

Final Report

An Integrated Pest, Disease and Weed Management Program for the Australian Apple and Pear Industry

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Agriculture Victoria, Department of Jobs Precincts and regions

Project code:

AP16007

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Summary

The project was initiated after a review into the status of Integrated Pest Management (IPM) in the Australian Apple and Pear Industry found that, while there was a high level of awareness of IPM and the tools required for growers to use IPM effectively were available, grower and advisor confidence in IPM could be improved by developing a better understanding of, and gaining experience with, the integration process.

The project aimed to assist the apple and pear industry by improving the ability and capacity of orchardists to develop and sustain a pest resilient farming system. A team of experts with knowledge of each growing region was assembled to review the existing IPM manual and provide region specific guidelines and training to engage growers and advisors. The revised manual, re-badged as an IPDM manual in recognition of the increased focus of integrating disease management, has a greater focus on the integration of management practices through timely monitoring and management of pests, diseases, and weeds. Regional differences in pest and disease issues were taken into consideration, and information on potential impacts of exotic incursions was provided. The short-term outcome of the project that the industry has access to current knowledge of tools and systems required to implement IPDM, and a community of practice for peer support has been achieved. The revised manual is formatted to allow adaptation to suit various platforms identified by growers and advisors as their preferred methods for receiving information. Training sessions and case studies were conducted in each apple and pear growing state, and a Community of Practice (CoP) was established for sharing of experiences and knowledge. The CoP has continued operating since the completion of the project. A website containing useful tools and resources, Facebook and Twitter accounts, and the CoP are hosted on the eXtensionAUS platform developed by AgriFutures Australia in partnership with the Victorian Government and the Grains Research and Development Corporation with funding from the Australian Government Rural R&D for Profit Programme. An Ask an Expert facility provides access to national expertise to provide timely answers to questions submitted by growers, agronomists, and other service providers.

During the life of the project there was a twenty percent increase in grower and advisor knowledge and confidence in their ability to implement IPDM. Three quarters of participants were growers and service providers, including consultants and pest management scouts made up the remaining quarter.

The desired longer-term outcome, to be achieved beyond completion of the project, will be an apple and pear industry with the confidence, knowledge and skills to adopt, implement and sustain a cost-effective low-risk IPDM-based farming system resilient to changes in regulatory policy and new pest incursions that impact pest management options. Knowledge gaps associated with this longer-term outcome are being addressed in new projects funded by Hort Innovation, using the Apple and Pear research and development levy and contributions from the Australian Government.

Keywords

Apple; Pear; Integrated Pest and Disease Management; Weeds; Biosecurity; Biocontrol in orchards; Pesticide impacts on beneficial species.

Introduction

Better understanding and increased knowledge of pest, disease and weed management through IPM practices is essential for the apple and pear industry to produce high quality fruit, reduce costs, mitigate biosecurity risks, and maintain/improve market access. The Australian apple and pear industry, one of our largest horticultural industries, has producers in the eastern states from Queensland, New South Wales, Victoria and Tasmania, in South Australia and Western Australia. Victoria produces most of the national apple (45%) and pear (88%) crops. The Apple and Pear Strategic Investment Plan (2017-2021) recognized that the industry faced many challenges to remain competitive including higher input costs relative to its competitors, threats of biosecurity incursions, lack of market access into potential markets and domestic over-supply depressing prices to uneconomic levels. To reduce production costs and overcome technical challenges impacting fruit quality, safety, regulatory compliance in order to be competitive, and to maintain and grow markets, the industry needs innovation. The integration of best management practices will be critical. The Australian apple and pear industry strategy to operate in an economically sustainable way, released in 1998, resulted in development of National Integrated Fruit Production (IFP) Guidelines for Pome Fruit in Australia (Williams, 2000). These guidelines represented minimum requirements, provided flexibility to cater for regional differences, and were designed to be incorporated into existing grower quality assurance schemes. IPM was a major component of the IFP system but uptake of IFP was slow. A market segmentation study aimed at identifying impediments to adoption found that the industry grassroots generally only respond to a crisis rather than pro-actively working toward avoiding the crisis in the first place, and that interest in adoption would remain low until threats of exclusion from markets became reality (Williams 2004). Changes in availability of pesticides, spread of pests into new regions, and new market access opportunities have re-ignited industry interest in IPM.

The IPM review (AP15014) commissioned by Hort innovation to investigate use and adoption of IPM in apple and pear production concluded that, although there was a high awareness of IPM and some components were commonly practiced, adoption of true IPM was low because growers often used pesticides disruptive to biological control agents. While that is true, the commercial reality is that sometimes no other choices are available and so long as growers have knowledge of, and factor in, the impact on biological control agents and take steps to re-introduce or enhance survival of the remnant beneficial populations then they are integrating chemical and biological control strategies.

Overseas experience shows that increased understanding and adoption of IPM practices can be achieved through effective extension activities such as IPM manuals containing relevant, understandable, accessible information for IPM decision-making, combined with field activities demonstrating economic benefits of IPM. Kaine and Bewsell (2005) found, in Australian apple and pear production, that grower age, education, experience, or size of enterprise was not important but economic advantage was the primary motivation for adoption. High cost of labor is a constraint and a challenge for IPM practitioners is to develop monitoring techniques that are simplified, integrated, cost-effective, and easy to interpret. Another challenge is maintaining current knowledge of the impact of newer pesticides on the suite of biological control agents available to growers. The existing Australian IPM manual, produced in 2009, required revision to incorporate the latest and more relevant information on insect pest phenology, disease risk models and pest and disease management strategies. IPM coordinates pest and disease management activities with other orchard activities including management of weeds to achieve effective, economical, and long-term solutions to these production problems. The goal of producing good quality fruit in a cost-effective way without damaging the environment or exceeding pesticide residue limits requires an understanding that complete absence of some pests or weeds in orchards is not necessarily a good thing. Biocontrol agents need, in the absence of prey, something such as nectar or pollen to eat, and diversity contributes to resilience. All pesticides (including those approved for use on organic certified farms) are, by definition, biocides and therefore have some side effects on non-target organisms that are providing ecosystem services such as biological control. A properly implemented IPM system accounts for all interactions that occur, optimal use of appropriate tools, reduces the incidence of highly disruptive events (such as pesticide induced mite flare) and provides long-term stability and economic benefits.

Project 16007 was initiated to review, synthesise and extend current knowledge of IPM in apple and pear orchards, particularly those new to the industry, and to update the current IPM manual. The objective was to assist the industry to gain the confidence, knowledge and skills to adopt, implement and sustain a cost-effective low-risk IPM-based farming system resilient to changes in regulatory policy and new pest incursions that impact pest management options.

Methodology

1. Project Governance

Coordinators were contracted to be responsible for organizing events, coordinating case studies grower, and contributing state specific input. Agriculture Victoria provided project management services. A Monitoring and Evaluation (M&E) plan (Appendix 1) was developed using the Hort Innovation templates. The data required for project governance were identified and incorporated into the M&E plan. The project logic was based on the project submission, circulated to all team members for comment and discussion before amendments were ratified, and the final plan was lodged with Hort Innovation as part of Milestone 102.

2. Review, synthesise and extend current knowledge of IPM (arthropods, diseases, weeds) in apple and pear orchards, particularly those new to the industry.

Current levels of engagement were reviewed using on-line surveys. An initial survey to provide baseline data on current levels of grower and advisor engagement with IPDM practices, and barriers limiting uptake was designed and conducted using the web-based Survey Monkey software. The survey was available to all growers, advisors, service providers, and researchers throughout July-August 2018. Survey respondents were actively recruited via State grower associations, APAL, and at industry events as they occurred. In preparation for the survey an awareness article was published in the April/May 2018 edition of the industry journal Australian Fruit Grower. A national media release on 9 July 2018 coincided with release of the survey and followed up with another media release 2 August 2018. Questions in the survey were related to the role of the respondent, pest management practices, size of the orchard, the most important pest management issues, use of IPDM, knowledge of life cycles and ability to identify pests (arthropods, diseases and weeds) and beneficial species, and use of thresholds and phenology models. Responses were collated and supplied as an excel worksheet by Survey Monkey. A second survey, conducted at the conclusion of the project, was designed to measure any changes to levels of grower and advisor engagement with IPDM practices at an industry level. It was not possible to measure changes for individual participants because privacy policies required all responses to be anonymous. In addition, a re-organisation of government departments resulted in loss of access to Survey Monkey and Survey Gizmo became the platform of choice.

Region-specific demonstrations (case studies) were conducted in each pome fruit growing state during years two and three after the IPM manual had been reviewed and the first training workshops had been conducted for growers, agronomists, chemical resellers and pest management scouts/advisors. The limited budget precluded provision of intensive season-long hands-on training by the project team. The intention was that trainees would be matched to growers and mentored over the duration of the case study. Collection and supply of case-study data was a requirement for all participants in training courses. Farm Use Agreements specifying roles and responsibilities of the landowner and the project team were developed, based on Agriculture Victoria templates, to ensure that all parties were clear on expectations and responsibilities. Each case study involved an initial site visit and interview in which the history of the orchard, problems encountered in the past and current issues, approaches to pest management, and constraints to adoption were discussed. Potential changes to the pest management strategies and practices were workshoped and an action plan was developed to suit the aspirations of the orchardist. The action plans were kept simple, were not prescriptive but instead provided scope for the orchardist to experiment with, and adapt, new concepts in order to gain confidence in the outputs and ensure the practicality of the proposed changes.

Improving communication on benefits of implementing IPM aimed to increase grower knowledge and confidence in IPDM decision making and give advisors and consultants confidence in provision of IPDM advice to growers. will be conducted in a range of ways identified as preferred by growers in the survey conducted in year one. Access to quality information, timely response to requests for information, and practical hands-on training were identified as important requirements. Case study growers were interviewed and short videos of those growers discussing their approaches to IPDM were produced and posted on the website. Growers experienced in IPDM were also engaged in the training workshops to provide local perspective and experience. These sessions were videoed and edited for presentation on the website.

Promoting practices that facilitate 'ultra-low' residues involved communicating the importance of proper spray timing, selection of pesticides with not only low non-target effects but also short with-holding periods, and maintenance of crop hygiene and biological control agents. Since we did not have access to decay curves for any of the registered pesticides information to promote better understanding of timing, selection, and

non-target impacts of pesticides was incorporated into the IPDM manual. Insufficient funds were available to conduct residue tests, or to conduct replicated trials of different spray timing, under this project.

Coordination with Future Orchards Extension Program was a requirement of the project contract. The project team included members who also act as Future Orchards Front Line Advisors, and Ross Wilson (AgFirst) already had access to material produced from the PIPS program, that was the basis for the most recent information we were promoting, as well as utilising research team leaders in the Future Orchards program. We anticipated that at least some of the growers involved with Future Orchards would become case studies for our project and that would allow greater involvement between the two project teams.

Improving capacity of advisors to provide reliable advice was dependent on their requirements for current, easy to access information and willingness to participate in case studies. The RIRDC eXtensionAUS platform was used to establish a Community of Practice (COP) linking experts, advisors and growers. An open invitation was sent to all consultants, service providers and growers to attend training sessions conducted as workshops and orchard walks conducted in each pome fruit growing state. Consultants were also given the opportunity to be paired with a case study orchard.

Setting up a network between consultants/advisors for information sharing. Several existing options were identified. These included MyPestGuide used in WA and the well-established Horticulture Industry Network. The advantages of eXtensionAUS included its low cost, comprehensive analytics that would assist with M&E as well as identifying shifts in trends, design that supported a Community of Practice, an “Ask an Expert” facility, and ability to establish and support Facebook and Twitter accounts, youtube videos, and webinars.

3. Update the current IPM manual:

A comprehensive review of the existing IPM Manual was undertaken by the project team and involved review of previous Hort Innovation project Final Reports, national and international scientific and industry publications to identify the relevant information needed to revise the manual. The national survey of orchardists and advisors provided data on use of the existing manual and generated suggestions for enhancements. The survey also identified the range and relative importance of various media that growers and consultants use to access content from the IPM manual.

