Further research into the source of thrips infestations in stored onion bulbs - 2005/06

Chhagan A, and Jamieson LE

September 2006

Research Report to New Zealand Onion Exporters Association
and MAF SFF
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Date:..27 September 2006	Date: 27 September 2006

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EXECUTIVE SUMMARY

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Research Report to New Zealand Onion Exporters Association and MAF SFF

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BACKGROUND

The following report details research investigating the source of thrips infestations in stored onion bulbs. This work follows on from previous studies, enhancing our knowledge of thrips populations in the field and storage. The current study was conducted in conjunction with a study investigating temperature development and damage rates of onion thrips. The results of that study have been reported separately (Jamieson and Chhagan 2006).

OBJECTIVES

- To monitor thrips populations in onions in the field and during storage
- To determine the average proportion of onion thrips on stored onions that originate from field sources.

METHODS

Thrips numbers before lifting were monitored in 12 commercial onion crops in the Pukekohe region. Based on the results of the pre-lift assessments, eight fields were selected to provide a range of thrips population levels. Onion samples were collected and assessed for thrips numbers, life stage and location on onion, every week until harvest and every fortnight for six weeks in storage. Storage samples consisted of both thrips-proof samples that were bagged following harvest, and thrips-accessible onions. Two methods (washing and dyeing) were also used to identify egg numbers at each sampling period.

KEY RESULTS

- Thrips numbers varied considerably before lifting, with thrips numbers ranging from one to 1014 per 50 plants.
- There was a significant decline in the number of thrips per 50 plants between pre-lift and harvest in six of the eight fields.
- The number of thrips on onions from early season crops increased between harvest and six weeks of storage. Alternatively, the number of thrips on onions in late season crops generally decreased between harvest and six weeks of storage.
- Two methods were used to determine the number of thrips eggs on onions during each sampling period. No eggs were found using the dyeing method. The washing method provided some success. However, the reliability of the method will need to be examined further.
- Higher numbers of thrips were found in thrips-accessible onions compared with thrips-proof onions at seven of the eight sites.

- The increase in thrips populations during storage seem to be the result of both field infestation reproducing in storage and immigration of thrips adults into stored bulbs from other sources.
- It was estimated that approximately 42% and 57% of thrips found in early and late season stored bulbs respectively probably "invaded" the onions during storage. This is compared with 58% and 43% of thrips in early and late season stored bulbs respectively, which were likely to be the result of reproducing field infestations.
- A mathematical model was developed in the 2004/5 season to predict the number of thrips on thrips accessible onions as a function of the number of thrips found on onions in thrips-proof bags (independent of season). The model was applied to this season's data and was found to be a good predictor of thrips numbers in early season stored bulbs.
- Before lifting, the majority of thrips were in the larval stage. Most thrips found during storage were adults. This suggests that thrips populations are "ageing" in storage. Although thrips are reproducing in storage, reproduction is below optimum.
- There was no statistically significant relationship between the numbers of thrips from field and storage samples.

RECOMMENDATIONS AND FUTURE RESEARCH PRIORITIES

- It has been shown many times that the number of thrips on onions from early season crops generally increases between curing and six weeks of storage, and alternatively the number of thrips on onions in late season crops generally decreases between curing and six weeks of storage. Therefore, future research on onion thrips in storage should focus on early season crops.
- Growers should be vigilant in minimizing the number of thrips on early season crops before top fall, to minimize the number of thrips on stored onions.
- Operators of storage facilities should be aware that thrips can "invade" lines of onions presumably from other heavily infested lines within storage or from external sources.
- We recommend investigation of the temperature flight thresholds of the summer and winter form of onion thrips in New Zealand.

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INTRODUCTION

Onions are one of New Zealand's most significant horticultural export crops. More than 80% of New Zealand onions are exported worldwide, with Europe being the major market for the produce. However, a high incidence of onion thrips (*Thrips tabaci*) in onion consignments arriving in Europe has caused major concerns for exporters in recent years. Onion thrips feed on the surface of onion bulbs causing blemishes, shrivelling, and skin separation. Consignments containing thrips not only lower the market value of the onions, but also infringe quarantine regulations of importing countries. As a result, a number of research projects were initiated to determine the factors contributing to thrips infestations in storage.

Initial work focused on monitoring onion thrips numbers in the field and in storage and identifying field-handling practices that might contribute to a high incidence of thrips in stored onions. Results indicated that key factors included topping methods and length, curing time, the time of season when onions were harvested, and storage temperature conditions (Chhagan and Jamieson 2003; Jamieson et al. 2001, 2002). As these factors did not entirely explain why some lines with low thrips pre-harvest still suffered significant damage during storage, further research was required. Chhagan and Jamieson (2005) further investigated thrips numbers in storage and examined whether the source of onion thrips infestations in stored onions were entirely from field populations. The study suggested that there are factors other than field infestations contributing to thrips populations in stored onions.

This project aimed to scrutinize further the source of onion thrips in stored onions by additional and intensive sampling at crucial periods between lifting, harvest and storage. The study will also assist in the interpretation and verification of past results.

The objectives of the commercial trial in 2005-06 were:

- To monitor thrips populations in onions in the field and in storage
- To determine the average proportion of onion thrips on stored onions that originate from field sources.

MATERIALS AND METHODS

The study was conducted on 12 commercial onion crops in the Pukekohe region. Fields were selected to provide a range of crop maturity times (i.e. a range of lifting and harvest dates). The crops and their respective sampling dates are shown in Table 1.

MONITORING THRIPS NUMBERS IN THE FIELD AND IN STORAGE

The pre-lift assessment was carried out in the field whereby 10 random samples of 10 onions (100 onions total) from each field were assessed for the presence of thrips. Each onion was assessed by counting the number of thrips present in the neck region and on the leaves of the plant. The life stage of any thrips found was also recorded.

Based on the results of the pre-lift assessments, eight fields were selected to provide a range of thrips population levels. Ten samples of 10 onion bulbs (100 onions total) were collected weekly between lifting and harvest from each of these fields. Each sample of 10 onions was placed in insect-proof bags and taken back to the laboratory for assessment. Each onion was dissected and examined under magnification for thrips numbers (live and dead), life stage (larva, pupa, adult) and location on the onion (neck, bulb, leaves).

