Horticulture Innovation Australia

Final Report

Identification and management strategies for true bugs in Tasmanian strawberries

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Contents

Summary

Tasmanian strawberry growers raised the alarm after experiencing disfiguring damage to several tonnes of strawberry fruit due to bug infestations. With the industry in a rapid expansion phase it was important to address this issue quickly. This project aimed to identify which bugs were causing damage and to help growers implement integrated pest management (IPM) practices. These practices focus on cultural and biological management with only strategic use of selective insecticides when necessary.

The project format included an IPM workshop, a crop monitoring and bug identification component and a season review workshop. Dr Paul Horne (IPM Technologies) provided expert support for workshops, on-farm training and bug identification. All Tasmanian strawberry growers, advisors and agronomists were invited to participate.

The IPM workshop provided growers with an introduction to the topic with information, discussion and specimens. On-farm training in IPM and crop monitoring was provided to the seven participating growers. Each grower was supplied with a bug monitoring collection kit and advice on how to monitor, record, collect and transport samples. Collected bug samples were sent to IPM technologies for identification. The season review workshop was an interactive session incorporating grower experiences, feedback on monitoring and bug identification, management strategy development and future possibilities for pest management.

The primary outcome of this project was identification of the bugs infesting Tasmanian strawberry crops. The species of bugs infesting Tasmanian strawberry crops showed a similar range of species present to those identified in a recent survey of Victorian strawberry crops, a mix of Lygaeidae and Miridae. This provides good evidence that management practices developed in either Victoria or Tasmania would be highly likely to be applicable to both these regions. The most common lygaeid bug identified in Tasmania was Rutherglen bug (*Nysius vinitor*). Crop mirid (*Sidnia kinbergi*) and other mirid species were also commonly encountered. Mirids are known to cause serious deformation of strawberry fruit whereas lygaeid bugs are a nuisance rather than a pest. This result prompted the development of two resources for growers: (1) a pictorial guide distinguishing the damaging mirid bugs from lygaeid bugs; and (2) a pocket card field guide of beneficial and pest species of strawberries. Distinguishing the two bugs is essential to prevent unnecessary intervention.

The project evaluation revealed a dramatic increase in grower's level of knowledge and skill with respect to the identification and management of bugs in Tasmanian strawberry crops. In the review workshop growers nominated their most effective insect management strategies. Significantly, of the seven management options nominated, six of these could be classified as either cultural or biological, highlighting the shift in grower's attitudes away from pesticide dominant bug management. This response indicates greater sophistication in their management practices and increased confidence in implementing IPM.

The project identified a range of strategies with potential to further enhance integrated pest management in strawberries.

Keywords

strawberry; integrated pest management; bugs; lygaeid; mirid;

Introduction

Mirid bug damage experienced by Tasmanian strawberry crops was nominated as a high priority for research and development in 2013 (Tasmanian berry research and development meeting, June 2013). This was coincident with a rapid expansion in the production of strawberries under protected cropping in new regions of Tasmania. In 2012/13 fruit damage attributed to mirid bugs resulted in several tonnes of strawberry fruit being unsaleable. Damage was reported from various locations around Tasmania. In an effort to protect their crop, strawberry growers faced the prospect of spraying broad spectrum insecticides whenever bugs appeared in their crop without sufficient knowledge or evidence as to which bugs caused damage and which did not. Broad spectrum and potentially frequent insecticide use posed a serious threat to established integrated pest management (IPM) practices and industry sustainability.

Previously in Victoria, a similar situation was faced by growers responding to western flower thrip infestation. The industry was not well prepared and the reliance on insecticides was costly in terms of development of resistance, residues in fruit and a loss of beneficial organisms. A concerted effort to shift growers to an integrated pest management system completely turned this situation around with near 100% uptake of integrated pest management achieved (HIA BS08011).

This current strawberry bug project aims to pre-empt such a crisis situation occurring in Tasmania. To do this requires identifying which bugs are responsible for damage in strawberries and proposing management strategies that fit with established integrated pest management practices. Fostering integrated pest management as a system for addressing pest issues proactively supports a sustainable future for the burgeoning Tasmanian strawberry industry.

Methodology

The target audience for this project includes:

- Tasmanian strawberry growers
- Consultants and agronomists servicing the strawberry industry

The project team:

- Project leader (Horticulture and extension): Michele Buntain
- IPM specialists and entomologist: Dr Paul Horne and Jessica Page from IPM technologies

The project methodology includes the following:

1. Preliminary Integrated Pest Management workshop
2. Monitoring and documentation of pests in strawberry crops
3. Identification of pests in strawberry crops
4. Season review workshop
5. Production of IPM identification guide for growers

Monitoring and evaluation was conducted by grower surveys at the commencement of the project (Preliminary Integrated Pest Management workshop) and towards the end of the project (Season Review workshop) to determine changes in grower's knowledge, skills attitudes and aspirations. Interview of non-participating growers was conducted at the end of the project to gauge the difference between participants and non-participants.

Preliminary Integrated Pest Management Workshop 'Strawberry Bug Workshop'

The Strawberry Bug Workshop was held at Elizabeth Town in Tasmania on July 31. Dr Paul Horne from IPM technologies conducted the workshop, facilitated by Michele Buntain (Tasmanian Institute of Agriculture). The workshop comprised 4 sessions:

1. Presentation of information on integrated pest management (IPM) and results of the Victorian strawberry bug study
2. A practical session where participants inspected specimens of pests and beneficial insects and mites
3. Lunch and networking
4. The development of an IPM plan based on input from participants and Dr Paul Horne

Monitoring and documentation of pests in strawberry crops

Strawberry growers were invited to participate in the bug monitoring program. In November 2014, Dr Paul Horne (IPM Technologies) and Michele Buntain (TIA) visited six Tasmanian strawberry farms to establish monitoring protocols and to deliver monitoring kits to growers. Crop monitoring commenced in late December 2014 and continued through to February 2015.

Identification of pests in strawberry crops

Dr Paul Horne (IPM Technologies) conducted identification of strawberry pests and beneficial insects and mites during his visit to Tasmanian strawberry crops in December 2014. Further identification was carried out on bugs collected by growers. Bugs from three farms were sent to IPM Technologies for identification. Identification was also conducted by growers with the assistance of a specialist agronomist.

Season review workshop

The season review workshop was held at Elizabeth Town on 25th June, 2015. The Strawberry IPM 'Season Review' workshop was instigated to provide a forum for growers to discuss their pest management experiences from the 2014/15 season with input from IPM specialist Dr Paul Horne from IPM technologies. It also provided the opportunity to reinforce the principles of IPM in strawberries and to provide feedback on the bug samples that were submitted for identification during the season.

The program for the review session included:

- A brief background to the project for participants that had not attended the first workshop
- An activity where participants were asked to write down their most challenging pest management issue for the 2014/15 season. Each participant then invited to introduce themselves to the group and briefly describe their major pest management challenge. This was 'posted' on the wall for reference throughout the workshop.
- A presentation by Dr Paul Horne on the development of an IPM strategy for strawberries with details of the damage potential of different pests and IPM management strategies for these. He reported on the specimens that were collected from Tasmanian strawberry crops in the 2014/15 season.
- An activity where participants were asked to write down what management strategies had worked well for them in the 2014/15 season. Each participant was invited to briefly talk about their management and discuss with the group. The management strategies were 'posted' on the wall for reference and discussion.
- A discussion with the group led by Dr Paul Horne based on their most challenging pests and the management strategies that are working well. The group also talked about current and future management strategies that might be used or tested.
- A presentation by Dr Dean Metcalf form Metcalf biocontrol on botrytis management in strawberries
- Wrap up session to highlight the key outcomes of the project and the discussions held during the day

Production of IPM identification guides for growers

Dr Paul Horne (IPM Technologies) produced a simple pictorial and descriptive guide for growers to assist in the differentiation of pest bugs and non pest bugs. As a supplement to this, Michele Buntain (TIA) produced a set of field use ID cards of the major strawberry pests and beneficial mites and insects.

Outputs

Preliminary Integrated Pest Management Workshop 'Strawberry Bug Workshop'

The workshop was conducted at the Elizabeth Town Café and meeting rooms on 31st July, 2014. Of the original 19 respondents, 12 participated in the workshop. Gale force winds on the day of the workshop prevented many growers from attending. Growers were forced to deal with wind damage and undertake preventative measures to prevent further structural damage to strawberry tunnels. This was disappointing but unavoidable.

