1999. Revista Chapingo Serie Horticultura 5: 297-300.

EFFECTS OF GREENHOUSE THRIPS (*Heliothrips haemorrhoidalis*) LIFE-STAGE, DENSITY AND FEEDING DURATION ON DAMAGE TO AVOCADO FRUIT

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SUMMARY

Greenhouse thrips (*Heliothrips haemorrhoidalis* Bouché) are an important pest of avocados in New Zealand. The presence of thrips colonies on fruit results in feeding damage which appears as a superficial 'bronze' scar. Any thrips damage covering an area greater than 2 cm^2 will result in fruit being rejected from premium export grade. As part of the development of an Integrated Pest Management system for avocados in New Zealand, a monitoring system and spray threshold is being developed for greenhouse thrips. A requirement of a useful monitoring system for greenhouse thrips in avocados is the ability to predict the accumulation of damage over time. The prediction of damage is necessary as there can be a need to delay sprays to ensure that harvesting of mature fruit is not disrupted by the need to observe withholding periods following the application of sprays which aim to protect immature fruit. Experiments were carried out to evaluate the effects of thrips developmental stage and thrips density per fruit on the severity of greenhouse thrips damage. Known numbers of thrips were artificially inoculated and contained on individual fruit using net bags and the resulting area of thrips damage was measured. Fruit infested with 20 adult greenhouse thrips for 2 weeks had significantly more damage than fruit infested with 20 larval thrips (P<0.05) (mean damage thrips-week for adults and larvae was 0.22 and 0.04 cm^2 respectively). There were significant linear relationships (P<0.05) between increasing density of adult thrips (1, 5, 10 and 20 thrips per fruit) and the area of fruit damaged after 1, 2 and 4 weeks feeding. These results suggest that a thrips monitoring system should distinguish between adult and larval thrips. There is also potential to predict the accumulation of feeding damage over time for any given thrips population level.

KEY WORDS: Damage-prediction, monitoring, Integrated Pest Management

INTRODUCTION

Greenhouse thrips (*Heliothrips haemorrhoidalis* Bouché) (Thysanoptera: Thripidae) are an important pest of avocados in New Zealand. Greenhouse thrips can also be a pest of avocados in Israel (Wysoki *et al.*, 1997), South Africa (Dennill and Erasmus, 1992a) and California (McMurtry *et al.*, 1991). Larval and adult greenhouse thrips cause feeding injury by piercing and sucking out the contents of cells, causing collapse of the cell wall and discolouration of the surface of the fruit or leaf. Greenhouse thrips live in all-female, mixed-aged aggregations, which expand their feeding area out from an initial feeding point, leaving an ever-increasing area of discolouration. More than 40 types of plants in New Zealand are hosts for greenhouse thrips and feeding damage is often described as ‘silvering’ (Spiller and Wise, 1982). However, on avocado fruit the damage is more accurately described as ‘bronzing’. While minor greenhouse thrips damage can be tolerated, any damage covering an area of more than 2 cm^2 will result in the fruit being unacceptable for premium export grade.

Greenhouse thrips in New Zealand avocado crops are currently controlled using a calendar spray programme based on broad-spectrum insecticides. However, it is estimated that some growers still lose up to 20% of fruit from export grade because of severe greenhouse thrips damage. In order to improve the levels of pest control and to reduce the use of broad-spectrum insecticides, research is underway to develop an Integrated Pest Management (IPM) programme for avocados in New Zealand. A key component of the IPM programme will be a monitoring system and spray threshold specifically designed for greenhouse thrips.

Most greenhouse thrips damage to Hass avocados in New Zealand occurs between January and June when fruit are between two and seven months old (Stevens, unpublished data). The timing of insecticide applications necessary to prevent greenhouse thrips damage to new season’s fruit potentially falls into the period of crop overlap, when previous season’s fruit are still being harvested. The application of insecticides can therefore result in a delay in picking of mature fruit due to withholding period requirements. It would be useful to have a greenhouse thrips monitoring system that would allow the accumulation of damage to be predicted over time, to determine the consequences of delaying sprays if it is important for picking not to be disrupted.

A potential thrips monitoring system for avocados in South Africa was described by Dennill and Erasmus (1992b). They found that greenhouse thrips were predominantly located in areas of contact between touching avocado fruit, rather than in association with single fruit. They described a thrips monitoring system based on assessing the percentage of damaged or infested fruit in a sample of both single and touching fruit, and then calculating the overall damage/infestation for the whole block by estimating the total proportions of single versus touching fruit in an orchard. However, no spray threshold was suggested and there was no suggestion of how many thrips could be tolerated before economic damage occurred. The thrips monitoring system did not distinguish between fruit with thrips damage and the numbers of fruit infested with live thrips, so the damage-causing potential for any given thrips population level could not be estimated.

Phillips (1997) introduced the concept of “thrips-weeks” to describe the relationship between thrips density and duration of feeding on the severity of damage. It was estimated that 25 thrips-weeks (any combination of thrips density x number of weeks feeding which equates to 25) would result in a ¾ inch scar to avocado fruit. The thrips-weeks concept potentially allows the prediction of damage caused by a particular thrips population density over time.