All bags of onions were stored at HortResearch (Mt Albert Research Centre) at 12°C, until assessed.

MONITORING THRIPS EGGS IN THE FIELD AND IN STORAGE

At each sampling time, a further 10 samples of five onions (50 onions total) were collected from each field to assess the number of eggs present. Two different methods were used: dyeing and washing.

Dyeing method

Twenty five onions were prepared by chopping off the top half of the onion. The first three scales were removed and gently washed with tap water. The scales were placed into a plastic container and covered with staining solution (0.2% Acid fuchsion in 95% Ethanol and Glacial acetic acid). After 24 hours, the staining solution was drained from the container and replaced with clearing solution (Distilled water, 99% Glycerine, 85% Lactic acid). The onion scales were removed from the solution and examined under a microscope for presence of eggs.

Washing method

Twenty five onions were prepared by chopping off the top half of the onion. The first three scales were removed and gently washed with tap water. The scales were placed in a plastic container for a week then examined under a microscope for presence of newly emerged larvae to provide an indication of thrips egg numbers.

SOURCE OF THRIPS INFESTATIONS IN STORAGE

At harvest, onions were collected from bins in storage. Ten onions were collected from each of 10 bins and placed in insect-proof bags (thrips-proof samples: 10 replicates). Each bag was labelled and left in the top of the bin for approximately six weeks. Ten onions from 10 bins were also collected and assessed at harvest and after two and four weeks in storage. Once the six-week period had lapsed, the thrips-proof samples were collected from the bins in storage. A further sample of 10 onions was also collected from each bin at this point (thrips-accessible

samples: 10 replicates). Each onion collected was dissected and the number of thrips larvae, pupae, adults and eggs assessed as described above.

TEMPERATURE MONITORING

At harvest, Tiny Talk® temperature loggers were placed within a bagged sample in one of the bins in each of the storage sheds.

STATISTICAL ANALYSES

The mean number of thrips per 50 onions from each field at each sampling time was calculated using the computer programme Excel (Microsoft® Excel 2000). Analysis of variance (ANOVA, R Development Core Team) was used to compare the numbers of thrips for each sampling time in each field. Regression analyses were also conducted using Excel.

Table 1: Location and sampling dates of each experimental field in onion thrips storage trial, 2005-06.

Field	Season category	Location	Pre-lift	Post-lift	7 days after lift	14 days after lift	Harvest	2 weeks of storage	4 weeks of storage	6 weeks of storage (Thrips-proof)	6 weeks of storage (Thrips-accessible)
1	Early	Pukeoware	10.1.06	16.1.06	23.1.06	31.1.06	15.2.06	1.3.06	23.3.06	29.3.06	29.3.06
2	Early	Pukekawa	23.1.06	31.1.06	7.2.06	13.2.06	1.3.06	15.3.06	29.3.06	12.4.06	12.4.06
3	Early	Waiuku	23.1.06	-	-	-	-	-	-	-	-
4	Early	Onewhero	17.1.06	19.1.06	23.1.06	31.1.06	15.2.06	1.3.06	15.3.06	12.4.06	12.4.06
5	Early	Papakura	10.1.06	12.1.06	16.2.06	23.2.06	15.2.06	1.3.06	15.3.06	12.4.06	12.4.06
6	Early	Tuakau	10.1.06	-	-	-	-	-	-	-	-
7	Late	Puni	21.2.06	1.3.06	7.3.06	15.3.06	12.4.06	26.4.06	10.5.06	19.5.06	19.5.06
8	Late	Patumahoe	13.2.06	15.2.06	21.2.06	1.3.06	15.3.06	29.3.06	12.4.06	26.4.06	26.4.06
9	Late	Ngapuke	13.2.06	-	-	-	-	-	-	-	-
10	Late	Pukekawa	13.2.06	-	-	-	-	-	-	-	-
11	Late	Pukekawa	13.2.06	15.2.06	21.2.06	27.2.06	15.3.06	29.3.06	12.4.06	26.4.06	26.4.06
12	Late	Tuakau	13.2.06	15.2.06	21.2.06	27.2.06	15.3.06	29.3.06	12.4.06	26.4.06	26.4.06

RESULTS AND DISCUSSION

The number of thrips found varied both within and between crops. Although both live and dead thrips were found, only live thrips data are presented here.

MONITORING THRIPS NUMBERS IN THE FIELD AND IN STORAGE

The mean number of thrips found per 50 plants from each field at various sampling periods is shown in Table 2 and Figures 1 & 2.

Numbers of thrips varied considerably before lifting, with the number of thrips per 50 plants ranging from 1 to 1014. There was a significant decline in the number of thrips per 50 plants between pre-lift and harvest in six of the eight fields. The number of thrips on onions from early season crops increased between harvest and six weeks of storage (Figure 1). However, this difference was significant in only three of the four fields (Table 2). Alternatively, the number of thrips on onions in late season crops generally decreased between harvest and six weeks of storage (Figure 2). This is consistent with the results found in past studies (Chhagan and Jamieson 2005, Jamieson et al. 2002). Temperature is likely to be one of the key factors influencing the difference in thrips numbers between early and late season crops. As with past surveys, the shed temperatures recorded this season revealed that early season crops experience a higher temperature regime during the storage period than those in late season crops (Figure 3). This higher temperature regime would facilitate an accelerated thrips development rate and ultimately result in higher thrips numbers. Alternatively the lower storage temperatures experienced by late season crops have the potential not only to reduce the development of thrips already on onions, but also to minimize any flight activity of thrips in storage. Overseas it is reported that thrips do not fly when temperatures are below 26.5^{o}C (Waterhouse and Norris 1989; CABI 2001); however, the flight temperature threshold of onion thrips in New Zealand is unknown.

LIFE STAGES OF THRIPS AT DIFFERENT SAMPLING TIMES

The percentage of thrips of each life stage at each sampling period is shown in Figure 4. Before lifting, the majority of thrips were in the larval stage. Most thrips found during storage were adults. This is consistent with results from past studies (Chhagan and Jamieson 2003, 2005; Jamieson et al. 2001, 2002) and indicates that thrips are not reproducing well on onion bulbs in storage. It could also indicate that adults are "invading" the stored onions.