The workshop structure:

Time	Activity	Who responsible
10:00 am	Morning tea and arrivals	Michele
10:15 am	Introduction: Who's who and purpose of the workshop	Michele
10:30 am	IPM basics – pests, beneficials: the use of chemical, biological, cultural management Victorian strawberry bug study results and relevance to Tasmania	Paul
11:30 am	Practical session looking at specimens	Paul – describing specimens Michele – organizing display
12:30 pm	LUNCH - networking	Michele
1:10 pm	Developing an IPM strategy for your farm	Paul
2:20 pm	Closure – summary of the day, what is next for project	Michele

The workshop participants interacted well and the day was dynamic with many discussions both formally and informally. The greatest value came from the combined experience and observations of participants which gave depth to the discussions and practical solutions.

Each grower helped develop a specific integrated pest management plan based on their current knowledge of pests infesting their strawberry crop.

A summary of information from the preliminary 'Strawberry Bug workshop' including the management plan is provided in Appendix 1. This report was distributed to all growers.

On farm training

The crop monitoring on farm training sessions targeted integrated pest management (IPM) issues of relevance to each farm and grower. The visits reinforced and expanded on IPM theory discussed at the IPM workshop held in July. It also gave growers, some who were unable to attend the workshop, the opportunity to enhance their IPM knowledge and relate this directly to their on farm management practices.

The farm visits proved to be highly interactive and engaging. Each farm offered quite different scenarios and site specific issues although often with a common thread. The level of grower experience with implementing IPM varied from novice to highly experienced. The farm visits allowed the more experienced IPM practitioner to explore the potential for refining IPM practices and testing innovative solutions whilst the less experienced grower was able to gain a good grasp of the basics in a 'safe' environment. Integrating thrips and mite management with bug management was the most common issue for growers.

Each grower was supplied with a bug monitoring collection kit and advice on how to monitor, record, collect and transport samples

Crop monitoring

Seven strawberry growers participated in the monitoring program. The group covered a range of grower experience, different production systems and from various locations.

Farm and location	Production system	Grower
Turners Beach Berry Patch, Turners Beach	in ground tunnel production, fresh market,	Craig Morris, Troy Ayers
Richmond Berries, Richmond	Outdoor field production pick your own and farm gate sales	Chris Wissey
Burlington Berries, Langford	Table top tunnel and in ground production for fresh market	Nick King
Berry Exchange, East Devonport	Table top tunnel production for fresh market	Rebecca Clarkson, Kalia Cameron
Tasmanian Berries, Christmas Hills	Table top tunnel production for fresh market	Andrew Terry
Meander Valley Berries	In ground tunnel production for fresh market	Simon Dornauf
Mountford Berries, Longford	In ground tunnel production for fresh market	Roly Mackinnon, Flynn Ruddick

Figure 1: Dr Paul Horne and Roly Mackinnon at 'Mountford'

Figure 2: Driscolls agronomist, Jason Barnes; Farm manager, Andrew Terry; Dr Paul Horne IPM technologies at Tasmanian Raspberries, Christmas Hills

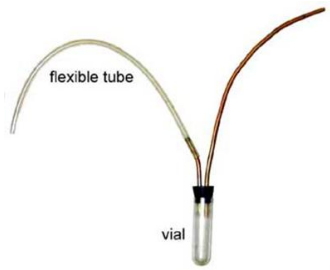

Figure 3: Bug collection device

Specimen identification

Bug specimens collected from two farms were sent to IPM Technologies for identification. One farm was located in the south of the state and one in the north.

Location	Date	True bugs	Beneficial	Other
Turners Beach Berry Patch	27 January	Crop mirid adults and juveniles	Brown lacewing (*Micromus tasmaniae*)	Juvenile cockroach
Turners Beach	27 January	Lygaeid adults and juveniles (2 species)		Parasitised moth pupa
	15 February	Juvenile shield bugs		

Location	Date	True bugs	Beneficial	Other
Richmond Berries	21 January			Leafhopper nymphs
Richmond	16 February	Crop mirid		
		Lygaeid adults and juveniles (2 species)		
		Rutherglen bugs		

Identification by growers and agronomist was conducted on site at

- Burlington Berries: Mirid and lygaeid (Rutherglen) bugs confirmed
- Mountford Berries: No bugs confirmed
- Meander Valley Berries: Lygaeid (Rutherglen bugs) confirmed
- Berry Exchange: No bugs confirmed

Season review workshop

Major pest management challenge

Participants listed more than one pest challenge. These were rated by the order of their listing. The first most important was given a score of 3, the second a score of 2 and the third a score of 1 to give an overall rating of the pest (Figure 4).

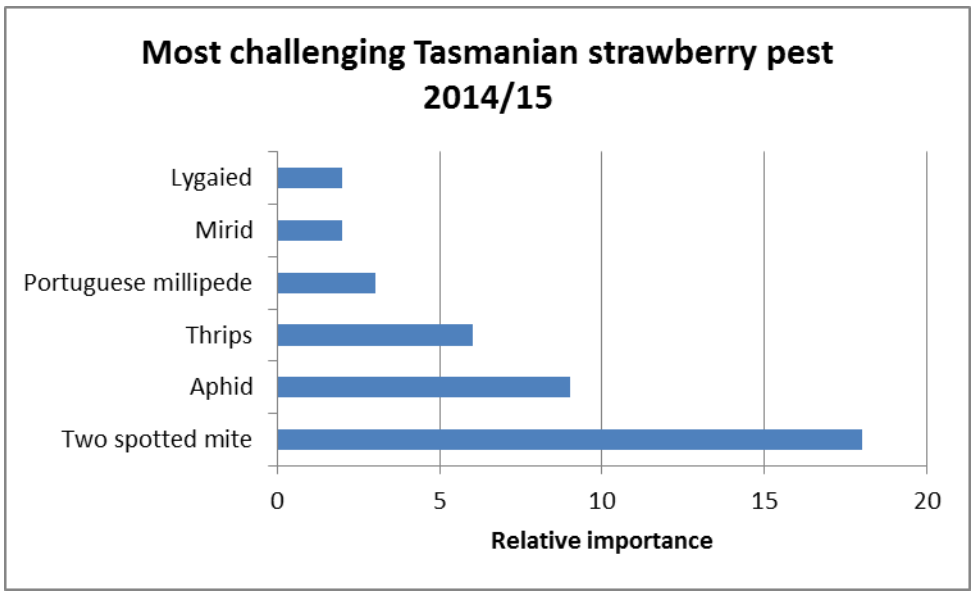

Figure 4: Grower rating of the relative importance of pests in Tasmanian strawberry crops 2014/15

What worked well? Effective management options

Introduction of beneficials

90% of growers rated the introduction of biocontrols or beneficials, primarily *Phytoseiulis persimilis* 'persimilis' as their most effective management strategy. Hypoapsis mite, aphidius wasp and orius bug were also effective as introduced biocontrol agents. One grower noted that naturally occurring hoverflies were effective in assisting aphid management.

Timing of introduction of beneficials

30% of growers found that introducing biocontrols/beneficial organisms at the correct time to their strawberry crop as having a positive impact on pest management. Scouting was included as a management technique that helped achieve good pest management through correct timing of either biocontrol agents or plant protection products.

Health of biocontrol agents

20% of growers highlighted the importance of checking the health status of beneficials prior to release in achieving good pest management results.

Weed control

20% of growers rated weed management as an effective pest management option by removing a preferred habitat and breeding site for pests. The removal of wireweed (*Polyganum spp*) was important.

Humidity management

Grass plantings between rows and tunnel ventilation were used effectively to manage humidity. One grower noted a "dramatic" improvement in biocontrol establishment and survival with better humidity management.

Pesticide use

60% of growers used targeted well timed pesticide as an effective management strategy. The majority rated perimeter or spot application of pesticide as the effective strategy rather than an overall crop spray. Pesticide use was primarily targeted at aphids (pirimor), perimeter spraying of mirids and minimal or spot use of acaricide for two spotted mites.

Runner inspection

One grower noted that runner inspection was a management strategy that worked well. This hygiene check ensured that only clean healthy plants were introduced to the growing system and helped avoid the introduction of pest and disease.

