THE DISTRIBUTION OF GREENHOUSE THRIPS AND LEAFROLLER CATERPILLARS IN AVOCADO ORCHARDS

P.A. Brookbanks and D Steven[2]

1) Avocado Industry Council Ltd
PO Box 16 004, Bethlehem, Tauranga
2) IPM Research Ltd
PO Box 36 012, Northcote, Auckland 1330

ABSTRACT

The AvoGreen protocols for monitoring pests in avocado orchards are based on representative leaf and fruit samples obtained through sampling undertaken at ground level. During the 2001-2002 season research was begun to validate aspects of the sampling methodology involved. Initial studies focussed on the distribution within blocks of leafrollers and greenhouse thrips. Sampling was carried out on several orchards in summer and autumn in the Whangarei and Bay of Plenty regions. All trees in a block were sampled from the ground with 10 shoots or 5 fruit sites/tree inspected. Results showed that leafroller caterpillars and greenhouse thrips were evenly distributed throughout the sampled blocks. In further studies the vertical distribution of these pests on host trees was investigated by taking samples from three height strata for 10 trees in a block. At least 300 sites were sampled in each block. The results showed that the height of sampling did not generally influence the number of thrips or leafroller caterpillars found, confirming that monitoring at ground level does provide a representative sample.
Keywords: sampling methodology, spatial distribution, systematic sampling

INTRODUCTION

Leafrollers (particularly brownheaded leafroller *Ctenopseustis obliquana*), greenhouse thrips *Heliothrips haemorrhoidalis*, and the armoured scales (latania scale *Hemiberlesia lataniae* and greedy scale *H. rapax*) are the major insect pests of avocados in New Zealand. Six-spotted mite *Eotetranychus sexmaculatus* (SSM) is also a serious pest of avocados, and their feeding on the leaves can lead to defoliation (Stevens *et al*., 2001). SSM has increased in incidence over recent years and now is ranked by some New Zealand growers as the worst pest of avocado production. The insect pests are all polyphagous species which have been studied on other local crops, while SSM is less well known. For none of these pests has the specific distribution in avocado orchards been determined, although this is a basic parameter which will affect the effectiveness of any sampling procedure.

All AvoGreen pest monitoring is currently carried out from ground level using the binomial (presence-absence) sampling method because of the inherent speed

conferred by this approach. Sampling to determine management decisions must be reliable but also cost-effective in order to be practical (Binns and Nyrop, 1992). The current AvoGreen monitoring protocols were drawn up pragmatically using ecological information on the pests gathered from research on other crops. The protocols incorporate low action thresholds, included to minimise the risk of significant fruit loss. The current research programme was initiated in order to validate the sampling methodology employed by AvoGreen, and to seek ways to further improve the systems used. The overall economics of the monitoring and action thresholds will be determined once sufficient data is available from packhouses.

The first stage was to determine the spatial distribution across orchards of the pests, beginning with leafrollers and greenhouse thrips. The pest distribution affects how trees to be sampled should be selected. "Snap-shots" of the pest distribution across an orchard block at a point in time were used, in order to examine the distribution under a wide range of orchard situations. This approach gives better understanding of the relevance of the adopted system across the industry. It does not provide detailed information on how the distribution may change over time at a particular site. A range of sites and times of sampling was used, with the focus on times thought to be most relevant in order to detect incipient pest outbreaks and so prevent damage.

Concurrently, some sampling of the vertical distribution of these pests on avocado trees was also undertaken, to determine whether the current ground sampling protocols accurately reflect the level of pests present at differing heights within the canopy. For both these assessments, enumerative sampling was used, counting all the live pests present, since this technique, although slower than binomial incidence recording, does provide greater discrimination of alternative hypotheses. SSM and armoured scales were not included in these initial assessments.

MATERIALS AND METHODS

The trial involved taking snap-shot samples of the pest distribution from a total of 8 orchard blocks spread through the Te Puke, Te Puna, Katikati and Whangarei regions, in December 2001 and January to May in 2002 (Table 1). The table indicates whether spatial distribution or vertical distribution (to determine if there was a pattern of height stratification) was being studied, and gives some orchard parameters.

The current AvoGreen sampling protocols use a combination of random and systematic sampling to obtain samples that represent pest levels within an orchard block. Sample areas (normally blocks) should be set up that are as uniform as possible for tree factors, including management aspects that could influence pest levels. Within these areas trees should be selected randomly for

monitoring so that there is no bias. Either 5% of the trees per block are monitored, or a minimum of 10 trees where there are less than 200 trees in a block. Where there are only 50 trees, a minimum of 5 trees are monitored.

