. The tests included chemicals involved with pungency, carbohydrates, total nitrogen and total sulfur. There were no effects of nitrogen treatments on pungency or total nitrogen. Bulbs of Kiwigold, but not M&R Regular, had a lower percentage of fructans with increasing nitrogen applications and higher percentage of sulfur per bulb dry weight with increased nitrogen.

6 *Conclusions and plans for 2004-05*

6.1 *Crop scouting*

The new protocol for testing crop scouting methods gave good data. It will be used on crops with low thrips numbers in 2004 with the assistance of Wilcox & Sons Ltd.

6.2 *Natural enemies*

Sampling of unsprayed onions again showed that natural enemies of onion thrips are rare in onion crops. Applications of the fungal pathogen, Verticillium lecanii, will be tested in 2004-05 if it is registered in time.

6.3 *Susceptibility of onion thrips to onion bulbs*

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