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Reduced pesticide use on tomatoes and capsicums

VG046

Know-how for Horticulture™

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South Australian Primary Industries

FINAL REPORT

VG046

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Reduced pesticide use on tomatoes and capsicums

Developing efficient sampling protocols for native budworm

1. SUMMARY

1.1 Industry Summary

This project commenced in the 1989-90 cropping season with the initial objective of introducing to outdoor capsicum and tomato crops on the Northern Adelaide Plains (NAP) the biological control of two-spotted mite using the predatory mite *Phytoseiulus persimilis* . Careful monitoring of two-spotted mite populations allowed successful control of this pest on 6 heetares of tomatoes and capsicums with *Phytoseiulus persimilis* and an integrated chemical spraying program.

The native budworm, *Helicoverpa punctigera (Wallengren)*, a key pest of outdoor tomato crops grown on the NAP, is controlled with insecticides applied in most seasons every 4-7 days from November to March inclusive. The chemical control of native budworm is disruptive to integrated control of two-spotted mite. Because little information was available on monitoring techniques and economic thresholds for native budworm this project was redirected to address these issues.

In this study a monitoring technique has been developed for use by growers and crop monitors to assess the abundance of native budworm eggs in these outdoor tomato crops. This is a prerequisite to improving decision-making on the need to spray.

Presently, despite the intensive insecticidal program, control of native budworm larvae is often poor and a high proportion of the fruit is damaged and rendered unmarketable. The ineffectiveness of this insecticidal program is not due to poor insecticidal activity of the chemicals used, because the same chemicals very effectively control native budworm when aerially applied to grain legume crops.

Inadequate spray coverage is considered the primary cause of the problem (D.Cavallaro and G.Furness, pers. comm.). Improvements in spray coverage would be expected to reduce crop losses and the frequency of spraying (and thereby the selection rate for insecticidal resistance), and to open the way for the development of innovative chemical - free strategies for native budworm control (eg. *Bacillus thuringiensis* used in conjunction with *Trichogramma* egg parasites).

Once improved spray-application methods have been adopted by the industry, the sampling methods developed in this study will play an integral part in any IPM strategy developed for controlling native budworm in outdoor tomato crops.

1.2 Technical Summary

The development of an efficient management scheme for deciding whether to spray infestations of native budworm in outdoor tomato crops requires research in three key areas:

1. sampling protocols for eggs or larvae,
2. better spray application method(s), and
3. economic spray thresholds for use with the improved spray method(s).

In this study the first of these requirements has been addressed. Eggs and leaves positioned three from the shoot apex have respectively been identified as the preferred life-stage and sampling unit for monitoring native budworm in outdoor tomato crops, and an efficient monitoring scheme has been developed, based on the degree of aggregation of budworm eggs, which allows growers or crop monitors to sample the minimum number of leaves needed to adequately estimate the mean density of eggs.

2. RECOMMENDATIONS

2.1 Extension/adoption by industry

The monitoring recommendations for estimating the abundance of native budworm eggs in outdoor trellis tomatoes are presented in Appendix I.

2.2 Directions for future research

For these monitoring recommendations to be widely and effectively used further research to improve spray coverage in outdoor trellis tomato crops and to generate economic spray thresholds for native budworm eggs is needed.

2.3 Financial/commercial benefits

Crop monitoring, using this project's recommendations in conjunction with economic thresholds and improved spray methods, will allow significantly greater pack-outs of quality tomatoes to be achieved with less spraying, and open the way for the development of chemical-free methods of controlling native budworm.

3. TECHNICAL REPORT

3.1 Introduction

The native budworm, *Helicoverpa punctigera* Wallengren, feeds on the fruit of tomatoes and is the most destructive pest of outdoor trellis tomato crops grown for fresh produce on the Northern Adelaide Plains of South Australia. These tomato crops are generally treated with insecticides on calender schedules rather than as a result of crop monitoring decisions based on reliable sampling methods. Sampling procedures which are accurate and efficient are needed for the development of predictive pest management strategies and the evaluation of spray treatment decisions. This study was initiated to develop such sampling protocols.

3.2 Materials and Methods

Between November 1991 and February 1992 100-200 tomato plants were sampled weekly in each of three outdoor trellis tomato crops grown for the fresh market at Virginia, 40 km North of Adelaide (Fig 1.). The number of eggs and larvae were counted on leaf and flower cluster samples, and the mean number of flower clusters and fruits estimated for a 10 plant sample.