Outputs

1. **Project Logic**, accepted by Hort Innovation, with linkage to Hort Innovation and industry objectives as part of M&E plan. (Appendix 1)
2. **Six-monthly milestone reports** lodged with Hort Innovation
3. **Revised Apple and Pear IPDM manual** comprised of 8 major chapters. The first 7 chapters, and the sub-chapters in the eighth chapter each start with a summary page formatted as IPDM Quick Facts that double as an Aide-Memoire reference for developing IPDM action plans.
4. **Guide to the Pests of Pome and Stone Fruit and their Predators and Parasitoids** converted to an interactive e-publication suitable for mobile devices. The guide is available at https://extensionaus.com.au/ozapplepearipdm/home/?_sft_category=usefultools
5. **Establishment of a Community of Practice**, with established network and communication channels.

The CoP Leadership group had 11 meetings. The CoP membership base was broadened in July 2019 to include non-project members, taking the membership to 16 members. This broader CoP had 5 meetings before the project ended

Membership: Alison Mathews, WA DPIRD; Kevin Dodds, NSW DPI; Jess Fearnley, NSW DPI; Peter Nimmo / Alan McWaters, QLD DAF; Stephen Quarrell, TAS TIA; Paul James, SA Lenswood Co-op ; David Williams, VIC DJPR, Project Leader; Megan Hill, VIC DJPR, Hort Industry Development Manager; Marcel Veens, (Marcel Veens Horticultural Advisor Pty Ltd, Qld); Matthew McMahon (Batlow Fruit Co-op, Batlow NSW); Russell Fox (IKCaldwell Cobram VIC); Stuart Doyle (AgVista consultancy, Tas); Glenn Masterton (Elders Hort Agronomist Shepparton VIC) ; Paul Horne (IPM Technologies, Vic); Jess Page (IPM Technologies, Vic); Rose Daniels (APAL)

Community of Practice survey: All respondents to a short survey at the end of the project found the CoP to be 'very beneficial' or 'extremely beneficial'.

Benefits of CoP membership: Below are comments from CoP members about what they liked about being involved in the CoP:

- *Meeting people from all around the country who work in the industry, what they are researching and their areas of expertise. Having presentations on specific topics. Having a place where people working in the same industry can get together and discuss things, this doesn't usually happen unless they are working on a project together.*
- *Learn from others, extends network and can get updates on where the other regions are at.*
- *I am new to apples/ pears, so it was a useful space for me to learn, and hopefully contribute more in the future. It is also a good way to hear about what is happening in the different regions and provides a great network.*
- *It gave a good indication of the issues faced around the country*
- *You can learn a lot from the other members*

Minutes from CoP meetings demonstrate the high level of information sharing and keen interest to learn from participants. Local updates from group members on what they were seeing in orchards would often spur questions from other members, and further discussion about issues. Members would ask others to distribute photos of what they were seeing for others to learn from. Further information and clarification on how to deal with pests and diseases would be sought from the more experienced members in the group.

Guest speakers on various topics were very well received by the group and resulted in much discussion and question time. Details are available in Appendix 2.

6. **Two IPM training courses delivered in each growing state**

Date	State	Time	Location
21 Aug 2018	VIC	12:00 – 15:30	Tatura
22 Aug 2018	VIC	10:30 – 14:00	Bundoora
23 Aug 2018	TAS	09:00 – 12:30	Campbell Town
28 Aug 2018	SA	08:30 – 12:30	Lenswood
29 Aug 2018	WA	11:00 – 15:00	Balingup
30 Aug 2018	WA	11:00 - 15:00	Walliston
4 Sep 2018	NSW	13:00 – 17:00	Batlow
5 Sep 2018	NSW	13:00 – 17:00	Orange
6 Sep 2018	QLD	14:30 – 17:30	Applethorpe
11 Oct 2019	VIC	10:00 – 13:30	Yarra Junction
30 Oct 2019	WA	09:00 – 13:00	Manjimup
19 Nov 2019	QLD	09:00 – 13:00	Cottonvale
26 Nov 2019	NSW	08:00 – 12:30	Batlow
27 Nov 2019	NSW	13:00 – 16:00	Orange
2 Dec 2019	TAS	12:30 – 15:00	Geeveston
3 Dec 2019	SA	08:00 – 13:00	Ashton

Summary of workshop evaluation scores (scale 1-10). “NA” indicates questions were not asked.

Year	2018-19	2019-20
Number of participants	116	74
Orchardist	65.5%	53.0%
Service provider	21.6%	27.0%
Other participants	12.9 %	23%
Relevance all (0-10)	8.5	NA
Relevance to grower (0-10)	8.5	NA
Satisfaction all (0-10)	8.6	8.5
Satisfaction grower (0-10)	8.5	8.8
Implement IPDM all	8.8	7.8
Implement IPDM grower	8.8	8.4
Improved IPDM knowledge all	NA	8.4
Improved IPDM knowledge grower	NA	8.3
ID/diagnose all	NA	8.4
ID/diagnose grower	NA	8.6

Monitoring all	NA	8.5
Monitoring grower	NA	8.8
Recommend to others	95%	NA

7. **The Ask an Expert function** has been used to diagnose problems and interact with users by commenting and debating issues

- 13 questions have been posted and answered on the 'Ask an Expert' webpage. Three of these were posted by staff as examples, the remainder were genuine. Two questions were asked using the privacy setting and do not display on the webpage, although the user received a response. It has taken time to build up this function and lately we have seen an increase in questions being asked – both via the IPDM Facebook group and via the webpage.
- Our most popular question on the website was about 'Rutherglen bug' and received 514 views with 4 comments from CoP members and members of the public.
- Several questions have also been posted in the Facebook group and received high levels of engagement.
- As project awareness and momentum grows, we are seeing more interactions from advisors and growers, and the planned expansion of the Community of Practice will further augment this. The Ask An Expert function is also a powerful learning tool for advisors- we have seen a recent example of pear damage photos sent to the webpage, with much ensuing debate from Community of Practice members on the cause of the damage and learnings occurring from referring the questions to Agriculture Victoria plant pathologists and members being able to advance their knowledge on identifying the difference between fungal damage and frost damage, complicated by bacteria in wet weather. The Community of Practice enables industry advisors and agronomists to learn from more experienced and highly qualified experts by using real field examples.

8. **Case studies** were conducted with 8 orchardists and 2 of those were paired with advisors. The Case Study Orchard approach has great potential, but the available funding limited the amount of time regional coordinators could contribute, so more regular and detailed information could not be collected and published. Regular site visits to document IPDM implementation and learnings would require significant resourcing of IPDM specialists who could work one on one with the grower throughout the entire season. Those extra visits would also provide more opportunities to capture relevant and timely video footage of issues as they arose. The limited number of videos with case study orchardists discussing their approaches were popular and conveyed the outcomes to a wide audience – all of which also takes time in editing and publishing. If this could be achieved, it would be a powerful extension tool that many growers and advisors have expressed their enthusiasm for and desire to see.

The landing page (<https://extensionaus.com.au/ozapplepearipdm/case-study-orchards/>) for the Case Study Orchards is the 4th most popular page with 521 pageviews

Eight action plans and 24 updates have been published covering the eight case study orchards. The action plans were based the SMEACS briefing template used by emergency management agencies to brief crews deployed to an incident. Pest management is like incident management in that both have phases of prevention, detection, size up, response, and recovery. The SMEACS acronym stands for Situation, Mission, Execution, Administration, Communication, and Safety. It is a simple and concise method for prompting memory and providing structure for planning response in advance. Details of individual case study action plans are provided in Appendix 3. Case study reports were posted on the website at https://extensionaus.com.au/ozapplepearipdm/home/?sft_category=casestudyorchards.

The focus of case study updates was on:

- a. What are the main issues being addressed?
- b. What are you doing currently?
- c. What has worked well? What hasn't?
- d. What would you do differently next time?

An Example is shown here <https://extensionaus.com.au/ozapplepearipdm/case-study-update-nannup-wa-spot-spraying-spring-beetles-and-oil-spray-combats-bryobia-at-green-tip/>

Some case study updates included annotated photos to demonstrate learnings and changes over time have been published: <https://extensionaus.com.au/ozapplepearipdm/case-study-update-batlow-nsw-february-2019/>

9. Australian Apple and Pear IPDM website (extensionAus)

<https://extensionaus.com.au/ozapplepearipdm/home>

Webpage Statistics (1/12/18 to 30/9/20)

- 7,873 users
- 17,338 pageviews
- 72% of page users were in Australia
- 44% of users accessed the site using a desktop computer, 49% using a mobile phone and 6% using a tablet
- 70% of users came to site through an organic search, 19% through directly typing the URL, 9% through social media.

User Behaviour

- Average time spent on a page was 2:03min – this is high when considering many users have very short view times that reduce the average, so many are spending a fair amount of time reading the content
- Average bounce rate was 79% – this is not overly high for a content page, especially when we are using social media to link through to just one page

In 2 minutes a user is engaged with the site, reading content and interacting with the page, particularly if they have been directed to the page from social media; i.e. they are getting what they came for, rather than bouncing from the site in a few seconds, which is what happens when people do not get what they came for or find it relevant. Also, from the graphs it is evident that the engagement in the site is growing over time. The numbers show that 1,436 are staying for a minute or more, 960 are staying longer than 3 minutes which shows a high level of engagement by those people. There is a high bounce rate of 10secs or under, but that is not surprising when 80% of people finding the site from a search engine, e.g. Google search

Tools/ articles published

- 113 webpage posts categorized under headings: Pests, Diseases, Weeds, Useful Tools, Case Study Orchards, Beneficials, Ask an Expert Q&A. The website can also be sorted by State.
- 16 posts with YouTube videos.
 - Mite monitoring <https://extensionaus.com.au/ozapplepearipdm/mite-management-in-orchards/>
 - Mite monitoring- understanding cumulative leaf infested days <https://extensionaus.com.au/ozapplepearipdm/mite-management-in-orchards/>
 - Controlling mites in orchards

- <https://extensionaus.com.au/ozapplepearipdm/mite-management-in-orchards/>
- Scab ground cover management
<https://extensionaus.com.au/ozapplepearipdm/scab-management/>
- Scab early season management
<https://extensionaus.com.au/ozapplepearipdm/scab-management/>
- Mealybug management
<https://extensionaus.com.au/ozapplepearipdm/mealybug-identification-monitoring-and-control-by-natural-predators/>
- Monitoring for apple dimpling bugs and thrips
<https://extensionaus.com.au/ozapplepearipdm/useful-tool-ipdm-monitoring-guidelines/>
- Codling moth biofix and phenology model
<https://extensionaus.com.au/ozapplepearipdm/codling-moth-biofix-and-phenology-model/>
- Trapping codling moth and mating disruption
<https://extensionaus.com.au/ozapplepearipdm/trapping-codling-moth-and-mating-disruption/>
- Post-harvest care to help control two-spotted mite
<https://extensionaus.com.au/ozapplepearipdm/post-harvest-care-to-help-control-two-spotted-mite/>
- Post-harvest care of beneficials
<https://extensionaus.com.au/ozapplepearipdm/post-harvest-care-of-orchards/>
- Silken fungus beetle
<https://extensionaus.com.au/ozapplepearipdm/silken-fungus-beetle/>
- Looking for loopers
<https://extensionaus.com.au/ozapplepearipdm/looking-for-loopers/>
- Hints for using a hand lens
<https://extensionaus.com.au/ozapplepearipdm/hints-for-using-a-hand-lens/>
- Queensland grower discusses IPDM techniques
https://extensionaus.com.au/ozapplepearipdm/draft_-queensland-grower-discusses-ipdm-techniques/
- Apple grower talks about implementing IPDM in his orchard
https://extensionaus.com.au/ozapplepearipdm/draft_-apple-grower-talks-about-implementing-ipdm-on-his-orchard/
- **Useful tools available for download**
 - Pest and Disease monitoring methods for apple and pear orchards
<https://extensionaus.com.au/ozapplepearipdm/useful-tool-ipdm-monitoring-guidelines/>
 - IPDM Monitoring Record Sheet
https://extensionaus.com.au/ozapplepearipdm/test-post_monitoring-sheet/
 - IPDM Monitoring Calendar
https://extensionaus.com.au/ozapplepearipdm/test-post_crowatch-monitoring-calendar/

- Pests of Pome and Stone Fruit and their Predators and Parasitoids- a pocket guide
https://extensionaus.com.au/ozapplepearipdm/draft_useful-tool-pests-pocket-guide/. Three months after publishing the e-version on the webpage this was the website's 4th most popular page. On 30/9/20 it was the 8th most popular page with 332 pageviews.
- The website also signposts to various other useful tools such as APAL and Future Orchard videos, NSW DPI plant protection guide, The Australasian Biological Control Association website and 'The Good Bug' book.