Table 1. Details of orchard blocks monitored

Region and site	Distribution studied	Sampling Date	Tree Age, Spacing and Height	Pests Sampled
Te Puke	Vertical and Spatial	17.12.01 12.04.02	Mature, 20x20m, 8m Young, 7x7m, 3m	leafrollers and greenhouse thrips
Te Puna A	Vertical	13.12.01 23.04.02	Mature, 9x15m, 6-8m	leafrollers and greenhouse thrips
Te Puna B	Spatial	13.12.01 23.04.02	Young, 7x7m, 3-4m	leafrollers and greenhouse thrips
Katikati A	Vertical	7.01.02	Mature, 20x20m, 6m	leafrollers
Katikati B	Vertical	18.04.02	Mature, 20x20m 6m	greenhouse thrips
Katikati C	Vertical	4.01.02	Mature, 15x15m, 6m	leafrollers
Katikati D	Spatial	1.05.02	Mature, 7x15m, 6m	greenhouse thrips
Whangarei	Spatial	2.05.02	Mature, 5-6m	greenhouse thrips

However the sites actually examined on each tree are spread in a systematic manner around the tree, and the type of site used is targeted at those most likely to be infested by pests, such as touching fruit in a cluster. Ten leaf sites/tree are sampled, with each site defined as all leaves in the distal 25 cm of a terminal shoot. For fruit sampling, 5 fruit sites/tree are used. A fruit site is defined as a cluster of touching fruit.

In this research, sampling consisted of

1. Spatial sampling - all the trees within a block were sampled from the ground using either
    a. 10 terminal shoots/tree monitored for leafroller presence (between 1 December until mid-January), or
    b. 5 fruit clusters/tree monitored for leafroller presence and damage, and the presence of larvae or adult greenhouse thrips, and damage (from January until May).

2. Vertical sampling – 10 trees/block were each sampled at 3 different strata levels, with the actual heights above ground used varying slightly with circumstances (see Results). 100 terminal shoots and/or 50 fruit sites were monitored at each level, giving a total of 300 terminal shoots or 150 fruit sites per block.

Scouts were asked to indicate in which quadrant of the compass each pest was found. i.e. N, E, S or W, where possible.

Blocks with low infestation levels have not been included in the results presented. Data was analysed using Excel surface charts to depict the distribution of pests in a block and the Chi-Squared Test at 5 % significance levels to determine differences in pests numbers at the 3 heights used in a block.

RESULTS

The results below are preliminary; a more rigorous analysis will be possible once more data becomes available as the project progresses.

Spatial analysis

Results from the monitoring showed an irregular pattern of distribution of both pests throughout the blocks sampled (Figures 1-6). An orchard with a high infestation of thrips showed the most even distribution throughout the block (Figure 5). This block faced south with established pine trees on all four boundaries. There was a slight tendency for leafroller caterpillars to be more abundant towards one side of some blocks (Figures 1, 2). This would not be unexpected as research in pipfruit has shown that ingression by moths flying into a block from sources outside the orchard can be important (Lo and Walker, 2002, unpublished data). However, there was not an edge effect or any other discernible pattern. At Te Puna, where leafrollers were more abundant, more caterpillars were recorded in the southern part of the block near, but not always adjacent to, the *Cryptomeria* shelter (Figure 2). The Te Puke block had pine shelter on the east and west boundaries.