MONITORING THRIPS EGGS IN THE FIELD AND IN STORAGE

Two methods were also used to determine the number of thrips eggs on onions during each sampling period. Unfortunately, no eggs were found using the dyeing method. The numbers of thrips larvae found (as an indication of eggs using the "washing method") per 50 onions from each field at each sampling time are presented in Table 3 and Figures 5 & 6. Egg numbers before lifting varied between 0 and 18 per 50 onions. For early onions numbers generally declined after lifting and varied at harvest and in storage (Figure 5). There were fewer eggs on late season onions and data were too variable to describe any trends (Figure 6). However, it can be concluded that eggs are being laid on onions throughout the curing process. Because of the variability in numbers of thrips found using the washing method, larger samples will be needed for any future work examining eggs on bulbs.

SOURCE OF THRIPS INFESTATIONS IN STORAGE

Higher numbers of thrips were found in thrips-accessible onions compared with on thrips-proof onions from all of the early season sites (Figure 7), and three of the four late season sites (Figure 8). However, t-tests revealed that these differences were not significantly different ($P > 0.05$). The increases in thrips populations during storage seem to be the result of both field infestation reproducing in storage and immigration of thrips adults into stored bulbs from other sources. It was estimated that approximately 42% and 57% of thrips found in early and late season stored bulbs respectively probably "invaded" the onions during storage. This is compared with 58% and 43% of thrips in early and late season stored bulbs respectively, which were likely to be the result of reproducing field infestations.

In the 2004/05 season, a mathematical model was developed to predict the number of thrips on thrips accessible onions as a function of the number of thrips found on onions in thrips-proof bags (independent of season) (Chhagan and Jamieson 2005). The model is presented below:

No. of thrips on thrips-accessible onions
= 8.05 + 1.36 * no. of thrips in thrips-proof bags
($F = 33.45$; df = 1, 13; $P < 0.001$)

The robustness of the model was tested with the data gathered this season. The actual number of thrips on thrips-accessible onions was compared with the number predicted (Table 2). The model was found to be a good predictor of thrips numbers in early season stored bulbs.

CORRELATION BETWEEN FIELD AND STORAGE POPULATIONS

Regression analyses were conducted on the relationship between the total number of thrips at all of the sampling periods before storage and the total number of thrips following 42 d storage (thrips-proof). There was no significant linear relationship between these two values on any of the sampling periods.

Table 2: Mean number of thrips per 50 onions (± SE) from each field at each sampling time and results of ANOVA tests, 2005-06.

Field	Season Category	Topping method	Pre-lift	Post-lift	7 days after lift	14 days after lift	Harvest	2 weeks of storage	4 weeks of storage	6 weeks of storage (Thrips-proof)	6 weeks of storage (Thrips-accessible)
1	Early	MT	358.5a (± 55.6)	415.0a (± 91.6)	75.5bf (± 10.9)	34.0ce (± 14.6)	1.0d (± 0.7)	7.5c (± 3.5)	45.0e (± 15.6)	51.5ef (± 27.0)	74.0f (± 27.0) *(78.1)*
2	Early	MT	100.5a (± 46.6)	7.0bc (± 3.5)	4.0bc (± 4.0)	6.0bc (± 3.4)	9.5bc (± 5.8)	1.5b (± 1.5)	2.5bc (± 2.0)	4.0bc (± 2.0)	12.5c (± 7.1) *(13.49)*
3	Early	MT	109.0 (± 30.2)	-	-	-	-	-	-	-	-
4	Early	HC	0.5a (± 0.5)	4.5ab (± 4.0)	9.0bc (± 3.5)	11.0bc (± 3.9)	22.0bc (± 7.4)	27.0bcd (± 16.7)	32.5bcd (± 14.7)	43.0cd (± 14.7)	62.5d (± 17.4) *(66.53)*
5	Early	HC	29.5a (± 11.8)	8.0a (± 3.9)	10.0a (± 4.4)	17.0a (± 5.6)	29.0a (± 5.3)	40.5ab (± 15.6)	72.5ab (± 19.0)	45.0ab (± 11.1)	75.5b (± 15.9) *(69.25)*
6	Early	MT	2.0 (± 1.1)	-	-	-	-	-	-	-	-

Field	Season category	Topping method	Pre-lift	Post-lift	7 days after lift	14 days after lift	Harvest	2 weeks of storage	4 weeks of storage	6 weeks of storage (Thrips-proof)	6 weeks of storage (Thrips-accessible)
7	Late	MT	26.0a (± 6.8)	4.0b (± 2.6)	5.5b (± 3.7)	3.0b (± 2.0)	0.0b (± 0.0)	1.0b (± 0.7)	6.5b (± 6.0)	3.0b (± 1.7)	5.5b (± 2.4) *(12.13)*
8	Late	HC	1013.5a (± 101.6)	1.5b (± 1.1)	1.0b (± 0.7)	1.5b (± 1.5)	4.0b (± 2.1)	3.0b (± 2.5)	10.5b (± 6.3)	2.0b (± 1.1)	1.0b (± 0.7) *(10.77)*
9	Late	MT	5.0 (± 1.1)	-	-	-	-	-	-	-	-
10	Late	MT	53.5 (± 27.3)	-	-	-	-	-	-	-	-
11	Late	HC	5.5ab (± 1.9)	2.0a (± 1.1)	2.5a (± 1.3)	7.5ab (± 2.3)	13.5b (± 3.3)	15.0b (± 3.9)	11.5ab (± 4.5)	2.5a (± 1.5)	5.0a (± 2.5) *(11.45)*
12	Late	MT	170.0a (± 33.1)	5.0b (± 1.7)	11.0b (± 5.9)	6.0b (± 3.0)	3.5b (± 1.7)	10.5b (± 4.2)	3.0b (± 1.3)	0.5b (± 0.5)	2.0b (± 2.0) *(8.73)*

Xabc Values within a row followed by the same letter are not significantly different (P>0.05)

(x) Number of thrips predicted using the mathematical model

MT Machine topped; HC Handclipped

Table 3: Number of thrips larvae (as an indication of eggs using the "washing method") per 50 onions (± SE) from each field at each sampling time and results of ANOVA tests, 2005-06.