10. Facebook (OzApplePear IPDM group) <http://bit.ly/OzapplepearIPDM>

- On 30th September 2020 the Facebook group had 111 members
- Over time the interactions have increased with many views and shares
- Group members have begun to interact more in the group – a recent example with a question on Granny Smiths prompted troubleshooting from other group members and the grower resolved his query (see Glenn Fahey post below)
- Posts often get seen by a high percentage of the membership base and likes, comments and shares are evidence of interactions (see Apple Dimple Bug post below)
- One orchardist sent us a photo of a pest infestation in this orchard, using Facebook messenger, which our Community of Practice was able to identify and respond to with management advice. This tool enabled confidentiality and quick and easy upload from smart phone to Facebook and may be something that could be built upon in future.
- Limited resourcing has meant the group could reach higher potential with more posts and interactions, and increased membership. No funds have been spent 'boosting the group page' which is commonplace, and very limited staff time has meant posts have been weekly or fortnightly which is not very high for a Facebook platform.
- The two main aims of the Facebook group were:
 - 1. Drive traffic to the webpage – which has been achieved
 - 2. Provide a platform for advisors and growers to bounce ideas, get advice, and interact on IPDM – this has also been achieved.

11. Media and other publishing

- 'Integrated Pest Management' presentation and report to APAL Speed Updating at Hort Connections 2018. This was also included in an article by Angus Crawford (APAL) 'Speed updating gives growers a fast serve of current R&D' published in Australian Fruitgrower August/September 2018
- Presentation 2018 Fruit Growers Victoria Conference 16-17 August 2018
- Media release 'Free pest and disease management training for apple and pear growers' 2 August 2018
- Media release 'Survey to focus on apple and pear industry' 9 July 2018.
- 'New IPM Manual on its way' Australian Fruitgrower April/May 2018, p17
- Media release 'Apple and pear industries get a boost with IPDM webpage' through Agriculture Victoria in June 2019 to promote the webpage and Facebook group.
- Article in APAL's 'Australian Fruitgrower' Winter (June) 2019 magazine (included webpage, experts, and a feature on the Batlow case study)
- 'Integrated Pest and Disease Management' WA Grower, August 2019

- Article 'IPDM withstands Pests, diseases, and natural disasters' in APAL's 'Australian Fruitgrower' Spring (September) 2020 magazine (included project update and detailed information on case study orchards)
- Promotion of the project by APAL sharing IPDM posts and events on the APAL Facebook page and Industry Juice (project highlights and workshops)
- Printed 'postcard' and that was distributed at workshops and at field days, all State Coordinators received a stack to distribute through their networks, and distributed at the Fruitgrower conference
- Media releases and flyers promoted through industry networks for all workshops in each State in 2018
- Online distribution of flyers through industry networks and e-newsletters for all workshops in each State in 2019
- Peer reviewed articles published on website
 - Think pollination
 - Benefits of cover cropping
 - Birds, bats and other animal problems
 - How to calculate cumulative leaf infested days
 - Grey headed flying fox moving south
 - Brush up on good bugs
 - Monitor while pruning to get ahead
 - Mite management
 - Mealybug management
 - European wasp management
 - Autumn snail control
 - Post-harvest scab control
 - Mite monitoring: key to sustainable chemical use
 - It's Canary Season!
 - Spring pest monitoring in WA orchards
 - Harlequin bug- manage hosts and hideouts
 - Broad-leaved weeds support orchard pests
 - Killer wasps and better pheromones target codling moth
 - Advances in codling moth control in orchards
 - Survey to focus on apple and pear industry
 - IPDM revised manual
 - What is IPDM?
 - Cost of biocontrol versus chemicals
 - Earwigs
 - Variable spray threshold for mainland apple dimpling bug

12. Industry Survey

Category of respondent	Percentage of respondents	
	2018	2020
Year		
Growers	72.3	70.8
Advisors	12.8	16.7
Pest Management Scouts	6.4	12.5
Other	8.5	0
Orchard category		
Conventional, not using IPDM	13.8	4.2
Conventional, using IPDM	76.9	58.3
Organic	4.6	12.5
Transitioning to organic	4.6	0
Orchard size (hectares)		
Less than 10	26.2	20.8
10-<20	12.3	8.3
20-<100	35.4	37.5
Over 100	26.2	33.3

Knowledge of pests, diseases, and weeds	Percentage of respondents	
	2018	2020
Year		
I can identify all pests in the orchard	62.5	83.3
I can identify all beneficials in the orchard	31.2	54.2
I can identify all diseases in the orchard	40.7	79.2
I can identify all the weeds in the orchard	40.6	58.3
I understand the lifecycles of the pests in the orchard	51.6	75.0
I understand the lifecycles of the beneficials in the orchard	32.9	50.0
I understand the life cycles of the diseases in the orchard	45.4	66.7
I understand the lifecycles of the weeds in the orchard	40.6	66.7
If I find something unusual, I know how to get it identified	85.9	87.5
Monitoring		
Weekly	70.9	61.1
Fortnightly	14.5	33.3
Monthly	7.3	5.6
Less frequently than above	7.3	0
Have written or electronic record of monitoring results	65.5	77.8
Monitor specific blocks	63.7	83.3
Monitor across whole orchard	80.0	83.3
Monitor individual varieties	54.6	72.2
Decisions on spraying		
Spray based on monitoring results	79.6	88.9
Spray based on weather forecasts relative to pest and disease	83.3	83.3
Spray based on predictive models	64.8	77.8
Spray based on advice from warning service	40.7	50.0
Pest thresholds for decision making	66.7	83.3
Disease thresholds for decision making	53.7	66.7
Use of prediction models		
Fruit flies	20.4	16.7
Codling moth	59.3	70.8
LBAM	37.0	29.2
Scab	57.4	66.7
Mites	27.8	20.8
Use of action threshold		
Fruit flies	30.9	50.0
Codling moth	58.2	79.2
LBAM	52.7	54.2
Scab	47.3	45.8
Mites	54.5	62.5
ADB	38.2	54.2
Birds	18.2	41.7

Biocontrol agents, present and giving good control. If present but not giving adequate control given in brackets (). Figures are % response	2018	2020
Lacewings	34.6 (36.5)	29.2 (45.8)
Hoverflies	38.5 (26.9)	37.5 (33.3)
Earwigs	32.7 (38.5)	25.0 (54.2)
Stethorus	38.5 (34.6)	45.8 (41.7)
Cryptolaemus	25.0 (38.5)	29.2 (45.8)
Persimilis	32.7 (26.9)	25.0 (58.3)
Galendromus (Typhlodromus) spp.	40.4 (19.2)	33.3 (33.3)
Californicus	17.3 (13.5)	25.0 (33.3)
<i>Aphelinus mali</i>	28.8 (25.0)	20.8 (41.7)
<i>Trichogramma</i> spp.	9.6 (21.2)	12.5 (33.3)
Know the impact of pesticides on beneficials	92.3	91.7
Historical records (multiple responses permitted)		
Available for orchard but not specific blocks	39.2	44.4
Available for specific blocks	49.0	38.9
Available for specific varieties	37.3	16.7
Available and used for future management decisions	54.9	79.2
Source of information on pest & disease management		
Other growers	73.5	75.0
Consultant/ agronomist	85.7	91.7
Government or University Officer	44.9	70.8
Internet	73.5	87.5
Australian IPM manual	49.0	66.7
Industry publications	63.3	79.2
Workshops and field days	85.7	91.7
I review historical records	54.9	79.2
Aware of Australian Apple and Pear IPDM website		
Aware of website		70.8
Have used website		33.3

Outcomes

The short-term outcome, expected by project completion, specified in the Monitoring and Evaluation Plan was that “high quality information on IPDM practices and technologies, economic benefits and costs, are easily accessible to, and used by, the apple and pear industry and service providers”. Case study reports, training course evaluation data, metrics from CoP website, industry survey, and interviews with producers and service providers were identified as methods by which to evaluate success based on the following measures:

- Increased grower knowledge and confidence in IPDM decision making
- Advisors and consultants confident and competent in providing IPDM advice to apple and pear growers
- Quality of information available
- Accessibility of information
- Number of consultants and advisors providing IPDM services

Comparison of the results from the industry surveys conducted in 2018 and 2020 indicates marked increases (averaging about 20% higher) in confidence to identify pests, diseases, weeds and beneficials and the understanding of their lifecycles. This was also reflected in increased percentages of growers with written records of monitoring results and monitoring of individual blocks and individual varieties. Use of monitoring results, predictive models, warning services, and action thresholds to determine the need for intervention also increased by about 20 percent of respondents.

The survey results suggest that over the life of the project the percentage of growers using other growers for information and advice related to pest and disease management remained stable at 73.5-75.0%, but there was increased use of other sources. Use of consultants increased from 85.7% in 2018 to 91.7% in 2020, Government or University officers from 44.9% to 70.8%, internet from 73.5% to 87.5%, the IPM manual from 49% to 66.7%, industry publications from 63.3% to 79.2%, workshops and field days from 85.7% to 91.7%, and growers who reviewed historical records to develop action plans increased from 54.9% to 79.2%. Participation in the surveys was voluntary and responses were not attributable to individual respondents, so the changes reported above are snapshots in time for the industry, rather than improvements based on paired sampling over time for individuals. Despite that limitation, the facts that service providers made up 22-27% of participants in training workshops, and the workshop evaluation scores for relevance (8.5), satisfaction (8.5-8.8), and skill improvement (8.4-8.8) were consistently high indicate that the project activities contributed to the improvements in knowledge and confidence for growers and their advisors. It is difficult to apportion a percentage of the national productive to IPDM but respondents to the surveys whose orchards were less than 10 hectares accounted for 20-26%, between 10 and 20 hectares 8-12%, twenty to 100 hectares 35-37%, and over 100 hectares 26-33%.

Advisors who were active participants in the Community of Practice (CoP) confidently and competently contributed to discussions, webinars and were presenters in videos posted on the IPDM website. Two consultants participated in case studies and have adopted monitoring methods and predictive models as a result of their participation. Some consultants who attended the workshops, but declined to join the CoP, indicated that they would be willing to participate in the CoP if their time was remunerated. Others were happy to participate freely because they believed that the interactions gave them a broader perspective of industry trends and the opportunity to broaden their skill base.

The Australian Apple and Pear IPDM website had, between 1/12/2018 and 30/09/2020, 7,873 users and 17,338 pageviews. Most users (49%) accessed the site using a mobile phone, 44% using a desktop computer, and 6% using a tablet. An organic search resulted in 70% of visits, 19%

directly typed the URL, and 9% resulted from social media. Although the average bounce rate was 79%, the average time spent on a page was 2:03 minutes. In that time a user is engaged with the site, reading content and interacting with the page, particularly if they were directed to the page from social media and are therefore getting what they came for. The website analytics showed that 1,436 users stayed for a minute or more, 960 stayed longer than 3 minutes. This indicates a high level of engagement. The average number of pages per session was 1.72. The high bounce rate of 10 seconds or less is not surprising when 80% found the site from a search engine such as Google search. The top three countries of origin for searches were Australia (71.96%), India (8.78%), and USA (7.80%).