Identification guides

Two identification guides were produced for growers. The pictorial guide produced by Dr Paul Horne of IPM Technologies is provided in Appendix 2. A visual representation of the field guide produced by Michele Buntain (TIA) is provided in Appendix 3.

Publications and extension information

The strawberry bug workshop was promoted with a fact sheet (Appendix 4) available at

- Fruit Growers Tasmania May conference (May 2014)
- Tasmanian Institute of Agriculture website
- Fruit Growers Tasmania newsletter (September 2014)
- e-news 'Berrylink'

An article describing the progress of the project was published in Fruit Growers Tasmania Spring 2014 edition (Appendix 5).

A report on the findings from the 'Strawberry IPM season review workshop' sent to all growers (Appendix 6).

A presentation on the findings of the project was delivered at Fruit Growers Tasmania Berry Night Seminar, June 2015.

Outcomes

The major outcomes of the project include:

- The mirid and lygaeid species identified as infesting Tasmanian strawberry crops are similar to those that infest Victorian crops. This means that management practices developed in one region should be applicable to the other.
- An increase in grower's knowledge and skills in integrated pest management, particularly with respect to the identification and management of bugs infesting strawberries. This has the long term benefit of reduced reliance on pesticides with concurrent social and environmental benefits.

Specimen identification

The species of bugs identified in Tasmanian strawberry crops showed a similar range of species present to those identified in a recent survey of Victorian strawberry crops, a mix of Lygaeidae and Miridae. The most common lygaeid bug identified was Rutherglen bug (*Nysius vinitor*). Crop mirid (*Sidnia kinbergi*) and other mirid species were commonly encountered in strawberry crops.

A recent Horticulture Australia Ltd project (BS13001, The effects of different species of true bugs on strawberries) investigated the types of bugs present in Victorian strawberry crops and the damage that they cause. This raised many questions about which species of bugs occur in strawberries and which of these species cause economic damage.

The Victorian trial tested the most commonly occurring bugs for their ability to cause damage to strawberries:

- Rutherglen bug - *Nysius vinitor*
- Green mirid – Creontides dilutes
- Brown mirid- Creontides pacificus
- Crop mirid – Sidnia kinbergi
- Lygaeidae spp.

The results indicated that Rutherglen bugs (*Nysius vinitor*) can cause some minor damage but species of mirid bugs (Family Miridae) usually cause severe damage. Lygaeid bugs (Family Lygaeidae) were found to cause no damage in the trials.

Samples from monitoring in Tasmania showed a similar range of species present, a mix of Lygaeidae and Miridae. This provides good evidence that management practices developed in either Victoria or Tasmania would be highly likely to be applicable to both these regions.

Preliminary Integrated Pest Management workshop

This workshop dispelled some myths that had been circulating in the industry regarding bugs in strawberries. This particularly related to which bugs and other insects are present in Tasmania and which cause damage.

A survey indicated that the workshop resulted in a significant increase in grower's knowledge and understanding of strawberry bugs and IPM with all participants indicating a positive response (Appendix 7).

Monitoring and identification skills

The major outcome of the on farm training sessions was increased grower knowledge of IPM implementation in the context of their particular farm and production system. It engaged growers and provided them with skills in the practical process of monitoring. The farm visits allowed the more experienced IPM practitioner to explore the potential for refining IPM practices and trialling innovative solutions whilst the less experienced grower was able to gain a good grasp of the basics in a 'safe' environment.

Growers knowledge, skills and practice

Participation in the project increased grower's level of knowledge and skill with respect to the identification and management of bugs in Tasmanian strawberry crops. 75% of growers who participated rated their knowledge and understanding as being average or above. All participants indicated that the project added to their knowledge and understanding of bugs that occur in Tasmanian Strawberry crops.

An example of changed behaviour as a result of this project was revealed at the review workshop. In previous seasons a particular grower had sprayed when a lygaeid bug (Rutherglen) was present in the crop. As a result of the workshop, the grower recognised that this bug caused little if any damage. This resulted in no insecticides being applied to the crop. This low intervention management was concurrent with the observation of large numbers of hoverflies and parasitism of aphids. This had the added benefit of not impacting on the integrated pest management in place for two spotted mite.

In the review workshop growers nominated what pest management option made a difference to their production during the season. Of the seven management options nominated, six of these could be classified as either cultural or biological. Although many growers (60%) indicated that pesticide use was part of their pest management strategy, the majority highlighted that pesticide use was as a spot treatment, border spray, a selective chemical or timed for minimal impact on beneficials.

Implementation of IPM

Although not measured directly, the interaction and responses of growers at the review workshop indicated a greater acceptance and much higher degree of implementation of integrated pest management in Tasmanian strawberry crops than at the start of the project. This was demonstrated in the workshop activity 'What worked well for you this season' (Appendix 6) where 90% of growers rated the introduction of biocontrols or beneficials as their most effective pest management strategy. This compared favourably to the first workshop where the imperative to produce a high pack out of fruit in a new production system showed a higher reliance and use of chemical intervention.

Evaluation and Discussion

Pre evaluation summary

An evaluation of the workshop was made using a feedback sheet which growers filled out at the conclusion of the workshop (Appendix 6). The evaluation indicated a broad range of prior knowledge and understanding of both integrated pest management and strawberry bugs amongst participants with some having very little and others having quite sophisticated knowledge and understanding. Understandably those participants with the least prior knowledge and experience made the greatest gains as a result of the the workshop. Overall, it was an overwhelmingly positive response by participants.

Post Project Evaluation Summary

A detailed report of this evaluation is provided in Appendix 8. The evaluation included:

1. A survey of participants attending the review workshop
2. A survey of growers who had little or no participation in the project

All growers rated pest management as important or very important to their strawberry operation. The majority of growers actively implemented an integrated pest management program or in some cases passively through minimal intervention. Growers who participated in all project activities demonstrated a greater level of understanding and confidence in identifying and managing bugs infesting strawberries with 75% rating this as average or above. Growers who had little or no participation in the project only rated their identification skill of bugs infesting strawberries as 50% or less.

Although not measured directly, the interaction and responses of growers at the review workshop indicated a greater acceptance and much higher degree of implementation of integrated pest management in Tasmanian strawberry crops than at the start of the project. This was demonstrated in the workshop activity 'What worked well for you this season' (Appendix 6) where 90% of growers rated the introduction of biocontrols or beneficials as their most effective pest management strategy. This compared favourably to the first workshop where the imperative to produce a high pack out of fruit in a new production system showed a higher reliance on and use of chemical intervention.

Methodology appropriateness

The format of the project worked very well with the introductory workshop occurring pre-season, the monitoring training occurring early season and the review workshop occurring post season. The activities yielded excellent results and the evaluation indicated its appropriateness to the audience.

Methodology that I would alter in future projects would be the monitoring program. The reliance on growers to independently collect samples was not overly successful. Whilst all growers actively monitored their crops, collection of samples was limited to a few growers. A better system would be for a trained agronomist to assist the grower to collect samples at critical times through the season.

Industry relevance

This project has direct industry relevance. The strawberry industry in the past has suffered from bad publicity due to pesticide residues in fruit. The active implementation of IPM by strawberry growers when faced by a potential new pest has positive implications for the industry, for human health, the sustainability of the production system and the environment.

Recommendations

The following recommendations have been developed through discussion with growers throughout this project.

Recommended study and or demonstration of future integrated pest management techniques for strawberries:

- Catch crops such as lucerne for mirid and bug management
- commercial use of light traps outside the strawberry production area
- border sprays
- suitable shelter belts to encourage natural predators
- alternative interrow and end of row plantings as shelter and bank crops for predators eg alyssum for orius
- humidity management for fruit quality and biocontrol establishment
- biological aphid control

Scientific Refereed Publications

None to report

Intellectual Property/Commercialisation

No commercial IP generated.