On three occasions the time taken to perform each part of the pest sampling operation was recorded. The distance traversed between each sample site was approximately 15 metres.

On one property successive plots (7m length of 3 rows) were pegged out every 2 to 3 weeks and left unsprayed for a similar period for damage assessment observations. A similar-sized area was left unsprayed for the duration of the study.

The mortality of native budworm eggs collected on tomato foliage 2 hours after applying a Lannate® (methomyl 112.5 g a.i. ha^{-1}) spray was assessed.

3.3 Results and Discussion

3.3.1 Egg abundance

The Northern Adelaide Plains is located at the southern extremity of the central South Australian grain belt (Fig 1). Approximately 100,000 ha of grain legume crops grown annually in this region are host to a spring generation of native budworm. The native budworm moths which colonise the NAP tomato crops in late spring and summer are thought to largely originate from these grain legume crops.

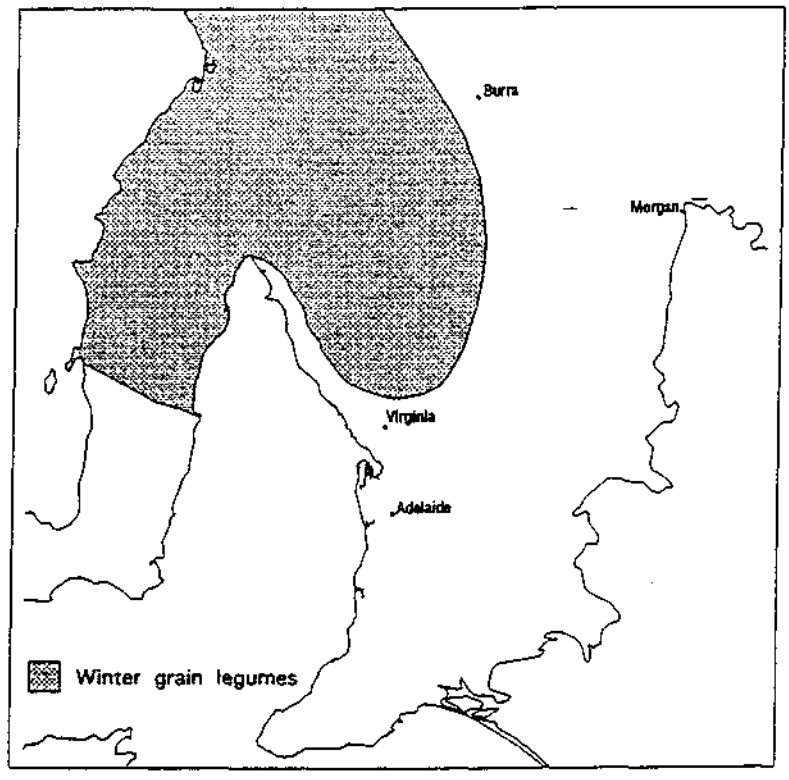

Fig 1. Location map of Northern Adelaide Plains (Virginia) and environs, South Australia.

Two peaks in native budworm egg laying occurred during the 15 week period from November 1991 to February 1992 in the three tomato crops sampled in this study (Fig 2).

The timing of these egg laying peaks was similar for each of these crops. The interval of about 50 days between the two egg laying peaks was well short of the 75 to 79 day generation time predicted by the Victorian Department of Agriculture DARABUG model. This indicates that the native budworm infestation in these crops originated from at least two periods of significant inflight of moths into the Virginia district.

The abundance of eggs was much greater in the Kapiris crop than in the other two study crops (Fig 2). Whether this was due to a greater number of invading moths or less effective insecticidal knockdown of moths before they began egglaying at Kapiris is unclear.