The most webpages viewed were harlequin bug (3,062 views), the home page (2,809 views), what is IPM (1,276 views), case study orchards (421 views), advances in codling moth controls (390 views) and ask an expert (374 views). An interesting twist to the Google analytics is that the most popular question on the ask an expert site was about Rutherglen bug and received 514 views but, because many of those came direct, they did not show as views of the ask an expert page.

IPDM training sessions or workshops were conducted in each growing state. Four were in NSW, 3 in VIC, 3 in WA, and 2 in QLD, SA, and TAS. There were 116 participants in the 2018-19 workshops, 65.5% of whom were growers and 21.6% service providers, and “others” 12.9%. The 2019-20 workshops were originally planned to be in conjunction with the Future Orchards farm walks in Spring 2019 but there was insufficient time available in the Future Orchards spring farm walk agendas to hold our sessions and feedback from industry indicated that the IPDM workshops should be delivered a few weeks after the Future Orchards farm walks to allow growers sufficient time to regroup. Spring is always a busy time for orchardists and the spring 2019 workshops only attracted 74 participants, 53% of whom were growers and 27% service providers, and “others” including chemical company field staff made up the remaining 23%. At each of the initial workshops in 2018-19 participants were encouraged to contribute in the project as case studies but, despite early enthusiasm, only 8 orchardists finally agreed to participate. It was later discovered that a service provider had organized independently for a consultant to provide IPM services to their larger clients in Victoria and NSW. That consultant was invited to join the CoP but has not participated to date.

Each case study orchard provided background information that was used to identify priority issues to address in an action plan. Two of the orchards had local service providers who had attended the workshops and agreed to participate in the case studies. Some of the case study orchardists had already been implementing various aspects of IPDM and there was a range of experience. Details of the case studies, including videos of the growers discussing their journey, were posted on the website. The landing page for the case studies attracted 521 views. Case study reports were also published in Australian Fruitgrower, and the orchards hosted the 2019-20 workshops. The videos of case study orchardists discussing their pest management approaches were popular and conveyed the outcomes to a wider audience than those able to attend the training sessions. Unfortunately, the fires in NSW and SA in summer 2019-20 impacted two of the case studies, and the travel restrictions imposed by the COVID 19 pandemic prevented conduct of harvest damage assessments in some cases, which also meant that cost-benefit analyses were not completed. However, the responses from the case study orchardists all clearly indicated that there were benefits to be achieved by adoption of IPDM.

Monitoring and evaluation

1. Effectiveness: To what extent has the project achieved its expected outcomes?

To what extent has the project increased the level of adoption of IPDM?

Increase in level of adoption of IPDM was identified in the M&E Plan as a medium to long-term outcome that was not a responsibility of the project team. However the short term outcome of having high quality information on IPDM practices and technologies easily accessible to, and used by, the apple and pear industry and its service providers has been achieved by completing the revision of the IPDM manual; creation, population, use, and on-going maintenance of the Australian Apple and Pear IPDM website; Facebook and Twitter accounts; creation of a web based IPDM Community of Practice, including a network of expertise to service the Ask an Expert facility; and provision of training.

To what extent has the project improved knowledge and confidence of growers to adopt IPDM?

Based on responses to the industry surveys, it appears that knowledge and confidence of growers to adopt IPDM has increased by about 20% during the life of the project. When coupled with increased use of consultants, better record keeping and action planning, and on-going support via the Community of Practice, it appears likely that the medium-term outcome of increasing the percentage of production under IPDM will be achieved.

2. Relevance: How relevant was the project to the needs of intended beneficiaries?

To what extent has the project met the needs of industry levy payers?

Levy payers who attended the workshops were very satisfied, with satisfaction scores averaging 8.5 to 8.8 out of 10 for the 2018 and 2020 workshops respectively.

Industry, through Hort Innovation, has invested in a new project “Strengthening cultural and biological management of pests and diseases in apple and pear orchards” that will continue to maintain and populate the Australian Apple and Pear IPDM website and support the Community of Practice.

3. Process appropriateness: How well have intended beneficiaries been engaged in the project?

How many training sessions were conducted?

Sixteen training workshops were conducted, 8 in 2018-19 and 8 in 2019-20. Four were in NSW, 3 in VIC, 3 in WA, and 2 in QLD, SA, and TAS.

How many participants attended the training?

There were 116 participants in the 2018-19 workshops, 65.5% of whom were growers and 21.6% service providers, and “others” 12.9%.

There were 74 participants in the 2019-20 workshops, 53% of whom were growers and 27% service providers, and “others” including chemical company field staff made up the remaining 23%.

Have regular project updates been provided through linkage with the industry communication project?

- APAL Speed Updating at Hort Connections 2018.
- Australian Fruitgrower August/September 2018
- Australian Fruitgrower April/May 2018
- Australian Fruitgrower Winter (June) 2019
- Australian Fruitgrower Spring (September) 2020

- Promotion of the project by APAL sharing IPDM posts and events on the APAL Facebook page and Industry Juice (project highlights and workshops)

How many participants completed the survey?

The 2018-19 survey had 128 participants but only 48 fully completed the survey. The 2019-20 survey had 24 participants who all fully completed the survey.

What were the changes in industry levy payers unprompted level of awareness of the project?

This was not tested because all communication went out under the banner of the project. However, 70.8% percent of respondents to the 2019-20 survey were aware of the website and there was an increase from 49% in 2018-19 to 66.7% in 2019-20 for use of the IPDM manual as a reference.

4. Process appropriateness: To what extent were engagement processes appropriate to the target audience/s of the project?

How accessible were extension events and material to industry levy payers?

Each training workshop was conducted in a fruit growing region and advertised via the local grower association, APAL, and state coordinators. The website was promoted at each workshop, through media releases, and through APAL channels. There were no attendance or subscription fees. The surveys were promoted through media releases, the website, local coordinators, and APAL communication channels. All training material and tools were available on the website.

5. Efficiency: What efforts did the project make to improve efficiency?

What proportion of engaged participants implemented project related actions and what barriers impeded actions?

All the case study orchards implemented their action plans. The available funding limited the amount of time regional coordinators could contribute so more regular and detailed information could not be collected and published. Regular site visits to document IPDM implementation and learnings would have required significant resourcing of IPDM specialists to work with the grower throughout the season. These visits would also provide more opportunities to capture relevant and timely video footage of issues as they arose. This was flagged in the original submission when addressing the requirement for demonstration blocks in all regions, and the decision to go with case studies rather than full-blown demonstration blocks was a response to the limited funding available.

Which extension elements of the project provided more informed knowledge to participants?

The workshop evaluation scores indicate that the workshops provided informed knowledge and practical experience to participants. The industry survey results suggest that participants had implemented much of that knowledge since confidence in identification of pests, diseases, weeds, and beneficials, and understanding of their lifecycles had improved by about 20%. Record keeping, monitoring programs, and use of prediction models and action thresholds to inform decisions to intervene also increased by 20%.

The website analytics indicate that case studies and video posts were also popular sources of information.

Video conferencing presented opportunities to compensate to some extent for the effects of travel restrictions due to the COVID 19 pandemic by providing access for the case study growers to a wider network of growers and IPDM experts. Differences in time zones created some logistical issues for grower participation in the group sessions because it was

not possible to synchronize with lunch time in each state but late afternoon in the eastern states worked out alright for all participants.

6. Other, if any, legacy: How and by whom should the legacy be managed?

What are the recommendations for the next steps of the project?

The new Hort Innovation funded projects provides time to negotiate the future of the website and Community of Practice. Ultimately it makes sense for APAL to incorporate maintenance and enhancement of both as part of an industry communication program with support from Hort Innovation, State agencies, grower associations and service providers.

Recommendations

The project has demonstrated the capacity and willingness of growers and advisors to adopt practices that advance the implementation of IPDM. Some of the tools required are now readily available but some of the important information sources in Australia are difficult to navigate and overseas data is limited in applicability to Australia. For example, the pesticide registration process does not support development of data on non-target effects on beneficial species, apart from honeybees, and strains of the predatory mite and parasitoid wasp species used in Australia are often different to those overseas. This is addressed to some extent by Australian suppliers of biocontrol agents but impacts on more generalist predators is lacking and the available information lags behind the commercial availability of new chemistry. Development of minor use permits has been funded through Hort Innovation as an on-going program. Perhaps it is time to develop a similar program to coordinate and fund development of robust data on the impact of pesticides on the important predatory and pollinator species in orchards.

Maintenance, curation, and support of the IPDM website and the Community of Practice will require baseline funding and co-investment of time and/or funding to maintain relevance and increase usage to achieve the longer-term outcomes specified in the project M&E Plan. APAL as the industry peak body is a logical choice to undertake this task but will require collaboration by state and federal agencies, consultants and other service providers, universities, and agrichemical companies.

Pest management consultants and service providers, including those specializing in IPDM, should be encouraged to collaborate in the Community of Practice to enhance uptake of IPDM by the apple and pear industry. That would increase their visibility without losing any competitive advantages they think they may have.

Refereed scientific publications

None produced

References

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Intellectual property, commercialisation and confidentiality

No project IP, project outputs, commercialisation or confidentiality issues to report

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Appendices

Appendix 1: Monitoring and Evaluation Plan

Appendix 2: Project Risk Register

Appendix 3: Case studies

Project M&E plan

AP16007: An Integrated Pest,
Disease and Weed Management
Program for the Australian
Apple and Pear Industry

Introduction

A recent review into the status of Integrated Pest Management (IPM) in the Australian Apple and Pear Industry found that, while there was a high level of awareness of IPM and the tools required for growers to use IPM effectively were available, grower and advisor confidence in IPM could be improved by developing a better understanding of, and gaining experience with, the integration process.

The project aims to improve the ability and capacity of the apple and pear industry to develop and sustain a pest resilient farming system. This will be achieved by extending current knowledge on IPM by updating the industry IPM manual and incorporating a greater focus on the integration of management practices that optimise monitoring and management of pests and diseases. Regional differences in pest and disease issues will be taken into consideration, and information on potential impacts of exotic incursions will be provided. The revised IPM manual and other information will be formatted to suit various platforms identified by growers and advisors as their preferred methods to receive information. A team of experts with knowledge of each growing region has been assembled to revise the IPM manual and provide region specific guidelines and training that will engage growers and advisors. This monitoring and evaluation plan is designed to track the progress of resource development, knowledge acquisition, adoption and to assess benefit to industry.

The desired outcome will be an apple and pear industry with the confidence, knowledge and skills to adopt, implement and sustain a cost-effective low-risk IPM-based farming system resilient to changes in regulatory policy and new pest incursions that impact pest management options.