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Industry participants, for their enthusiasm and contributions

- Craig Morris, Troy Ayers, Matt Morris
- Simon Dornauf
- Nick King, Marius Boarta,
- Sophie Nichols
- Andrew Terry
- Roly Mackinnon, Flynn Ruddick
- Dennis Betts
- Rebecca Clarkson, Kalia Cameron, Erik
- Sally Kershaw, Jason Barnes

Dean Metcalf from Metcalf Biocontrol for workshop presentation on botrytis management

Suppliers of biocontrol agents and materials for workshops

- Bioworks, Matthew Parker
- Biomite, Paul Jones
- Bugs for bugs, Wes Allen

Denis Crawford, Graphic Science for beautiful images for bug identification cards

Appendices

Appendix 1: Strawberry bug workshop summary

Appendix 2: Pictorial identification guide

Appendix 3: Field guide to pests and beneficial insects and mites

Appendix 4: Fact sheet 'Strawberry Bugs'

Appendix 5: Article 'Strawberry bugs, good guys and bad guys

Appendix 6: Strawberry IPM season review report

Appendix 7: Strawberry bug workshop evaluation

Appendix 8: Post project evaluation

Appendix 1: Strawberry bug workshop summary

Notes from Strawberry Bug IPM workshop

Conducted by Dr Paul Horne (IPM technologies)

Elizabeth Town, 31 July 2014

Beneficials and predators

These can be either commercially available for release or naturally occurring. They can be insects, mites, fungi, nematodes or viruses.

Check your consignment

- Important that you check your consignment to make sure your beneficials arrive in good health i.e. not dead
- High temperature/low humidity in summer through the supply chain, including at release, can kill off your beneficials before they get to work for you
- No or very low humidity is particularly bad for P. persimilis (2 spot predator). Transport in vermiculite is more risky in summer.

Releasing beneficials in strawberries

Question: when is the best release time for predatory mites (P. persimilis)?

Most beneficials (insects/fungi/nematodes) require time to establish and bring down pest populations so that an immediate effect is not evident. Two exceptions to this are Montdorensis (thrip larvae predator) and Trichogramma (moth egg parasite, e.g. light brown apple moth, loopers, diamondback, heliothis) which have an immediate impact.

Most growers agreed late October/ early November was the ideal time for introducing the predatory mite persimilis as an inoculant beneficial, but this was site specific. A good guide was when no further frosts were expected.

Release of *P. persimilis* on table top strawberries requires more care as it is a drier environment. Table top growers add humidity through mist to encourage establishment. Table tops also are less likely to have a continuous or touching canopy early in the season so that even distribution up and down the rows was considered important. Distribution could start or be more concentrated at doorways where more likely for 2-spot to establish first but even distribution on every row is important.

Trimming of strawberries in mid-summer also offers a challenge to P.persimilis as much of their canopy cover is removed and humidity is reduced. Releasing at this time would be challenging.

Dust

Dust is more detrimental to predators than pests. It is an irritant and can seriously impact on beneficial populations.

Shelter belt plants as natural predator hosts

The aim is not to provide a nice sanctuary for your pest. Pests tend to prefer introduced plants and natural predators are generally adapted to native plants. The preferred plants to have around your crop to encourage natural predators are flowering natives.

Sulfur

Rate and timing of application is important. This is damaging at 6kg/ha but safer at 2 kg/ha.

Repellents vs attractants:

Question: Is it useful to use compost or inter row substrate such as poppy mulch that could potentially repel pests?

Caution was raised about making sure that you are not providing a food source or comfy habitat for pests. However, the use of composts is generally beneficial.

Chemical persistence, protected cultivation and beneficials

Pesticides that disrupt beneficial populations can be an option if used appropriately. However, things to consider include:

- Are there many life stages of the beneficial present? There will be a faster recovery of beneficial insects if more life stages are present to begin with (eggs, larvae, nymphs etc)
- Pesticides have a longer residual life when not exposed to natural rainfall or UV. This is the case for poly tunnel production. This is an important consideration when reintroducing beneficials as the pesticide will have a longer residual life;
- A pesticide used once is less disruptive than multiple applications. When a pesticide is used consecutively then it increases the residual life and also knocks out more life stages of beneficial insects;
- Timing of application is a useful tool. For example an end of season 'clean up' spray can be useful in some circumstances but can be very disruptive in other circumstances.

Fertilisers and pests:

Does plant nutrition impact on pest infestation/damage? Are they less attractive at different nutrition status?

Not a lot is known about this.

Thrips

Thrips can be pests or predators of pests. The quickest way to check if your thrip is a goodie or a baddie is to check to see if it has a tube at its rear end. This is the predatory tubular black thrip, a predator of western flower thrips and other thrips. When juvenile, this thrip is bright red and looks like a mini chili.

Study of thrips on strawberries in Victoria:

150 adult onion and plague thrips/flower were 'caged' on a number of Albion strawberry flowers. The fruit produced was assessed for damage. Only minor damage at most was observed.

Questions:

1. Are thrip juveniles responsible for the damage? Maybe the wrong life-stage to replicate damage was present on the flower (just adults)? Maybe adults are in dispersal/ mating phase not eating phase. Maybe no damaging life stage of thrip was present during critical stage of floral development/fruit set? Would the result have been different if another life stage had been caged on the flower? Anecdotal evidence from growers who have ceased thrip chemical management has found no increase in thrip damage.
2. Was the strawberry variety used (Albion) indicative of most strawberry varieties or was it less sensitive to thrip damage than other varieties?

Western Flower Thrip:

Are WFT resident in Tasmania and what is the risk to tunnel and outdoor strawberries?

Talking to Lionel Hill (DPIPWE entomologist) WFT is well established in greenhouses/glasshouses throughout Tasmania. It occasionally turns up outdoors from recently released glasshouse plants or occasionally on flowering weeds immediately adjacent to glasshouse. Establishment outside of any significance has not been encountered. Lionel mentioned that even in the Sydney basin, glasshouse growers can have significant WFT infestation but thrips can be hard to find in flowering weeds just outside the glasshouse. This reinforces the view that WFT generally is a poor competitor and may have many natural predators outdoors. In an environment which has been nuked of all natural predators with insecticide use, they are free to establish. So WFT has potential to establish in Tasmanian protected cultivation in particular where insecticide use has eliminated any natural or introduced predator population. Flowering white clover would probably be pretty attractive to a WFT.

Plague Thrips/Onion Thrips

Orius (minute pirate bug) is a voracious feeder on thrips larvae but is also a general predator. It likes pollen and nectar so a flowering plant is a great banker plant for this commercially available predator. Biobest have screened a number of plants to work out which ones are best for Orius. Initially a pepper plant 'black pearl' was found useful. Now the small, easily grown, long flowering plant 'sweet alyssum' (*Lobularia maritime*) has proved to be a great host for orius (see attached sheet on banker plants).

Aphids

Pesticides for managing aphids are either not working due to resistance issues (Pirimor – green peach aphid resistance) or kill predatory mites (Movento) are harmful to bees (neonictinoids) or slow to work (Chess). Increased aphid pressure is predicted with increased warming. Brown lacewings are a useful predator but green lacewings are less so.

Catch crops

These can be useful for some pests, e.g. long grass for Rutherglen bug, but timing and monitoring are critical.

Study of Bugs infesting and damaging Victorian strawberries

What options are available?

Cultural:

Trap crops such as lucerne? No data yet.

Chemical:

- Synthetic pyrethroids (SP), but these are not selective
- Organophosphate (Malathion) at half strength but residual
- Oils – again not selective
- Success-Neo: possible effects on persimilis and cucumeris

A question was raised about spraying the inter-row: This would have to be done very carefully and drift is an issue. It would also affect beneficial populations resident in inter-row.

Biological:

Predators of bugs include other bugs such as damsel bugs but none commercially available.

Which bugs caused the most damage?

Mirids

Mirids were found to be the most damaging. These include crop mirids (broken back bug) green mirids and brown mirids. They all cause similar symptoms and are managed similarly. Mirids can be distinguished from aphids by their antennae. Mirids have very stout antennae whilst aphids have slender delicate antennae. Mirid damage is caused by their toxic saliva which injects into the plant as they feed.

Mirids carry-over in 2 year old crops and breed easier than Rutherglen bugs in crops.

Lygaeids

These include Rutherglen bug, strawberry bugs. They tend to be more a contaminant or tainting issue and damage viewed from caging trials was classed as minor.

Nick commented that he had observed mirids and Rutherglen infesting at the same time.

Damage symptoms on strawberries and level of tolerance:

There are multiple causes of distortion/malformation in strawberries including bug damage. This might be mildew or poor pollination. The degree of damage (% of crop or % of strawberry) that is acceptable is up to individual business but must be weighed up against the potential for uncontrollable levels of pests due to IPM failure.

Predicting bug infestations:

Drying off of surrounding vegetation and northerly winds were key predictors of bug infestation.