Field	Season category	Topping method	Pre-lift	Post-lift	7 days after lift	14 days after lift	Harvest	2 weeks of storage	4 weeks of storage	6 weeks of storage (Thrips-proof)	6 weeks of storage (Thrips-accessible)
1	Early	MT	18.0a (± 0.3)	12.0a (± 0.3)	6.0a (± 0.2)	8.0a (± 0.1)	0.0b (± 0.0)	2.0a (± 0.1)	14.0a (± 0.2)	14.0a (± 0.2)	24.0a (± 0.5)
2	Early	MT	6.0a (± 0.2)	0.0a (± 0.0)	0.0a (± 0.0)	0.0a (± 0.0)	0.0a (± 0.2)	0.0a (± 0.0)	0.0a (± 0.0)	0.0a (± 0.0)	4.0a (± 0.2)
4	Early	HC	4.0ab (± 0.1)	0.0a (± 0.0)	2.0ab (± 0.1)	0.0a (± 0.1)	10.0b (± 0.2)	16.0b (± 0.3)	8.0ab (± 0.1)	10.0b (± 0.2)	6.0ab (± 0.2)
5	Early	HC	0.0a (± 0.0)	0.0a (± 0.0)	0.0a (± 0.0)	2.0ab (± 0.0)	12.0bc (± 0.2)	18.0c (± 0.3)	12.0bc (± 0.2)	6.0abc (± 0.5)	30.0c (± 0.5)
7	Late	MT	0.0a (± 0.0)	0.0a (± 0.0)	0.0a (± 0.0)	0.0a (± 0.0)	0.0a (± 0.0)	0.0a (± 0.0)	0.0a (± 0.0)	2.0a (± 0.1)	2.0a (± 0.1)
8	Late	HC	6.0a (± 0.2)	0.0a (± 0.0)	0.0a (± 0.0)	0.0a (± 0.0)	0.0a (± 0.0)	0.0a (± 0.0)	0.0a (± 0.0)	0.0a (± 0.0)	0.0a (± 0.0)
11	Late	HC	0.0a (± 0.0)	0.0a (± 0.0)	0.0a (± 0.0)	0.0a (± 0.0)	4.0a (± 0.1)	8.0a (± 0.1)	2.0a (± 0.1)	0.0a (± 0.0)	0.0a (± 0.0)
12	Late	MT	2.0a (± 0.1)	0.0a (± 0.0)	2.0a (± 0.1)	0.0a (± 0.0)	0.0a (± 0.0)	2.0a (± 0.1)	0.0a (± 0.0)	0.0a (± 0.0)	0.0a (± 0.0)

Values within a row followed by the same letter are not significantly different (P>0.05)

MT Machine topped; HC Handclipped

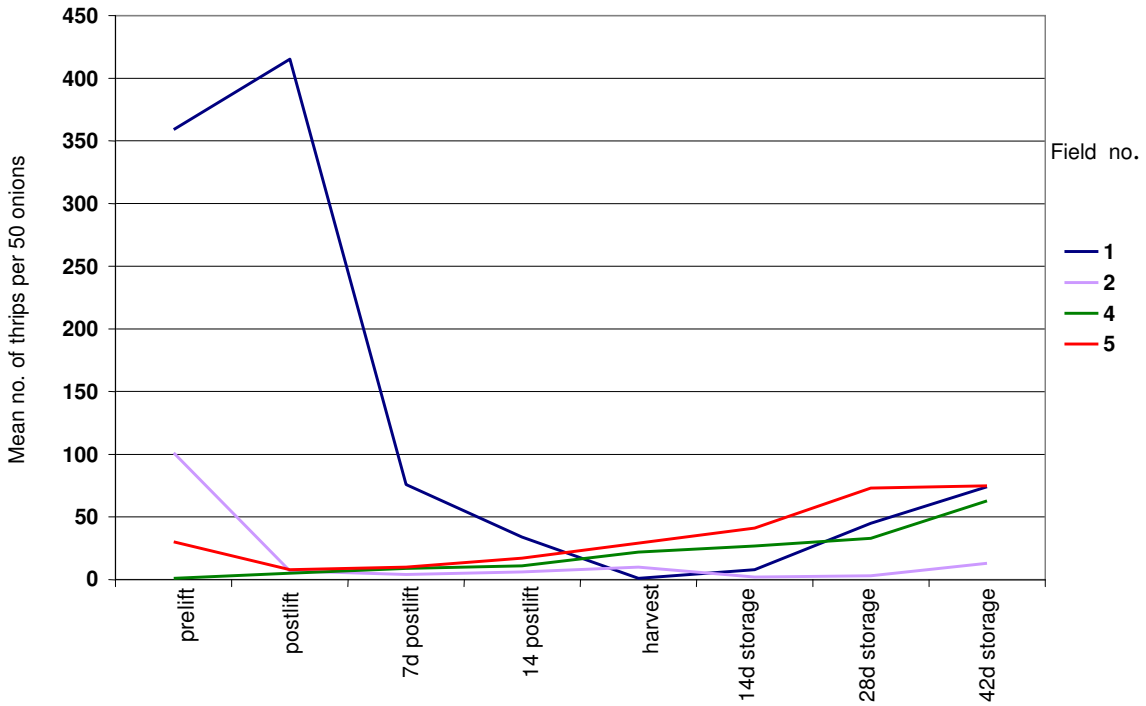

Figure 1: Mean number of thrips per 50 onions from each early season field at various sampling times, 2005-06.