Document structure

The document contains several sub-sections that collectively form a comprehensive Project M&E Plan:

- 1 Program logic
- 2 Scope of project M&E
- 3 Performance expectations, and data collection and analysis

1 Program logic

Figure 1 Logic model for project

Project Logic: AP16007 An Integrated Pest, Disease and Weed Management Program for the Australian Apple and Pear Industry

Long-term Outcomes (>10yrs)	Objective 2: Production of high quality apples and pears at internationally competitive prices (costs and risks)				
	Strategy 2.1 Enhanced orchard productivity and management				
Mid-term Outcomes (5-10 yrs)	Apple and Pear industry able to respond to regulatory policy (Government and market) and new pest/disease incursions without major disruption to IPDM systems, productivity, and viability	At least 50% of total production will be grown under full IPDM (which does not equate to organic production or the complete withdrawal of pesticides)		Apple and Pear industry has the confidence, knowledge, skills and resilience to adopt, implement and sustain a cost effective low risk IPDM-based farming system.	
Short-term Outcomes (by end of project)	Increased grower knowledge and confidence in IPDM decision making	Advisors and consultants are confident/ competent in providing IPDM advice to apple and pear growers	High quality information on IPDM practices and technologies, economic benefits and costs, are easily accessible to the apple and pear industry and its service providers		Improved connectivity between researchers, advisors, growers, and the broader industry facilitates increased quality, and reduces cost and risks in the adoption of IPDM
Outputs	M&E Plan	Revised IPDM Manual	Training courses	Community of Practice	Reports
	Program logic with linkage to Hort Innovation and Industry objectives	New sections on diagnosis and quarantine pests	Course notes	network and communication channels	Milestone reports
	Project risk register listing how the risks will be managed	Links to updatable, web-linked spray guide	Reference materials	Ask an Expert	Final report
	Stakeholder engagement plan				Case studies
Activities	Project Governance	Review, synthesise and extend current IPDM knowledge		Update IPM Manual	
	Monitor & evaluate	review current levels of engagement		review current manual	
	Stakeholder engagement	improve capacity of advisors to provide reliable advice		review relevant projects	
	Reporting	case studies for regional demonstration		revise format	
	Quality assurance	coordinate with Future Orchards program		write new content	
		Establish community of practice			

2 Project M&E scope

The purpose of this plan is to document the process for managing the collection, analysis, and reporting of evidence that: Demonstrates impact of the project; Tracks performance against milestones; and Provides guidance to the project team on the performance indicators for the project.

2.1 Audience

- The primary audience includes the stakeholders who have invested in the project and need to report on value for money and return on investment. Also included in this group are APAL and the Portfolio Managers within the organisations co-funding and/or delivering the project. (See Table 1)
- The secondary audience are the stakeholders whose livelihoods may be impacted in various ways by the activities, outputs, and outcomes of the project. This group may read the reports produced and provide input via representatives on the Stakeholder Advisory Group. However, this group is extremely diverse, may not be interested in the details of the M&E Plan, and therefore the plan is not designed specifically to meet their needs.

Table 1: M&E audience and their information needs

Audience	Information need
Primary	
Project team	Monitoring data and feedback on activities and outputs. Performance against budget.
Hort Innovation	Project progress against milestone achievement criteria. Number of training sessions completed. Extent of levy payer engagement in the project.
DEDJTR via Agriculture Victoria	Project expenditure, milestones achieved on time, impact of outputs.
DPIRD WA	Milestones achieved on time, impact of outputs.
DPI NSW	Milestones achieved on time, impact of outputs.
DAF Qld	Milestones achieved on time, impact of outputs.
UTAS	Milestones achieved on time, impact of outputs.
Lenswood Co-operative	Milestones achieved on time, impact of outputs.
APAL	Communication opportunities, impact of outputs.
Secondary	
Apple and Pear growers in all states	Awareness of project, access to events, access to extension material. Opportunities for training. Opportunities to provide input.
Service providers such as consultants, agronomists, agricultural pesticide companies, biological control suppliers	Awareness of project, access to events, access to extension material. Opportunities for training. Opportunities to provide input.
Universities and vocational training providers	Awareness of project, access to events, access to extension material. Opportunities for training.
Other researchers	Awareness of project, access to events, access to extension material.

2.2 Key evaluation questions

Table 2: Project key evaluation questions

Key evaluation questions	Relevant?	Project-specific questions
Effectiveness		
1. To what extent has the project achieved its expected outcomes?	✓	To what extent has the project increased the adoption of IPDM? To what extent has the project improved knowledge and confidence of growers to adopt IPDM?
Relevance		
2. How relevant was the project to the needs of intended beneficiaries?	✓	To what extent has the project met the needs of industry levy payers?
Process appropriateness		
3. How well have intended beneficiaries been engaged in the project?	✓	How many training sessions were conducted? How many participants attended the training? Have regular project updates been provided through linkage with the industry communication project? How many participants completed the survey? What were the changes in industry levy payers unprompted level of awareness of the project? How well have the diverse needs identified in the survey been addressed?
4. To what extent were engagement processes appropriate to the target audience/s of the project?	✓	How accessible were extension events and material to industry levy payers?
Efficiency		
5. What efforts did the project make to improve efficiency?	✓	What proportion of engaged participants implemented project related actions? and what barriers impeding actions? Which extension elements of the project provided more informed knowledge to participants ?
Other (if any) Legacy		
How and by whom should the legacy be managed	✓	What are the recommendations for next steps of the project?

2.3 M&E budget

The M&E activities identified in this plan will be conducted as integral components of the project activities and are not budgeted for separately.

Monitoring & Evaluation Plan for HIA Project AP16007: An Integrated Pest, Disease and Weed Management Program for the Australian Apple and Pear Industry

Measures	Evaluation method	Reporting
Longer-term outcomes (timing dependent upon medium-term outcomes, and not a responsibility of project team)		
"Production of high quality apples and pears at internationally competitive prices" - Industry statistics on costs of production for both export and domestic product - Backouts >80% for established crops % production costs attributed to pest and disease management 10-20% increase in marketable yields (tonnes/ha) 10-20% increase in value (\$/kg)	- Industry benchmarking studies - Data from Future Orchards or similar project	
Medium-term outcomes (up to 5 years post-project, and not a responsibility of the project team)		
"Apple and Pear industry has the confidence, knowledge, skills and resilience to adopt, implement and sustain an IPDM-based farming system able to respond to regulatory policy and new pest or disease incursions without major disruption to IPDM systems, productivity, and viability"	- Level of grower knowledge and confidence in IPDM decision-making processes - Number of advisors and consultants providing IPDM advice to apple and pear growers % production under IPDM - No loss of markets due to inability to meet regulatory policy changes. - Number of incursions that disrupted IPDM	- Industry surveys and benchmarking - Market reports - Regulatory responses - Industry surveys
Short-term outcomes (by project completion)		
"High quality information on IPDM practices and technologies, economic benefits and costs, are easily accessible to, and used by, the apple and pear industry and its service providers"	- Increased grower knowledge and confidence in IPDM decision-making. - Advisors and consultants confident and competent in providing IPDM advice to apple and pear growers - Quality of information available - Accessibility of information - Number of consultants and advisors providing IPDM services	- Case study reports - Training course evaluation data - Metrics from COP website - Industry survey - Interviews with producers and service providers
Activities and Outputs (during project)		
Project governance	Outputs delivered on time and within budget	Milestone reports and acquittals
Review, synthesise and extend current IPDM knowledge	- Review current levels of engagement - Number of training courses delivered - Number of participants in training courses - Quality of training and course notes - Number participating in "Ask an Expert"	- Survey Monkey - Metrics from COP website - Case studies - Training evaluation forms
Update IPDM manual	- Number of new sections - Number of revised sections - Number of knowledge gaps identified - Number of formats developed - Quality of the new manual	- Milestone 102 report - Feedback from training courses - Feedback from case study participants - Final report

3 Performance expectations, data collection and analysis

Logic level	What to monitor	Performance expectation (KPIs) and/or monitoring questions	Data collection – method (e.g. survey) and source (e.g. growers)	Timing of, and responsibility for, data collection
Foundational activities	Formation of project team	Sub-contracting completed	Contracts on register	Part of Milestone 101
Activities and outputs	Project governance	Outputs delivered on time and within budget Action items completed	Milestone reports and acquittals Agenda & Minutes from Project team, and SAG, meetings	Ongoing every six months (Project Leader)
	Update IPDM manual	Number of new sections.	Milestone reports.	March 2019 (Project Leader)
		Number of revised sections.		
		Number of knowledge gaps identified.		
		Number of formats developed.	Final report.	End of Project (Communication Leader)
		Quality of the new manual.	Feedback from training courses. Feedback from case study participants.	Ongoing (Regional Coordinators)
	Review , synthesise and extend current IPDM knowledge	Review current levels of engagement.	Industry survey	Ongoing (Survey coordinator)
		Number of training courses delivered.	Training register	Ongoing (Regional Coordinators)
		Number of participants in training courses.		
		Quality of training and course notes.	Case studies Training evaluation forms	
		Number participating in “Ask an Expert”.	Metrics from COP website	Ongoing (Communication Leader)

Logic level	What to monitor	Performance expectation (KPIs) and/or monitoring questions	Data collection – method (e.g. survey) and source (e.g. growers)	Timing of, and responsibility for, data collection
Short-term outcomes	High quality information on IPDM practices and technologies, economic benefits and costs, are easily accessible to, and used by, the apple and pear industry and its service providers	Increased grower knowledge and confidence in IPDM decision-making.	Case study reports	Annually and as required for Milestone Reports (Regional coordinators)
		Advisors and consultants confident and competent in providing IPDM advice to apple and pear growers	Interviews with producers and service providers	
		Quality of information available	Training course evaluation data	
		Accessibility of information	Metrics from COP website	
		Number of consultants and advisors providing IPDM services	Industry survey	
End-of-project outcomes	Uptake and adoption of IPDM by growers	Percentage of production area covered by IPDM	Industry survey	At end of project for Final Report (Project Leader)

Appendix 2: Risk Register

Project Risk Register and Risk management Plan

Risk	Potential cause	Potential impacts on project delivery	Controls	Likelihood with controls in place	Consequence with controls in place	Treated risk assessment	Risk evaluation: Is the risk acceptable?	Responsible person
Poor project governance	Confusion over milestones leads to failure to meet deadlines.	Delay in delivering project outputs	1.Subcontracts specify deadlines for submission of content to project leader 2. Team meetings clarify roles, responsibilities and timelines	Remote	insignificant	low	yes	Project leader
	Roles & responsibilities for milestone contributions unclear.	Delay in delivering project outputs	1. Communication channels established to encourage early notification of difficulties. 2. State coordinators identified and have membership of SAG. 3. SAG meetings prior to milestone submission deadlines to provide feedback.	Remote	insignificant	low	yes	
	Lack of interest from industry members to serve on SAG.	Outputs do not meet industry expectations	1. Call for EOI 2. Target suitable applicants 3. Revise TORs and/or composition of SAG	unlikely	minor	medium	yes	
Unable to review current levels of engagement	Poor response to digital survey	Unable to measure improvements against baseline	1. Face to face surveys at field days, training sessions, industry conference 2. Use industry members on SAG to communicate	unlikely	insignificant	low	yes	M&E Team

Risk	Potential cause	Potential impacts on project delivery	Controls	Likelihood with controls in place	Consequence with controls in place	Treated risk assessment	Risk evaluation: Is the risk acceptable?	Responsible person
			importance and lobby for responses					
Failure to establish COP	No growers and/or consultants join and/or actively participate	Underachievement of intended project outputs and outcomes	Promote the COP to raise awareness and demonstrate its usefulness at field days, training sessions, industry conference and through other industry social media platforms.	unlikely	moderate	medium	yes	Extension coordinator
Failure to maintain COP	Not enough content is generated for the Ausextension and social media platforms to keep them relevant, 'fresh' and in the public eye	Low uptake of new practices. Outputs do not meet industry expectations.	Have a project team member with social media experience designated to the upkeep of platforms	unlikely	minor	medium	yes	Extension coordinator

Risk	Potential cause	Potential impacts on project delivery	Controls	Likelihood with controls in place	Consequence with controls in place	Treated risk assessment	Risk evaluation: Is the risk acceptable?	Responsible person
Delays in completing revision of current IPM manual	Cannot access electronic original. Original software files not compatible with current programs. Cannot agree on format. Loss of key personnel.	Delays to delivery of training. Underachievement of intended project outputs and outcomes	Mark changes as comments on pdf circulated to all team members. Attempt to source original software or start from scratch in Word and then contract printer. Team has sufficient breadth of knowledge and expertise to complete revision. Contract allows for multiple formats.	possible	minor	medium	yes	Project Leader
Loss of key personnel	Resignation, retirement or redirection	Loss of key knowledge and experience.	Structure of work program is designed to capture key knowledge and expertise early in project. Regular team meetings, with recorded minutes, to share information. Establish central repository for documents in shared drive on Google Docs.	possible	insignificant	low	yes	All
Low grower engagement in training activities	Poor timing. Content not deemed relevant.	Low uptake of new practices and knowledge. Underachievement of intended project outputs and outcomes	Development of stakeholder advisory group and stakeholder engagement plan. Team members have extension and knowledge transfer experience and expertise.	possible	insignificant	low	yes	Project Leader and regional Coordinators

APPENDIX 3: Case study reports

Initial interview results and the resultant action plans for each case study are presented, along with a summary of damage assessed at the 2019-20 season harvest. The damage assessments were conducted using the monitoring protocols recommended on the extensionAus OzApplePearIPDM webpage.