Other discussion

Commercial supply of new beneficials

There is potential to develop fungi for aphid management but cost and likely demand will drive this.

Commercial development is dependent on supply and demand/chicken and egg! If a suitable beneficial fungi is found then factors such as cost of rearing and commercial demand will determine if it is a viable proposition for a biocontrol company.

The quarantine restrictions on entry to Tasmania are governed by the Animal control act and beneficials that are allowed in can be accessed from this site:

http://dpipwe.tas.gov.au/biosecurity/quarantine-tasmania/importing-animals/unrestricted-entry

New beneficials would have to be approved through Rod Andrewartha (Chief Quarantine officer). This is often done in consultation with Nature conservation department.

Pest	Beneficials	Cultural	Chemical (support)
2 Spotted mite ***T. urticae***	• P.persimilis (c) • Californicus (c) more tolerant of pesticides than persimilis • Stethorus (n)	Prefer humidity; keep humidity up, temperature down, micro mist.	• Milbenknock= softest • Acramite -= resistance • Vertimec – use early only
WFT **(western flower thrip)**	• Cucumeris (c) • Montdorensis (c) – less persistent • Hypoapsis (c) • Orius (c)	Lure-M (sticky trap) inside glasshouses or tunnels only	Develops resistance very quickly
Plague/Onion thrips	• Orius (c) general predator • Montdorensis (c) used as a bio insecticide	• Trap crop – cosmos? • Bank crops (Orius) - alyssum	• Be careful under plastic • Success neo + sugar – will kill beneficials • Timing is important, apply when 2-spot under control
Mirids and other bugs	• Nabid bud *Nabis kinbergi* (n) eat larvae • Damsel bug(n) eat nymphs	**Alternatives:** • Mozzie zappers for small areas • Mercury vapour lights on one side to draw bugs away not into crop • Trap crop – Knott grass • Bug vac's – but not selective	**All non selective** • Maldison • Bug master(carbaryl) • Chlorpyrifos as an end of season clean up • Potential new chemistry coming from DuPont
Aphids	• Aphidius wasp (c) • Hover flies (n) • Ladybirds (n) • Brown lacewing (n)	• Hoverflies love cloches and are really useful early in spring • Weed control is important	• Pirimor – does it work? Volatile – fumigates aphids and only knocks out a proportion of wasps • Transform – 2 applications maximum – is disruptive and an end of season only option

(c) = commercially available

(n) = not commercially available

Pest	Beneficial	Cultural	Chemical (Support)
Heliothis • ***Punctigera (early)*** • ***Armigera (on warm winds)*** **Loopers**	• Damsel bugs • Trichogramma wasps (c) but need correct species, only attack eggs		BT, (dipel) great for loopers but not armigera Vivus (virus) Success
Crickets/Grasshoppers		Control dry grass, use perimeter baiting - bran flakes and lorsban	
Black vine weevil	Nematodes (c) must be >16°C and grubs must be big		
Portuguese millipede		Like organic matter	
Slugs and snails		Baiting: Multiguard (Iron chelate) is safest; metaldehyde (not so disruptive)	
Earwigs		Potential for pheromone baiting	Insecticide bait traps

(c) = commercially available

(n) = not commercially available

Appendix 2: ID Guide for mirids and lygaeids

Mirids and Lygaeids

Both these groups are families of true bugs (Hemiptera – sucking insects), Miridae and Lygaeidae.

Mirids are the ones to be concerned about in strawberry production as they cause distorted berries. In Europe these are often referred to as "capsids". Lygaeids do not cause the same level of damage and do not generally require control with insecticides.

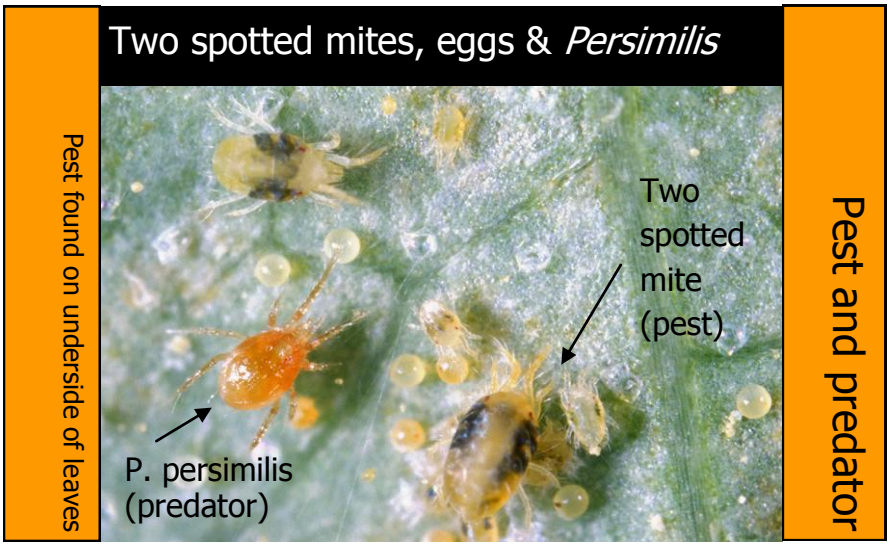
Mirid Nymph

Mirid Adult

Lygaeid Nymph

Lygaeid Adult

Appendix 3: IPM Field Guide cards for strawberries



Phytoseiulis **persimilis**—Commerical PREDATOR

- Check the **health** of your predator consignment
- Maintain **good humidity** (60%+) or canopy cover at release
- Distribute evenly up **every row** and concentrate in hotspots or doorways
- At optimum temperature **25°C** persimilis will multiply twice as fast as 2 spotted mites
- *Neoseiulus* ***californicus*** is an alternative predator in difficult conditions

Mirid nymph

Pest
deforms fruit by sucking

Adult mirid or broken back bug

Pest
fast moving found in top of canopy

Lygaeid bug - nymph

Minor pest or contaminant

Often found under plastic

Keep crop weed free

Lygaeid bug - adult

Contaminant—minor damage

fast moving, moves in when surrounding vegetation dries

Damsel bug or nabid

Beneficial insect

eats mirid nymphs & larvae

Encouraging natural PREDATORS

- **Plant** low maintenance **grass** at ends and between rows to provide unsprayed **habitat**
- **Remove broad leaf weeds** especially cape weed and wireweed
- **Reduce dust** by keeping roadways gravelled and edges grassed

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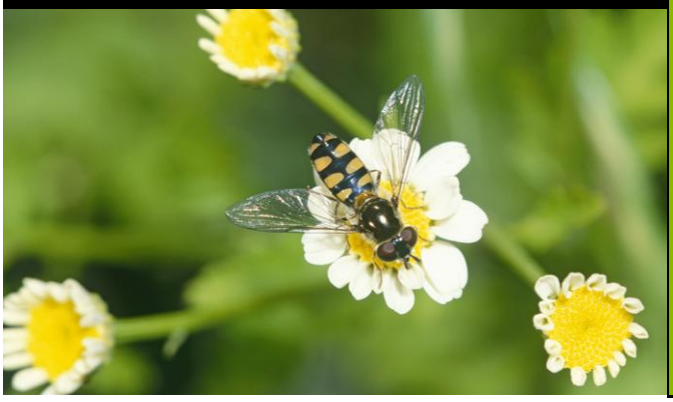
Beneficial insect (natural) eats aphids

Brown lacewing larvae

Brown lacewing adult

Beneficial insect (natural) larvae eats aphids

Hoverfly adult



Beneficial insect (natural)
eats aphids

Hoverfly larvae

Beneficial insect (natural)
eats aphids

Ladybird beetle larvae

Beneficial insect
naturally occurring eats

Beneficial insect

naturally occurring, eats aphids

Ladybird beetle

Aphids

Pest

Found on underside of leaves

Rutherglen bug

Contaminant - low level damage - found scurrying around base of plant and foliage

Aphidius wasp adult

Beneficial insect commercial & naturally occurring - parasitizes

Aphids parasitized by Aphidius wasp

Beneficial insect parasitizes aphids

Hypoapsis mite

Beneficial mite (commercial) eats thrips

Orius—minute pirate bug

Beneficial insect (commercial)
eats thrips, pollen and nectar

Plague thrip

Pest—found on flowers
Can blow in on hot northerly winds
when surrounding vegetation dries

Western flower thrip

Pest - difficult to distinguish
from plague thrips

Appendix 4: Strawberry Bug Fact Sheet

Strawberry bugs

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In recent seasons, strawberry bugs have caused havoc in in both Victorian and Tasmanian strawberry crops. This has prompted investigation into which bugs cause damage, what type of damage they cause and potential management strategies to deal with them. The aim is to prevent kneejerk spraying, protect beneficial insects and produce excellent fruit. Growers have worked hard to establish integrated management of some serious strawberry pests including western flower thrips and two spotted mites. This project, supported by Horticulture Australia and Strawberries Australia, aims to protect this achievement.