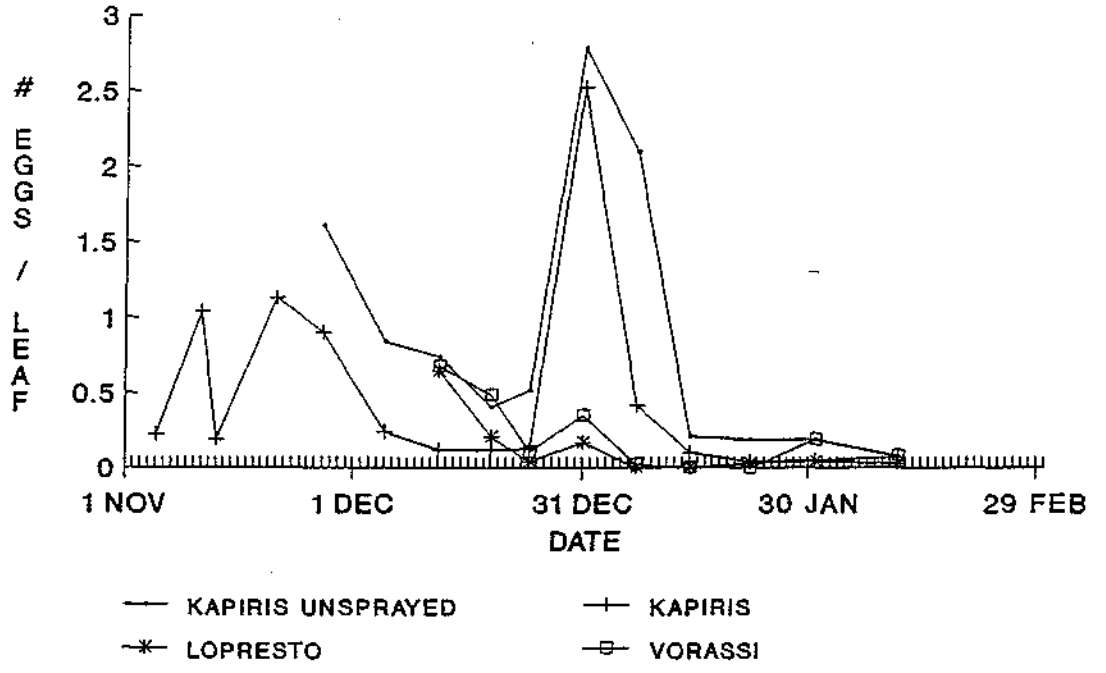

Fig 2. The incidence of native budworm eggs on foliage (3rd leaf from shoot apex) in 3 outdoor tomato crops, Northern Adelaide Plains (Virginia), 1991-92.

3.3.2 Oviposition sites

Eggs were laid on foliage and flowers (Fig 3).

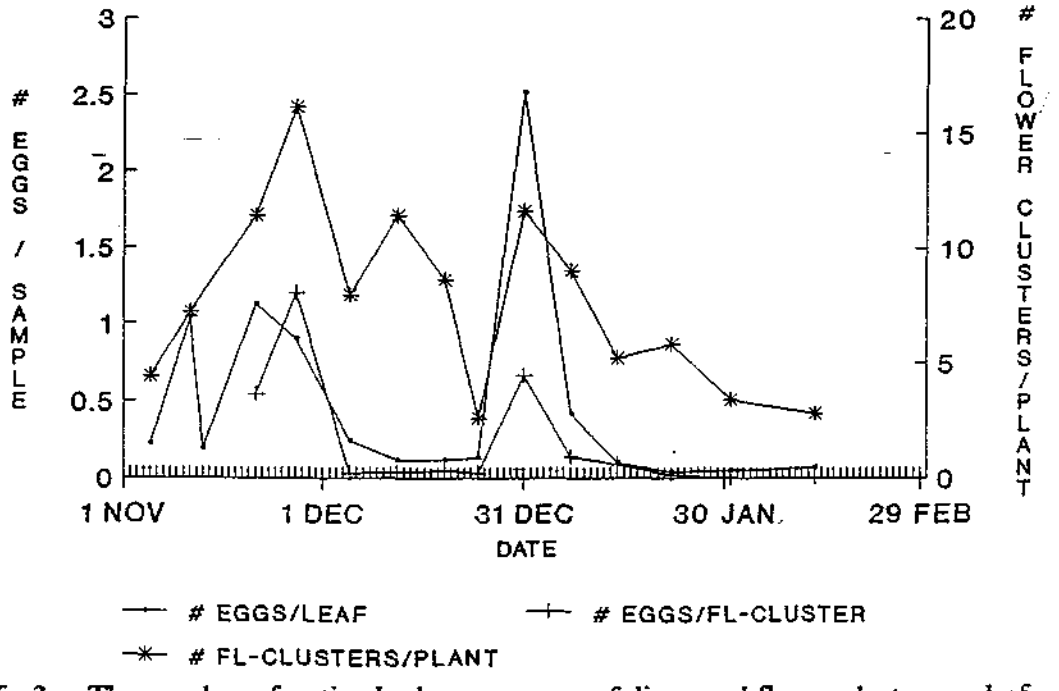

Fig 3. The number of native budworm eggs on foliage and flower clusters and of flower clusters per plant, Kapiris' outdoor tomato crop, Northern Adelaide plains (Virginia), 1991-92.