Case study: Finger

Initial consultation

Grower name: David Finger

Location: Yarra Junction

What are the main IPDM issues being focussed on?

- Main concerns are black spot and codling moth but mites, birds, heliothis, kangaroos and fruit bats are becoming issues.

What are you doing currently with IPDM?

- I am using RIMPRO to guide my spray timing for black spot and codling moth.
- I have a staff member dedicated to scouting the orchard.
- Last season I was disappointed with performance of predatory mites despite having released a range of predatory mites for control of my mite complex (I have TSM, ERM, and bryobia as pests).
- Aphelinus mali is present in good numbers so I am trying to restrict insecticide use and to use 'softer' products where possible.
- I maintain a weed-free tree-line but don't worry too much about weeds in the inter-row because I root-prune to control vigour, which means that the weeds are probably not competing with the trees. When I do mow I use a narrow mulching mower that leaves some weeds at the edges to support predators.

What has worked well? What hasn't?

- Combining RIMPRO with MetEye provides extra weather data, such as wind speed, including 7-day forecasts that help with planning orchard operations (especially spray applications).
- The recent training workshop confirmed that my IPDM program is working.

What would you do differently next time?

- I am going to try to reduce the use of Altacor, consider the use of Vertimec early, more strategic release of predatory mites, and then try to track the impact.

Any interesting learnings?

- Too early in the season to say much. Pest management is a dynamic system with a lot of interactions going on. No single recipe or prescription covers it.

Take home message

- We have a lot of tools and there is a lot of information out there but the suppliers are not on the front line. The decision maker needs ground truthing (good situational awareness) to interpret the outputs and advice.

Action Plan

Situation:

- Codling moth and scab are under control but treatments may be impacting biocontrol agents (specialist and generalist) that would otherwise be maintaining pests below economic levels. A staff member trained in scouting is providing regular data on pest and disease incidence. RIMPRO is used for guidance on spray timing but does not account for pest pressure.

Mission:

- To capitalise on the low pest and disease population and attempt to further reduce pesticide use while maintaining effective control and confidence in the approach being taken.

Execution:

- Implement codling moth trapping grid to ground-truth RIMPRO predictions and use trap results to determine need to spray when model predicts egg hatch should be occurring.
- Convert mite monitoring results to CLIDs to gain a better understanding of the risk associated with mite infestation.
- Continue approach of using “softer” products to reduce side effects on non-target species
- Trial planting nectar sources amongst inter-row sward to enhance performance and survival of parasitoids

Administration

- David Finger to develop pre-plan for responding to issues that may develop.
- Steve Leeves to monitor pests and diseases, David Finger to monitor traps
- Ask an Expert facility in IPDM website is available additional support and expertise
- David Williams is available for technical advice

Communication

- David Williams: 0417549891 david.williams@agriculture.vic.gov.au
- IPDM Website: www.extensionaus.com.au/australianappleandpearIPDM

Safety

- Experiments can be stressful but no useful results will occur unless the participants maintain their nerve
- Stress can be reduced by setting realistic targets that stretch comfort zones without creating major financial risks
- Over-use of chemical applications will create residue issues, pest resistance issues, possible mite flare, and potential health issues for staff
- Stress can be reduced by taking the time to seek expert advice on the problem, either in the planning phase or before the problem gets out of control, rather than making knee-jerk decisions
- Regular assessments of pest and disease populations and damage levels will allow timely changes to approach before significant damage occurs
- Use of prediction models based on local data will provide early indications of potential danger periods

Outcome 2019-20

Codling moth, scab, LBAM, mites, ADB, and WAA are well controlled. Damage due to *Helicoverpa* was a bit high and probably reflects the difficulty in prediction and monitoring for this pest, or the timing of Dipel. Some WAA is evident on trees in the lead up to harvest but *Aphelinus mali* is very actively attacking the colonies. Spray records have not been received due to grower being busy with harvest.

Case study Nicoletti

Initial consultation

Grower name: Daniel Nicoletti

Location: Pozieres, near Stanthorpe Qld

What are the main IPDM issues being focussed on?

- Main issues are mites, mealybugs, and QFF. Codling moth is no longer an issue

What are you doing currently with IPDM?

- Attempting to get mealybug control by releasing predatory beetle (Cryptolaemus). Have also mowed every second alley to encourage predatory mites that eat TSM.
- Using traps to monitor moths and a scout to monitor mites and other pests.

What has worked well? What hasn't?

- Have given up use of mating disruption "Twisties" against codling moth because spraying Samurai, Altacor, Delegate, Cormoran against codling moth is helping reduce mealybug. Unfortunately, this appears to be creating a mite problem. Elders are monitoring mites but Daniel forgot to spray when they indicated he should

What would you do differently next time?

- Pay more attention to advice and timing!
- Develop a monitoring plan for mealybug using limb bands established in April to monitor crawler emergence from shelter in spring.
- Develop alternative chemical plan to support predators.
- Consider release of P.persimilis predatory mite in autumn to reduce TSM carryover.
- Work with Elders to trial use of CLIDs (cumulative leaf infested days) as a predictive tool to improve management of TSM

Any interesting learnings?

- Do not be complacent. Need to keep on top of monitoring results and advice.
- Lack of water is complicating things by stressing trees (but has probably helped in management of black spot).
- Need more information to be available on impact of pesticides on non-target species.
- Cryptolaemus appears to prefer egg-laying mealybugs but longtailed mealybugs do not lay eggs so may not be a good host. Need to look for a better predator for this pest.

Take home message

Monitoring and planning responses to contingencies is important so you can act on advice and have appropriate chemicals on hand if you need them

Action Plan

Situation:

Codling moth and black spot are under control via chemical sprays timed according to monitoring of moth numbers in traps and weather conditions affecting disease infection periods. Mites and mealybugs have become major problems. This could be due to pesticide resistance or side effects on beneficials.

Mission:

To reduce pest status of mites and mealybugs, without causing outbreaks of codling moth, within the next two seasons.

Execution:

- Investigate comparison between current mite monitoring interpretation and use of cumulative leaf infested days (CLIDs)
- Investigate impact of introducing Chilean predator mite *P.persimilis* in autumn to clean up mite populations
- Investigate/implement mealybug monitoring program to better indicate when crawlers move out onto foliage and fruit and therefore be more susceptible to sprays.
- Develop plots in orchard where some potentially disruptive chemicals are removed and compare these to areas where those chemicals were retained
- Develop sampling plan for pest populations and levels of damage, then implement plan

Administration:

- Andrew Hennoste to maintain monitoring records and provide analysis to Daniel on weekly basis for the case study block
- Daniel and Andrew to develop a pre-plan for the case study block, covering potential scenarios and appropriate responses
- Peter Nimmo and David Williams are available for feedback
- Ask an expert facility in IPDM website is available for additional support and expertise

Communications:

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Daniel Nicoletti		
Andrew Hennoste	0429635366	andrew.hennoste@elders.com.au
IPDM Website		www.extensionaus.com.au/australianappleandpearlPDM

Safety:

- Experiments can be stressful but no useful results will occur unless the participants maintain their nerve
- Stress can be reduced by setting realistic targets that stretch comfort zones without creating major financial risks
- Over-use of chemical applications will create residue issues, pest resistance issues, possible mite flare, and potential health issues for staff
- Stress can be reduced by taking the time to seek expert advice on the problem, either in the planning phase or before the problem gets out of control, rather than making knee-jerk decisions
- Regular assessments of pest and disease populations and damage levels will allow timely changes to approach before significant damage occurs

Outcome 2019-20

The main problem encountered this season appears to be lenticel cracking which accounted for 17.8% of damaged fruit. This is related to environmental/climatic conditions. Mealybug damage was limited to 4.2% this season. Codling moth and Helicoverpa damage were a bit high at 2.0% and 1.6% respectively but are manageable. A low level of bitter rot/target spot (0.4%) was detected.

Case study Evans

Initial consultation

Grower name: John Evans

Location: Geeveston, Tasmania

Background:

- John is the 6th generation of orchardists. He is a sole operator of the 40 ha orchard, with 25 ha under production and the rest being new plantings. By 2023 the majority of the orchard will have been planted at 0.7m X 3.5m

What are the main IPDM issues being focussed on?

- John feels he has no major pest and disease problems but he still focusses on scab (black spot), codling moth, native bud worm (Heliothis/ Helicoverpa), and Dimple bug as potential threats that need to be addressed.

What are you doing currently with IPDM?

- Experimented with line trapping for codling moth as a result of the workshop presentation by Chis Adams.
- Is working with neighbours to reduce potential influx of codling moth.
- Is protecting populations of earwigs and Aphelinus mali by modifying the rate and timing of sprays that may impact these important predators.

What has worked well?

- In John's words; everything worked well, despite limitations imposed by climate, topography and fires.
- He is currently using systemic fungicides as protectants rather than relying on kick-backs, because in wet weather it is not always possible to apply a kick-back within the necessary time frame.
- One positive to come from the recent nearby bush fire, is that his fruit were coated with ash which appears to have enhanced fruit skin quality.

What hasn't worked well?

- There were no issues, but he did recognise that reliance on some of his current pesticides leaves him vulnerable if they are deregistered.

What would you do differently next time?

- Experiment with line trapping for monitoring codling moth, to get a better picture of distribution in the orchard and size of population.
- Install an additional weather station to provide localized data that can be fed into a prediction model for CM, LBAM and scab.
- Try to further reduce pesticides by improving timing
- Remove the Macrocarpa tree that is probably supporting Dimple bug over winter

Any interesting learnings?

- Too early in program to comment

Take home message

- Chill out a bit if everything is going well, but do not stop doing things properly. Look after the beneficials that are working in your favour.

Action Plan

Situation:

- Codling moth, black spot and lightbrown apple moth (LBAM) are under control. Despite the use of chlorpyrifos sprays from early green tip until early pink bud earwigs are still contributing good control of codling moth and woolly apple aphid. The parasitoid wasp *Aphelinus mali* that attacks woolly apple aphid is still present. The spray program has not caused any mite issues.

Mission:

- To capitalise on the low pest and disease population and attempt to further reduce pesticide use while maintaining effective control and confidence in the approach being taken.