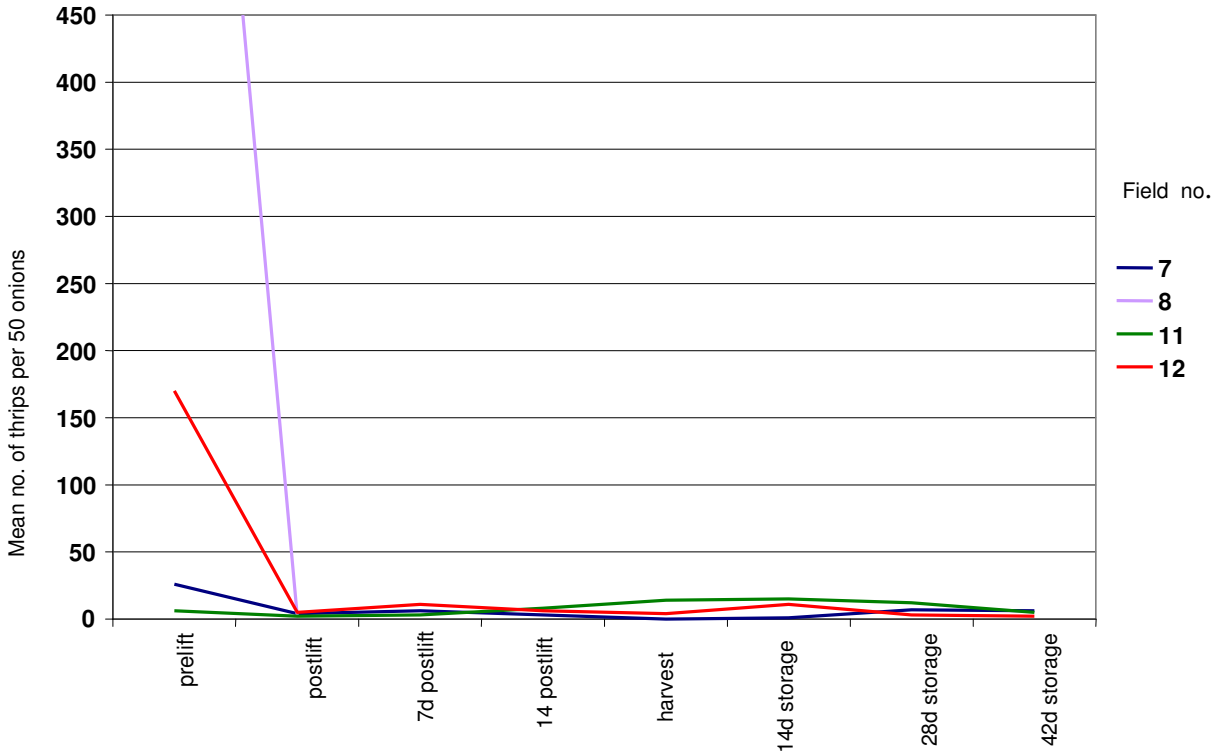

Figure 2: Mean number of thrips per 50 onions from each late season field at various sampling times, 2005-06.

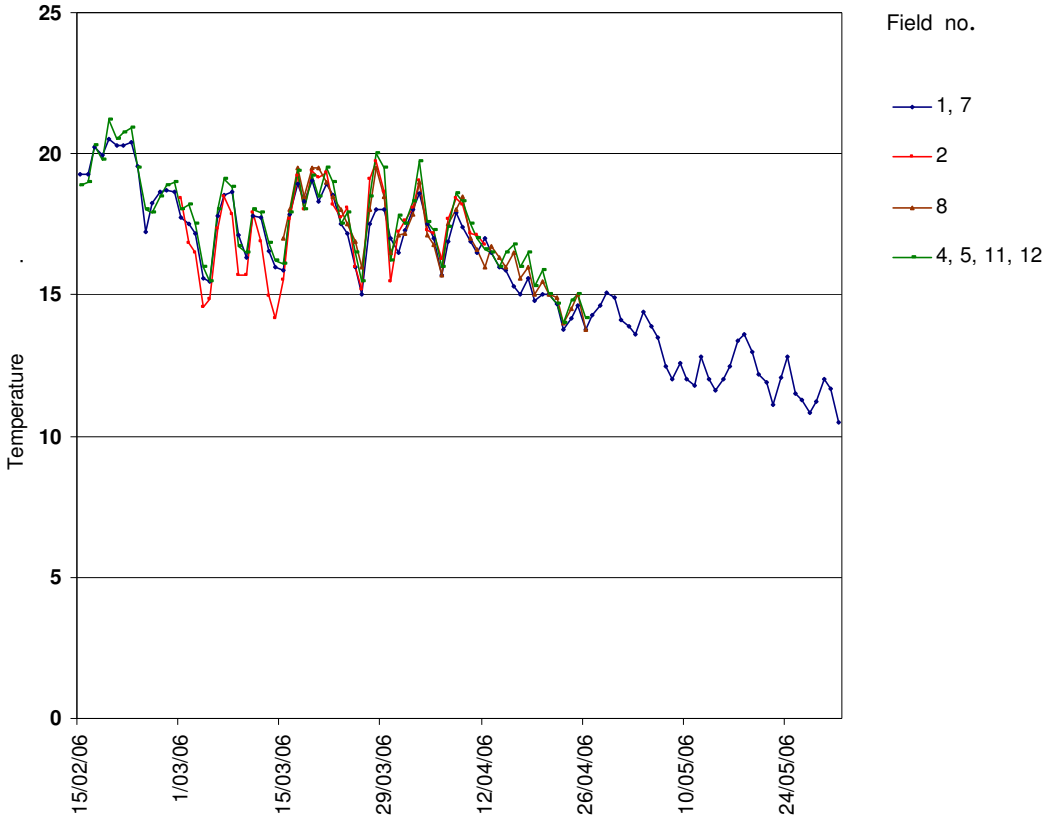

Figure 3: The average daily temperature in onion storage facilities in Pukekohe during the 2005-06 season.