On the foliage almost two-thirds of the eggs sampled were located on the upper leaf surface (U:L = 1.00:0.55 eggs).

Eggs on foliage were not distributed evenly along the length of shoots. Unhatched eggs were only found on the first six leaves from the shoot apex 77.4% of these eggs occurred on the apical three leaves, with the third leaf (generally the first leaf of length greater than 10 cm) on average being the most infested (Table 1).

Generally eggs were more numerous on foliage than on flowers. In three samples of 250 leaves (3rd leaf from the shoot apex) and adjoining flower clusters collected in early November and late December about twice the number of eggs were found on the leaves as compared to the flower clusters (Leaf: flower cluster = 1.00: 0.52 eggs).

The density of eggs on the foliage relative to the flower cluster was greater in late December - early January than in November (Fig 3). Whether this temporal difference occurs each season is not known.

Table 1. The percentage of native budworm eggs found on leaves at six consecutive leaf positions on 150 tomato shoots, outdoor tomatoes, Northern Adelaide Plains (Virginia), 1991-1992.

Leaf position	1#	2	3	4	5	6
Percentage of Eggs	21.7	19.0	36.7	10.6	9.3	2.7

 # 1 = 1st leaf from shoot apex
2 = 2nd leaf from apex, etc

Wellik *et al* (1979) in Texas and Alvarado - Rodriguez *et al* (1982) and Zalom *et al* (1983) in California found that the tomato fruitworm *H. zea* exhibited a strong preference for laying eggs in processing tomato crops on leaves rather than on flowers or fruits. In NSW processing tomato crops the preferred sites for *H.punctigera* and *H.armigera* egglaying were leaves on the upper half of the plant, with the greatest numbers of eggs being laid on the third leaf from the plant apex. In the present study a similar preference for laying eggs on the foliage, and in particular on still-expanding leaves of length 10-15 cm positioned three from the shoot apex, was observed with *H.punctigera* in Virginia tomato crops.

3.3.3 Larval abundance

Early in this study the third leaf from the shoot apex and the adjacent flower cluster were selected as the sampling units for assessing the incidence of native budworm eggs. They were also used for larval assessment.

In the sprayed areas of the 3 study crops no larvae were found during weekly assessments of either 100, 150 or 200 leaf and flower-cluster samples. (Fig 4).
In the unsprayed section of Kapiris' crop in early to mid December a very low incidence of larvae on foliage and flower clusters was recorded.

The accompanying levels of larval infestation of tomato fruits were high, and ranged between 48-63%, 15-22%, 10-22% and 90-97% of fruit infested at Kapiris', Lopresto's and Vorassi's crops and Kapiris' unsprayed crop area respectively.

These results indicate that foliage and flower cluster sampling is inadequate for assessing larval abundance.