The damage caused by larvae versus adult thrips was not distinguished in the thrips-weeks model. While severe, well-established infestations consist mainly of larval life-stages, early colonisation of fruit consists predominantly of adult thrips. This paper describes experiments comparing the effect of greenhouse thrips life-stage (adults versus larvae) and the effect of adult thrips density and duration of feeding on the level of fruit damage.

MATERIALS AND METHODS

All trials were carried out in a mature block of Hass avocado in Whangarei, Northland, New Zealand.

Experiment 1: Quantifying the damage caused by adults and larvae

Individual avocado fruit were artificially infested with either 20 1st instar or 20 adult greenhouse thrips on the 12th November 1998. Twenty replicates of each life stage were set up on fruit with no thrips or thrips damage. The thrips used in the trial were reared from a laboratory colony. Thrips were collected into glass vials (25 mm x 60 mm) containing a small piece of grape leaf as a temporary food source and then inoculated onto fruit within 24 hours. Each vial was taped upside down onto a fruit stem with the open end of the vial almost touching the top of the fruit. A net bag was tied around the fruit and vial before the lid of the vial was removed. The thrips were observed to move quickly from the dehydrated grape leaf onto the fruit. Fruit were collected after 14 days and the area of fruit damaged by thrips was measured (cm^2).

Experiment 2: The effects of adult thrips density and duration of feeding on severity of damage

Individual fruit were artificially inoculated with adult thrips using the methods described in experiment 1. However, fruit were infested with either 1, 5, 10, or 20 adult thrips. Thrips were left on the fruit for either 1, 2, or 4 weeks. Ten replicates of each density/duration combination were set up. This experiment was carried out on mature fruit (thrips placed out on 9.12.98) and on immature fruit (thrips placed out on 4.3.99).

Data analysis

Data were analysed using the statistics package SAS (SAS Institute Inc., 1985). The area of fruit damaged by larval or adult thrips was compared using a t-test. The areas of fruit damage resulting from the various thrips density/feeding duration combinations were converted into thrips-weeks and compared using analysis of variance. The lines of best fit for feeding duration versus damage were calculated using linear regression.

RESULTS AND DISCUSSION

Experiment 1: Quantifying the damage caused by adults and larvae

Adult thrips caused significantly more damage than larval thrips (Table 1). All fruit inoculated with adult thrips had greater than 2 cm^2 damage and would have been rejected from export grade. These results suggest that a greenhouse thrips monitoring system needs to distinguish between the presence of larval and adult thrips.

The Californian thrips-weeks model for mixed-aged thrips populations predicts approximately 0.14 cm^2 damage per thrips-week. If the amount of damage for adults and larvae obtained in these experiments is averaged, an accumulation of 0.13 cm^2 damage per thrips-week would be predicted for a 50:50 adult-larval colony.

Table 1. The area of avocado fruit with greenhouse thrips feeding damage 14 days after inoculation with 20 larval or 20 adult thrips (mean ± standard error).

Life stage	Area of damage/20 thrips/14 days (cm^2)	Area of fruit damaged per thrips-week (cm^2)	% reject fruit (damage >2cm^2)
Larvae	1.46 ± 0.21 a[z]	0.04 ± 0.01 a	20
Adults	8.97 ± 0.47 b	0.22 ± 0.01 b	100

[z]Figures within columns followed by the same letter are not significantly different (P>0.05, t-test).

Experiment 2: The effects of adult thrips density and duration of feeding on severity of damage

The area of fruit damage for each adult thrips density/duration combination was converted to thrips-weeks units (Table 2). The overall mean damage per adult thrips-week (± standard error) was 0.26 ± 0.01 cm^2, but individual means for each density/duration combination ranged from 0.1 to 0.5 cm^2 per thrips-week. There was a significant interaction between duration of feeding and thrips density on the damage per thrips-week in the December trial (P<0.05). There was no significant difference in thrips-weeks with increasing thrips density (P>0.05) but there were differences between feeding durations (P<0.05). There was no significant interaction between duration of feeding and thrips density on the damage per thrips-week in the March trial (P>0.05). There were significant differences in damage per thrips-week for the various thrips densities (P<0.05) and feeding durations (P<0.05) in March. However, the differences between treatments were not clearly related to increasing thrips density or feeding duration, and do not suggest that damage is strongly affected by 'interference' between thrips over time or space.

The significant differences in damage per thrips-weeks resulting from the different thrips density/duration combinations suggests that a prediction model could not reliably be based on a simple additive approach. However, calculations of the regression lines describing damage versus feeding duration may allow the development of a more accurate predictive model.

There were significant linear relationships between thrips density and feeding damage, for each feeding duration (P<0.05) (Table 3). The regression lines were able to account for much more of the variation in the data in the December trial than in the March trial, as indicated by the R^2 values.