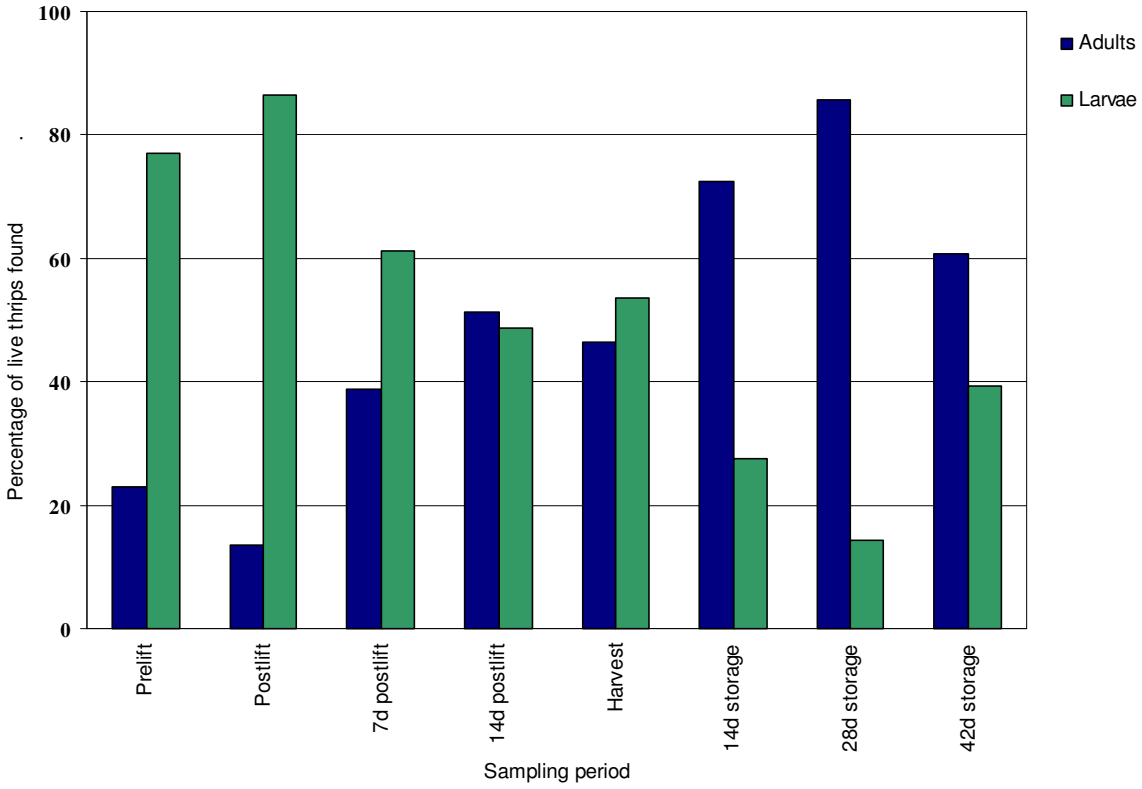

Figure 4: Percentage of thrips of each life stage on onions at each sampling period, 2005-06.

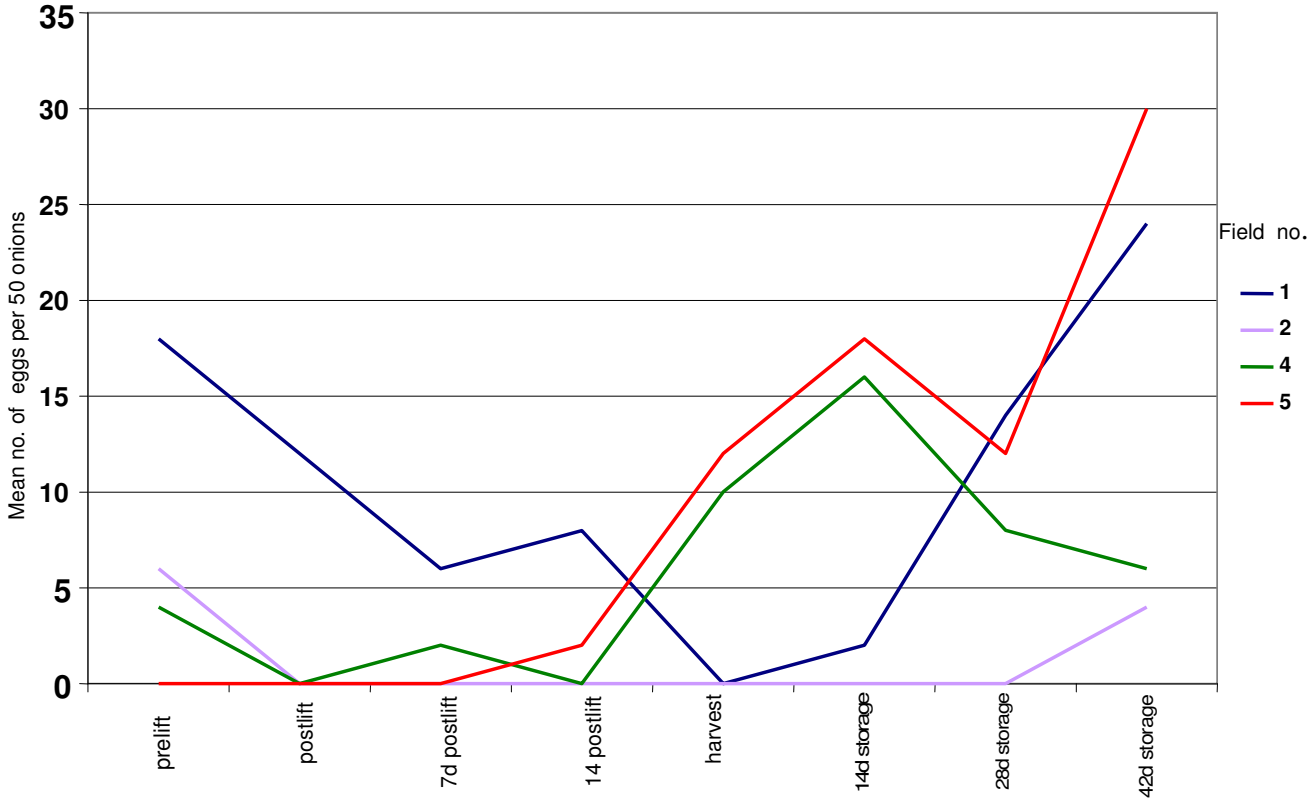

Figure 5: Mean number of thrips larvae (as an indication of eggs using the "washing method") per 50 onions from each early season field at various sampling times, 2005-06.