Execution:

- Establish codling moth traps along the border with neighbour and in a transect parallel to the border traps but through the middle of the orchard
- Remove the large Macrocarpa tree over late autumn/winter and assess changes in dimple bug damage in 2019-20
- Develop some plots, within the orchard, in which some pesticides are not used. Compare populations of pest and beneficial species, and damage levels, in these plots against what is experienced in the treated plots.
- Consider monitoring for budworm and looper activity from pink bud through to 2 weeks after petal fall. Initially look for budworm adults around lights as an indicator, and check flowers for presence of eggs. Eggs are distinctive, with ridging visible with a hand lens.
- Develop a sampling plan for pest populations and levels of damage, then implement plan
- Install a weather station in the block so that temperature and leaf wetness data and trapping results can be used in a predictive model to guide the need for sprays

Administration:

- John Evans and Stephen Quarrell (Tom) to organise experimental plots, traps, and the monitoring plan/ record sheets
- David Williams to supply pest prediction program
- John and Stephen to develop a pre-plan for responding to issues that may develop
- Ask an expert facility in IPDM website is available for additional support and expertise
- David and Stephen are available for feedback

Communications:

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Stephen Quarrell	0427833334	stephen.quarrell@utas.edu.au
John Evans		
IPDM Website		www.extensionaus.com.au/australianappleandpearIPDM

Safety:

- Experiments can be stressful but no useful results will occur unless the participants maintain their nerve
- Stress can be reduced by setting realistic targets that stretch comfort zones without creating major financial risks
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- Stress can be reduced by taking the time to seek expert advice on the problem, either in the planning phase or before the problem gets out of control, rather than making knee-jerk decisions
- Regular assessments of pest and disease populations and damage levels will allow timely changes to approach before significant damage occurs
- Use of prediction models based on local data will provide early indications of potential danger periods

Outcome 2019-20

Codling moth and scab control was excellent with only 0.2% damage for each recorded. Mites were not an issue but 14% of leaves were infested with Canary fly. This is not considered a serious infestation and does not require further action other than continued monitoring of canary fly infestations next season. The damage is similar in effect to mite damage and, since there are no thresholds available, it may be useful to use the CLIDs system (used for mites) to assess the canary fly infestation next season.

Case study Smart

Initial consultation

Grower name: Jeremy Smart

Location: Batlow

What are the main IPDM issues being focussed on?

- Key focus through Spring and Summer has been on Woolly Apple Aphid (WAA) and Codling Moth (CM) management.

What are you doing currently with IPDM?

- WAA – We’ve been keeping a close eye on WAA populations throughout our orchard by carrying out regular informal inspections whilst working in the various blocks.
- CM – This season we had some blocks under Mating Disruption (MD) and some conventionally sprayed. We monitored these with a combination of 10x and 1x lures. We also established a 3 trap line similar to what was discussed at the first training workshop just to get some experience with this approach. We informally inspected blocks for CM damage throughout the Spring and Summer and used our trap data and observations to adjust our approach to CM management as required.

What has worked well? What hasn’t?

- WAA - Some of our older trees needed selective intervention with insecticide in November – December. Although this insecticide is known to disrupt the parasitic wasp *Aphelinus mali*, we are now (2-3 months after spraying) we are seeing plenty of parasitism by *A.mali* in these older blocks. It looks like this will be kept under control for the remainder of the season. In some of our younger blocks we found hotspots of WAA in Spring but made a decision not to spray in these blocks. It has been proven to be the right decision, as the hotspots did not spread and there is now widespread parasitism in these blocks. You can actually look closely at the colonies and see the minute adult wasps moving around the canopy.
- CM – We learnt part way through the season that our 10x lures in our mating disruption blocks needed to be set higher in the canopy. We weren’t catching anything. We adjusted their position, but this didn’t make much difference to the catches. At the same time we were finding low levels of moth stings on the edges of one block. So we supplemented the pheromones with some spraying. This approach seems to have kept the moth in-check.
- We think our 1x traps in sprayed blocks may have been compromised by their closeness to neighbouring MD blocks thereby not trapping moth although they were present.
- Our initial experience with the line of traps idea was inconclusive for us.

What would you do differently next time?

- WAA – Will consider holding off spraying even in our older blocks next season. We’re also considering if it’s worth taking some parasitised WAA cuttings in the lead-up to harvest and storing these for release next Spring.
- CM – Will be more aware of correct trap height placement. In our non-mating disruption blocks we will make sure our 1x traps are far enough away from adjacent MD blocks so the 1x lures are not disrupted.

Any interesting learnings?

- WAA – it’s not new, but *A.mali* can be very effective and we will look to encourage this parasitic wasp more in the future. We were pleased to see (in February), such good *A.mali* parasitism of Woolly Aphid in our insecticide sprayed older blocks. It seems that our early spray may have helped tip the balance in favour of the *A.mali* and the wasps were able to re-establish themselves in these blocks despite the early season insecticide.

Take home message

- Our focus on these pests and use of IPM principles has produced a benefit this season. Looking forward to trying more ideas next season.

Action Plan

Situation:

- The orchard is a family business operated by 3rd generation orchardists. The orchard is 46 ha of apples for the domestic market. The main issues focussed on are woolly apple aphid (WAA), black spot (apple scab), codling moth, and weeds. Current IPDM involves mating disruption for codling moth backed up by spraying Altacor or Insegar if necessary when monitoring indicates a potential problem, and spot spraying an early Lorsban for WAA. A small block with WAA has been “sacrificed” to allow *Aphelinus mali* to build up for redistribution as needed. There have been some issues with codling moth damage in blocks not being monitored, and mites have also been a problem due to the drought but only one spray was required to bring them under control.

Mission:

- To achieve acceptable control of pests and diseases without negative effects on beneficials.

Execution:

- Consider storing some *Aphelinus mali* parasitised WAA from the “sacrificed” block for release of *A. mali* in late spring.
- Start monitoring mites early.
- Investigate use of cumulative leaf infested days (CLIDs) instead of mites/leaf or percentage leaves infested to determine the need to spray mites

Administration:

- David Williams to supply information on CLIDs
- Jeremy, Kevin and Matt to develop a pre-plan for responding to issues that may develop
- Ask an expert facility in IPDM website is available for additional support and expertise
- David and Kevin are available for feedback

Communications:

David Williams	0417549891	david.williams@djpr.vic.gov.au
Kevin Dodds	0427918315	kevin.dodds@dpi.nsw.gov.au
Jeremy		
Matt		
IPDM Website		www.extensionaus.com.au/australianappleandpearlIPDM

Safety:

- Experiments can be stressful but no useful results will occur unless the participants maintain their nerve
- Stress can be reduced by setting realistic targets that stretch comfort zones without creating major financial risks
- Stress can be reduced by taking the time to seek expert advice on the problem, either in the planning phase or before the problem gets out of control, rather than making knee-jerk decisions
- Regular assessments of pest and disease populations and damage levels will allow timely changes to approach before significant damage occurs

Outcome 2019-20

Focus on Woolly Apple Aphid (WAA) and Codling Moth (CM) continued with the implementation of an earwig monitoring trial and installation of new weather station with degree day prediction model for CM. Mites could have become a problem with the high temperatures experienced early-mid season but the damage assessment near harvest indicated good mite control and 46% of leaves having predatory mites present.

The rolled cardboard traps used to monitor earwigs as biological control agents against woolly aphid did not capture any earwigs despite the grower avoiding all insecticides known to be toxic to earwigs and they also inoculated the block to try to establish a population for the future.

In November, releases of *Aphelinus mali* were made by distributing parasitized WAA colonies on shoots stored from late last season. The damage assessment at harvest indicated good levels of *A. mali* activity.

Codling moth traps were monitored to determine a biofix in Spring to start accumulating Degree Days with a new Metos weather station and the RIMPro software package. Codling moth damage at harvest was 0.4%.

The weather station and RIMPRO also helped management of the apple scab spray program relative to the local infection pressure. No scab infested fruit were detected in the damage assessment at harvest.

The bushfire that hit Batlow burned into part of the orchard.

Case study Ceravolo

Initial consultation

Grower name: Joe Ceravolo

Location: Adelaide Hills

What are the main IPDM issues being focussed on?

- Trying to use minimal chemical inputs. AgXtra are doing a trial on predators for two-spotted mite. There are no codling moth issues in the block but looper, Helicoverpa and lightbrown apple moth (LBAM) are issues.

What are you doing currently with IPDM?

- Using mating disruption for codling moth but not trapping for codling moth.
- Carbaryl applied as a thinner has controlled LBAM, looper and Heliothis (Helicoverpa).

What has worked well?

- Minimal application of insecticide and mite sprays.
- Transform has controlled apple dimpling bug (ADB) and woolly apple aphid (WAA).
- Orchard is fully netted using 16mm mesh.

What hasn't worked well?

- Transform may be causing some mite issues and may have hit Aphelinus mali parasitoid against WAA.

What would you do differently next time?

- Local agronomist will monitor for codling moth, LBAM, and mites.

Any interesting learnings?

- We need to think more carefully about side effects of pesticides and this means we need more information to be readily available to us.

Take home message

- The more chemicals we spray the more damage we do.

Action Plan

Situation:

- Codling moth, black spot and lightbrown apple moth (LBAM) are under control. Mating disruption is used for codling moth control but no trapping is used to monitor codling moth populations. Carbaryl used as a thinner has apparently controlled LBAM, looper, and Heliothis (Helicoverpa). Joe has AgXtra doing trials on predators for two-spotted mite, and he is also trying to minimise use of pesticides. The case study block is fully netted using 16mm mesh. Transform has been used against apple dimpling bug (ADB) and woolly apple aphid (WAA). He is concerned that Transform may be causing mite issues and may also have impacted on his *Aphelinus mali* populations.

Mission:

- To capitalise on the low pest and disease populations and attempt to further reduce pesticide use while maintaining effective control and confidence in the approach being taken.

Execution:

- Establish codling moth and LBAM traps to determine population levels and monitor trends
- Monitor ADB populations in wattles and other flowering shrubs in the vicinity of the orchard from green tip to assess risk from local ADB populations
- Monitor weather trends, especially movement of fronts from the channel country in Qld, as indicators of potential ADB incursions during pink bud to full bloom
- Develop some plots, within the orchard, in which Transform is not used. Compare populations of pest and beneficial species, and damage levels, in these plots against what is experienced in the treated plots.
- Consider monitoring for budworm and looper activity from pink bud through to 2 weeks after petal fall. Initially look for budworm adults around lights as an indicator, and check flowers for presence of eggs. Eggs are distinctive, with ridging visible with a hand lens and you can also see developing larvae in the eggs as they get closer to hatching
- Work with Mark Staniford to develop a sampling plan for pest populations and levels of damage, then implement plan
- Mark to compare use of cumulative leaf infested days (CLIDs) vs his current mite monitoring
- Install a weather station in the block so that temperature and leaf wetness data and trapping results can be used in a predictive model to guide the need for sprays

Administration:

- Joe Ceravolo and Mark Staniford to organise experimental plots, traps, and the monitoring plan/ record sheets
- David Williams to supply pest prediction program
- Joe and Mark to work with Paul James to develop a pre-plan for responding to issues that may develop
- Ask an expert facility in IPDM website is available for additional support and expertise
- David and Paul are available for feedback

Communications:

David Williams	0417549891	david.williams@djpr.vic.gov.au
Paul James	0419826956	paul@lenswoodcoop.com.au
Mark Staniford	0417209145	mstaniford@eemuir.com.au
Joe Ceravolo		
IPDM Website		www.extensionaus.com.au/australianappleandpearlIPDM

Safety:

- Experiments can be stressful but no useful results will occur unless the participants maintain their nerve
- Stress can be reduced by setting realistic targets that stretch comfort zones without creating major financial risks
- Over-use of chemical applications will create residue issues, pest resistance issues, possible mite flare, and potential health issues for staff
- Stress can be reduced by taking the time to seek expert advice on the problem, either in the planning phase or before the problem gets out of control, rather than making knee-jerk decisions
- Regular assessments of pest and disease populations and damage levels will allow timely changes to approach before significant damage occurs
- Use of prediction models based on local data will provide early indications of potential danger periods

Outcome 2019-20

An assessment in December 2019 indicated that:

- codling moth, black spot and lightbrown apple moth (LBAM) were under control.
- No mite issues were evident, but it was still early in the season.
- Transform has controlled apple dimpling bug (ADB).
- Transform may be causing some mite issues and may have hit *Aphelinus mali* parasitoid against WAA.
- Block where Mastrus was released against codling moth still has virtually no codling moth.
- Joe is trying to capitalise on the low pest and disease populations and attempting to further reduce pesticide use while maintaining effective control and confidence in the approach being taken.
- Need more information on the side effects of pesticides on beneficials so better choices to suit the Action Plan can be made.