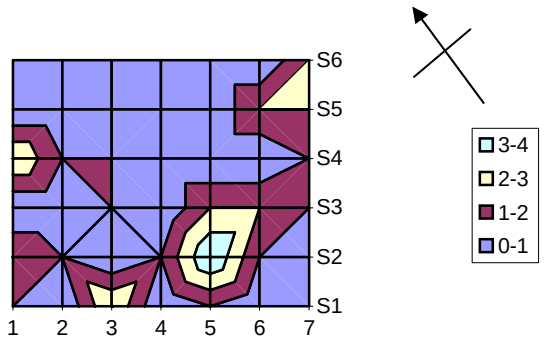


Figure 1. Distribution of leafroller at Te Puke, 17th December 2001

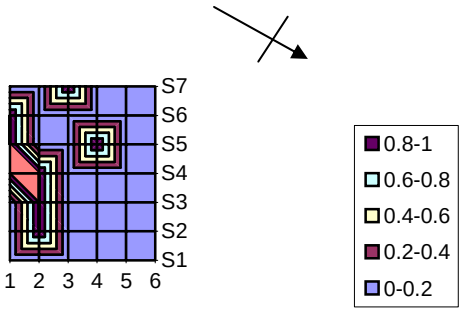


Figure 2. Distribution of leafroller on Te Puna B, 13th December 2001

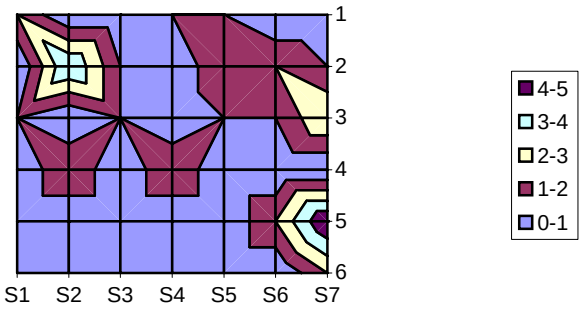


Figure 3. Distribution of greenhouse thrips at Te Puke, 12th April 2002

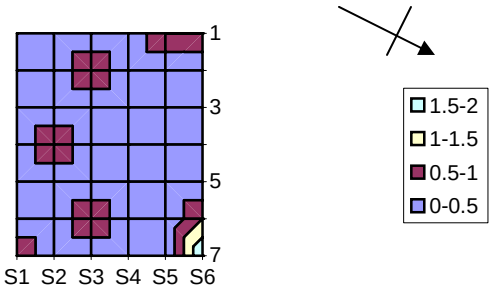
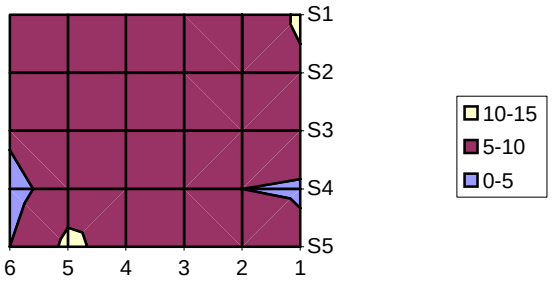


Figure 4. Distribution of GHT at Te Puna B, 23rd April 2002

Aspect

At Katikati D, where high levels of thrips were encountered, the spatial distribution across the block was even (Figure 5). However, within each tree the distribution with regard to aspect showed a distinct aggregation in the NE sector (Figure 5A). At another block in this region, Katikati B, which was sampled with respect to vertical distribution of thrips, the aspect of infested sites was also noted (Figure 7). Again the same concentration to the NE was recorded.



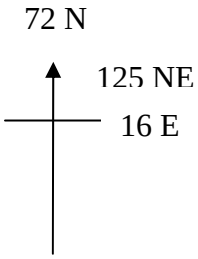
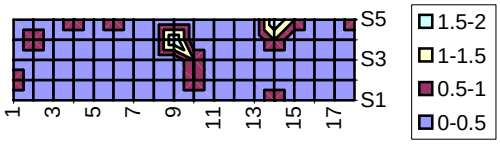
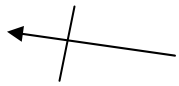


Figure 5. Distribution of GHT at Katikati D, 1.05.2002

Figure 5A

However at Whangarei, the other site where aspect was recorded for thrips, these insects were found in all quadrants around the tree, but with a preponderance on the southern side (Figure 6A). Greenhouse thrips are known to favour shaded micro-habitats (Bodenheimer 1951), so that some concentration on the southern aspect of trees could be expected in New Zealand. The Katikati results (Figure 5) indicate that this southern shade effect is not powerful and can be superseded by local factors. Block contour and shelter would affect shading on individual trees.





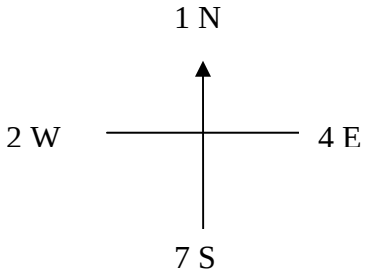


Figure 6. Distribution of GHT at Whangarei, 2nd May 2002

Figure 6A

Vertical distribution

In most cases, the number of greenhouse thrips and leafroller caterpillars found at the various heights sampled was not significantly different ($P < 0.05$) (Table 2). However, in two cases there was a significant variation. The number of leafrollers recorded in sampling at ground level at Katikati A was significantly greater than at the two higher strata, while with thrips at Te Puna A more were

recorded from the 6m stratum (Table 2). The infestation at Te Puna A was not high and all spraying on this orchard is by ground application, which may have affected the vertical distribution.

The tree aspects in Figure 7 indicate the orientation of thrips found at Katikati B sampled on the 18th April 2002. This shows that all thrips were found in the north to east aspect of the trees at varying heights.