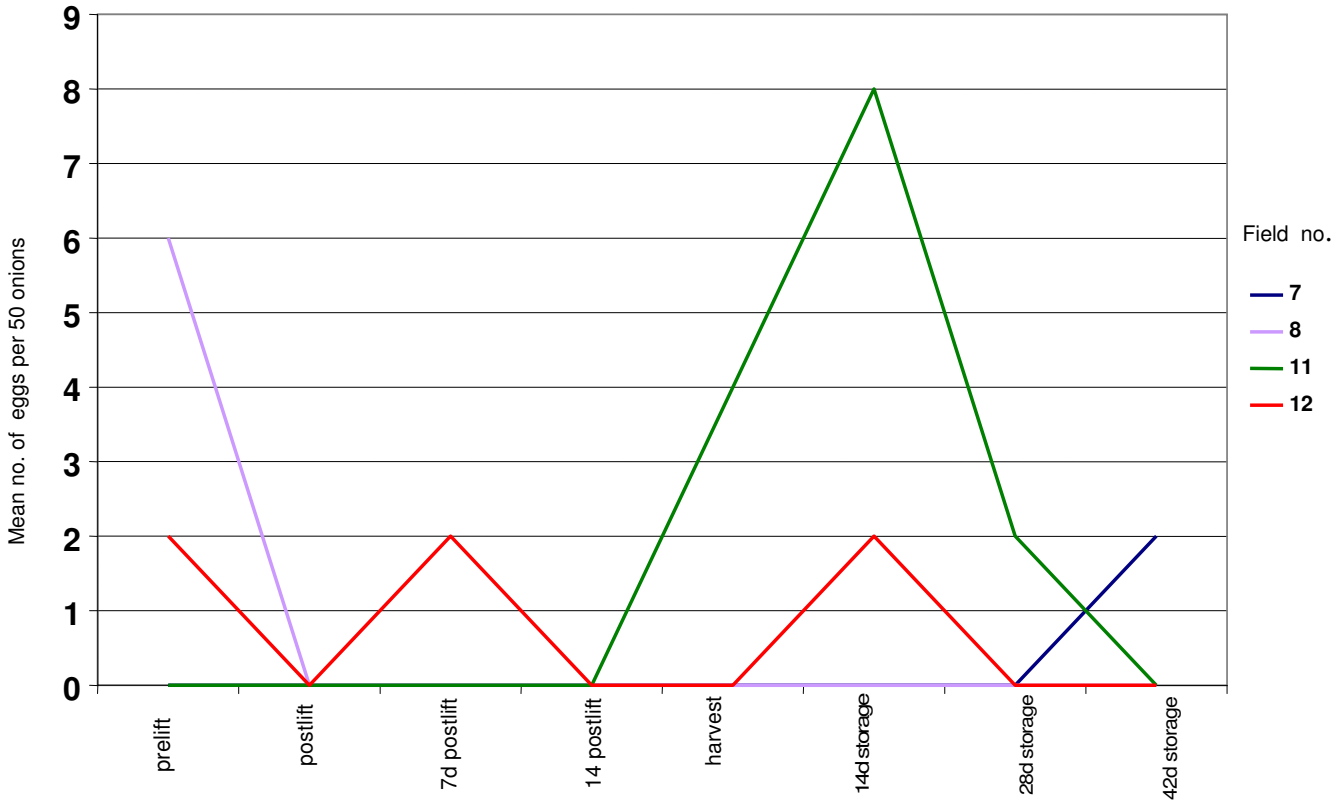

Figure 6: Mean number of thrips larvae (as an indication of eggs using the "washing method") per 50 onions from each late season field at various sampling times, 2005-06.

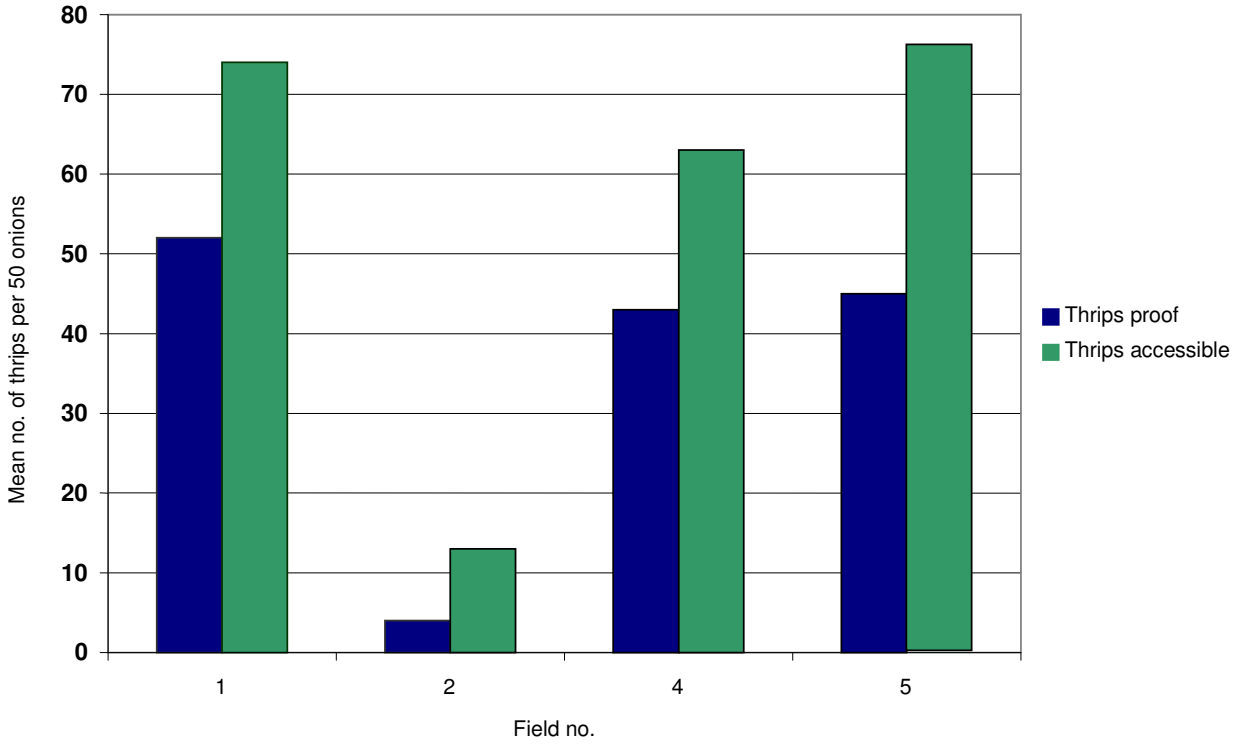

Figure 7: Mean number of thrips per 50 onions on early season onions stored for six weeks in thrips-proof bags or on exposed onions that thrips could access, 2005-06.