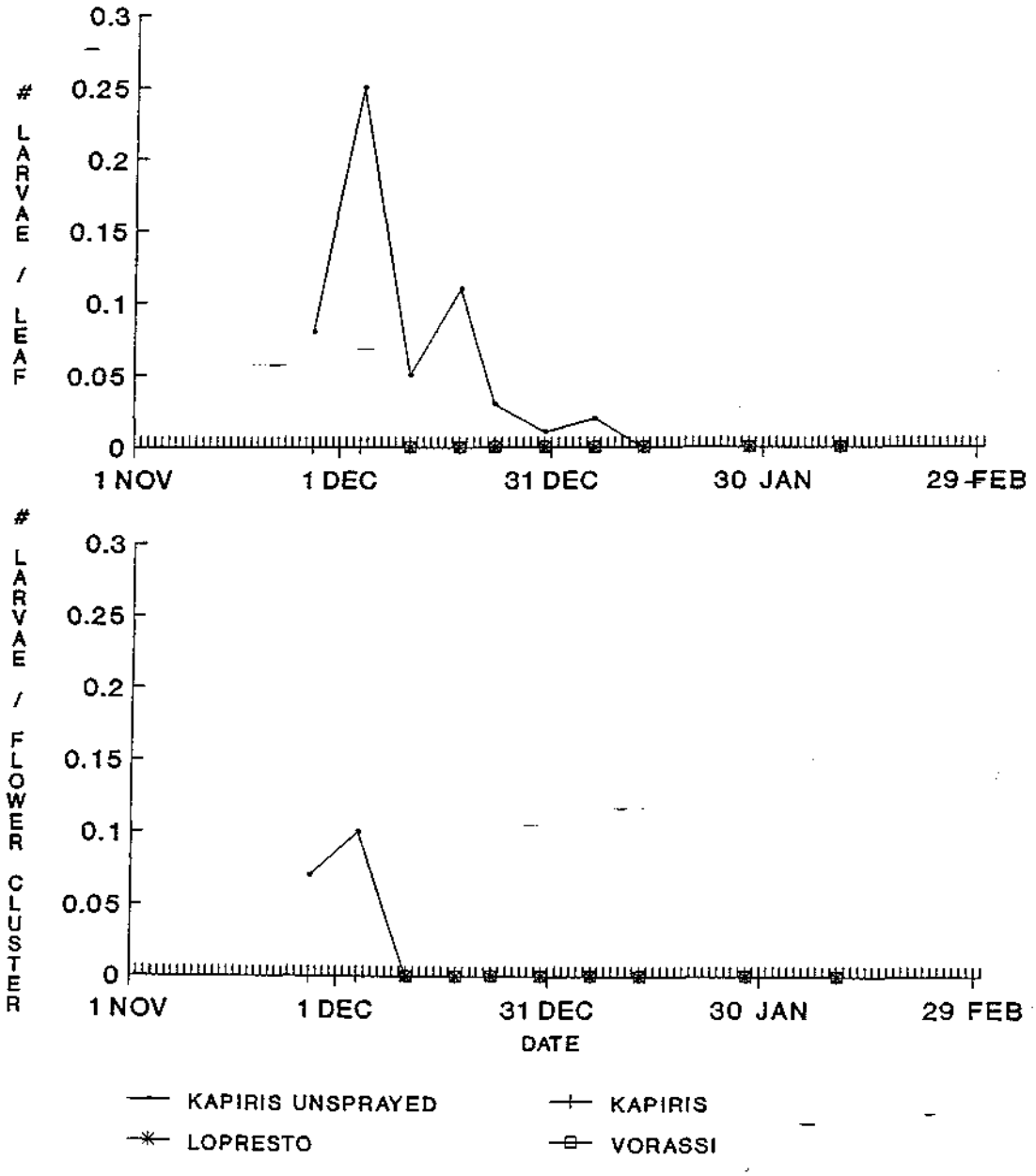

Fig 4. The incidence of native budworm larvae on foliage and flower clusters in 3 outdoor tomato crops, Northern Adelaide Plains (Virginia), 1991-92.

3.3.4 Development of a Sampling Method for Crop Monitoring

3.3.4.1 The insect stage to monitor

Eggs are the preferred life-stage for monitoring native budworm in tomato crops. They are easy to detect and their density is generally estimated with greater precision than larvae. Further, egg sampling provides earlier warning of potential crop risk than larval sampling and hence greater lead-time if insecticidal control is required.

3.3.4.2 Choice of a sampling unit

Native budworm eggs are laid on tomato foliage and flower clusters. This study revealed that native budworm eggs are generally located in greatest numbers on the upper surface of leaves positioned three from the shoot apex.

To choose the most cost-effective sampling unit for estimating egg abundance the sampling times and the coefficients of variation of the egg density estimates were calculated for the following sampling units: upper surface of 3rd leaf (UL), both surfaces of 3rd leaf (TL), flower cluster (F), upper surface of 3rd leaf plus flower cluster (ULF), both surfaces of 3rd leaf and flower cluster (TLF).

The coefficient of variation, V, was calculated using the formula:

$$V = s/m$$

where m is the mean estimate of the egg density and s is the standard deviation of this estimate. The relative net cost for the same precision for each sampling unit is proportional to:

$$CV$$

where C = is the cost (time in seconds) per sampling unit (Southwood 1978). The lower the value of CV, the lower the cost for the same sampling precision.