What's being done

In Victoria, Dr Paul Horne of IPM Technologies is investigating damage caused by 4 of the most commonly found true bug species in strawberry crops. These include Rutherglen bug, crop mirids and two species of Lygus or *lygaeidae*. The bugs are currently being collected from crops and caged on Albion strawberries plants to induce damage symptoms. Photos of the bugs and the damage they cause will be used to produce a 'Grower Guide'.

Figure 1 Damage caused by strawberry bugs

What's happening in Tasmania

A complementary strawberry bug investigation will run in Tasmania in 2014/15.

Growers workshop

A workshop with Paul Horne for interested strawberry growers is planned for July in Tasmania. This workshop will cover the principles of Integrated Pest Management, strawberry bug identification with specimens, discussion of management options for different strawberry pests and reporting on the findings from the Victorian strawberry bug investigation.

Monitoring for strawberry bugs

Participating growers have the opportunity to monitor and collect bugs from their strawberry crops in the 2014/15 season. Assistance with materials, monitoring protocols and identification of bugs will be provided.

How to get involved

If you would like to participate in the workshop or the monitoring program or would just like to find out the results from this investigation, please contact me:

Contact:
Michele Buntain
Perennial Horticulture Centre
Tasmanian Institute of Agriculture
michele.buntain@utas.edu.au
62336814 / 0429 957 975

HAL Horticulture Australia

UNIVERSITY of TASMANIA

TIA is a joint venture between the University of Tasmania and the Tasmanian Government

Tasmanian Government

Bugs that could be in your strawberries

TASMANIAN INSTITUTE OF AGRICULTURE

Broken back bug

Taylorligus spp

Broken back bug

Taylorligus pallidus

Strawberry bug

Euander lacertosus

Mirid, Potato mirid, Potato bug

Clostertomus norvegicus

Green mirid bug

Creontiades dilutes

Apple Dimpling bug, Yellow mirid

Campylomma liebknechti

Rutherglen bug

Nysius vinitor

Tarnished plant bug, lygus

Lygus lineolaris

NOT IN AUSTRALIA

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Appendix 5: Article, Fruit Growers Tasmania

Strawberry bugs, good guys and bad guys

Michele Buntain

Tasmanian strawberry growers braved extreme wind conditions to take part in the 'Strawberry Bug Workshop'.

The workshop brought together the expertise and experience of growers and IPM specialist Dr Paul Horne (IPM Technologies). We sadly missed a few growers as wild winds threatened to transform their strawberry tunnels into an expensive display of twisted metal and plastic.

A case for Integrated Pest Management in strawberries

The overriding message of the workshop was 'minimise harm to beneficial organisms to minimise the impact of pests' or 'look after the good guys'. A classic tale from recent history is the story of Western Flower Thrip (WFT) management in Victorian strawberries. In 2008 the Victorian strawberry industry was in crisis. Growers were spraying multiple times with multiple insecticides in an effort to manage WFT. Pesticide residues were picked up in fruit and WFT was resistant to most insecticides. The IPM specialists were called in and after a nervous start WFT is now well managed by IPM. With almost 100% uptake of IPM for WFT management by Victorian strawberry growers, the strategies have proven very effective. This has involved a combination of re-evaluating damage thresholds, monitoring and implementing IPM strategies such as

- reduced use of broad spectrum, persistent insecticides
- biocontrol with the introduction of commercially available predators including predatory mites (*T. montdorensis, N. cucumeris, Hypoapsis*) and the predatory bug Orius.
- conserving natural predators including the black tubular thrip

What is the risk of WFT to strawberry growers in Tasmania?

WFT is well established in greenhouses/glasshouses throughout Tasmania. It occasionally turns up outdoors from recently released glasshouse plants or occasionally on flowering weeds including clover immediately adjacent to glasshouse. Establishment outside of any significance has not been encountered. According to DPIPWE entomologist, Lionel Hill, even in the Sydney basin, glasshouse growers can have significant WFT infestation whilst it is hard to detect in flowering weeds just outside the glasshouse. This reinforces the view that WFT generally is a poor competitor and may have many natural predators outdoors. In an environment which has been nuked of all natural predators by liberal insecticide use, they are free to establish. So WFT has potential to establish in Tasmania under protected cultivation, particularly where insecticide use has eliminated predator populations.

Bugs in strawberries

With growers opting to use softer more selective insecticides, there has been a resurgence of bugs threatening strawberry quality and fruit production. The main thrust of the workshop was to find out which bugs are the really bad guys in strawberry cultivation and what options are available to manage these. IPM Technologies conducted trials in the 2013/14 season where bugs and thrips were caged on developing Albion strawberry flowers.

The mirid family of bugs proved to be the most damaging to strawberries. These include crop mirids (broken back bug) green mirids and brown mirids. They all cause similar symptoms and are managed in a similar way. Mirids can be distinguished from aphids by their stout antennae. Mirids inject toxic saliva as they feed, causing deformation and often blackening of the plant tissue. Low numbers can cause significant damage. Mirids will carry over in 2 year old crops and breed easier than Rutherglen bugs in crops.

The other bug family of concern, the Lygaeids, includes prime suspects Rutherglen bug and strawberry bug (Euander). These bugs were found to cause only minor damage to strawberries but have an undesirable impact as a contaminant and taint to strawberries.

Growers discussed how infestations often correlated with drying off of surrounding vegetation and hot northerly winds. However, infestations can be sporadic and unpredictable.

Management options are currently limited as no commercial biocontrol agents are available and insecticides currently registered are non-selective. However, bug management could be tackled through a number of combined strategies that included:

- *Encouraging natural predators:* Use native plants in preference to introduced plants as buffers around the strawberry operation. The Nabid bug (*Nabis kinbergi*) is a voracious consumer of bug larvae and damsel bugs love to eat bug nymphs.
- *Using trap crops:* This can be risky and involves planting something more attractive to the bug than strawberries that can be managed separately, eg knotgrass
- *Monitoring:* Mirids can be tricky to monitor, they move fast and drop easily and they occur sporadically. Tapping plants onto a yellow or white tray is a useful technique
- *Pesticides:* Only apply when infestation and damage potential is confirmed. This option works best when other pests such as mites, thrips and aphids are well controlled by IPM and potential for predators to recover is high. New more selective chemistry with potential for use on mirids is being developed
- *Novel alternatives:* Glasshouse growers have used lights to attract bugs away from their crop or mozzie zappers

The workshop highlighted a range of IPM strategies and techniques and growers had the opportunity to inspect specimens of pests, beneficial insects and mites. The next phase of this project involves monitoring bugs in Tasmanian strawberries over the coming season. This will help determine which bugs are most problematic in Tasmanian strawberry crops and how their management can be integrated with other pest management strategies.

Contact:

Michele Buntain
Perennial Horticulture Centre
Tasmanian Institute of Agriculture
michele.buntain@utas.edu.au

Appendix 6: Strawberry Season Review Workshop

Strawberry IPM

'Season Review'

Thursday 25th June

Elizabeth Town Café

10:00 am till 2 pm

Major pest management challenge

Participants listed more than one pest challenge. These were rated by the order of their listing. The first most important was given a score of 3, the second a score of 2 and the third a score of 1 to give an overall rating of the pest (Figure 2).