Assessment at harvest confirmed good control of codling moth, LBAM and mites. A small amount of scab was evident and looper damage was higher than expected.

Case Study Green

Initial consultation

Grower name: Kym Green

Location: Lenswood, Adelaide Hills.

Background:

- The family business involves 12.5 ha apples and cherries. Kym is a 5th generation farmer in partnership with brother Peter. They grow club varieties that are distributed through cooperative and through Ceravolo. Using IPM since 1980, beginning with mites.

What are the main IPDM issues being focussed on?

- Gone organic this season. In transition, Biodynamic Principles since 2006.
- Main issues are moth, scab, bryobia, and canary fly

What are you doing currently with IPDM?

- Cydex for Codling Moth using model. 2 sprays.
- Wetttable sulphur as protectant. 3-5 kg /ha.
- Lime sulphur after event.
- Eco-carb as eradicant.
- Copper (Organic hydroxide) @ green tip.

What has worked well?

- Cydex gave good results initially.
- Scab program until major event.

What hasn't worked well?

- Got caught with 2nd generation CM.
- Hail damage influenced decision making.
- Spraying in rain with lime sulphur during major event.

What would you do differently next time?

- Increase rate to the registered rate (sulphur) bearing in mind potential to burn.
- Explore organically acceptable ways of reducing inoculum.

Any interesting learnings?

- Too early at this stage

Take home message

- Observation is Key. Get out into the orchard and "listen" to what the trees are telling you.

Action Plan

Situation:

- Kym is a 5th generation orchardist running the family business in partnership with his brother Peter. They do most of their own packing but some goes via the Lenswood Cooperative and some through Ceravolo's. They have been involved with IPM since the 1980s, have been using Biodynamic principles since 2006 and are in transition to organic certification. Their main issues are codling moth, black spot, canary fly and some bryobia mite. Kym times application of codling moth granulosis virus according to a predictive model but got caught out this year with the second cohort of codling moth. His black spot program worked well until a major event caused prolonged wetting.

Mission:

- To achieve acceptable levels of damage while working within organic production guidelines by improving performance against codling moth and black spot.

Execution:

- Establish codling moth trapping to determine biofix for the first cohort, monitor trends in population and to ground-truth predictions for the 2nd cohort
- Explore organically acceptable ways of reducing disease inoculum over winter.
- Conduct small plot trials with different rates (no higher than the registered rate) of sulphur to investigate efficacy and also any side effects on beneficials or phytotoxicity.
- Install a weather station in the block so that temperature and leaf wetness data and trapping results can be used in a predictive model to guide the need for sprays

Administration:

- Kym Green and Paul James to organise experimental plots, traps, and the monitoring plan/ record sheets
- David Williams to supply pest prediction program
- Kym and Paul to develop a pre-plan for responding to issues that may develop
- Ask an expert facility in IPDM website is available for additional support and expertise
- David and Paul are available for feedback

Communications:

David Williams	0417549891	david.williams@djpr.vic.gov.au
Paul James	0419826956	paul@lenswoodcoop.com.au
Kym Green		
IPDM Website		www.extensionaus.com.au/australianappleandpearlPDM

Safety:

- Experiments can be stressful but no useful results will occur unless the participants maintain their nerve
- Stress can be reduced by setting realistic targets that stretch comfort zones without creating major financial risks
- Stress can be reduced by taking the time to seek expert advice on the problem, either in the planning phase or before the problem gets out of control, rather than making knee-jerk decisions
- Regular assessments of pest and disease populations and damage levels will allow timely changes to approach before significant damage occurs
- Use of prediction models based on local data will provide early indications of potential danger periods

Outcome 2019-20

This property was severely affected by the Adelaide Hills bushfire. No harvest damage assessment was conducted due to the extent of the fire damage.

Case study Martella

Initial consultation

Grower name: Terry Martella, B Martella & Sons

Location: Kiriip, WA

Background:

- Have used scouting for years, dating back to original IPM course delivered by WA dept.
- Terry is a 2nd generation orchardist who works with his brother Joe and sons Basil and Mark. The business runs a 35ha intensive orchard that is all trellised and planted at 3m x 1m, and 30% is fully netted. The crop consists of apples, plums, cherries, and some pears. They grow, pick, and store but packing is contracted out.

What are the main IPDM issues being focussed on?

- Mites, ADB, weevils, mealybug, powdery mildew (influenced by netting), and looper.

What are you doing currently with IPDM?

- Resistance program based on activity groups
- Monitoring mites and mealybug

What has worked well? What hasn't?

- Mite monitoring generally paying off because it allows observation of predators.
- Vertimec appeared to fail this year

What would you do differently next time?

- Consider replacing Klartan for ADB
- Investigate CLID's

Any interesting learnings?

- Trying to stop post-harvest dipping. Netting has resulted in less scald, probably due to sun. Sanitise bins with ozone but need to use/monitor it better

Take home message

- Be observant. Every time you change the environment you change a lot of other things in the system.

Action Plan

Situation:

- The business has been using pest scouting for years, dating back to the original IPM course conducted by the Western Australia Department of Agriculture. There are 35 ha of intensive orchard, all trellised, some fully netted. About 30% of the orchard is apples. The remainder consists of plums, cherries, and some pears. They grow, pick, and store but packing is contracted out.
- The main issues focussed on are mites, apple dimpling bug (ADB), weevils, mealybug and powdery mildew. They have a resistance management program based on activity groups, and a monitoring program for mites and mealybugs. Vertimec appeared to fail this year.

Mission:

- To achieve acceptable control of pests and diseases without negative effects on beneficials.

Execution:

- Consider replacing Klartan against ADB.
- Investigate use of cumulative leaf infested days (CLIDs) instead of mites/leaf or percentage leaves infested to determine the need to spray mites

Administration:

- David Williams to supply information on CLIDs
- Terry and Yoon to convert mite monitoring data to CLIDs and use results to develop preliminary thresholds for their context.
- Terry and Alison to develop a pre-plan for responding to issues that may develop
- Ask an expert facility in IPDM website is available for additional support and expertise
- David and Alison are available for feedback

Communications:

David Williams	0417549891	david.williams@djpr.vic.gov.au
Alison Mathews	0429409092	alison.mathews@dpird.wa.gov.au
Terry Martella		
IPDM Website		www.extensionaus.com.au/australianappleandpearIPDM

Safety:

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- Stress can be reduced by setting realistic targets that stretch comfort zones without creating major financial risks
- Stress can be reduced by taking the time to seek expert advice on the problem, either in the planning phase or before the problem gets out of control, rather than making knee-jerk decisions
- Regular assessments of pest and disease populations and damage levels will allow timely changes to approach before significant damage occurs

Outcome 2019-20

At the start of the 2019-20 season Terry had adjusted his monitoring program so that he could record mites/leaf and percentage leaves infested and allow him to compare mites/leaf and CLIDs (cumulative leaf infested days) as decision making tools. He had developed a season long plan based on monitoring rather than reacting ad hoc. This provided him the ability to observe the effects of predators and parasitoids.

He recognizes that understanding that interactions occur between most activities helps to determine potential causes of problems before they occur. This then feeds into the season-long plan. Covid 19 travel restrictions prevented completion of a harvest damage assessment

Case Study Scott

Initial consultancy

Grower name: Mark Scott

Location: Nannup, WA

Background:

- Mark has been orcharding since 1992 and is running Nannup Fresh Fruit.
- He contributed to the original WA IPDM manual by Martine Combet. The orchard is 20ha – 8ha apples and pears, 10ha stone fruit, 2 ha of mixed

What are the main IPDM issues being focussed on?

- Mites, Apple Dimple Bug, Woolly Apple Aphid, MedFly, brown snails, apple scab, pear scab, powdery mildew, spring beetle, weevils (Apple, G.W, FRW)

What are you doing currently with IPDM?

- Monitoring Apple Dimple Bug and spring beetle
- Spot monitor for mites through season, pay attention to known hot spots.
- Look out for signs of damage.

What has worked well? What hasn't?

- Ducks have worked well for snails, it's extra work though. Apple Dimple Bug monitoring has worked well.
- Woolly Apple Aphid is starting to come back. Need alternatives to Dominex butt sprays and Avatar for weevils

What would you do differently next time?

- Consider storing some Aphelinus for release
- Consider sward that supports predators over winter
- Oil sprays at green tip for Bryobia

Any interesting learnings?

- When you spray something to kill something you usually kill something else as well.

Take home message

- The longer I am in the industry the more I realise that I don't know.

Action Plan

Situation:

- The business has been using pest scouting for years and Mark contributed to the original IPM manual in WA. The orchard is 20 ha including 8 ha of apples and pears, 10 ha of stone fruit, and 2 ha of mixed fruit.
- The main issues focussed on are mites, apple dimpling bug (ADB), weevils, wooly apple aphid (WAA), MedFly, spring beetle, snails, powdery mildew, apple scab and pear scab. Current IPDM involves monitoring for ADB and spring beetle, spot monitoring for mites through the season paying attention to known hotspots, and looking out for signs of damage. Monitoring for ADB has worked well and ducks have been used successfully to manage snails (although managing ducks is extra work). WAA is starting to re-appear, possibly due to choice of pesticides to control weevils.

Mission:

- To achieve acceptable control of pests and diseases without negative effects on beneficials.

Execution:

- Consider storing some *Aphelinus mali* parasitised WAA for release of *A. mali* in late spring.
- Investigate use of cumulative leaf infested days (CLIDs) instead of mites/leaf or percentage leaves infested to determine the need to spray mites
- Consider developing inter-row sward that supports predators over winter and limits weeds.
- Apply oil spray at green tip against bryobia mite.

Administration:

- David Williams to supply information on CLIDs
- Mark and Alison to develop a pre-plan for responding to issues that may develop
- Ask an expert facility in IPDM website is available for additional support and expertise
- David and Alison are available for feedback

Communications:

David Williams	0417549891	david.williams@djpr.vic.gov.au
Alison Mathews	0429409092	alison.mathews@dpird.wa.gov.au
Mark Scott		
IPDM Website		www.extensionaus.com.au/australianappleandpearIPDM

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- Regular assessments of pest and disease populations and damage levels will allow timely changes to approach before significant damage occurs

Outcome 2019-20

- Apple Dimple Bug monitoring has worked well. No ADB or thrips detected therefore did not spray. No sign of damage from these pests.
- Oil spray at green tip against Bryobia mite appears to have given good control.
- Mark decided to leave *A.mali* predated WAA colonies in the orchard rather than store them. He was checking for any new infestations.
- Spring beetles were spot sprayed with Avatar rather than treating whole orchard.
- Mark let 'weeds' in tree row grow in winter and then used Sprayseed in early October before green tip. Used a mulching mower with side throw when necessary for inter-row sward management

Table 1. Summary of damage assessed at harvest 2019-20.

Pest or Disease	Percentage fruit damaged in each case study based on a random selection of 500 fruit (5 tree-equivalents x 100 fruit) at harvest 2019-2020					
	Finger G.smith	Nicoletti Pink lady	Evans Fuji	Smart Rosy glow	Ceravolo G.smith	Scott Pink Lady
Apple dimpling bug	1.4	0	0	0	0	0
Codling moth	0.4	2.0	0.2	0.4	0.2	0
Helicoverpa	2.8	1.6	0	0	1.0	0
Looper	0	0	0	0	4.6	0
LBAM	0.4	0	0	0	0	0
OFM	0	0	0	0	0	0
Weevil	0	0	0	0	0	0.4
Scab	0.6	0	0.2	0	0.8	0
Alternaria	0	0	0	0	0	3.2
Bitter rot/ Target spot	0	0.4	0	0	0	1.0
Powdery mildew	0	0	0	0	0	0.6
Mealybug	0	4.2	0	0	0	0.4
Fruit fly	0	0.4	0	0	0	0
Blister mite	0	0	0	0	0	0
Lenticel spot/ cracking	0	17.8	0	0	0	0