The results (Table 2) indicate that leaf sampling was consistently more cost-effective than flower-cluster sampling, irrespective of whether the flower clusters were sampled alone (F) or in combination with leaf samples (ULF and WLF). The cost effectiveness of upper-leaf surface versus whole-leaf sampling was very similar at each of the 3 sampling occasions.

Based on these findings the preferred sampling unit for native budworm eggs in outdoor tomato crops is a leaf sample comprising the 3rd leaf from the shoot apex, of which either the upper surface or both the upper and lower surfaces are searched.

IPM monitoring programs for budworms in processing tomato crops have been developed in California and NSW which are based on the sampling of eggs on foliage (Aochi and Baker 1985, Hamilton and Macdonald 1990). Such sampling plans provide a low-cost, reliable indicator of budworm abundance with sufficient lead-time to arrange for insecticidal control if required.

Table 2. The relative cost and precision of 5 sampling units used to sample native budworm eggs on outdoor tomato crops, Northern Adelaide Plains (Virginia), South Aust, 1991-92.

Date	Sampling Unit	V	C	CV
20.11.91	UL	181.8	18.0	3272
20.11.92	WL	144.2	23.0	3317
30.12.91	UL	112.0	8.6	963
30.12.91	WL	99.6	9.8	976
30.12.91	F	267.0	9.5	2537
30.12.91	ULF	142.9	12.6	1801
30.12.91	WLF	122.7	13.8	1693
13.1.92	UL	318.8	8.6	2742
13.1.92	WL	275.6	9.8	2701
13.1.92	F	910.4	9.5	8649
13.1.92	ULF	297.8	12.6	3752
13.1.92	WLF	263.3	13.8	3634

3.3.4.3 Spatial distribution of the eggs in the crop and a sampling plan

Reliable sampling procedures are essential for monitoring insect pest populations. Insects often exhibit a clumped distribution within a crop, and a large number of sampling units are required to obtain a precise estimate of mean density.

The minimum number of sampling units (Nmin) needed to obtain an estimate (m) of the mean density of eggs has been determined in this study using the formula (Ruesink 1980):

$$Nmin = 4\ am^{b-2}/p^2$$

Where p is the precision level required and a and b are derived from Taylor's power law (Taylor 1961):

$$\log_{10}(s^2) = a + b \log_{10}(m)$$

b is a measure of aggregation and a is a scaling factor which varies with sampling method and habitat. Values of $b>1$ indicate an aggregated distribution, $b = 1$ a random distribution and $b<1$ a regular distribution. Analysis of the data showed that the slope was >1, confirming an aggregated distribution for native budworm eggs on tomato leaves. The regression equation was ($r^2 = 0.92$; d.f. = 40; Fig 5).