Solving the regression lines for Y=2 cm^2 gives the adult thrips population density which would be expected to result in a reject fruit (Table 4). The three methods used to make predictions (i.e. regression lines calculated separately for the December and March trials, and values calculated from the overall mean damage per thrips-week obtained over all trials) have very similar results over 2-4 weeks feeding. However, there is a large difference in the thrips density predicted to result in 2 cm^2 damage over 1 week's feeding duration.

Table 2. The area of avocado fruit damaged (mean damage per thrips-week ± standard error) by greenhouse thrips feeding after inoculation with various densities of adult thrips after 1, 3, or 4 weeks feeding duration.

Thrips density/fruit	Damage per thrips-weeks (cm^2) Duration of feeding (weeks)		
	1	2	4
December			
1	0.2 ± 0.06	0.5 ± 0.03	0.3 ± 0.08
5	0.3 ± 0.04	0.3 ± 0.01	0.3± 0.03
10	0.2 ± 0.02	0.3 ± 0.02	0.2 ± 0.03
20	0.3 ± 0.03	0.3 ± 0.02	0.2 ± 0.01
March			
1	0.4 ± 0.10	0.4 ± 0.09	0.4 ± 0.06
5	0.1 ± 0.02	0.4 ± 0.07	0.3 ±0.06
10	0.1 ± 0.02	0.2 ± 0.05	0.2 ± 0.05
20	0.2 ± 0.02	0.3 ± 0.06	0.2 ± 0.06

Table 3. The areas of avocado fruit damaged, and regression lines of best fit for densities of 1, 5, 10 and 20 greenhouse thrips per fruit over 1, 2, and 4 weeks feeding duration.

Thrips density per fruit	Effect of feeding duration on area of fruit damaged (cm^2) (Mean ± standard error)		
	1 week	2 weeks	4 weeks
December			
1	0.2 ± 0.1	0.9 ± 0.1	1.1 ± 0.3
5	1.3 ± 0.2	2.1 ± 0.1	5.8 ± 0.6
10	1.8 ± 0.2	5.0 ± 0.4	9.5 ± 1.4
20	6.2 ± 0.5	10.9 ± 0.6	18.1 ± 0.5
Regression line	Y=-0.47+0.31x	Y=0.03+0.53x	Y=0.83+0.87x
R^2	0.84	0.93	0.90
March			
1	0.4 ± 0.1	0.7 ± 0.2	1.5 ± 0.3
5	0.3 ± 0.1	3.5 ± 0.7	5.3 ± 1.2
10	1.1 ± 0.2	4.7 ± 0.9	6.1 ± 2.1
20	3.6 ± 0.4	10.3 ± 2.4	15.2 ± 4.5
Regression line	Y=-0.25+0.18x	Y=0.41+0.49x	Y=0.84+0.69x
R^2	0.72	0.45	0.33

Table 4. Adult thrips density/fruit predicted to result in 2 cm^2 scarring on fruit.

Type of predictive model	Adult thrips density predicted to result in 2 cm^2 damage Duration of feeding (weeks) 1	2	4
Regression – December	8.0	3.7	1.3
Regression – March	12.5	3.2	1.7
Additive (0.26cm^2 thrips-week)	7.7	3.8	1.9

These results contribute to the development of a spray threshold for greenhouse thrips in avocados. However the thrips density predicted to result in reject fruit cannot be used as a spray threshold on its own, as the level of thrips feeding damage already present on the fruit and the time of year will also affect the spray threshold. The aim of the thrips monitoring system will be to only have a small proportion of the fruit with damage severe enough to cause rejection from export quality. Damage on most fruit must be less than 2 cm^2.

A key result from these experiments is the finding that larval thrips result in significantly less thrips damage to avocado fruit than adults. A useful decision model for managing greenhouse thrips therefore requires information on the mean area of current fruit damage, and the mean density of thrips/fruit (by life stage). The area of current damage could be added to the area of predicted damage over time to make spray decisions. The presence of larval thrips or low levels of adult thrips may permit insecticide applications to be delayed so that picking timetables are not disrupted. However, once picking is completed, lower spray thresholds may be used to reduce overall thrips population pressure in the orchard.

In the longer term, a reduced reliance on insecticides for control of greenhouse thrips is desirable. Control of greenhouse thrips in California (McMurtry *et al*., 1991) and Israel (Wysoki *et al.*, 1997) is based on biological control using the parasitoid *Thripobius semiluteus* but this parasitoid is not currently present in New Zealand. In California, greenhouse thrips are also controlled by the practice of selective early harvesting. On Hass avocados, greenhouse thrips are generally restricted to the fruit, so harvesting effectively removes the population and reduces the crop overlap period. Research in California has shown that early harvesting of thrips-infested trees results in a significant reduction in thrips damage during the following season (Phillips *et al.*, 1995). Both biological control, and early harvesting practices need to be investigated in the New Zealand situation.

CONCLUSIONS

Adult greenhouse thrips cause significantly more damage than larval thrips. The levels of current damage as well as thrips population levels will affect the spray threshold. Any thrips monitoring system should record current damage level, and numbers of larval and adult thrips/fruit.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the New Zealand Avocado Industry Council for funding this research. We would also like to thank Leonie Batt for allowing us to carry out the trials on her orchard.

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