Pest	Most important	2nd most important	3rd most important
Two spotted mites	6		
Aphids	0	4	1
Thrips	1	1	1
Lygaeid	0	2	
Black millipede	1		

Table 1: Grower rating of pest management challenges in Tasmanian strawberry crops 2014/15

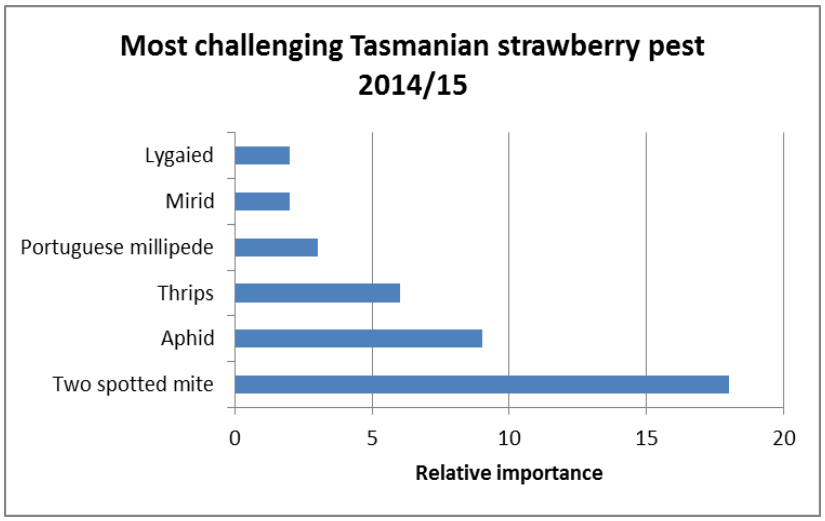


Figure 2: Grower rating of the relative importance of pests in Tasmanian strawberry crops 2014/15

What worked well? Effective management options

1. *Introduction of beneficials*

90% of growers rated the introduction of biocontrols or beneficials, primarily *Phytoseiulis persimilis* 'persimilis' as their most effective management strategy (Figure 2). Hypoapsis mite, aphidius wasp and orius bug were also effective as introduced biocontrol agents. One grower noted that naturally occurring hoverflies were effective in assisting aphid management.

2. *Timing of introduction of beneficials*

30% of growers found that introducing biocontrols/beneficial organisms at the correct time to their strawberry crop as having a positive impact on pest management. Scouting was included as a management technique that helped achieve good pest management through correct timing of either biocontrol agents or plant protection products.

3. Health of biocontrol agents

20% of growers highlighted the importance of checking the health status of beneficials prior to release in achieving good pest management results.

4. *Weed control*

20% of growers rated weed management as an effective pest management option by removing a preferred habitat and breeding site for pests. The removal of wireweed (*Polyganum spp*) was important.

5. Humidity management

Grass plantings between rows and tunnel ventilation were used effectively to manage humidity. One grower noted a "dramatic" improvement in biocontrol establishment and survival with better humidity management.

6. *Pesticide use*

60% of growers used targeted well timed pesticide as an effective management strategy. The majority rated perimeter or spot application of pesticide as the effective strategy rather than an overall crop spray. Pesticide use was primarily targeted at aphids (pirimor), perimeter spraying of mirids and minimal or spot use of acaricide for two spotted mites.

7. Runner inspection

One grower noted that runner inspection was a management strategy that worked well. This hygiene check ensured that only clean healthy plants were introduced to the growing system and helped avoid the introduction of pest and disease.

Outcomes

Major pest management challenge

Lygaeid bugs were present in relatively high numbers as a resident in one strawberry crop. Chemical treatment was not pursued by the grower based on information from the first workshop and farm visits. The grower reported that lygaeid bugs were a nuisance but not damaging to strawberry plants or fruit. This low intervention management was concurrent with the observation of large numbers of hoverflies and parasitism of aphids.

Pest management changed during the season with different pests being dominant at different times. One grower (tunnel strawberries) reported two spotted mites were an issue early in the season with aphids coming in mid-season. In an outdoor uncovered crop, the reverse was true with two spotted mites requiring management intervention only late in the season.

What worked, effective management options

Of the seven categories of management options that growers nominated as 'what worked well', six of these could be classified as either cultural or biological. Although many growers (60%) indicated that pesticide use was part of their pest management strategy, the majority highlighted that pesticide use was as a spot treatment, border spray, a selective chemical or timed for minimal impact on beneficials.

What's next? Future management strategies

Dr Paul Horne (IPM technologies) led a discussion of future management options for strawberry pests.

Two spotted mites:

Fine tuning predator release was discussed. This included

- Targeting release by introducing predators to hotspots vs over the entire crop and let natural spread
- Timing release so that there is a food source available
- Ensuring conditions at release were conducive to predator survival – including coverage provided by foliage, maintain humidity by closing tunnels during establishment
- Quality of biocontrol: Inspecting predators on arrival to ensure viability
- The

Thrips:

Western Flower Thrips is an inevitable pest in Tasmania. By encouraging natural predators by reduced chemical intervention, management will be much simpler and cheaper. The options for biocontrol include *Cucumeris* mite and *orius (*Minute pirate bug*)*. Outdoor beneficials were considered just as important as introduced beneficials and much cheaper.

Aphids:

Whilst there are currently a range of beneficial insects available, a fungus from Qld company Biogrow has potential as a new management option for aphids. Humidity control would be important to establish this. Movento is a new chemical option but is potentially toxic to persimilis

Mirids

The first and best management strategy is to correctly identify the presence of mirids and to be able to distinguish these from lygaeid bugs and prevent unnecessary chemical intervention. Options for management include

- Trap crop such as lucerne which is attractive to the mirid. This is monitored and managed when any mirid is present.
- Light traps on outside of strawberry production area
- Border sprays to control prior to entry into the strawberry production area.
- Weed control: managing particularly broad leave weeds in the strawberry production area is very important. Wireweed is highly favoured by a number of pests including mirids.

Lygaeid bugs

The best option is to ignore these unless causing significant contamination. Options for management could be the same as for mirids.

Encouraging natural populations of beneficial insects

Grass planting at the end of rows is a method of providing habitat and breeding refuge for beneficial insects, particularly hoverflies.

Appendix 7: Strawberry Workshop Evaluation

Event Evaluation

Strawberry bug IPM workshop

ETC Elizabeth Town, July 31, 2014.

Thank you for completing this evaluation. It will help us organise future events to better suit your needs.

Please tell us about yourself. Please tick boxes that apply if you are comfortable doing so.

Strawberry grower	8	Industry representative	1
Agronomist – service provider	1	Other	2

How would you rate your knowledge/understanding of strawberry bugs before this workshop?

Knowledge and understanding of strawberry bugs prior to the workshop ranged from none (25%) to very good (17%). The average rating for knowledge and understanding of strawberry bugs prior to the workshop was 51%, (0% rated as none to 100% rated as excellent)

To what extent did this event add to your current knowledge/understanding of strawberry bugs?

All participants but one believed the event added greatly or better to their understanding of strawberry bugs. One participant believed the event added slightly to their understanding of strawberry bugs. The average rating of the extent to which the event added to current knowledge and understanding of strawberry bugs was 81%. (0% rated as none to 100% rated as blew my mind)

How would you rate your knowledge/understanding of strawberry IPM before this workshop?

Knowledge and understanding of IPM prior to the workshop ranged from none (8%) to very good (17%). The average rating for knowledge and understanding of strawberry bugs prior to the workshop was 48%, (0% rated as none to 100% rated as excellent).

To what extent did this event add to your knowledge/understanding of strawberry IPM?

All growers believed the event increased their knowledge and understanding of strawberry IPM to some extent. The majority of growers believed the event added greatly or better to their knowledge and understanding of strawberry IPM (84%). The average rating of the extent to which the event added to participant's knowledge and understanding of strawberry IPM was 75%. (0% rated as none to 100% rated as blew my mind).

How satisfied were you with the information and feedback you received during the workshop?

Only one participant was neither satisfied nor dissatisfied with the information and feedback during the workshop. The majority of participants (83%) were very satisfied or better with the information and feedback during the event. The average rating to how satisfied participants were with the information and feedback received during the event was 90% (0% rated as completely unsatisfied and 100% rated as extremely satisfied)

What did you find most useful from the workshop?

Networking

- Networking/Interaction with industry people
- Listening to growers talk about their problems / Discussion amongst all the growers/Hearing grower issues

Information on research and techniques

- Research feedback / Bugs project
- New information/New technology and improvements of old technology and information
- How to fix FR017 issues
- Opportunity to consider the possibilities of better management/learning of possible options to trial for new methods of controlling insects such as attractants or repellents and parasitic fungi

Pest specific

- Problems that fruit growers have with pests
- Information on pests
- Thrip information

What did you find least useful about the workshop?