$$\log_{10}(S^2) = 0.3988 + 1.1476 \log_{10}(m)$$

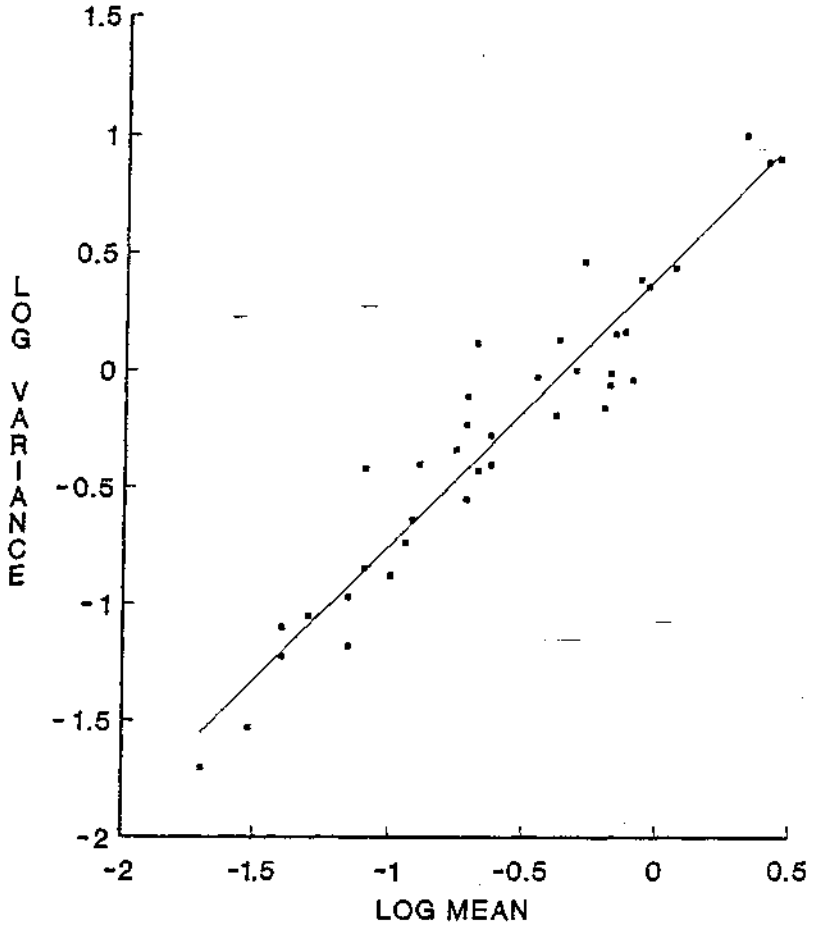

Fig 5. Description of native budworm egg distribution in outdoor tomato crops. The relationship between log (mean) and log (variance) and the regression line of best fit for the Northern Adelaide Plains (Virginia) crops, 1991-92.

Using these values the minimum number of leaf samples needed to have a 95% probability of estimating the mean number of native budworm eggs within 25% ($p = 0.25$) of the true value of the mean has been calculated (Table 3). Values of 0.25 for p are within the acceptable range as set forth by Southwood (1978) for damage assessment and pest control sampling programs.

As egg density increases, progressively fewer samples are required to adequately estimate the mean density.

Table 3. Minimum number of leaves (Nmin) in sample to have a 95% probability of estimating the mean number of native budworm eggs with 25% (p = 0.25) of the true value of the mean.

Mean no. of eggs/leaf	Minimum sample size
0.05	328
0.1	182
0.15	129
0.20	101
0.25	83
0.30	71
0.40	56
0.50	46
0.60	39
0.80	31
1.0	26
2.0	14

3.3.5 Damage assessment study

The damage assessment study to relate native budworm abundance and fruit damage from observations on successive plots of sprayed and unsprayed tomato plants failed because the unsprayed plots were frequently oversprayed during routine property spray operations.

3.3.6 Effect of methomyl on the viability of native budworm eggs.–

165 eggs, collected on tomato leaves 2 hours after a 112.5 g a.i. ha^{-1} methomyl spray had been applied to the crop (Kapiris, 21.11.91), were laboratory incubated.

94.7% of the 151 unparasitized eggs hatched. This spray treatment was ineffectual, probably because of either inadequate spray coverage or poor insecticidal activity. The spray equipment that was used, a boom-spray fitted with drop-lines, is common in this industry. The poor spray result calls into question the merit of spraying methomyl as an ovicide to kill native budworm eggs in outdoor tomato crops as commonly practiced in the Virginia district.

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APPENDIX I

Monitoring Recommendations

Native budworm eggs on tomato foliage.

The leaf sample: the first leaf of 10 - 15 cm length on a shoot, usually the 3rd leaf from the shoot apex. Examine the upper and lower surface of each sampled leaf and count the number of native budworm eggs present.

Selection of the leaf samples: initially select 40 leaves by choosing an unbiased sample of 10 leaves from each of 4 quarters of the crop. Move at least 15 - 20 m to select each new leaf.

Interpretation of the initial 40 leaf count:

- no eggs - stop sampling
  - no spraying needed
  - resample in 4 - 7 days

- eggs found - calculate the egg density per leaf (the number of eggs scored ÷40) of this initial sample and read off from the Table below the number of additional leaves that must be sampled to estimate the egg density with adequate accuracy.
  - proceed with sampling this additional leaf sample.
  - then calculate the egg density of the complete sample.

$$\text{Egg density} = \frac{(\#\text{ eggs on initial + additional sampled leaves})}{40 + \#\text{ leaves in additional sample}}$$

Egg density estimate for initial sample	Number of additional leaves that must be sampled to adequately estimate egg density
0.05	140
0.10	140
0.15	90
0.20	60
0.25	40
0.30	30
0.40	15
≥0.50	0

Interpretation of the final egg density estimate:

- egg density ≥ economic threshold - spray
  - resample in 4 - 7 days
- egg density < economic threshold - no spraying needed
  - resample in 4 - 7 days