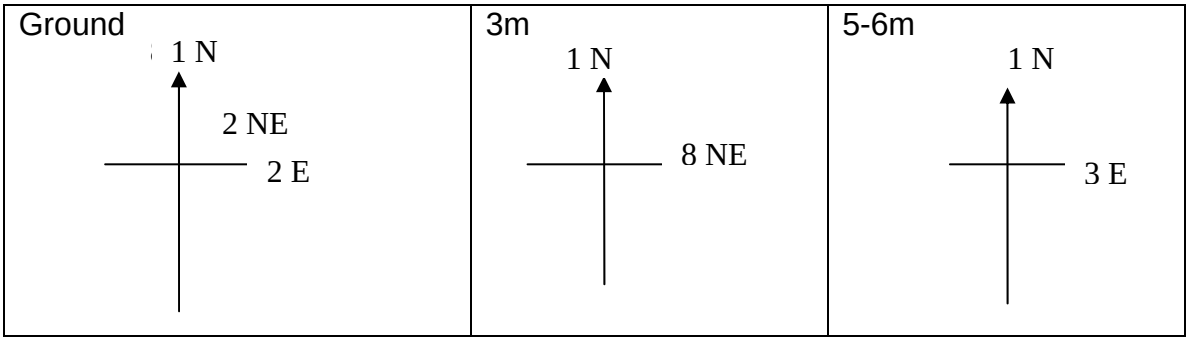


Figure 7. Number of thrips recorded at different aspects at 3 different heights, Katikati B.

Table 2. Vertical sampling results for leafroller caterpillars and thrips. Gd = ground.

Orchard	Date	Pest	Height of each stratum						χ^2 [1]
			Gd	2m	3m	5m	6m	8m	
Te Puke	17.12.01	leafroller		54			56	37	NS
Te Puke	12.04.02	thrips		11			22	15	NS
Katikati C	4.1.02	leafroller	76		24	21			*
Te Puna A	13.12.01	leafroller	12			9		7	NS
Te Puna A	23.4.02	thrips	2		4		13		*
Katikati A	7.01.02	leafroller	7		4	11			NS
Katikati B	18.4.02	thrips	11		5	10			NS

[1] **χ^2 values tested using 5 % probability levels, NS = not significant, *= significant**

DISCUSSION

The results largely confirmed that current AvoGreen sampling protocols for greenhouse thrips and leafrollers do provide techniques that are inherently suitable for monitoring these pests. Although at this stage of the programme only provisional analyses have been conducted, these do indicate that there are no distribution factors that would require drastic changes to the protocols. The accuracy obtained using the current number of samples will be the subject of future studies. Further refinements to the AvoGreen protocols may still arise from this work. The aggregation of thrips with respect to compass aspect is an example of distribution information which may allow more targeted sampling. However the variability noted from different orchards in this particular case may make it difficult to exploit without better understanding of the underlying biological reasons.

The presence – absence assessment currently used in AvoGreen is recognised as the most suitable technique for determining the pest levels in an orchard in order to make control decisions (Binns and Nyrop 1992). It is relatively quick with 100 sites/block taking on average 40-50 minutes for trained scouts.

One problem that has been recognised is that the number of fruit in older blocks that can be reached from the ground is often inadequate. Canopy management can have a profound effect on the amount of fruit set low on the trees, especially where there is poor light interception at these levels. Sampling from the ground is therefore dependant on growers adopting best practice management procedures with respect to light management. The alternative, taking all fruit samples from higher strata on the trees, is unlikely to be economic. Thus orchards with inadequate fruit for sampling at ground level may be unsuitable for AvoGreen monitoring.

The validity of sampling from the ground for pests has been questioned by some growers. Results in this research show that pest levels are well distributed throughout the canopy, so that monitoring at ground level will accurately represent pest populations (Table 2). In fact, results of leafroller sampling at Katikati C showed a higher level of infestation ($P<0.05$) at ground level. Only the thrips sampling at Te Puna A found a significantly higher ($P<0.05$) number of pests at 6m compared to 3m or to ground sampling. However the total number of infested sites in this block was low, and distribution of thrips may have been affected by previous exposure to sprays. Overall, the results show that ground–based sampling would be the most effective height stratum to use to monitor pest numbers.

SUMMARY

- The results confirm that current AvoGreen sampling protocols for greenhouse thrips and leafrollers do provide techniques that are inherently suitable for monitoring of these pests.
- The presence-absence assessment currently used in AvoGreen is recognised as the most suitable, most cost effective, technique for determining the pest levels in an orchard in order to make control decisions.
- Orchard blocks where sufficient fruit are not available at ground level may be unsuitable for AvoGreen monitoring.
- Ground sampling protocols do give effective indications of insect pest populations.

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