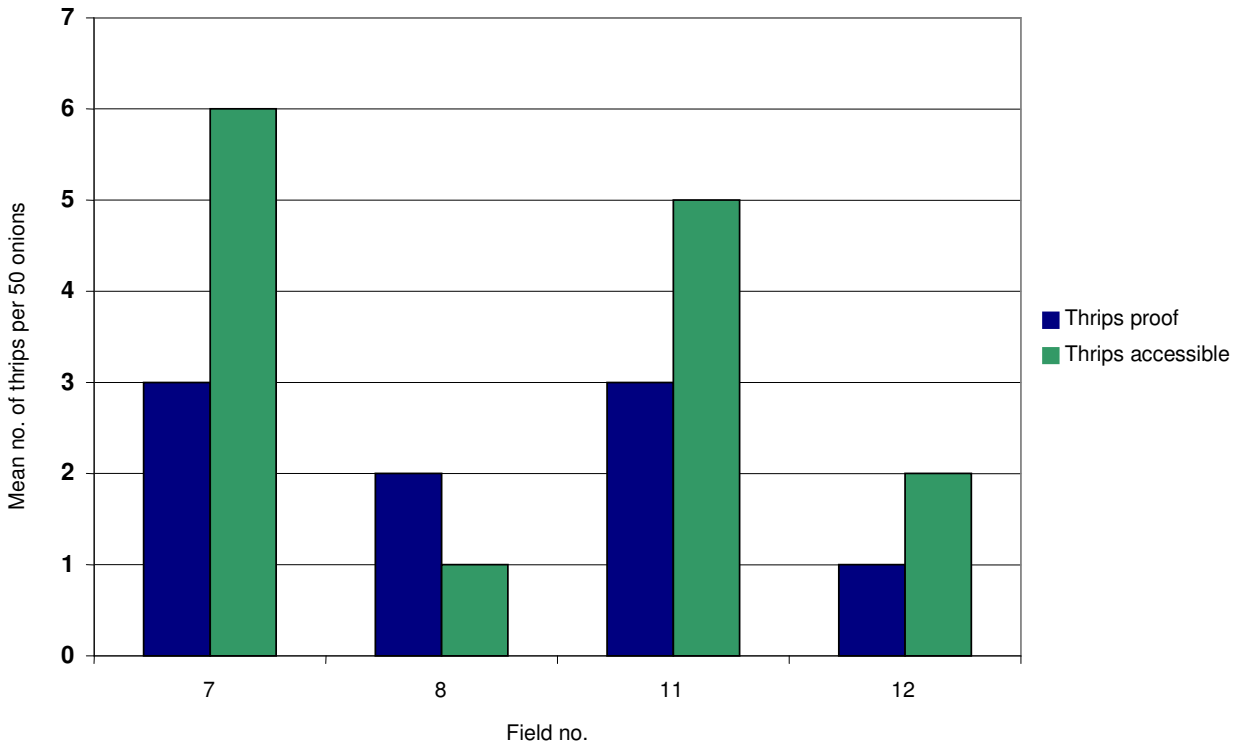

Figure 8: Mean number of thrips per 50 onions on late season onions stored for six weeks in thrips-proof bags or on exposed onions that thrips could access, 2005-06.

CONCLUSIONS

- Thrips numbers varied considerably before lifting, with thrips numbers ranging from one to 1014 per 50 plants.
- There was a significant decline in the number of thrips per 50 plants between pre-lift and harvest in six of the eight fields.
- The number of thrips on onions from early season crops increased between harvest and six weeks of storage. Alternatively, the number of thrips on onions in late season crops generally decreased between harvest and six weeks of storage.
- Two methods were used to determine the number of thrips eggs on onions during each sampling period. No eggs were found using the dyeing method. The washing method provided some success however the reliability of the method will need to be examined further.
- Higher numbers of thrips were found in thrips-accessible onions compared with thrips-proof onions at seven of the eight sites.
- The increase in thrips populations during storage seem to be the result of both field infestation reproducing in storage and immigration of thrips adults into stored bulbs from other sources.
- It was estimated that approximately 42% and 57% of thrips found in early and late season stored bulbs respectively probably "invaded" the onions during storage. This is compared with 58% and 43% of thrips in early and late season stored bulbs respectively, which were likely to be the result of reproducing field infestations.
- A mathematical model was developed in the 2004/5 season to predict the number of thrips on thrips accessible onions as a function of the number of thrips found on onions in thrips-proof bags (independent of season). The model was applied to this season's data and was found to be a good predictor of thrips numbers in early season stored bulbs.
- Before lifting, the majority of thrips were in the larval stage. Most thrips found during storage were adults. This suggests that thrips populations are "ageing" in storage. Although thrips are reproducing in storage, reproduction is below optimum.
- There was no statistically significant relationship between the numbers of thrips from field and storage samples.

RECOMMENDATIONS

- It has been shown many times that the number of thrips on onions from early season crops generally increases between curing and six weeks of storage, and alternatively the number of thrips on onions in late season crops generally decreases between curing and six weeks of storage. Therefore, future research on onion thrips in storage should focus on early season crops.
- Growers should be vigilant in minimizing the number of thrips on early season crops before top fall, to minimize the number of thrips on stored onions.
- Operators of storage facilities should be aware that thrips can "invade" lines of onions presumably from other heavily infested lines within storage or from external sources.
- We recommend investigation of the temperature flight thresholds of the summer and winter form of onion thrips in New Zealand.

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