- Nothing
- The weather
- Verbal information

Please make any comments about this workshop and/or the strawberry bug IPM project here

- Keep it up – happy to fund continuation of the project
- Was great to gain new info
- It's good to be able to discuss practices with other growers to all learn from each other
- In terms of the project it is good to clarify which bugs actually do what
- Great information for new growers and young agronomists in the industry

Would you like to participate in future TIA berry projects?

Yes	12	No	**0**

THANK YOU ☺

Please return your completed form to

Michele Buntain, Tasmanian Institute of Agriculture, 13 St Johns Ave, New Town, TAS 7008;

Phone: 0429 957 975 |email: michele.buntain@utas.edu.au

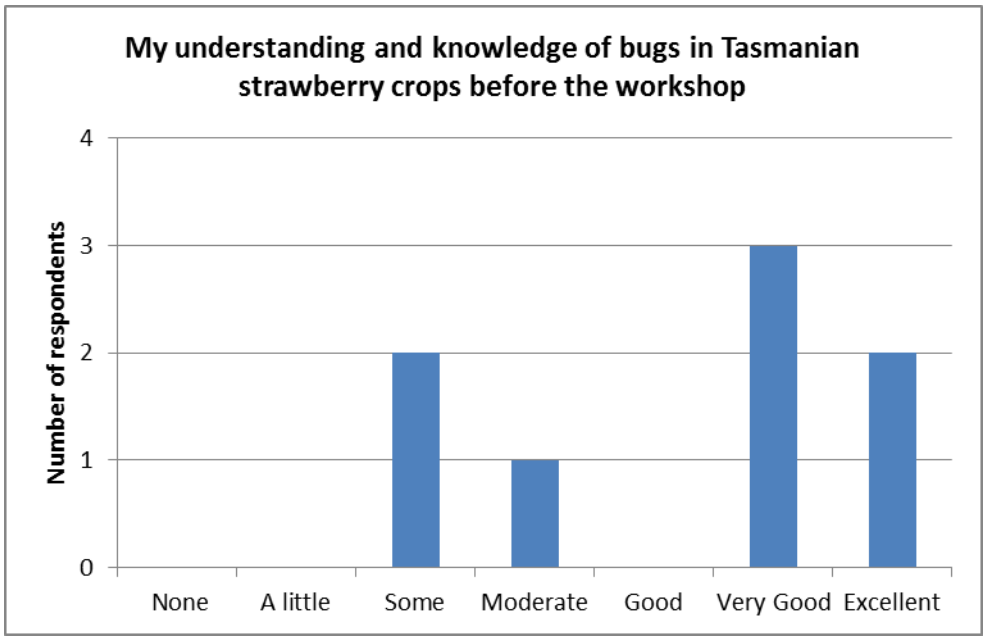
Appendix 8: Post Project evaluation

Survey of growers who attended the review workshop

The aim of this survey was to gauge how the level of knowledge, understanding and attitudes of participating growers had changed over the course of the project. The participants were involved in the monitoring and observations throughout the project, had attended the first workshop and /or the farm visits.

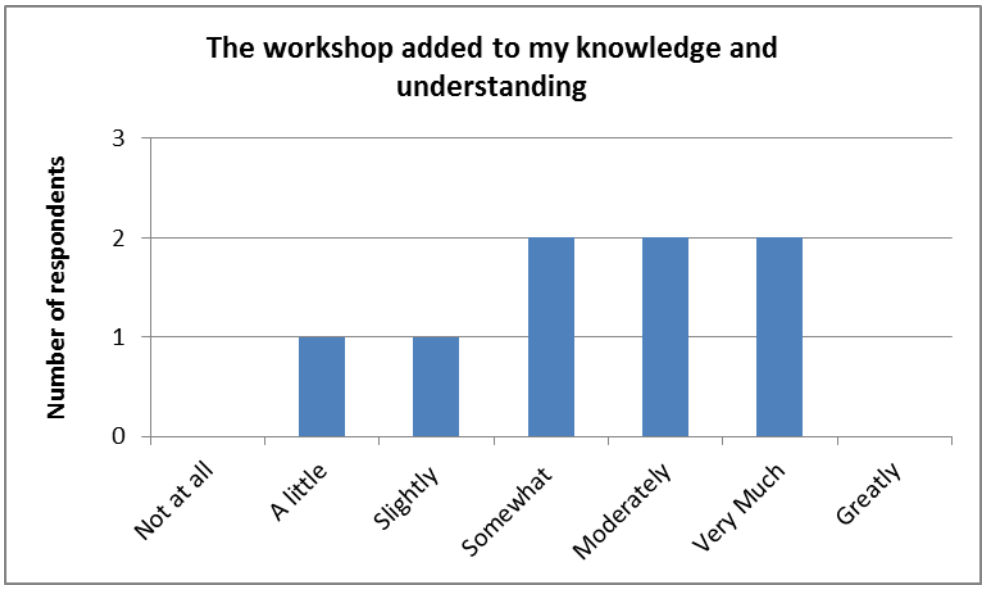
Before this workshop, how would you rate your knowledge/understanding of bugs that infest Tasmanian strawberry crops?

There was a wide range of how participants rated their knowledge and understanding of bugs that infest Tasmanian strawberry crops from 'a little' through to 'excellent'. The majority of growers rated their knowledge and understanding as being average or above (75%), Figure 1. This compared favourably to the first workshop where only 50% of growers rated their knowledge and understanding of bugs as average or above, none rating higher than good and with 25% having no knowledge of bugs that infest Tasmanian strawberry crops.



To what extent did this event add to your knowledge/understanding of bugs that occur in Tasmanian strawberry crops?

The majority of participants indicated that the event added to their knowledge and understanding of bugs that occur in Tasmanian Strawberry crops (75%). This ranged from '*somewhat*' to '*greatly*' with 63% scoring this at '*very much*' to '*greatly*' increased their knowledge and understanding. Two participants indicated that their knowledge and understanding increased '*only a little*' (25%).



All participants indicated they had an opportunity to contribute and participate with the majority indicating that they were able to participate '*very much*' or '*greatly*' (75%).

What did you find most useful from the workshop?

- Discussion of management options, new up and coming management methods Throwing around ideas and having Paul Horne refine our understanding of how new management methods may or may not work Discussion of issues and what other growers have had success with in the past season, different approaches to common problems (5 respondents)
- Fungal control science, Trichoderma research (3 respondents)
- New biological controls (1 respondent)
- Identification pictures (1 respondent)
- All of it! (1 respondent)

Although not measured directly, the interaction and responses of growers at the review workshop indicated a greater acceptance and much higher degree of implementation of integrated pest management in Tasmanian strawberry crops than at the start of the project. This was demonstrated in the workshop activity 'What worked well for you this season' (Appendix 2) where 90% of growers rated the introduction of biocontrols or beneficials as their most effective pest management strategy.

Survey of growers who had little or no involvement with the project

Three growers with a little or no involvement in the project were interviewed to determine

1. their level of knowledge of bugs and their management in strawberries; and
2. their attitude to pest management in strawberries

The participation of the three growers in the strawberry bug project (workshops x 2 and monitoring) was limited by conflicting business commitments at the time of the events. The growers indicated that they would have liked to have been more involved. The growers included a diverse range of operations from a large outdoor/in soil operation, a medium size substrate culture tunnel operation and a small pick-your-own soil grown operation.

The growers rated pest management, bug management and the use of IPM as important or very important to their strawberry management operation. One grower indicated that although pest management was important, disease management was slightly more important.

All growers indicated that they would only be somewhat confident in distinguishing a lygaeid bug from a mirid bug. One grower indicated that he would be reliant on his farm manager or advisor to be responsible for this.

The growers rated which pests were the most significant in terms of management effort to their strawberry operation.

Grower	Pest 1	Pest 2	Pest 3
1	Two spotted mite	Mirids	Aphids
2	Birds	Mirids	Millipedes
3	Two spotted mite	Mirids	

The larger scale operations selling punnet fruit to fresh market were most concerned with two spotted mite and mirids. The pick your own operation was least concerned by pests but had suffered fruit deformity which they believed to be mirid damage. Mirids as a pest were rated second most significant by all growers.

Comparison of non-workshop participants to workshop participants

All growers acknowledged the importance of pest management to their strawberry operation. The majority of growers actively implemented an integrated pest management program or in some cases passively through minimal intervention. Growers who participated in all project activities demonstrated a greater level of understanding and confidence in identifying and managing bugs infesting strawberries.